

## for Television — 1920 × 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates

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### 1 Scope

**1.1** 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<sub>P</sub>R color encoding and analog interface;
- Y'C'B<sub>C</sub>R color encoding and digital interface.

An auxiliary component A may optionally accompany Y'C'B<sub>C</sub>R; this interface is denoted Y'C'B<sub>C</sub>RA.

**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<sub>R</sub>, E<sub>G</sub>, and E<sub>B</sub>, which, in turn, refer to signals to which the transfer characteristics given in clause 5 have been applied. Such signals are commonly described as being gamma corrected.

**1.2** This standard specifies multiple system formats (table 1), but 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 system formats are supported.

### 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 177-1993 (R1977), Derivation of Basic Television Color Equations

CIE Publication 15.2 (1986), Colorimetry, Second Edition

**Table 1 – Scanning systems**

	System nomenclature	Samples per active line (S/AL)	Active lines per frame	Frame rate (Hz)	Scanning format	Interface sampling frequency $f_s$ (MHz)	Samples per total line (S/TL)	Total lines per frame
1	1920 × 1080/60/1:1	1920	1080	60	Progressive	148.5	2200	1125
2	1920 × 1080/59.94/1:1	1920	1080	$\frac{60}{1.001}$	Progressive	$\frac{148.5}{1.001}$	2200	1125
3	1920 × 1080/50/1:1	1920	1080	50	Progressive	148.5	2640	1125
4	1920 × 1080/60/2:1	1920	1080	30	2:1 interlace	74.25	2200	1125
5	1920 × 1080/59.94/2:1	1920	1080	$\frac{30}{1.001}$	2:1 interlace	$\frac{74.25}{1.001}$	2200	1125
6	1920 × 1080/50/2:1	1920	1080	25	2:1 interlace	74.25	2640	1125
7	1920 × 1080/30/1:1	1920	1080	30	Progressive	74.25	2200	1125
8	1920 × 1080/29.97/1:1	1920	1080	$\frac{30}{1.001}$	Progressive	$\frac{74.25}{1.001}$	2200	1125
9	1920 × 1080/25/1:1	1920	1080	25	Progressive	74.25	2640	1125
10	1920 × 1080/24/1:1	1920	1080	24	Progressive	74.25	2750	1125
11	1920 × 1080/23.98/1:1	1920	1080	$\frac{24}{1.001}$	Progressive	$\frac{74.25}{1.001}$	2750	1125

IEC 60169-8 (1978-01), 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 (1993), and Amendment 1 (1996-03)

ITU-R BT.709-2 (1994), Parameter Values for the HDTV Standard for Production and International Programme Exchange

### 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 signal interaces are implemented (R'G'B', Y'P'BP'R, Y'C'BC'R, or Y'C'BC'RA; and
- whether the digital representation employs eight bits or ten bits.

**3.2** Digital codeword 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  $\pm 10$  ppm.

**4.2** A frame shall comprise the indicated total lines per frame, each line 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 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.

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

**4.5** An interlaced system shall scan a frame as a first field then as 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** 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 agreements.

**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 reference white conforms to CIE D<sub>65</sub> as defined by CIE 15.2:

	CIE $x$	CIE $y$
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:

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

**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 given in SMPTE RP 177:

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

**5.7** Color-difference component signals P'<sub>B</sub> and P'<sub>R</sub> 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'<sub>B</sub> and P'<sub>R</sub> are filtered as shown in figure B.2 and may be coded as C'<sub>B</sub> and C'<sub>R</sub> components for digital transmission.

## 6 Raster structure

**NOTE ON INTERLACED VERSIONS** – All of the scanning systems defined in this standard use 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 562½ 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 clause 8). 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.

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

**6.2** According to this standard, 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.

**6.3** According to this standard, 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.

**6.4** Ancillary signals 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 9.3. 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 specifi-

cation 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 sample number 0 (192 clock intervals after  $0_H$ ) and the 50% point of its trailing transition at sample number 1919 (2111 clock intervals after  $0_H$ ). The production aperture defines the maximum extent of picture information (see annex C).

**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 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 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  $Y'C'_BC'_R$  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).

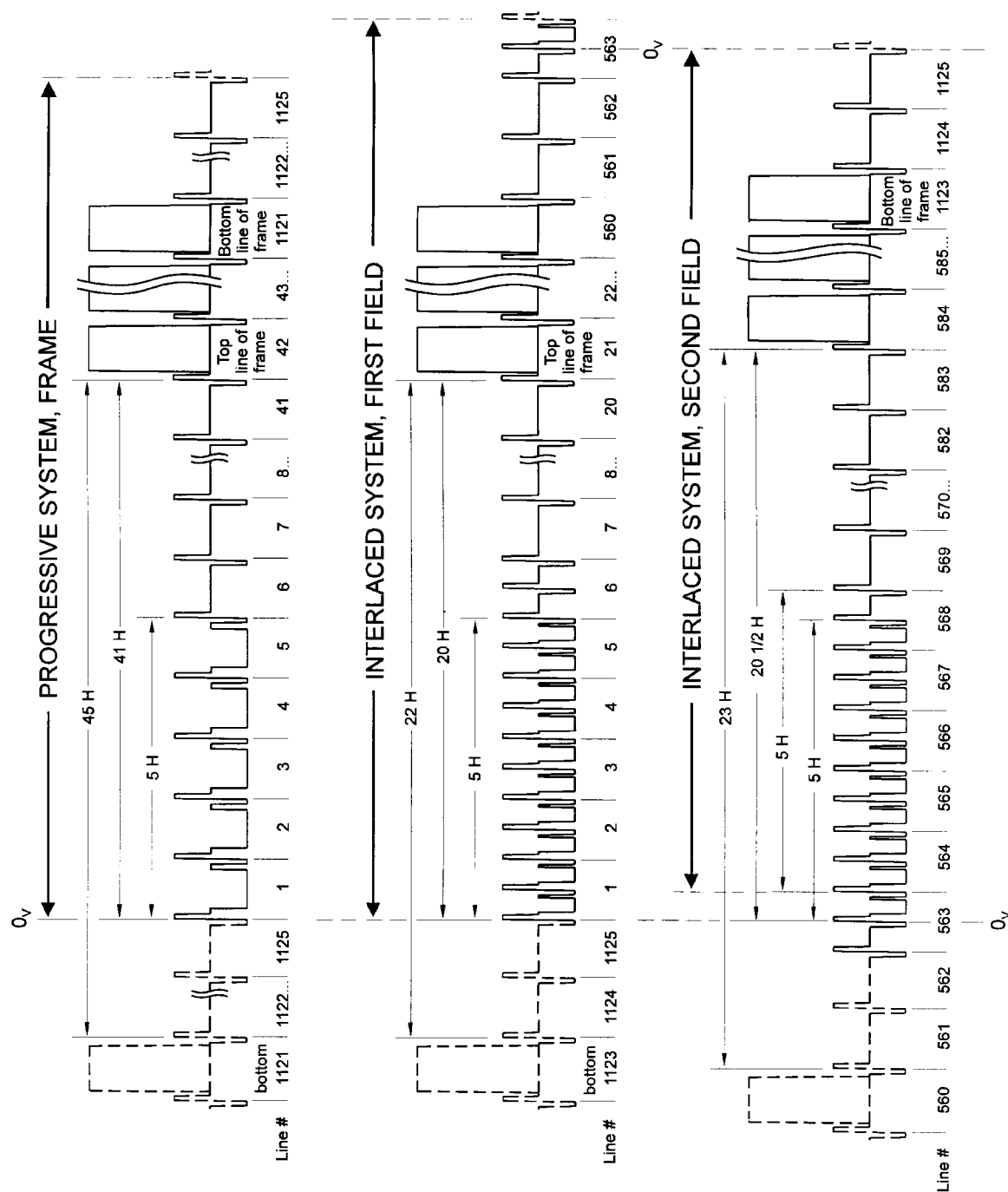
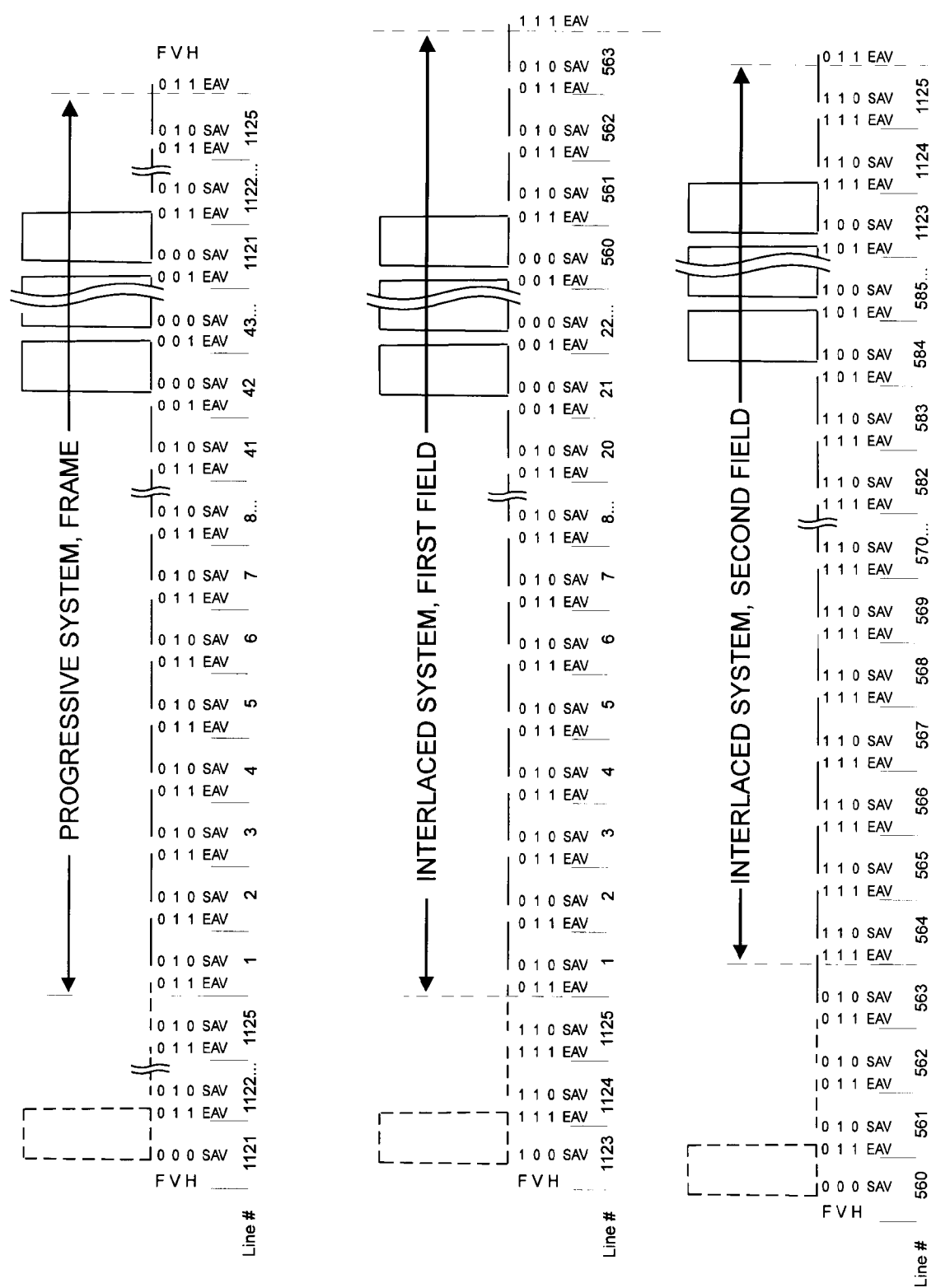


Figure 1 - Analog interface vertical timing details



### Figure 2 - Digital interface vertical timing details

**7.3** R'G'B' signals and Y' signals shall have bandwidth nominally 60 MHz for systems 1, 2, and 3 in table 1 and 30 MHz for systems 4 through 11 in table 1. 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 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.

**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:

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

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 codewords 64 and 940 in a ten-bit representation or codewords 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:

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

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 codewords 64 and 960 in a ten-bit representation or codewords 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). 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.

**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/signals.

**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.

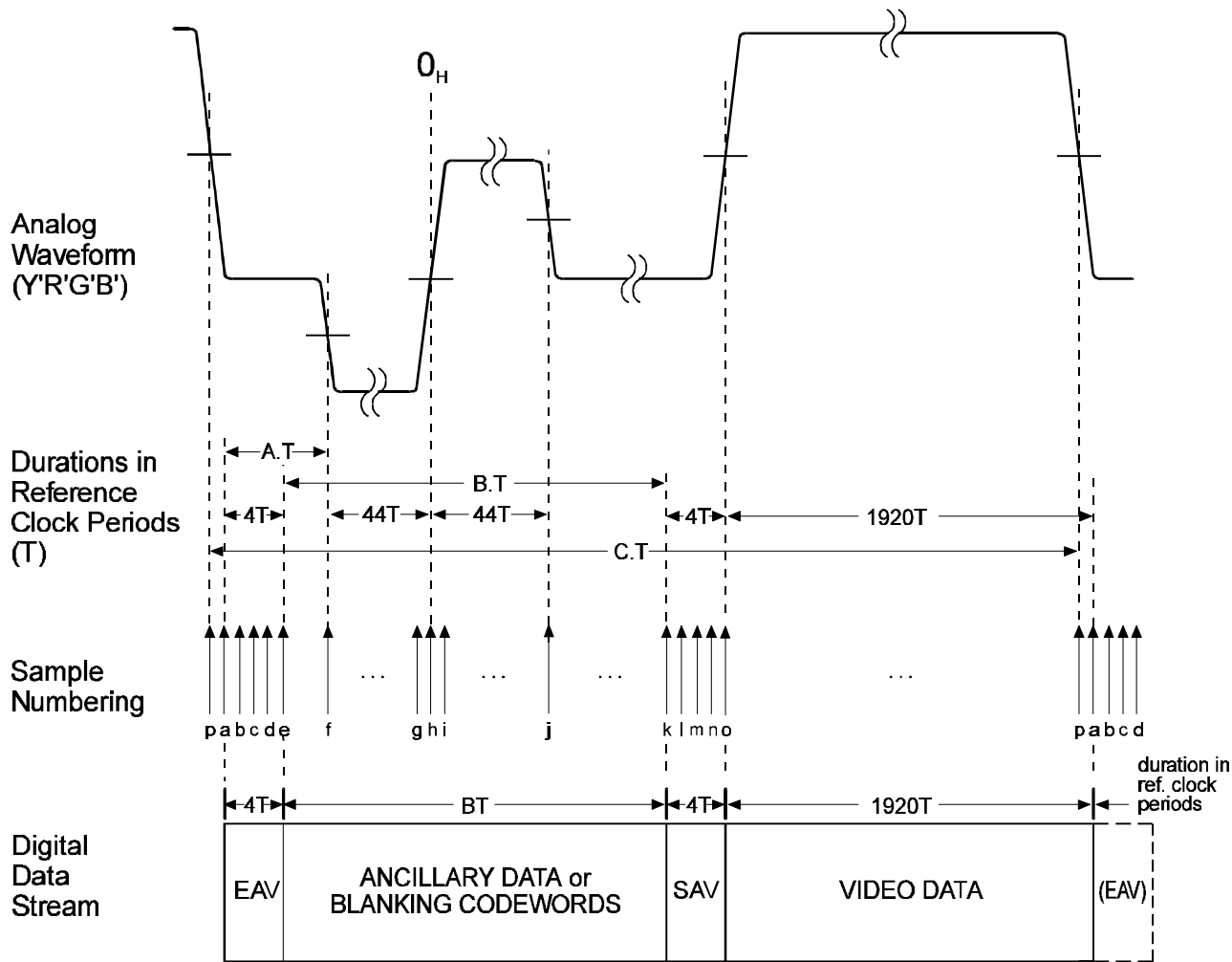
**7.12** For Y', R', G', and B' signals, undershoot and overshoot in video processing may be accommodated by the use of codewords 4 through 63 and codewords 941 through 1019 in a ten-bit system, or codewords 1 through 15 and codewords 236 through 254 in an eight-bit system.

For C'B and C'R signals, undershoot and overshoot in video processing may be accommodated by the use of codewords 4 through 63 and codewords 961 through 1019 in a ten-bit system, or codewords 1 through 15 and codewords 241 through 254 in an eight-bit system.

## 8 Digital timing reference sequences (SAV, EAV)

**8.1** SAV (start of active video) and EAV (end of active video) digital synchronizing sequences shall define synchronization across the digital interface. Figures 2 and 4 show the relationship of the SAV and EAV sequences to analog video and digital video.

**8.2** An SAV or EAV sequence shall comprise four consecutive codewords: a codeword of all ones, a codeword of all zeros, another codeword of all zeros, and a codeword including F (field/frame), V, H (horizontal), P3, P2, P1, and P0 (parity) bits. An SAV sequence shall be identified by having  $H = 0$ ; EAV shall have  $H = 1$  (tables 3 and 4 show details of the coding).

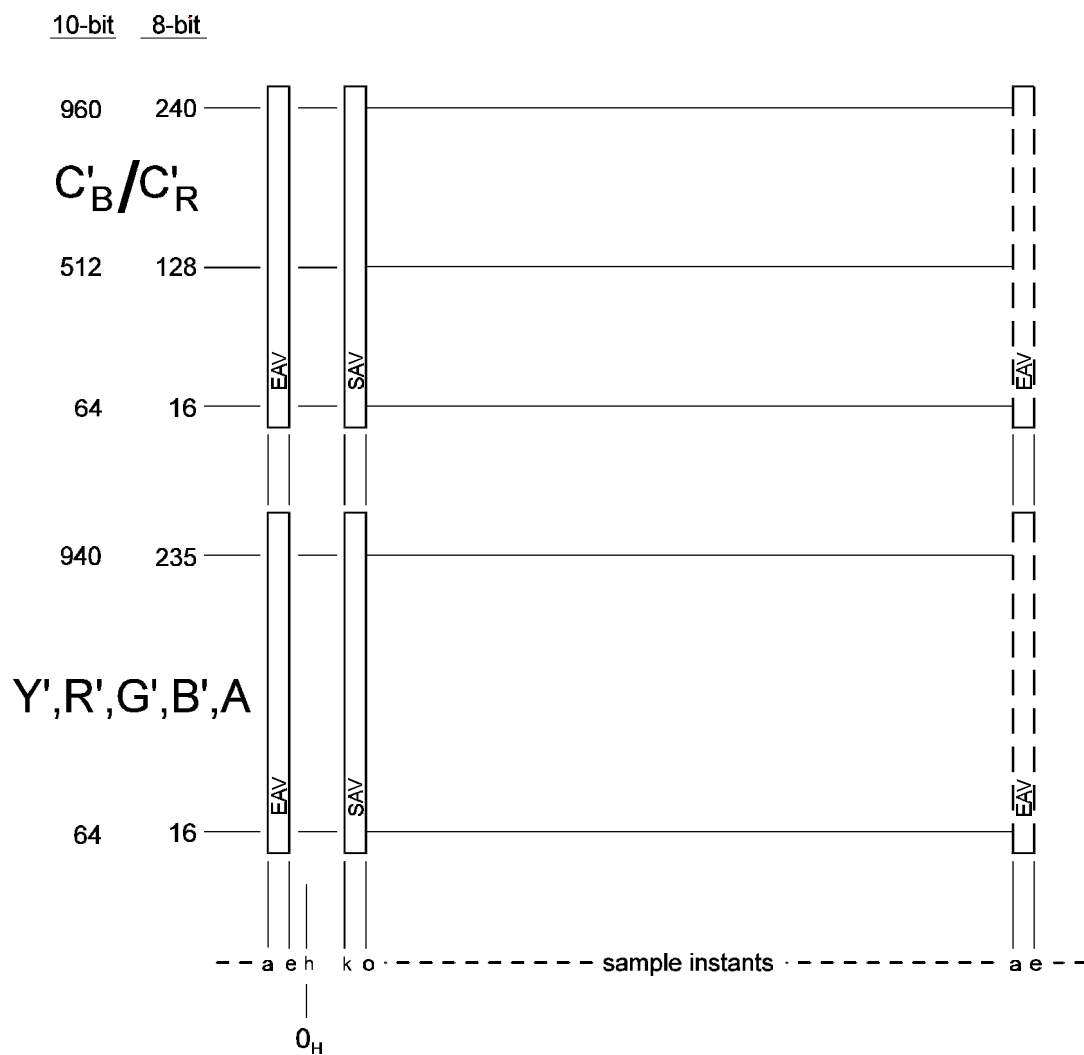


- NOTES
- 1 Horizontal axis not to scale.
  - 2  $0_H$  is the analog horizontal timing reference point, and in the analog domain is regarded as the start of the line.
  - 3 A line of digital video extends from the first word of EAV through the last word of video data.

Figure 3 – Analog and digital timing relationships

Table 2 – Values for figures 3 and 4 for different scanning systems

System	Sample numbering															
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
1,2,4,5,7,8	1920	1921	1922	1923	1924	1964	2007	2008	2009	2052	2196	2197	2198	2199	0	1919
3,6,9	1920	1921	1922	1923	1924	2404	2447	2448	2449	2492	2636	2637	2638	2639	0	1919
10,11	1920	1921	1922	1923	1924	2514	2557	2558	2559	2602	2746	2747	2748	2749	0	1919
System	Durations in reference clock periods (T)															
	A				B				C							
1,2,4,5,7,8	44				272				2200							
3,6,9	484				712				2640							
10,11	594				822				2750							



## NOTES

- 1 Figure 3 and table 2 show numbering of sample instants for each of the systems covered in this standard.
- 2  $0_H$  is the analog horizontal timing reference point.

Figure 4 – Digital interface horizontal timing details

**Table 3 – Video timing reference codes**

Bit number		9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
Word	Value										
0	1023	1	1	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3		1	F	V	H	P3	P2	P1	P0	0	0

**Table 4 – Protection bits for SAV and EAV**

Bit number	9	8	7	6	5	4	3	2	1	0
Function	1 Fixed	F	V	H	P3	P2	P1	P0	0 Fixed	0 Fixed
0	1	0	0	0	0	0	0	0	0	0
1	1	0	0	1	1	1	0	1	0	0
2	1	0	1	0	1	0	1	1	0	0
3	1	0	1	1	0	1	1	0	0	0
4	1	1	0	0	0	1	1	1	0	0
5	1	1	0	1	1	0	1	0	0	0
6	1	1	1	0	1	1	0	0	0	0
7	1	1	1	1	0	0	0	1	0	0

**8.3** When digitized, every scan line shall include a four-sample EAV sequence commencing either 88 clocks prior to 0<sub>H</sub> (scanning systems 1, 2, 4, 5, 7, and 8), or 528 clocks prior to 0<sub>H</sub> (scanning systems 3, 6, and 9), or 638 clocks prior to 0<sub>H</sub> (scanning systems 10 and 11), and a four-sample SAV sequence commencing 188 clocks after 0<sub>H</sub>. Digitized lines shall be numbered and the numbering shall change state prior to the horizontal timing point (0<sub>H</sub>), as shown in figure 2. The EAV sequence immediately preceding the 0<sub>H</sub> datum of line 1 shall be considered to be the start of the digital frame.

**8.4** In a progressive system:

- The EAV and SAV of all lines shall have F = 0;

NOTE – In future progressive scan systems, if there are two different types of frames (such as number of lines), the

differentiation between frames shall be indicated by the F bit.

- The EAV and the SAV of lines 1 through 41 inclusive and lines 1122 through 1125 inclusive shall have V = 1;
- The EAV and SAV of lines 42 through 1121 inclusive shall have V = 0.

**8.5** In an interlaced system:

- The EAV sequence of line 1 shall be considered to be the start of the first digital field and the EAV sequence of line 564 shall be considered to be the start of the second digital field;
- The EAV and SAV of lines 1 through 563 inclusive shall have F = 0. The EAV and SAV of lines 564 through 1125 inclusive shall have F = 1;

– The EAV and SAV of lines 1 through 20, lines 561 through 583, and lines 1124 and 1125 shall have  $V = 1$ ;

– The EAV and the SAV of lines 21 through 560 and lines 584 through 1123 shall have  $V = 0$ .

**8.6** A line, which in the analog representation is permitted to convey ancillary signals, may convey digitized ancillary signals.

NOTE – The inclusion of line-number information, following the EAV sequence, is under study.

## 9 Ancillary data

**9.1** Ancillary data may optionally be included in the blanking intervals of a digital interface according to this standard.

**9.2** Any interval between EAV and SAV may be employed to convey ancillary data packets.

**9.3** The interval between SAV and EAV of any line that is outside the vertical extent of the picture (as defined in 6.4), and that is not employed to convey vertical blanking interval signals that can be represented in the analog domain through direct (D/A) conversion (such as D-VITC), may be employed to convey ancillary data packets.

**9.4** Independent ancillary data packets may be conveyed across each of the three  $R'$ ,  $G'$ , and  $B'$  channels, or across each of the three  $Y'$ ,  $C'_B/C'_R$ , and  $A$  channels.

**9.5** In the case of 10-bit representation, intervals not used to convey SAV, video data, EAV, or ancillary data shall convey the codeword 64 (black) in the  $R'$ ,  $G'$ ,  $B'$ ,  $Y'$ , or  $A$  channels, or 512 in the  $C'_B/C'_R$  channels. They shall be 16 and 128 respectively in the case of 8-bit representation.

**9.6** In the case of 10-bit representation, codewords 0, 1, 2, 3, 1020, 1021, 1022, and 1023 shall be prohibited from ancillary data words. In the case of 8-bit representation, codewords 0 and 255 shall be prohibited from ancillary data words.

NOTE – Specifications of the details of ancillary data will be the subject of future SMPTE standards.

## 10 Bit-parallel electrical interface

**10.1** This clause describes a bit-parallel electrical interface which is applicable to all the scanning systems specified in this standard. It is a point-to-point interface with one transmitter and one receiver. (The parallel signal is also the referenced source format for the serial interface which is specified in ANSI/SMPTE 292M. The serial interface is applicable to scanning systems with nominal sampling frequency values near 74.25 MHz [systems 4 - 11] in this standard.) The parallel interface may be used to convey  $R'G'B'$  components,  $Y'C'_B C'_R$  components, or  $Y'C'_B C'_R$  components augmented by an auxiliary component  $A$  coded similarly to video but otherwise outside the scope of this standard.

**10.2** Video data shall be transmitted in NRZ form in real time (unbuffered) in blocks, each comprising one active line.

**10.3** A pair of conductors conveys a clock signal at the sampling rate of  $Y'$  (or  $R'G'B'$ ).

**10.4** Data shall be transmitted in parallel by means of eight or ten shielded conductor pairs for each of the channels.

**10.5** The signals on the interface shall be transmitted without equalization in systems 4 - 11 in table 1 for a distance of up to 20 m (65.6 ft), and in systems 1 - 3 in table 1 for a distance of up to 14 m (46.3 ft).

**10.6** The data bits of each component shall be numbered nine through zero, where zero is the least significant bit.

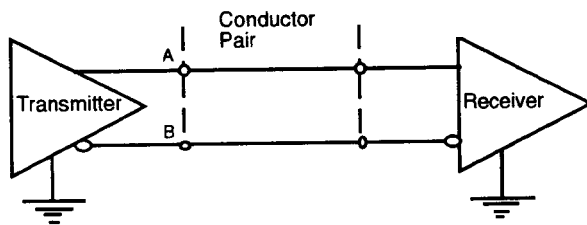
**10.7** The  $R'G'B'$  interface shall use three sets of the same number of either eight or ten pairs to convey  $R'$ ,  $G'$ , and  $B'$  components on the contacts shown in table 5.

**10.8** The  $Y'C'_B C'_R$  interface uses a set of eight or ten pairs to convey the  $Y'$  signal (on the pins indicated for the  $G'$  signals in table 5), and a second set of the same number of pairs to convey time-multiplexed  $C'_B$  and  $C'_R$  signals (on the pins indicated for  $R'$  in table 5).

**10.9** The  $Y'C'_B C'_R A$  interface conveys eight or ten bits of  $Y'C'_B C'_R$  as above, and conveys an

**Table 5 – 93-contact connector contact assignments**

	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
MSB	1	CK+	17	GND	33	CK--	49	B4+	64	GND	79	B4--
	2	G9+	18	GND	34	G9--	50	B3+	65	GND	80	B3--
	3	G8+	19	GND	35	G8--	51	B2+	66	GND	81	B2--
	4	G7+	20	GND	36	G7--	52	B1+	67	GND	82	B1--
	5	G6+	21	GND	37	G6--	53	B0+	68	GND	83	B0--
	6	G5+	22	GND	38	G5--	54	R9+	69	GND	84	R9--
	7	G4+	23	GND	39	G4--	55	R8+	70	GND	85	R8--
	8	G3+	24	GND	40	G3--	56	R7+	71	GND	86	R7--
LSB <sub>8</sub>	9	G2+	25	GND	41	G2--	57	R6+	72	GND	87	R6--
LSB <sub>10</sub>	10	G1+	26	GND	42	G1--	58	R5+	73	GND	88	R5--
	11	G0+	27	GND	43	G0--	59	R4+	74	GND	89	R4--
	12	B9+	28	GND	44	B9--	60	R3+	75	GND	90	R3--
	13	B8+	29	GND	45	B8--	61	R2+	76	GND	91	R2--
	14	B7+	30	GND	46	B7--	62	R1+	77	GND	92	R1--
	15	B6+	31	GND	47	B6--	63	R0+	78	GND	93	R0--
	16	B5+	32	GND	48	B5--						

**Figure 5 – Transmitter and receiver connection**

auxiliary signal A of the same number of bits (on the pins indicated for B' in table 5).

## 11 Electrical characteristics

**11.1** The arrangement of the transmitter and receiver devices and conductors for one balanced conductor pair shall be as shown in figure 5.

**NOTE** – The transmitter and receiver parameters are ECL-compatible so as to permit, in systems 4 - 11 in table 1, the use of standard ECL (10KH series) devices.

**11.2** The signalling polarity of voltage appearing across the interface shall be positive binary, defined as follows:

- The A terminal of the line driver shall be negative with respect to the B terminal for a binary 0 state;
- The A terminal of the line driver shall be positive with respect to the B terminal for a binary 1 state.

**11.3** The transmitter in an eight-bit system shall assert bits 1 and 0 to logic zero.

**11.4** The receiver in an eight-bit system shall terminate bit pairs 1 and 0.

**11.5** The transmitter shall have a balanced output with a maximum impedance of 110 Ω.

**11.6** The average of the voltages on the two terminals of the line driver with reference to the ground terminal shall be  $-1.29\text{ V} \pm 15\%$ .

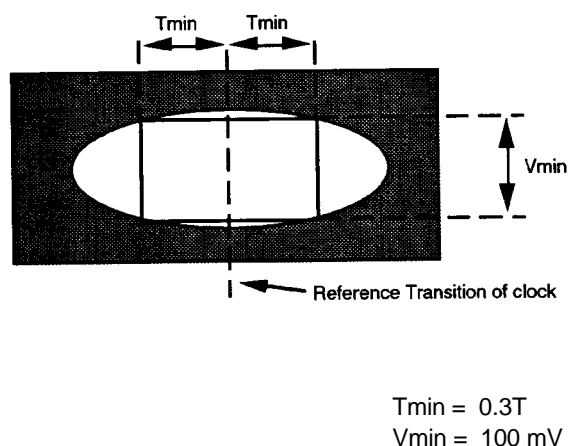
**11.7** The generated signal shall lie between 0.6 V peak-to-peak and 2.0 V peak-to-peak, measured across a 110-Ω resistor connected to the output terminals without any transmission line.

**11.8** Rise and fall times shall be no greater than  $0.15T$  when measured between the 20% and the 80% amplitude points across a  $110\text{-}\Omega$  resistive load. The difference between rise and fall times shall not exceed  $0.075T$ .

**11.9** The receiver shall present an impedance of  $110\text{ }\Omega \pm 10\text{ }\Omega$ .

**11.10** Maximum input signal amplitude shall be  $2.0\text{ V}$  peak-to-peak.

**11.11** The receiver shall require a differential input voltage of no more than  $185\text{ mV}$  peak to peak to correctly attain the intended binary state. Additionally, the line receiver must sense correctly the binary data when a random data signal produces, at the data detection point, the conditions represented by the eye diagram shown in figure 6.



NOTE — Cable response losses, frequency response characteristics of the interface electronics, propagation delay skew, data source timing skew, and clock jitter all affect reliable detection of received data, and must be taken into account in system timing margin considerations. This figure assumes propagation skew of  $0.18T$ , data source skew of  $0.075T$ , and clock jitter of  $0.04T$  to show the minimum eye opening of  $2 \times T_{min}$ , due only to frequency characteristics of the cable and interface electronics. In this case, the total system timing margin goes to zero.

**Figure 6 — Idealized eye diagram corresponding to the minimum input signal level**

**11.12** The receiver shall operate correctly in the presence of common mode noise (comprising interference in the range 0 to line frequency,  $f_H$ , with both terminals to ground) having a maximum amplitude of  $0.3\text{ V}$ .

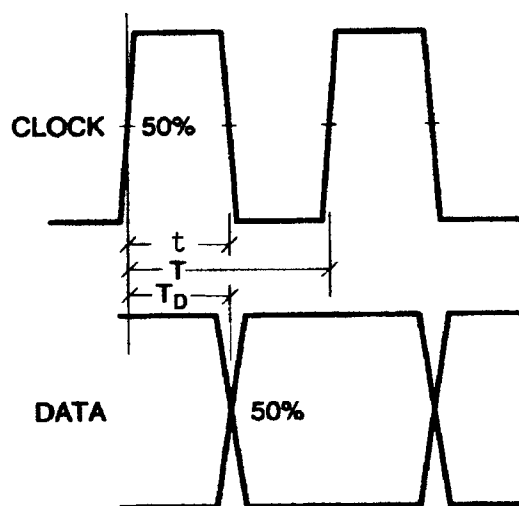
**11.13** Data shall be correctly sensed when the relative differential delay between the received clock and the received data is less than  $0.3T$ .

## 12 Clock

**12.1** One pair on the interface shall convey a clock signal at the sampling frequency, which shall have a positive pulse width of  $(0.5 \pm 0.11) T$ .

**12.2** Peak-to-peak jitter between rising edges of the transmitted clock shall be less than  $0.08T$ , measured over a period of one frame.

**12.3** Data signals shall be asserted by the transmitter at a time interval  $(0.5 \pm 0.075)T$ , denoted  $T_D$ , following the 0-to-1 transition of the clock, according to figure 7.



Clock period,  $T = 1/(C \cdot f_H)$

Clock pulse width,  $t = (0.5 \pm 0.11)T$

Data timing (sending end),  $T_D = (0.5 \pm 0.075)T$

(where  $C$  equals the number of reference clock periods per horizontal scan line; for values of  $C$  for the various scanning systems, refer to table 2)

**Figure 7 — Clock-to-data timing (at sending end)**

**12.4** Data signals shall be sampled at the receiver by the 0-to-1 transition of the clock.

### **13 Bit-parallel mechanical interface**

**13.1** The multichannel cable shall consist of twisted-pair conductors with individual shields. The nominal characteristic impedance of each twisted pair shall be 110  $\Omega$ .

**13.2** This standard applies to applications where the physical length of the cable is at most 20 m for systems 4 - 11 in table 1 and 14 m for systems 1 - 3 in table 1. Within this range, equalization of the cable characteristics is not required.

**13.3** The multichannel cable shall consist of either 21 or 31 twisted pairs of conductors with individual shielding of each pair. The cable should be constructed to minimize the differential delay between any two conductor pairs. Cable with controlled differential delay may be appropriate for transmission distances longer than that specified in 13.2.

**13.4** The cable shall contain an overall shield to minimize electromagnetic interference (EMI) carried through the cable assembly and connectors via the cable shield and the connector bodies.

**13.5** An interface according to this standard shall employ a 93-pin connector. Figures 8, 9, and 10 show the mechanical drawings and dimensions of the pin connector (cable plug), the socket connector (equipment receptacle), and the connector metal hood and retaining mechanism, respectively. The cable assembly shall provide pin contacts at both ends. Transmitter and receiver equipment shall have connectors with socket contacts. The connector hood shall be designed to prevent radiation of electromagnetic interference.

**13.6** Connector contact assignment shall be according to table 5. The shield for each conductor pair shall use the ground pin located between pins for the signal pair as shown in table 5.

**13.7** The overall shield of the multichannel cable shall be electrically connected to the connector hood. The connector hood, in turn, shall be grounded to the frame of the equipment. The

shield wire of each twisted pair shall be grounded to the system ground of the equipment through a pin contact. There shall be electrical conduction between the overall cable shield and the connector hood and equipment frame.

**13.8** The cable connectors shall be provided with two M4 mounting screws and the equipment connectors shall be provided with two M4 female threaded bosses.

### **14 Analog sync (60/59.94/50-Hz systems only)**

NOTE – This clause, including table 6, applies to 60-, 59.94-, and 50-Hz scanning systems only (table 1 systems 1-5 and 8), because direct analog interconnection is not recommended for use with slow-rate systems (30-Hz and below).

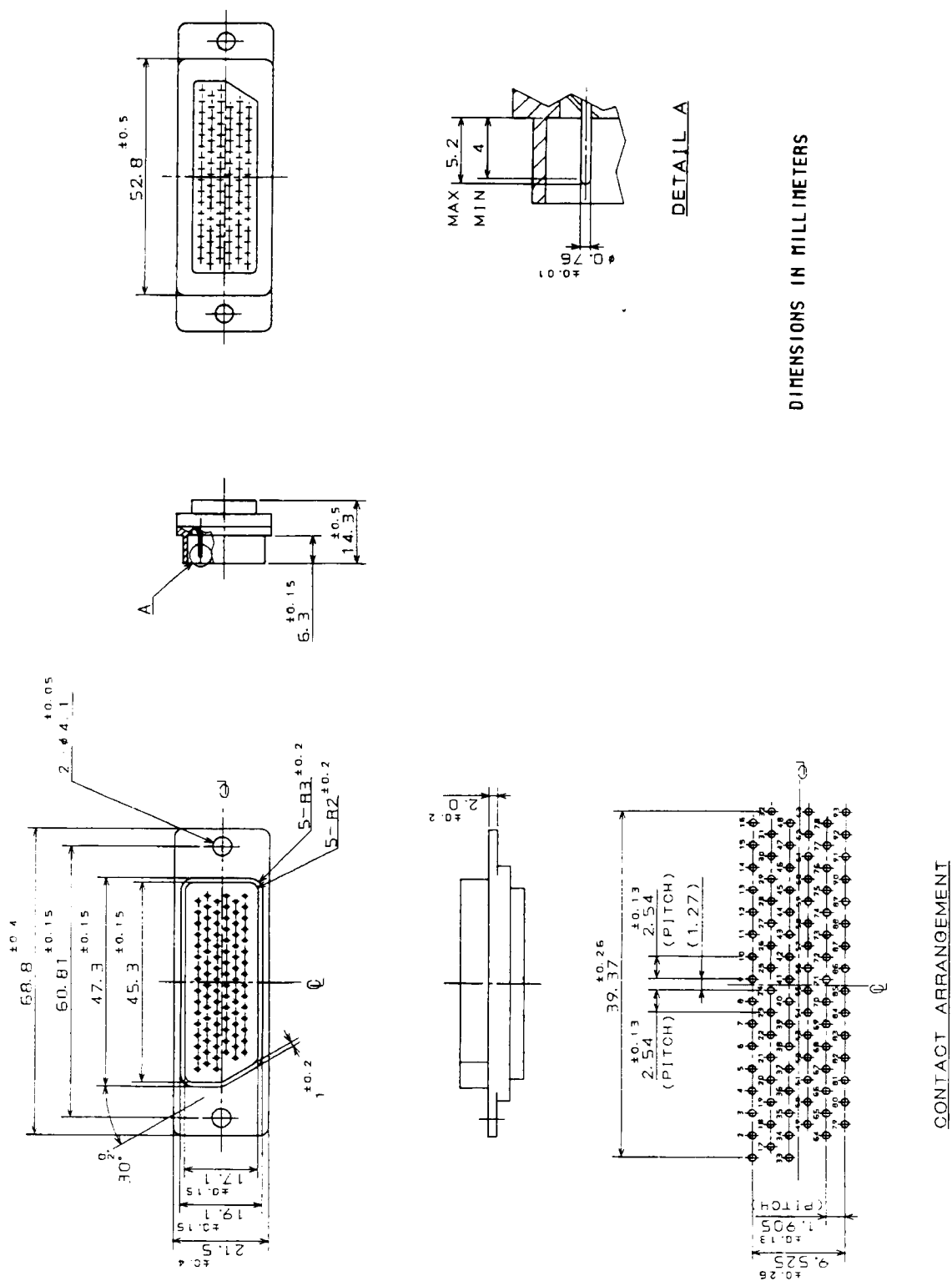
**14.1** Details of analog sync timing are shown in figures 1, 3, and 11, and are summarized in table 6. The parameter  $\phi$  not shown in these figures is the duration of the rising edge of the horizontal sync pulse.

**14.2** A positive zero-crossing of a trilevel sync pulse shall define the 0<sub>H</sub> datum for each line. A negative-going transition precedes this instant by 44 reference clock intervals, and another negative-going transition follows this instant by 44 reference clock intervals.

**14.3** The positive transition of a trilevel sync pulse shall be skew symmetric with a rise time from 10% to 90% of  $4 \pm 1.5$  reference clock periods. The midpoint of each negative transition shall be coincident with its ideal time within a tolerance of  $\pm 3$  reference clock periods.

**14.4** The trilevel sync pulse shall have structure and timing according to figures 3 and 11. The positive peak of sync shall have a level of  $+300 \text{ mV} \pm 6 \text{ mV}$ ; its negative peak shall have a level of  $-300 \text{ mV} \pm 6 \text{ mV}$ . The amplitude difference between positive and negative sync pulses shall be less than 6 mV.

**14.5** Each line that includes a vertical sync pulse shall maintain blanking level, here denoted zero, except for the interval(s) occupied by sync pulses. During the horizontal blanking interval, areas not occupied by sync shall be maintained at blanking level, here denoted zero.



**Figure 8 - 93-contact plug connector (cable)**

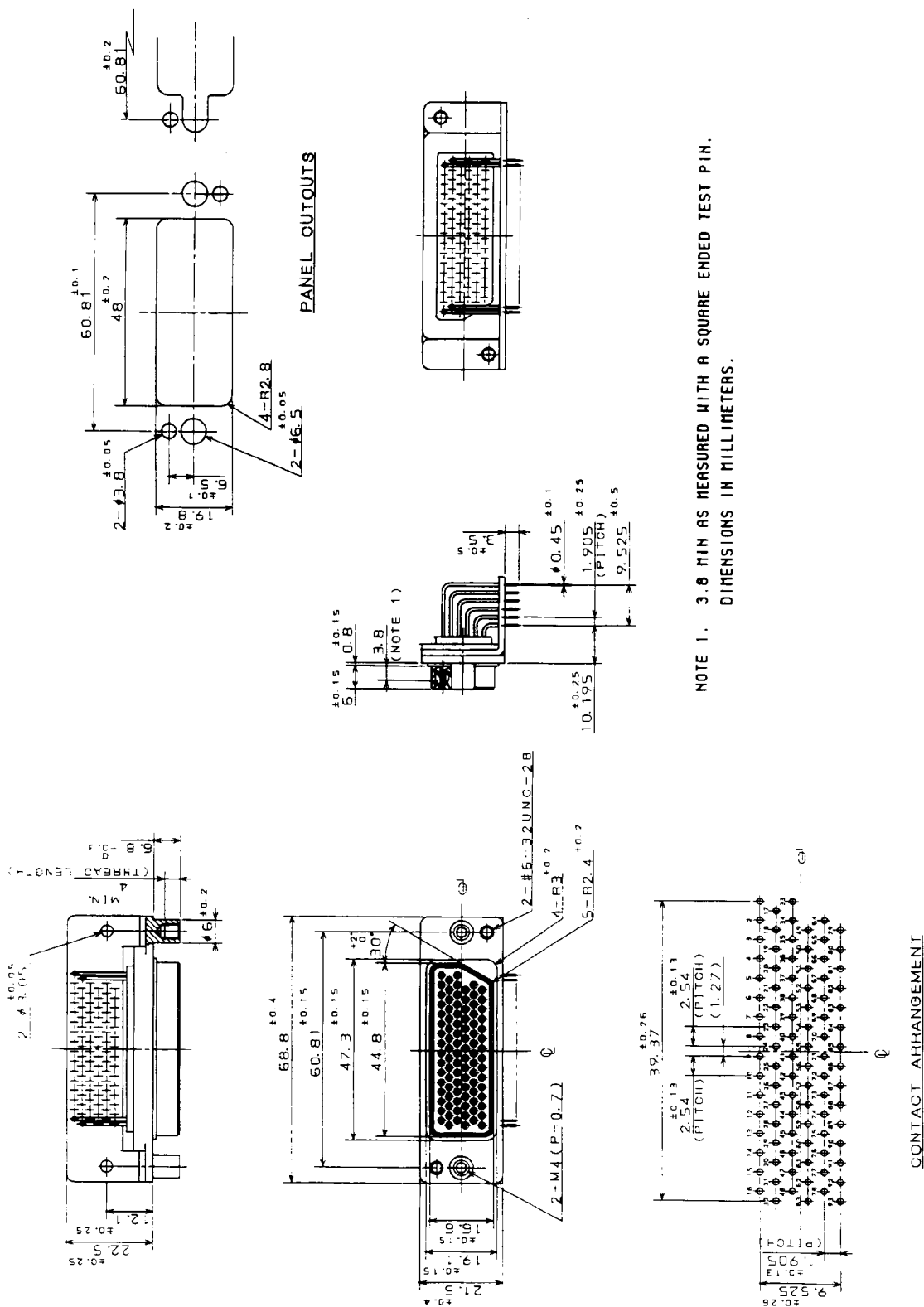


Figure 9 - 93-contact socket connector (equipment)

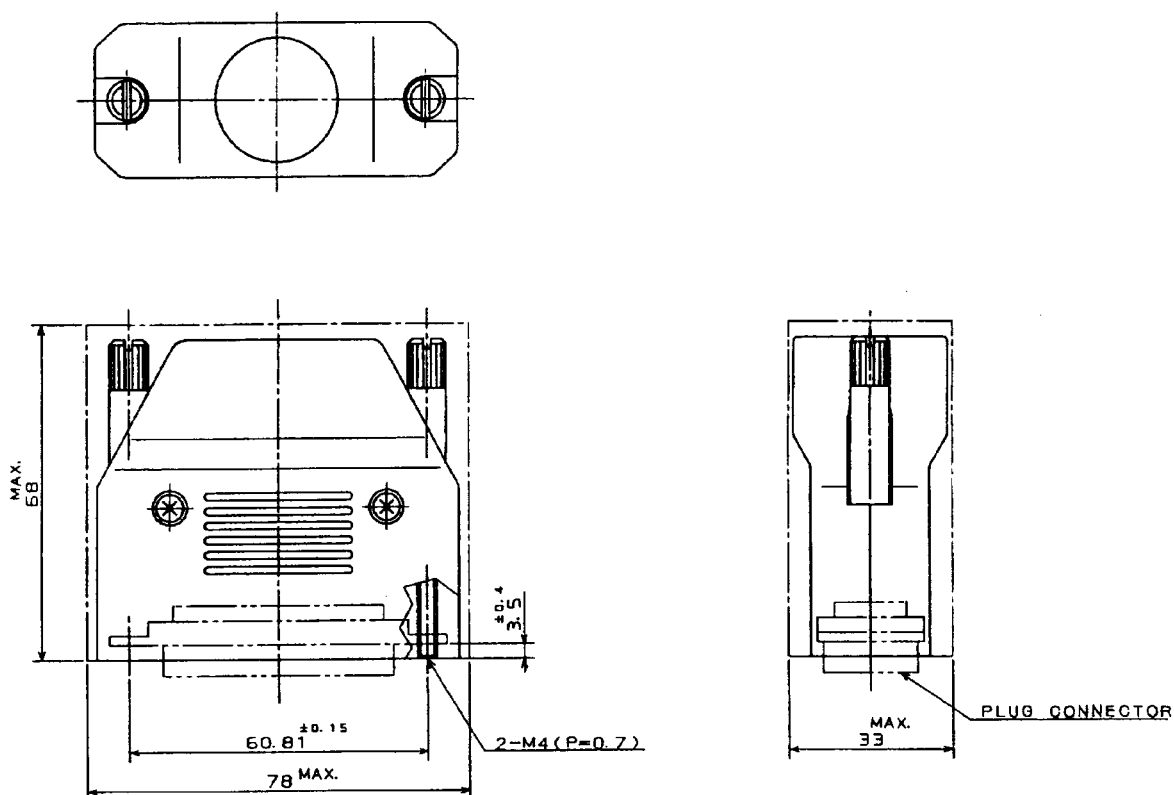


Figure 10 – 93-contact plug (hood)

Table 6 – Analog sync timing (60/59.94/50 Hz)

		Duration (T)	Tolerance (T)
$\alpha$	See figure 11	44	$\pm 3$
$\beta$	See figure 11	2112	$-6$ $+0$
$\chi$	See figure 11	44	$\pm 3$
$\delta$	See figure 11	132	$\pm 3$
$\varepsilon$	See figure 11	192	$-0$ $+6$
$\phi$	Sync rise time	4	$\pm 1.5$
$\gamma_i$	See figure 11	(interlaced) 1100	
$\gamma_p$		(progressive) 2200	
$\eta_i$	See figure 11	(interlaced) 1012	$\pm 3$
$\eta_p$		(progressive) 2112	
	Total line	2200	
	Active line	1920	$-12$ $+0$

**14.6** In addition to the trilevel sync pulse that defines  $0_H$ , an interlaced system vertical sync line may include a midline trilevel sync pulse whose elements are delayed from  $0_H$  by one-half the line duration. Certain vertical sync lines may, therefore, contain a broad pulse during the first half line, and may contain a broad pulse during the second half line, in the manner described in 14.8 and 14.9. The leading 50% point of a broad pulse shall be 132T after the preceding trilevel zero-crossing; its duration shall be 880T interlaced or 1980T progressive (see figure 11).

**14.7** In a progressive system, a frame shall commence with five vertical sync lines each containing a broad pulse.

**14.8** The first field of an interlaced system shall commence with five vertical sync lines (see figure 1):

- five lines having broad pulses in both the first and second half lines;
- plus a sixth line having only a midpoint trilevel pulse.

**14.9** The second field of an interlaced system shall commence as shown in figure 1. The vertical sync associated with the second field shall be contained within six lines comprising:

- the second half of a line having blanking in the first half line, a midline trilevel pulse, and a broad pulse in the second half line;
- four lines having broad pulses in both the first and second half lines and a midline trilevel pulse between them; then
- the first half of one line having a broad pulse in the first half line and a midline trilevel pulse.

## 15 Analog interface

NOTE – This clause applies to 60-, 59.94-, and 50-Hz scanning systems only (table 1 systems 1-6), because direct analog interconnection is not recommended for use with slow-rate systems (30-Hz progressive and below).

**15.1** An analog interface according to this standard may employ either the R'G'B' component set or the Y'P'B'P'R component set.

**15.2** R'G'B' signals and Y' signals shall have bandwidth nominally 60 MHz for systems 1 - 3 in table 1 and 30 MHz for systems 4 - 11 in table 1.

**15.3** P'B and P'R signals shall have the same bandwidth as that of the associated Y' signal at analog originating equipment. Therefore, the analog interface for P'B and P'R signals shall have the same bandwidth as for the Y' signal. P'B and P'R signals may have 0.5 the bandwidth of the associated Y' signal for digital equipment.

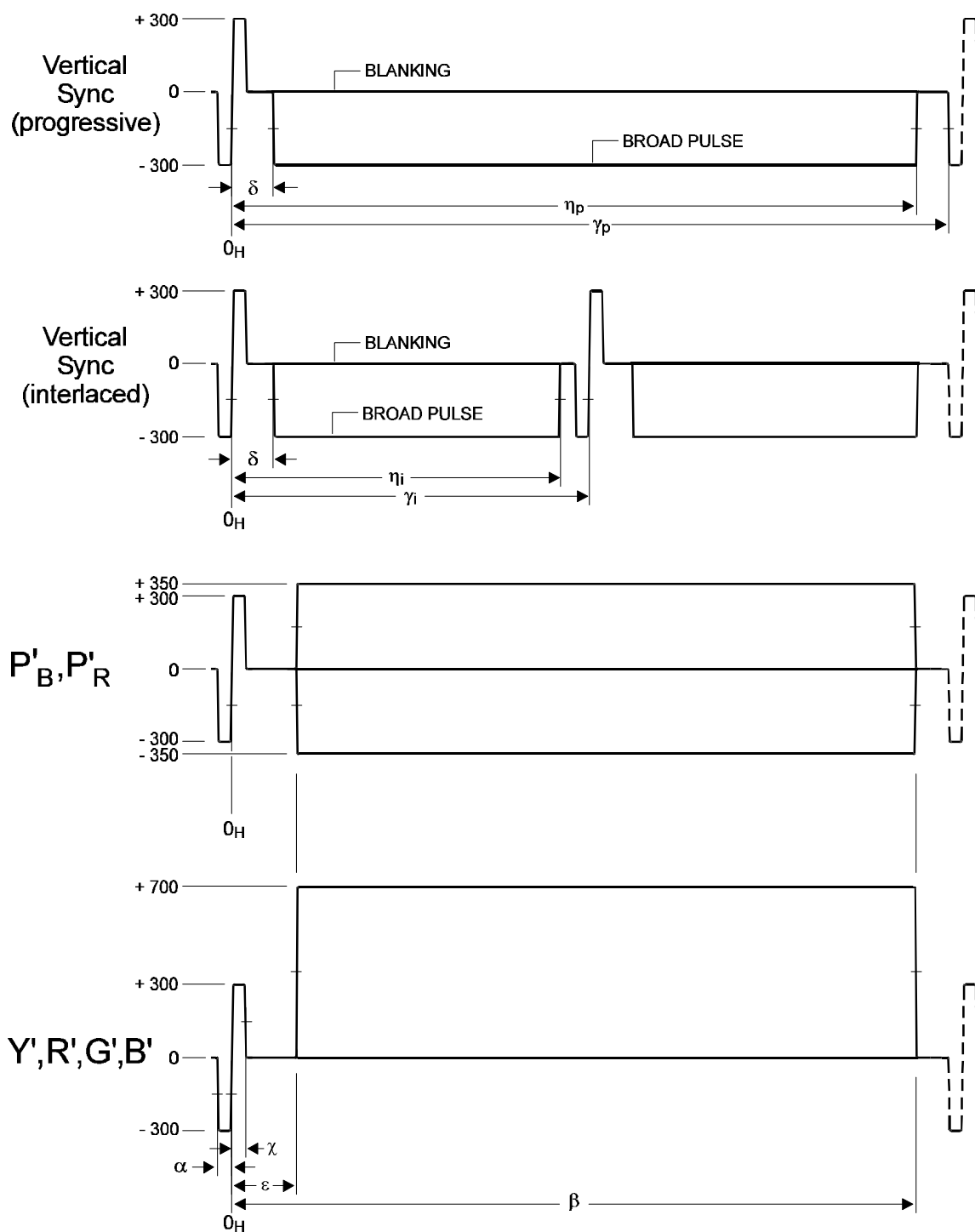
**15.4** Each component signal shall be conveyed electrically as a voltage on an unbalanced coaxial cable into a pure resistive impedance of 75  $\Omega$ .

**15.5** For the Y' component, reference black (zero) in the expressions of clauses 5 and 6 shall correspond to a level of 0 Vdc, and reference white (unity) shall correspond to 700 mV.

**15.6** P'B and P'R components are analog versions of the C'B and C'R components of 5.7, in which zero shall correspond to a level of 0 Vdc and reference peak level (value 0.5 of equations in 5.7) shall correspond to a level of +350 mV.

**15.7** Trilevel sync according to clause 13 shall be added to each analog component.

**15.8** Each of the electrical signals in an analog interface employs a connector that shall conform to IEC 60169-8, with the exception that the impedance of the connector may be 75  $\Omega$ , or to SMPTE RP 160.



## NOTES

- 1 Values for  $\alpha$ ,  $\beta$ ,  $\chi$ ,  $\delta$ ,  $\epsilon$ ,  $\gamma$ , and  $\eta$  are given in table 6.
- 2 Sync rise time,  $\phi$ , is not shown here.
- 3 See also figure 3.
- 4 Amplitudes are expressed in millivolts.

**Figure 11 — Analog interface horizontal timing details**  
 (Valid for 60-, 59.94-, and 50-Hz systems only — see table 6 note)

## **Annex A (informative)**

### **Relationship to ANSI/SMPTE 240M scanning**

ANSI/SMPTE 240M defines 1125/60 and 1125/59.94 interlaced systems having 1035 active picture lines. The first field has 517 active picture lines starting at line 41. The

second field has 518 active picture lines starting with the top line of the picture at line 603 and including the bottom line of the frame at line 1120.

## **Annex B (informative)**

### **Pre- and post-filtering characteristics**

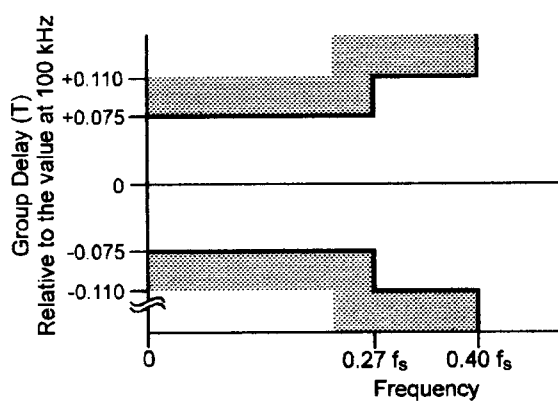
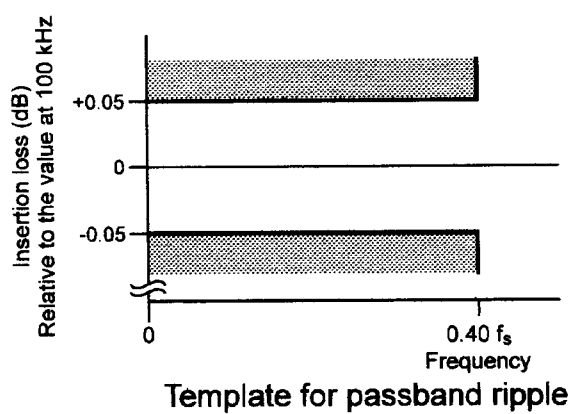
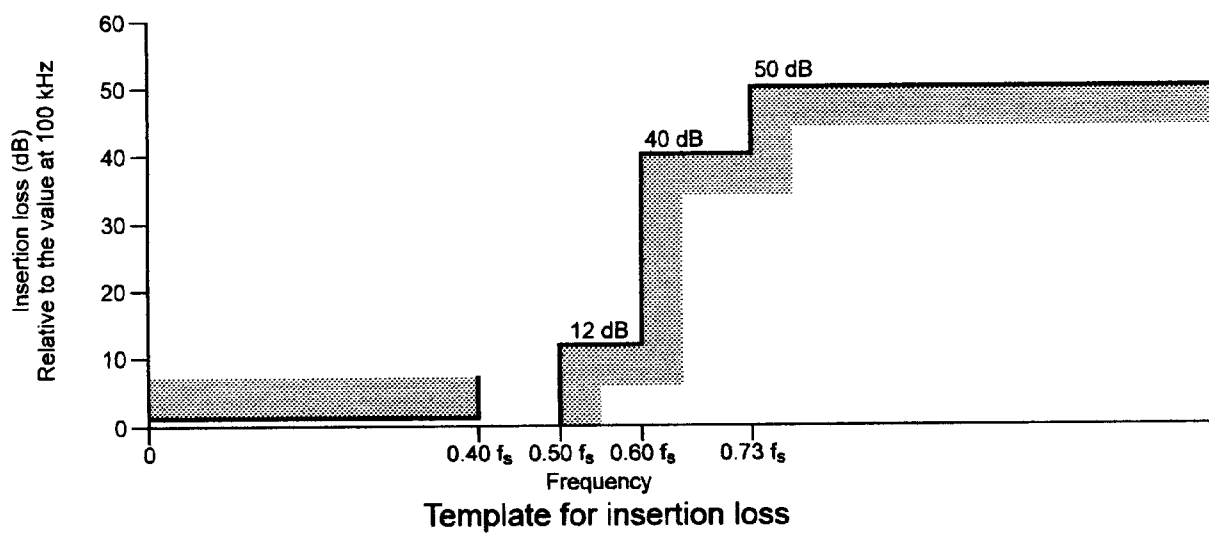
**B.1** Figure B.1 depicts example filter characteristics for pre- and post-filtering of  $Y'$ ,  $R'$ ,  $G'$ , and  $B'$  component signals. Figure B.2 depicts example filter characteristics for pre- and post-filtering of  $P'_B$  and  $P'_R$  component signals.

**B.2** The passband frequency of the component  $Y'$ ,  $R'$ ,  $G'$ , and  $B'$  signals is nominally 60 MHz for systems 1, 2, and 3, and 30 MHz for systems 4 through 11.

**B.3** The value of the amplitude ripple tolerance in the pass-band is  $\pm 0.05$  dB relative to the insertion loss at 100 kHz.

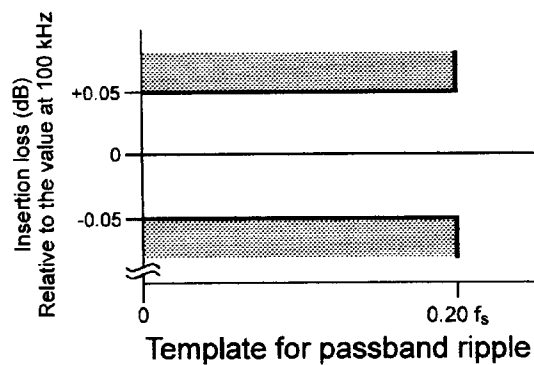
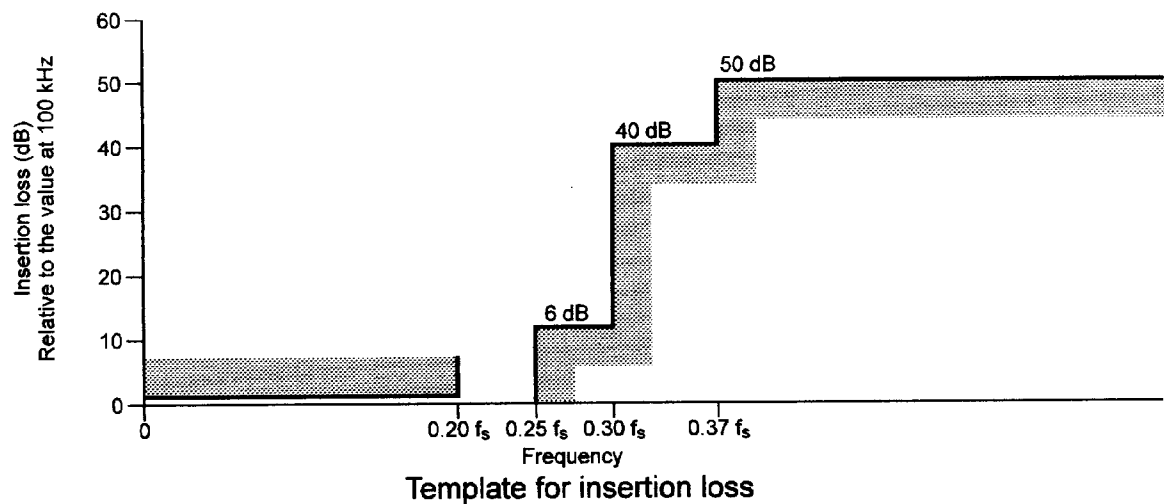
**B.4** The insertion loss characteristics of the filters are frequency-scaled from the characteristics of ITU-R BT.601. Insertion loss is 12 dB or more at half the sampling frequency of the  $Y'$ ,  $R'$ ,  $G'$ , and  $B'$  components, and 6 dB or more at half the sampling frequency of the  $P'_B$  and  $P'_R$  components, relative to the insertion loss at 100 kHz.

**B.5** The specifications for group-delay in the filters are sufficiently tight to produce good performance while allowing the practical implementation of the filters.



NOTE - The value of  $f_s$  is given in table 1

Figure B.1 – Example filter template for Y' and R'G'B' components



NOTE - The value of  $f_s$  is given in table 1

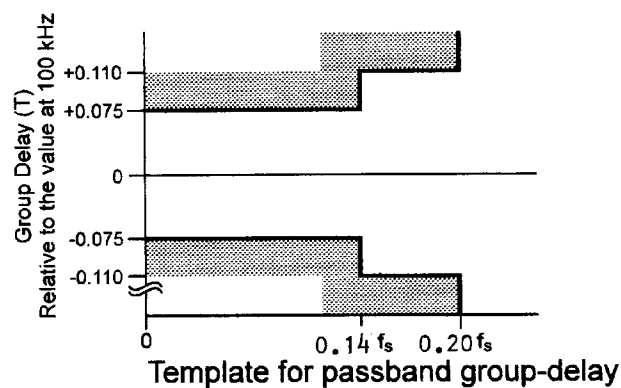


Figure B.2 – Example filter template for  $P'_B$  and  $P'_R$  components

## Annex C (informative)

### Production aperture

#### C.1 Production aperture

A production aperture for the studio digital signal defines an active picture area of 1920 pixels by 1080 lines produced by signal sources such as cameras, telecines, digital video tape recorders, and computer-generated pictures conforming to this standard.

#### C.2 Analog blanking tolerance

**C.2.1** The duration of the maximum active analog video signal measured at the 50% points is standardized as 1920 clock periods. However, the analog blanking period may differ from equipment to equipment and the digital blanking may not coincide with the analog blanking in actual implementation.

**C.2.2** To maximize the active video duration in picture origination sources, it is desirable to have analog blanking match digital blanking. However, recognizing the need for reasonable tolerance in implementation, analog blanking may be wider than digital blanking (see figure 3).

**C.2.3** To accommodate a practical implementation of analog blanking within various studio equipments, a tolerance of six clock periods is provided at the start and end of active video. Accordingly, the analog tolerances to parameters  $\beta$  and  $\epsilon$  of table 6 are as follows:

Parameter	Definition	Nominal value (ref.clocks)	Tolerance (ref. clocks)
$\beta$	$0_H$ to end of active video	2112	$-6$ $+0$
$\epsilon$	$0_H$ to start of active video	192	$-0$ $+6$

**C.2.4** The relationship of the associated analog representation (inclusive of this tolerance) with the production aperture is shown in figure 3.

#### C.3 Transient regions

**C.3.1** This standard defines a picture aspect ratio of 16:9 with 1920 pixels per active line and 1080 active lines. However, digital processing and associated spatial filtering can produce various forms of transient effects at picture blanking edges and within adjacent active video that should be taken into account to allow practical implementation of the studio standard.

**C.3.2** The following factors contribute to these effects:

- Bandwidth limitation of component analog signals (most noticeably, the ringing on color-difference signals);
- Analog filter implementation;
- Amplitude clipping of analog signals due to the finite dynamic range imposed by the quantization process;
- Use of digital blanking in repeated analog-digital-analog conversions; and
- Tolerance in analog blanking.

#### C.4 Clean aperture

**C.4.1** The bandwidth limitation of an analog signal (pre- and post-filtering) can introduce transient ringing effects which intrude into the active picture area. Also, multiple digital blanking operations in an analog-digital-analog environment can increase transient ringing effects. Furthermore, cascaded spatial filtering and/or techniques for handling the horizontal and vertical edges of the picture (associated with complex digital processing in post-production) can introduce transient disturbances at the picture boundaries, both horizontally and vertically. It is not possible to impose any bounds on the number of cascaded digital processes which might be encountered in the practical post-production system. Hence, recognizing the reality of those picture edge transient effects, the definition of a system design guideline is introduced in the form of a subjectively artifact-free area, called clean aperture.

**C.4.2** The clean aperture defines an area within which picture information is subjectively uncontaminated by all edge transient distortions. The clean aperture should be as wide as is needed to accommodate cascaded digital manipulations of the picture. Computer simulations have shown that a transient effect area defined by 16 samples on each side and 9 lines at both top and bottom within the digital production aperture, would represent an acceptable (and practical) worst-case level of protection in allowing two-dimensional transient ringing to settle below a subjectively acceptable level.

**C.4.3** This gives rise to a clean aperture of 1888 horizontal active pixels by 1062 active lines whose quality is guaranteed for final release. The clean aperture lies within the production aperture as shown in figure C.1.

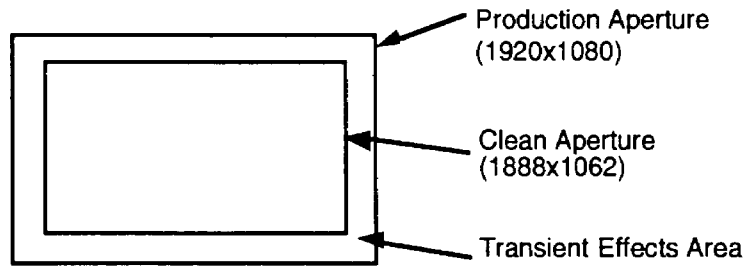


Figure C.1 – Clean aperture

## Annex D (informative)

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ANSI/SMPTE 292M-1996, Television — Bit-Serial Digital Interface for High-Definition Television Systems

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ITU-R BT.601-5, Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios