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SMPTE STANDARD

ANSI/SMPTE 295M-1997

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

Contents

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;
– $Y'P'_BP'_R$ color encoding and analog interface; and
– $Y'C'_BC'_R$ color encoding and digital interface.

An auxiliary component A may optionally accompany $Y'C'_BC'_R$; this interface is denoted $Y'C'_BC'_RA$.

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 $Y'P'_BP'_R$ and/or which of the digital R′G′B′, $Y'C'_BC'_R$, or $Y'C'_BC'_RA$ interfaces are implemented;

– whether the digital representation employs eight bits or ten bits.

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American National Standard

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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 fs (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:

	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:

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

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.

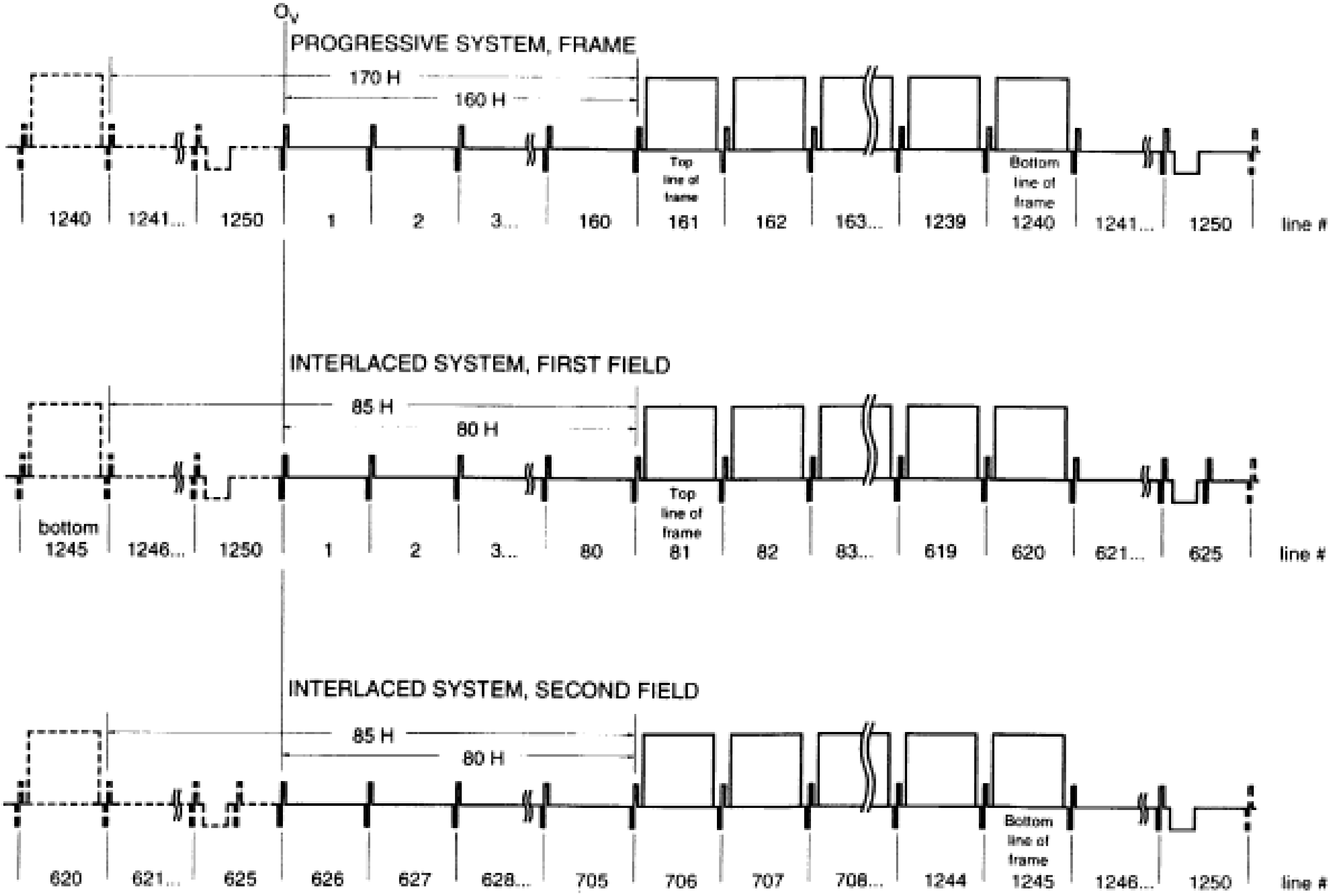


Figure 1 - Analog interface vertical timing details

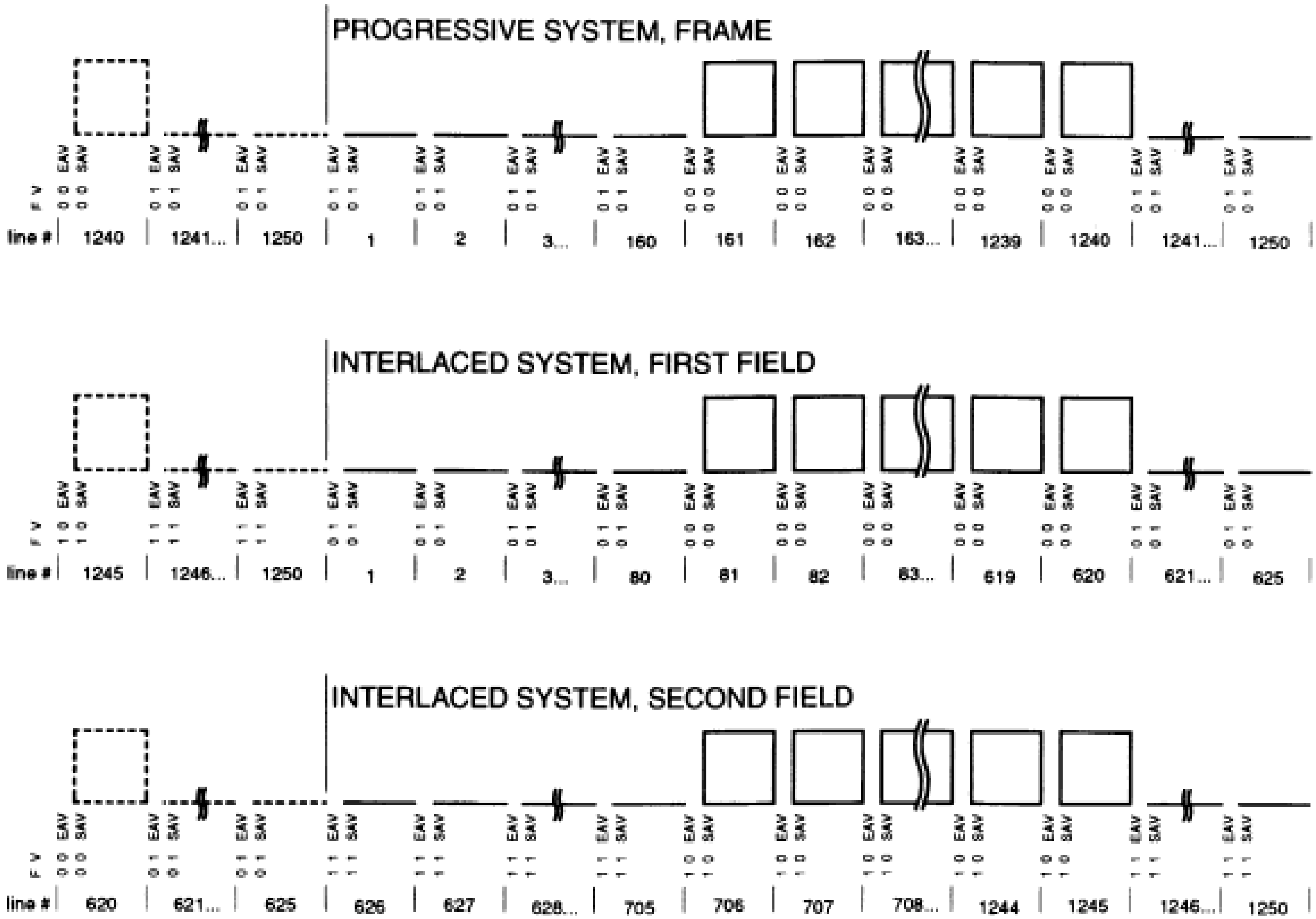


Figure 2 - Digital interface vertical timing details

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. $C'_BC'_R$ signals shall have bandwidth nominally half that of the associated Y′ signal.

7.4 R′,G′,B′ signals, and the Y′ signal of the $Y'C'_BC'_R$ 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 $Y'C'_BC'_R$ set shall be computed as follows:

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

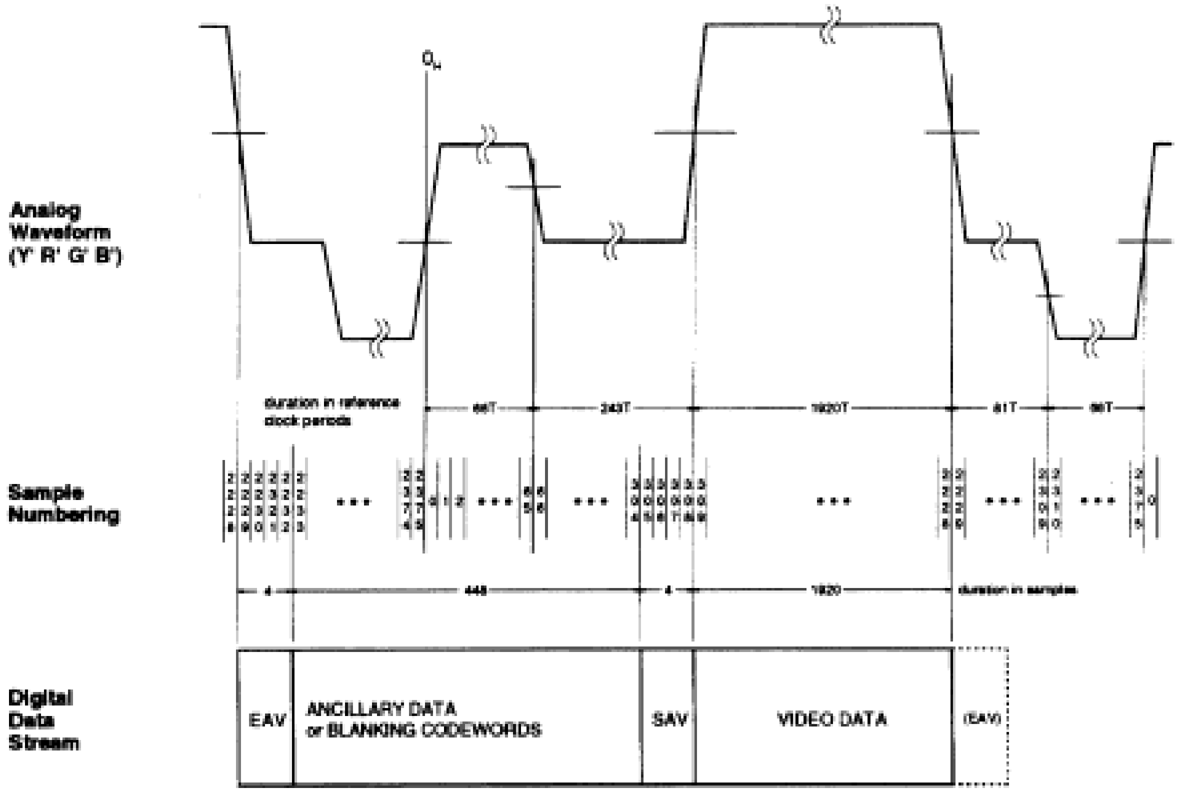
where C′ is the component value in abstract terms from – 0.5 to + 0.5 and C'_d is the resulting digital code.

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.



NOTES
1 Horizontal axis not to scale.
2 The sampling instant occurs at the leading edge of each numbered sample.
3 A line of digital video extends from the first word of EAV to the last word of video data.

Figure 3 – Analog and digital timing relationships

7.12 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.

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 compose four consecutive code words: a code word of all ones, a code word of all zeros, another code word of all zeros, and a code word including F (field/frame), V (vertical), 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 2 and 3 show details of the coding.

8.3 Every scan line shall include a four-sample EAV sequence commencing 147 clocks prior to 0_H, and a four-sample SAV sequence commencing 305 clocks after 0_H. The EAV sequence immediately preceding the 0_H datum of line 1 shall be considered to be the start of the digital frame.

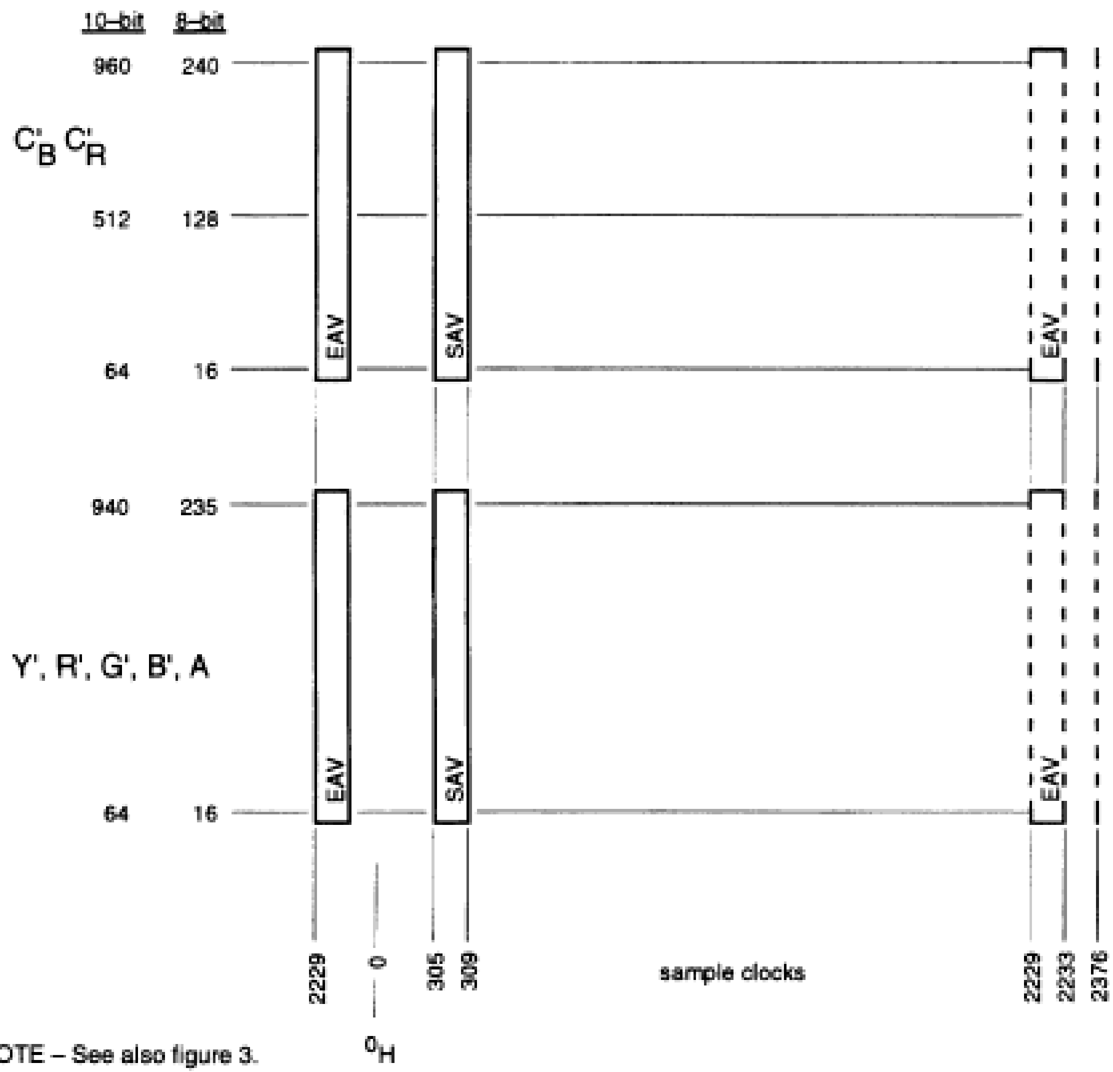
8.4 In a progressive system:

– 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 160 inclusive and lines 1241 through 1250 inclusive, shall have V = 1;

– the EAV and SAV of lines 161 through 1240 inclusive shall have V = 0.



NOTE – See also figure 3.

Figure 4 – Digital interface horizontal timing details

Table 2 – 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 3 – 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

8.5 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 626 shall be considered to be the start of the second digital field;

– the EAV and SAV of lines 1 through 625 inclusive shall have F = 0. The EAV and SAV of lines 626 through 1250 inclusive shall have F = 1;

– the EAV and the SAV of lines 1 through 80, lines 621 through 705, and lines 1246 through 1250 shall have V = 1;

– the EAV and the SAV of lines 81 through 620 and lines 706 through 1245 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, and that is not employed to convey digitized ancillary signals, 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′, $C'_BC'_R$, 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 code word 64 (black) in the R′, G′, B′, Y′, or A channels, or 512 in the $C'_BC'_R$ channels. They shall be 16 and 128, respectively, in the case of 8-bit representation.

9.6 In the case of 10-bit representation, code words 1, 2, 3, 1020, 1021, 1022, and 1023 shall be prohibited from ancillary data words. In the case of 8-bit representation, code words 1 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 point-to-point electrical interface with one transmitter and one receiver. The interface may be used to convey R′G′B′ components, $Y'C'_BC'_R$ components, or $Y'C'_BC'_R$ 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 the interlaced system for a distance of up to 20 m (65.6 ft), and in the progressive system 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 4.

Table 4 – 93-contact connector contact assignments

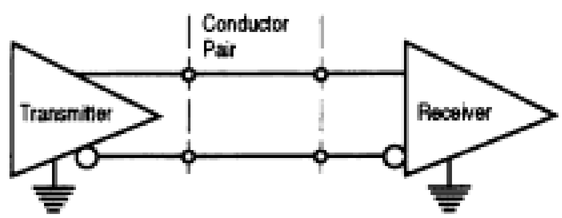
	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
	1	CK+	17	GND	33	CK–	49	B4+	65	GND	81	B2–
MSB	2	G9+	18	GND	34	G9–	50	B3+	66	GND	82	B1–
	3	G8+	19	GND	35	G8–	51	B2+	67	GND	83	B0–
	4	G7+	20	GND	36	G7–	52	B1+	68	GND	84	R9–
	5	G6+	21	GND	37	G6–	53	B0+	69	GND	85	R8–
	6	G5+	22	GND	38	G5–	54	R9+	70	GND	86	R7–
	7	G4+	23	GND	39	G4–	55	R8+	71	GND	87	R6–
	8	G3+	24	GND	40	G3–	56	R7+	72	GND	88	R5–
LSB_8	9	G2+	25	GND	41	G2–	57	R6+	73	GND	89	R4–
	10	G1+	26	GND	42	G1–	58	R5+	74	GND	90	R3–
LSB_{10}	11	G0+	27	GND	43	G0–	59	R4+	75	GND	91	R2–
	12	B9+	28	GND	44	B9–	60	R3+	76	GND	92	R1–
	13	B8+	29	GND	45	B8–	61	R2+	77	GND	93	R0–
	14	B7+	30	GND	46	B7–	62	R1+	78	GND		
	15	B6+	31	GND	47	B6–	63	R0+	79	B4–		
	16	B5+	32	GND	48	B5–	64	GND	80	B3–		

10.8 The $Y'C'_BC'_R$ interface uses a set of eight or ten pairs to convey the Y′ signal (on the pins indicated for the G′ signals in figure 4), 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 4). C'_B and C'_R signals shall be time-multiplexed by sample basis in the order of C'_B and C'_R.

10.9 The $Y'C'_BC'_RA$ interface conveys eight or ten bits of $Y'C'_BC'_R$ as above, and conveys an auxiliary signal A of the same number of bits (on the pins indicated for B′ in table 4).

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 the interlaced system, the use of standard ECL (10KH series) devices.

Figure 5 – Transmitter and receiver interconnection

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 V ± 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-Ω resistive load. The difference between rise and fall times shall not exceed 0.075T.

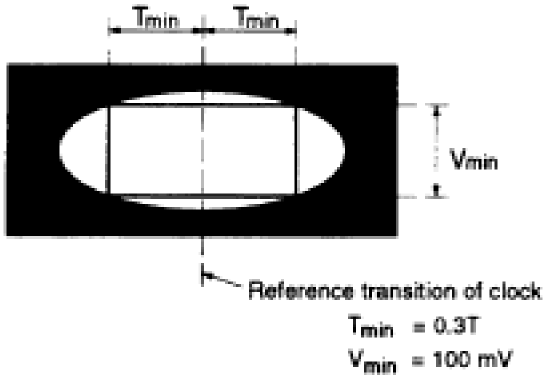
11.9 The receiver shall present an impedance of 110 Ω ± 10 Ω.

11.10 Maximum input signal amplitude shall be 2.0 V peak to peak.

11.11 The receiver shall require a differential input voltage of no more than 185 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.

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 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.



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 propagaton skew of 0.18T, data source skew of 0.075T, and clock jitter of 0.04T to show the minimum eye opening of 2 × Tmin, 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

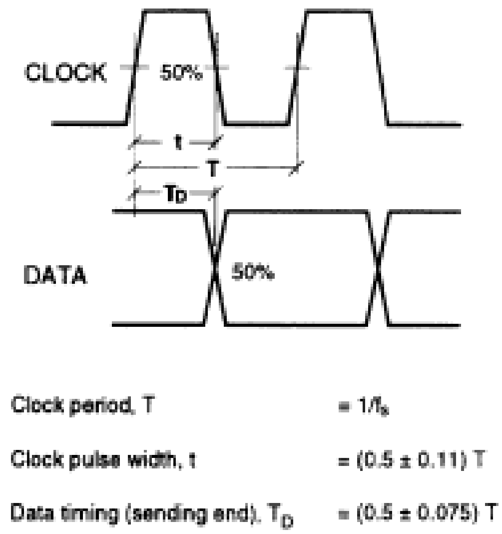


Figure 7 – Clock-to-data timing (at sending end)

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 ± 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 ± 0.075)T, denoted T_D, following 0-to-1 transition of the clock, according to figure 7.

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 Ω.

13.2 This standard applies to applications where the physical length of the cable is at most 20 m for interlaced systems and 14 m for progressive systems. 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.

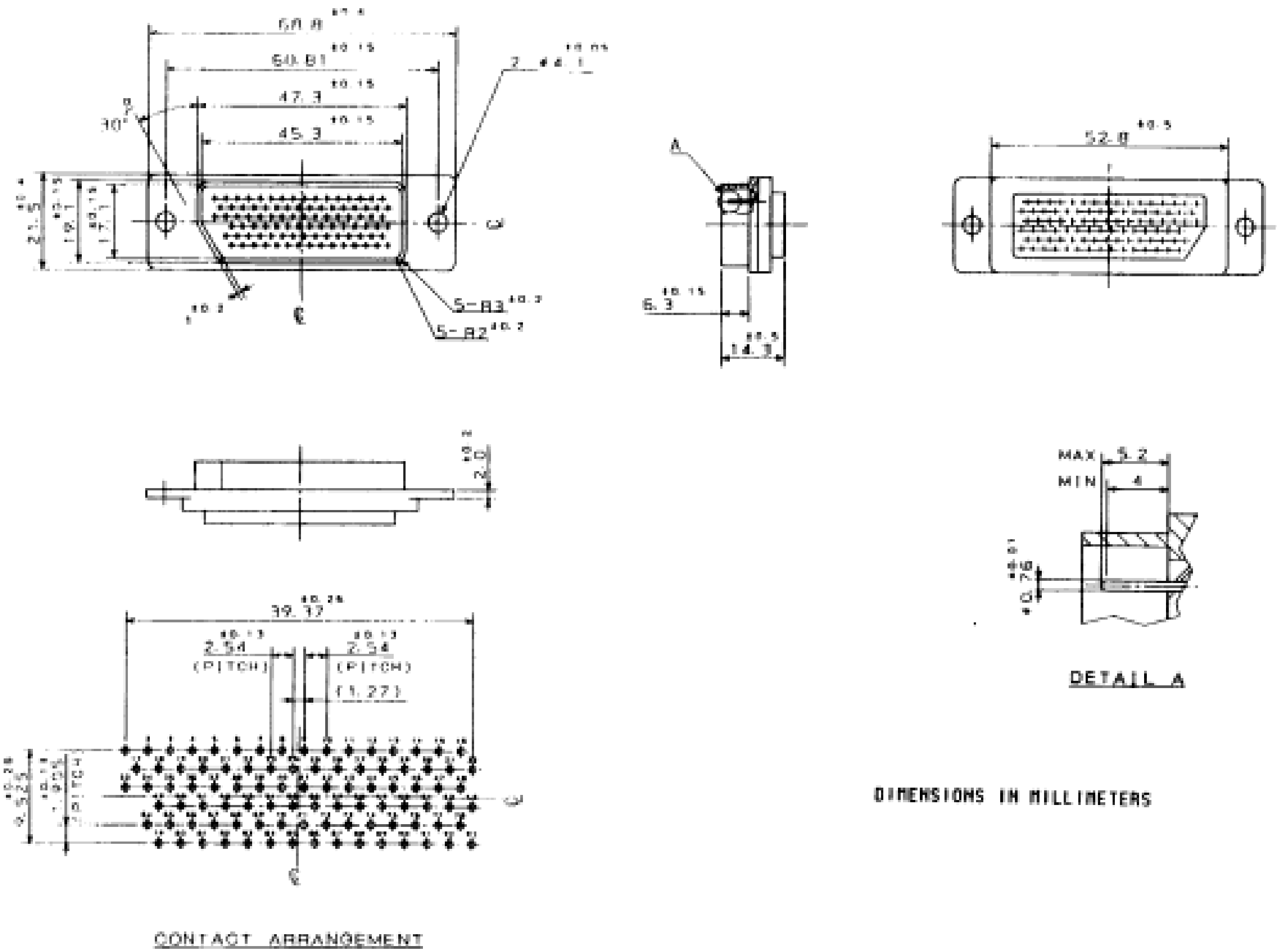


Figure 8 - 93-contact plug connector (cable)

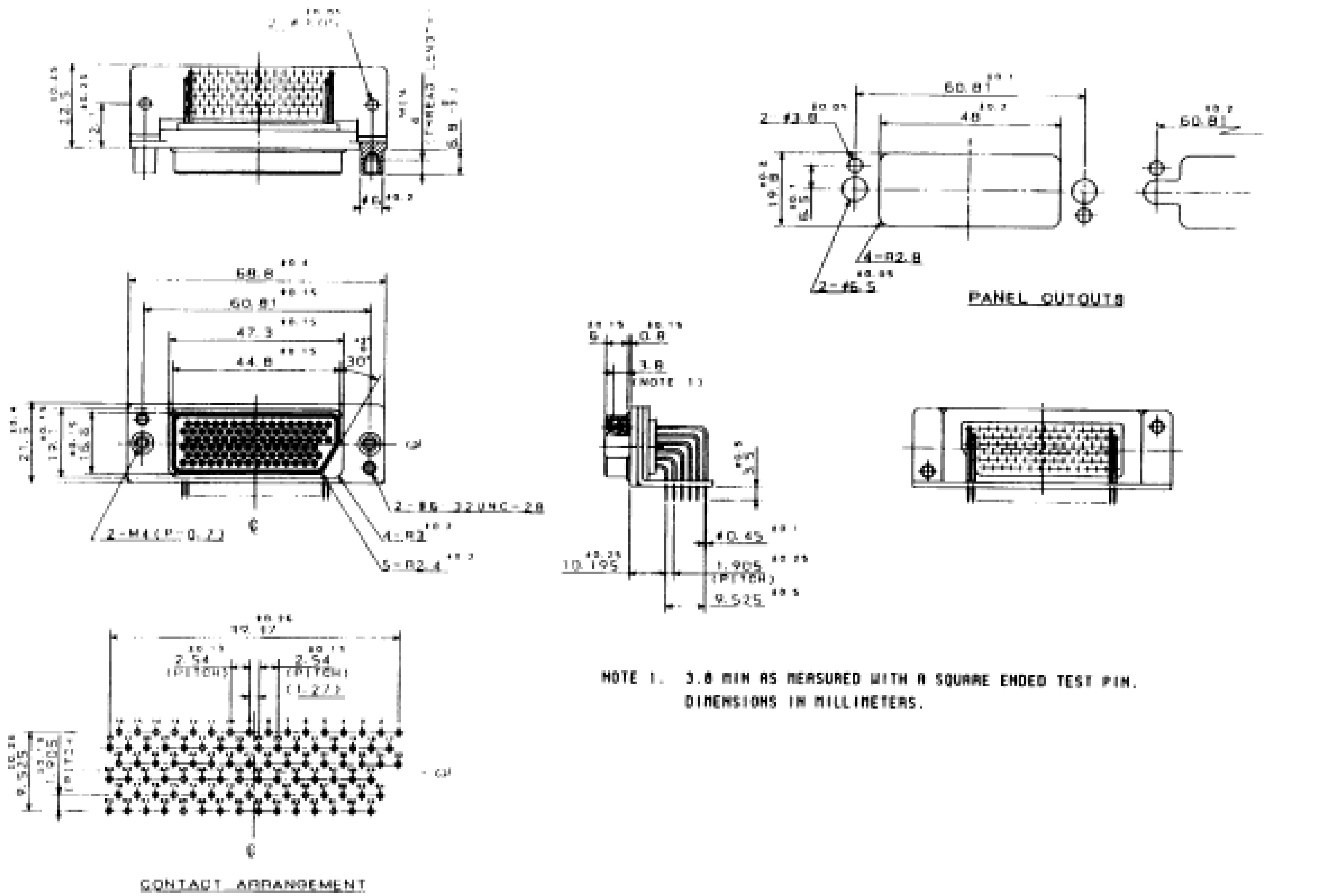


Figure 9 - 93-contact socket connector (equipment)

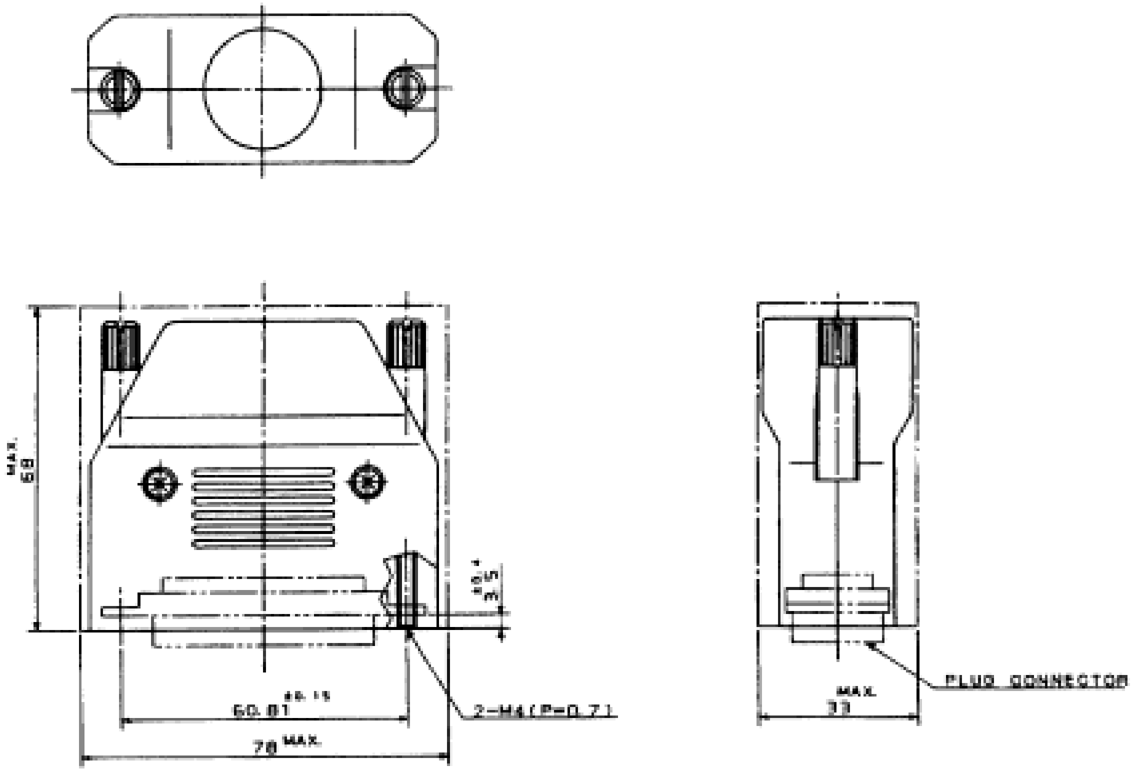


Figure 10 – 93-contact plug (hood)

13.6 Connector contact assignment shall be according to table 4. The shield for each conductor pair shall use the ground pin located between pins for the signal pair, as shown in table 4.

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.

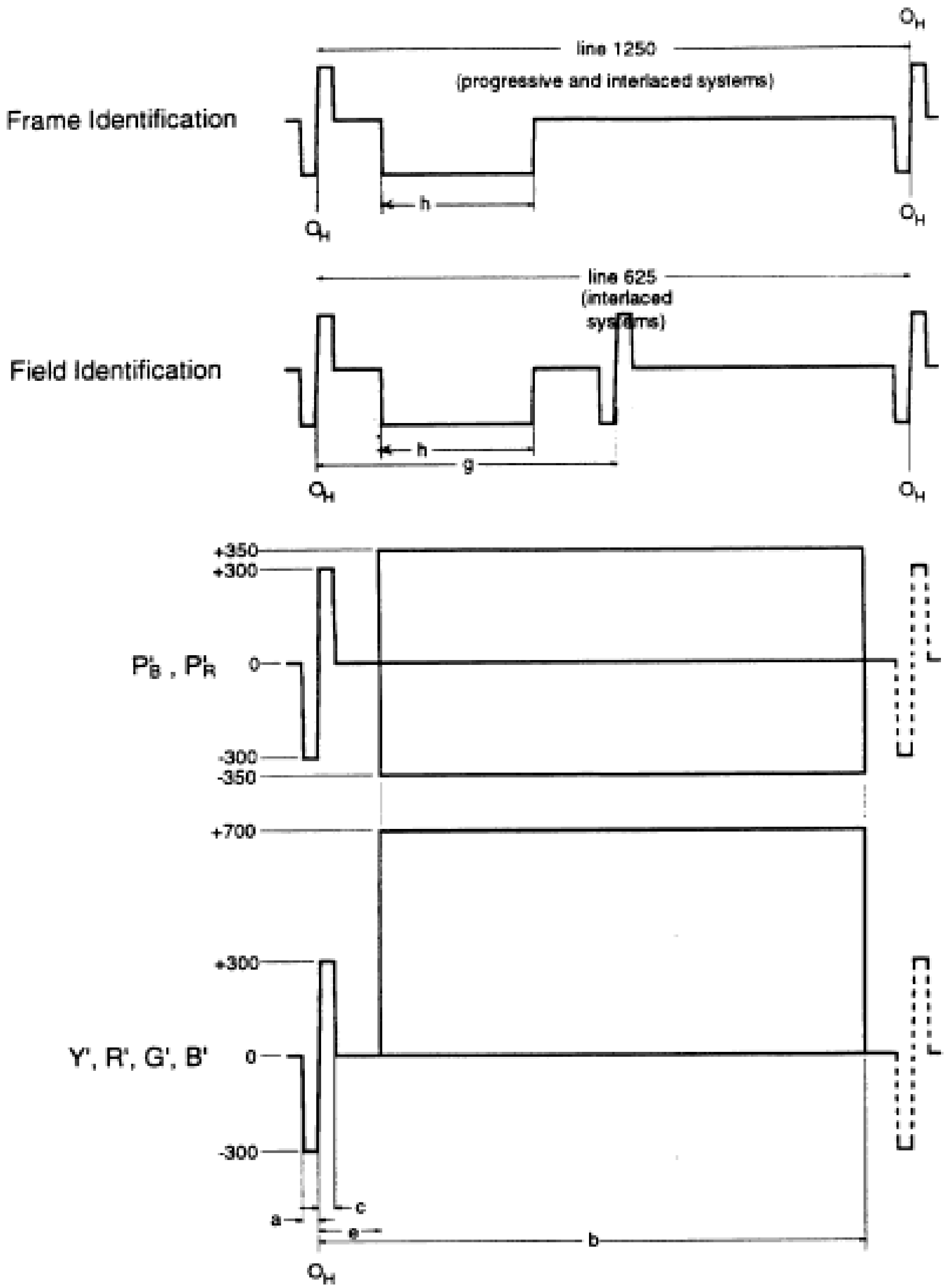
13.8 1 The cable connectors shall be provided with two M4 mounting screws and the equipment connectors shall be provided with two M4 female screws.

14 Analog sync

14.1 Details of analog sync timing are shown in figures 1, 3, and 1 1, and are summarized in table 5. The parameter f not shown in these figures is the duraton of the rising edge of the horizontal sync pulse.

Table 5 – Analog sync timing

		Duration (T)	Tolerance (T)
a	(See figure 11	66	± 3
b	(See figure 11)	2229	– 6 + 0
c	(See figure 11)	66	± 3
e	(See figure 11)	309	– 0 + 6
f	Sync rise time	4	± 1.5
g	(See figure 11)	1188	
h	(See figure 11)	594	± 3
	Total line	2376	
	Active line	1920	– 12 + 0



NOTES

1 Values for a, b, c, e, g, and h are given in table 5.
2 See also figure 3.

Figure 11 – Analog interface horizontal timing details

14.2 A positive zero-crossing of a trilevel sync pulse shall define the 0_H datum for each line. A negative-going transition precedes this instant by 66 reference clock intervals, and another negative-going transition follows this instant by 66 reference clock intervals.

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

14.4 The trilevel sync pulse shall have structure and timing according to clause 6. The positive peak of sync shall have a level of + 300 mV ± 6 mV; its negative peak shall have a level of – 300 mV ± 6 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.

14.6 The end of each field and frame shall be identified by the presence of a field pulse in the final line of the field or frame. The pulse shall have a duration of 594T, and shall be situated as shown in figure 11. It will occur in line 1250 for a progressive system, and in lines 625 and 1250 in interlaced systems.

14.7 In addition, the end of the first field of an interlaced system shall be marked by a midline trilevel sync pulse whose elements are delayed from 0_H by one-half the line duration as shown in figure 11, lying in line 625.

15 Analog interface

15.1 An analog interface according to this standard may employ either the R′G′B′ component set or the $Y'P'_BP'_R$ component set

15.2 R′G′B′ signals and Y′ signals shall have bandwidth nominally 60 MHz for progressive systems and 30 MHz for interlaced systems.

15.3 $P'_BP'_R$ signals shall have 0.5 the bandwidth of the associated Y′ signal.

15.4 Each component signal shall be conveyed electrically as a voltage on an unbalanced coaxial cable into a pure-resistive impedance of 75 Ω.

15.5 For the Y′ component, reference black (zero) in the expressions of clause 5 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 14 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 169-8, with the exception that the impedance of the connector may be 75 Ω, or to SMPTE RP 160.

Annex A (informative)
Production aperture

A.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.

A.2 Analog blanking tolerance

A.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.

A.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.

A.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 b and e of table 5 are as follows:

	Definition	Nominal (ref. clocks)	Tolerance (ref. clocks)
b	0_H to end of active video	2229	–6 +0
e	0_H to start of active video	309	–0 +6

A.3 Transient regions

A.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.

A.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.

A.4 Clean aperture

A.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.

A.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 manipulation 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.

A.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 A.l.

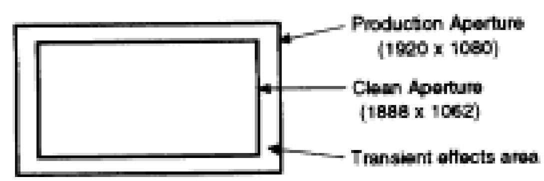


Figure A.1 – Clean aperture

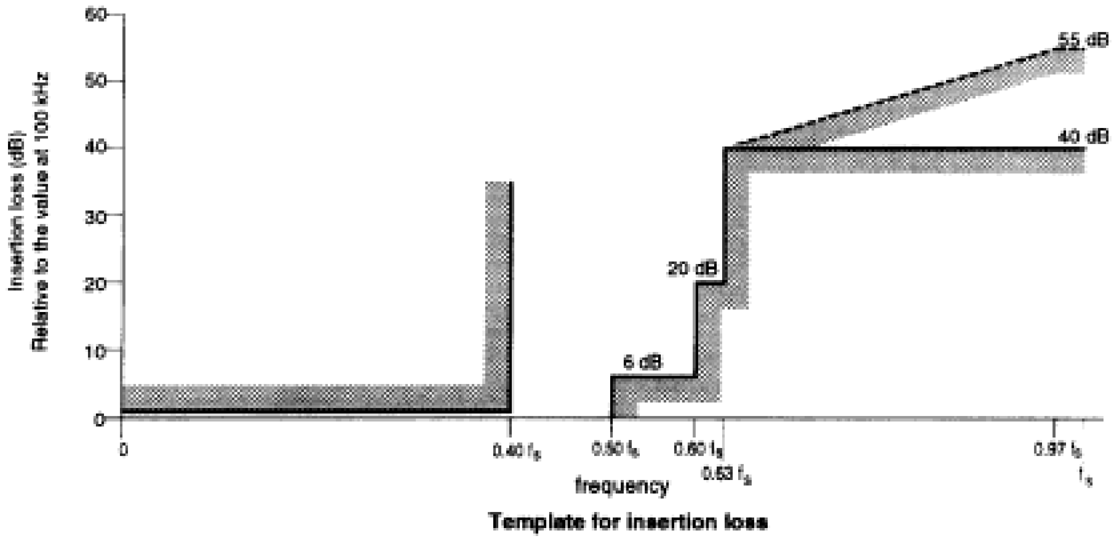
Annex B (informative)
Pre- and post-filtering characteristics

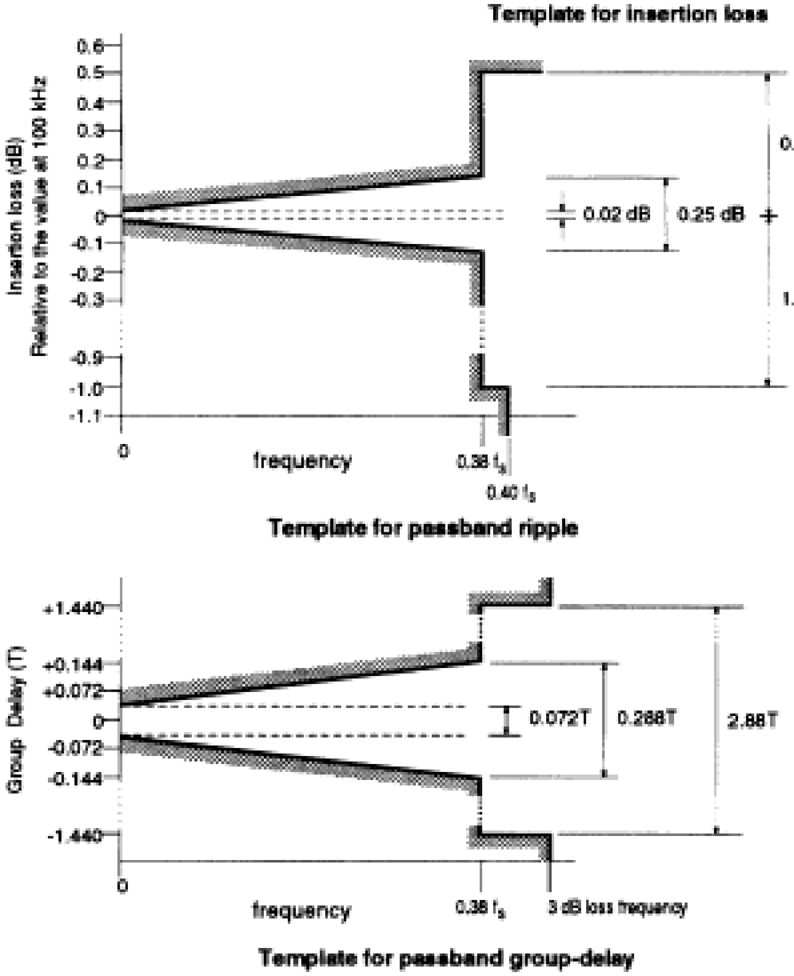
B.1 Figure B.1 depicts filter characteristics for pre- and post-filtering of Y′, R′, G′, and B′ component signals. Figure B.2 depicts filter characteristics for pre- and post-filtering of P'_B and P'_R component signals.

B.2 The passband frequency of the component Y′, R′, G′, and B′ signals is nominally 60 MHz for progressive systems and 30 MHz for interlaced systems.

B.3 The insertion loss characteristics of the filters are frequency-scaled from the characteristics of ITU-R BT.601. Insertion loss is 6 dB or more at half the sampling frequency of all components, relative to the insertion loss at 100 kHz.

B.4 The specifications for group-delay in the filters are sufficiently tight to produce good performance while allowing the practical implementation of the filters.





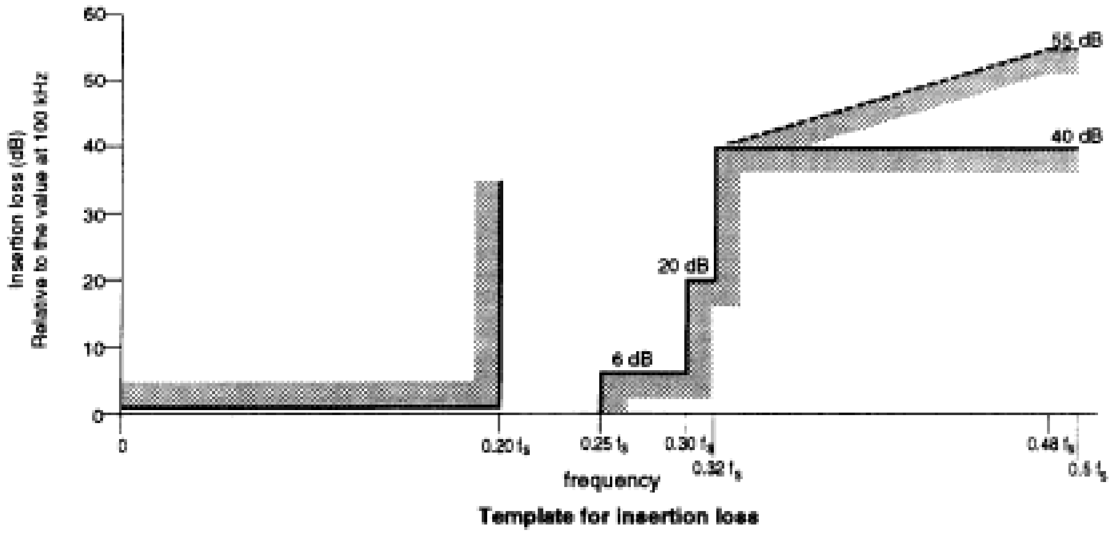
NOTES

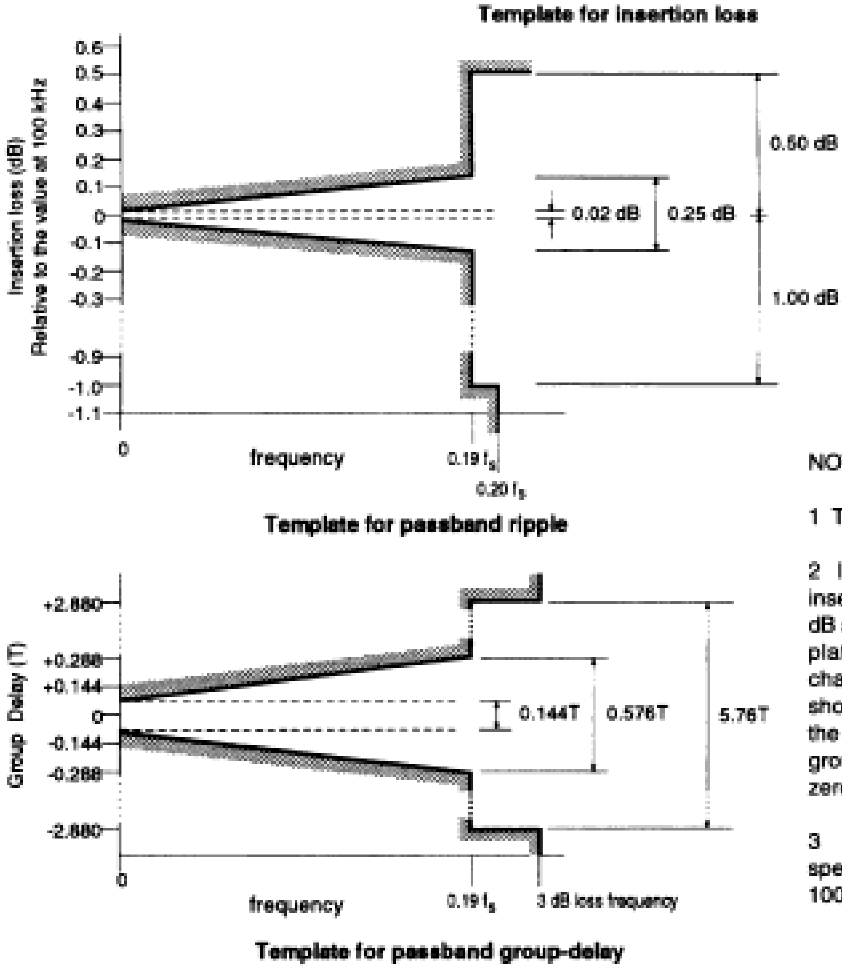
1 The value of f_s is given in table 1.

2 In a digital implementation, the insertion loss should be at least 55 dB above 0.97 f_s (dashed line template); the amplitude/frequency characteristic (on linear scales) should be skew-symmetric about the nail amplitude point; and the group-delay distortion should be zero by design.

3 Ripple and group delay are specified relative to their values at 100 kHz.

Figure B.1 – Filter template for Y′ and R′G′B′ components





NOTES

1 The value of f_s is given in table 1.

2 In a digital implementation, the insertion loss should be at least 55 dB above 0.48 f_s (dashed line template); the amplitude/frequency characteristic (on linear scales) should be skew-symmetric about the nail amplitude point; and the group-delay distortion should be zero by design.

3 Ripple and group delay are specified relative to their values at 100 kHz.

Figure B.2 – Filter template for P'_B and P'_R components

Annex C (informative)
Bibliography

CIE Publication 15.2 (1986), Colorimetry, Second Edition

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

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