SMPTE Journal, April 1992

SMPTE RECOMMENDED PRACTICE

RP 65-1991
Revision of RP 65-1987

Step Optical Reduction Printing of 35-mm Images to 16-mm Prints and Duplicate Negatives

1 Scope

This practice specifies the dimensions of the minimum picture area on 16-mm film made from 35-mm images by *step reduction printing*.

2 Objectives

2.1 *This practice specifies the maximum reduction ratio* in step optical printing necessary to provide the minimum image area as specified in American National and International Standards.

2.2 The specified dimensions apply to the image area only, taking into account that printer apertures may be reduced to avoid stray light from clear framelines or increased to provide dark surround about prints or certain intermediates.

3 Dimensions

3.1 The height and width of the 35-mm negative and positive image are established by ANSI/SMPTE 59-1991. The size of the positive image is also controlled by ANSI/SMPTE 59 because *all the negative area is used when prints* are derived as specified by ANSI/SMPTE 111-1988.

3.2 *For the production of 16-mm positive prints* or intermediates from images with clear (low density) surround, the following dimensions are recommended:

3.2.1 The minimum height of the 35-mm image to be printed shall be 15.95 mm (0.628 in).

3.2.2 The minimum width of the 35-mm image to be printed shall be 21.90 mm (0.862 in).

3.2.3 *The size and location of the reduced* 16-mm image and surround will be in accordance with ANSI/SMPTE 48-1989, except that a B minimum value of 7.42 mm (0.292 in) is adopted to conform to the specified minimum image area and to the maximum reduction ratio (see note 2).

3.2.4 The maximum reduction ratio for step optical printing is 2.15:1.

3.3 For the production of 16-mm duplicate negatives or intermediates from images with dark (high density) surround, the following dimensions are recommended:

3.3.1 The minimum height of the 35-mm image *to be printed shall be 16.00 mm (0.630 in).*

3.3.2 The minimum width of the 35-mm image to be printed shall be 21.95 mm (0.864 in).

3.3.3 The size and location of the reduced 16-mm duplicate negative image will be in accordance with ANSI/SMPTE 7-1988, except that a B minimum value of 7.42 mm (0.292 in) is adopted to conform to International Standards.

3.3.4 The maximum reduction ratio for step optical printing is 2.15:1.

NOTES —

1 Metric dimensions are primary in this practice.

2 When printing reduced 16-mm positive images according to 3.2, it is intended that no transparent frameline be produced. The usual practice is to overlap the printed area by increasing the height of the 16-mm printing aperture. It is *also acceptable to butt adjoining areas.*

Approved December 18, 1991

When printing reduced 16-mm duplicate negative images according to 3.3, it is intended that the frameline be transparent and that the image area printed conform to International Standards. Therefore a 16-mm printing aperture may *be used with a height of 7.42 mm* (0.292 in) slightly cropping the height of the image projected toward the 16-mm aperture.

3 If means are provided to round the corners of the 16-mm image, the radius of the corner shall not exceed 0.51 mm (0.020 in).

4 The center of the reduced 16-mm image normally shall coincide with the center of the 35-mm image from which it is was printed within ± 0.05 mm (0.002 in).

Annex A (informative)
Additional data

In continuous optical reduction printing, the reduction ratio is determined by the ratio of four times the perforation pitch of the 35-mm film source to one times the perforation pitch of the 16-mm print material. Table A.1 compares image dimensions in step optical and continuous optical printing.

Note that in continuous printing, the picture material from style A or style B negatives, as specified in ANSI/SMPTE 59-1991, does not fill the normal 16-mm projector aperture as defined in ANSI/SMPTE 233-1987. A 35-mm intermediate made from the 35-mm style A or style B original with a 16% enlargement will produce a 16-mm print at 2.49:1 reduction, which will fill a 16-mm projector aperture satisfactorily. Also note that a 35-mm original with a *style C image area will be satisfactory for direct* 2.49:1 reduction.

Table A.1 – Dimensions in step optical and continuous optical printing

		Minimum 35-mm image to be reproduced		Image projected toward 16 mm	
		Height	Width	Height	Width
STEP PRINTER 2.15:1					
	Positive	15.95 mm 0.628 in	21.90 mm 0.862 in	7.42 mm 0.292 in	10.19 mm 0.401 in
	Negative	16.00 mm 0.630 in	21.95 mm 0.864 in	7.44 mm 0.293 in	10.21 mm 0.402 in
CONTINUOUS PRINTER 2.49:1					
	Positive	16.00 mm 0.630 in	21.90 mm 0.862 in	6.43 mm 0.253 in	8.80 mm 0.346 in
	Negative	16.00 mm 0.630 in	21.95 mm 0.864 in	6.43 mm 0.253 in	8.82 mm 0.347 in

Annex B (informative)
Bibliography

ANSI/SMPTE 7-1988, Motion-Picture Film (16-mm) — Camera Aperture Image and Usage

ANSI/SMPTE 48-1989, Motion-Picture Film (16-mm) — Printed Areas — Picture and Sound Contact Printing

ANSI/SMPTE 59-1991, Motion-Picture Film (35-mm) — Camera Aperture Images and Usage

ANSI/SMPTE 111-1988, Motion-Picture Film (35-mm) — Exposed Areas for Picture and Audio — Prints Made on Continuous Contact Printers

ANSI/SMPTE 233-1987, Motion-Picture Film (16-mm) — Projectable Image Area

SMPTE RECOMMENDED PRACTICE

RP 66-1991
Revision of RP 66-1987

Step Optical Enlargement Printing of 35-mm Images from 16-mm Images

1 Scope

This practice specifies the dimensions of the minimum picture area on a 16-mm film used to produce an optically enlarged 35-mm nonanamorphic step printed image.

2 Objectives

2.1 This practice specifies the minimum enlargement ratio in step optical printing necessary to provide the minimum 35-mm image area as specified in American National and International Standards.

2.2 The specified dimensions apply to the image area only, taking into account that printer apertures may be reduced to avoid stray light from clear framelines or increased to provide dark surround about prints or certain intermediates.

3 Dimensions

3.1 The size and location of the 16-mm camera image is specified in ANSI/SMPTE 7-1988, except that a B minimum value of 7.42 mm (0.292 in) is adopted to conform to International Standards.

3.2 For the production of enlarged 35-mm positive or negative prints or intermediates from images with clear (low density) or dark (high density) surround, the following dimensions are recommended:

3.2.1 The minimum height of the 16-mm camera image to be printed shall be 7.42 mm (0.292 in).

3.2.2 The minimum width of the 16-mm camera image to be printed shall be 10.07 mm (0.396 in).

3.2.3 The size and location of the enlarged 35-mm image will be in accordance with ANSI/SMPTE 59-1991.

3.2.4 The resulting minimum optical enlargement ratio for step optical printing is 2.18:1.

NOTES —

1 Metric dimensions are primary in this practice.

2 If means are provided for rounding the corners of the 35-mm image, the radius of the corner shall not exceed 0.8 mm (0.03 in).

3 The center point of the enlarged 16-mm image normally shall coincide with that of the 35-mm printed image within ± 0.05 mm (0.002 in).

Annex A (informative)
Additional data

A.1 Under the conditions specified for step optical enlargement printing, projection of the enlarged 35-mm image within the dimensions specified in ANSI PH22.195-1984 will result in an area of the image projected corresponding to that included in an area of 7.01 mm (0.276 in) maximum by 9.61 mm (0.378 in) reference of the original 16-mm frame. Camera users should note the desirability of employing a camera finder matte of these dimensions when exposing 16-mm film which is to be enlarged to 35 mm.

A.2 In continuous optical enlargement printing, the enlargement ratio is determined by the ratio of the perforation pitch of the 16-mm film source to four times the perforation pitch of the 35-mm print material. Table A.1 compares image dimensions in step optical and continuous optical printing.

Approved December 18, 1991

Table A.1 does not take into account any cropping or oversize surround printing produced by the 35-mm printing aperture. Note that in continuous printing, the 16-mm camera image will be cropped in the 35-mm projector aperture as defined by ANSI PH22.195-1984.

Table A.1 – Dimensions in step optical and continuous optical printing

	Minimum 16-mm image to be reproduced		Image projected toward 35 mm	
	Height	Width	Height	Width
STEP PRINTER 2.18:1	7.42 mm 0.292 in	10.07 mm 0.396 in	16.18 mm 0.637 in	21.95 mm 0.864 in
CONTINUOUS PRINTER 2.50:1	7.42 mm 0.292 in	10.07 mm 0.396 in	18.55 mm 0.730 in	25.18 mm 0.991 in

Annex B (informative)
Bibliography

ANSI/SMPTE 7-1988, Motion-Picture Film (16-mm) — Camera Aperture Image and Usage

ANSI/SMPTE 59-1991, Motion-Picture Film (35-mm) — Camera Aperture Images and Usage

ANSI PH22.195-1984, Motion-Picture Film (35-mm) — Projectable Image Area — Motion-Picture Prints

SMPTE Journal, April 1992

PROPOSED SMPTE STANDARD

SMPTE 260M

for Television — Digital Representation and Bit-Parallel Interface — 1125/60 High-Definition Production System

Table of Contents

1 Scope

This standard specifies the digital representation of the signal parameters of the 1125/60 high-definition production system as given in their analog form by SMPTE 240M.

This standard also specifies the signal format and the mechanical and electrical characteristics of the bit-parallel digital interface for the interconnection of digital television equipment operating in the 1125/60 high-definition production system.

2 Applications

The technical information provided in this standard applies to origination, storage, interconnection and processing of digital 1125/60 high-definition production system signals as they exist in studio production and post-production environments.

3 Normative references

The following documents 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 editions of the documents listed below.

SMPTE 240M-1988, Television — Signal Parameters — 1125/60 High-Definition Production System

CCIR Recommendation 601-1, Encoding Parameters of Digital Television for Studios

CCIR Recommendation 656, Interfaces for Digital Component Video Signals in 525-Line and 625-Line Television Systems

4 Digital encoding and format specifications for SMPTE 240M analog signals

4.1 General considerations

This standard complements the technical specifications of the analog signals described in SMPTE 240M.

The studies that resulted in this standard have taken into account prior international technical agreements on the digitization of television signals, as documented in CCIR Recommendations 601-1 and 656. For ease of comparison, the description of the bit-parallel interface follows the same form as CCIR Rec. 656.

The digital coding is based on the use of one luminance, E_Y', and two color-difference signals, E_{PB}', and E_{PR}', or on the use of three primary color signals E_G', E_B', E_R'.

E_Y', E_{PB}', E_{PR}' are transmitted at the 22:11:11 level of the CCIR digital hierarchy for digital television signals, with a nominal sampling frequency of 74.25 MHz for the luminance signal and 37.125 MHz for each of the color-difference signals. E_G', E_B', E_R' signals are transmitted at the 22:22:22 level of the CCIR digital hierarchy with a nominal sampling frequency of 74.25 MHz.

Provision is made for the coding of the SMPTE 240M signals to a precision of 8 or 10 bits.

Technical information is given in annex A[1] concerning an example of filter characteristics for pre- and post-filtering of the SMPTE 240M signals.

This standard describes the bit-parallel digital interface only. The complete specification of the bit-serial interface requires further studies. However, in defining the digital representation, consideration has been given to making the signal format equally applicable to the bit-serial interface.

The interface consists of one transmitter and one receiver in a point-to-point connection.

The bits of the digital code words that describe the video signal are transmitted in parallel using 10 conductor cables (shielded twisted pairs) for each of the component signals. Each pair carries bits at a nominal sample rate of 74.25 Mwords/s. For the transmission of E_Y', E_{PB}', E_{PR}', the color-difference components are time-multiplexed into a single signal E_{PB}'/E_{PR}' of 74.25 Mwords/s.

The digital bit-parallel interface uses a 93 multi-pin connector for transmission of E_Y', E_{PB}', E_{PR}', or for transmission of E_G', E_B', E_R', with 8- or 10-bit precision.

The connecting cable shall carry 31 shielded conductor pairs for transmission of E_G', E_B', E_R' signals or for transmission of E_Y', E_{PB}'/E_{PR}' components and an additional data stream (auxiliary channel). Twenty-one shielded conductor pairs shall be used in the case of E_Y', E_{PB}'/E_{PR}' transmission.

The digital video signals on the interface are transmitted using shielded, balanced conductor pairs for distances up to 20 m (65.6 ft) without equalization (see annex D).

The interface allows the transmission of ancillary data that may be multiplexed into the data stream during blanking intervals.

4.2 Encoding parameters

Table 1 specifies the encoding parameter values of the digital representation of SMPTE 240M video signals.

4.2.1 Filtering characteristics

The spectral characteristics of the component video signals must be restricted to eliminate aliasing. Various filter designs can be used to accomplish this. One example of such filtering characteristics, when using E_Y', E_{PB}', and E_{PR}' signals as defined in table 1, is depicted in annex A, figures A.1 (for E_Y') and A.2 (for E_{PB}' and E_{PR}'). When using E_G', E_B', E_R' signals, the characteristics depicted in figure A.1 can be used.

4.2.2 Dynamic range of the analog signals and their relationship to quantization levels

To ensure the proper digital acquisition of large dynamic range signals from cameras (resulting from creative exposure beyond nominal white level in the viewed scene), the following relation between the camera analog signal values and their quantized representation shall be observed:

- an upper level of 700 mv and a black level of 0 mv shall correspond to the absolute maximum (peak-white) and minimum (black level) SMPTE 240M signal levels, respectively;
- the effects of camera highlight processing, such as knee and slope characteristics, shall be included within the aforementioned range;
- overshoot/undershoot effects caused by video processing circuitry may exceed the above limits;
- the peak-white level of 700 mv shall correspond to the quantization level 940 in a 10-bit system or to level 235 in an 8-bit system;

1) The purpose of the annexes is to convey results of studies on technical matters that relate to the processing of digital signals described in this standard. They also contain information on implementation examples that should be regarded as technical guidelines for equipment design.

Table 1 — Encoding parameter values for digital representation of SMPTE 240M signals

Parameter		Value
Matrix formulas	E_Y', E_{PB}', E_{PR}' E_G', E_B', E_R'	E_Y', E_{PB}', E_{PR}' are derived from gamma corrected values of E_G, E_B, E_R as defined by the linear matrix specified in SMPTE 240M.
Number of samples per line	Video components	E_Y' 2200 E_G' 2200 E_{PB}' 1100 E_B' 2200 E_{PR}' 1100 E_R' 2200
	Auxiliary channel	2200
Sampling structure	E_G', E_B', E_R', Luminance signal E_Y', Auxiliary channel	Identical sampling structures – Orthogonal sampling, line, field and frame repetitive.
	Color difference signals (E_{PB}', E_{PR}')	Samples are co-sited with odd (1st, 3rd, 5th, ...) E_Y' samples in each line.
Sampling frequency The tolerance of the sampling frequency shall be ± 10 ppm.	Video components	E_Y' 74.25 MHz E_G' 74.25 MHz E_{PB}' 37.125 MHz E_B' 74.25 MHz E_{PR}' 37.125 MHz E_R' 74.25 MHz
	Auxiliary channel	74.25 MHz
Form of encoding		Uniformly quantized, PCM 8 or 10 bits per sample for each of the video component signals and the auxiliary channel.
Active number of samples per line	Video components	E_Y' 1920 E_G' 1920 E_{PB}' 960 E_B' 1920 E_{PR}' 960 E_R' 1920
	Auxiliary channel	1920
Timing relationship between video data and the analog synchronizing waveform		The time duration between the end of active video (EAV) timing reference code and the reference point 0H (see figure 1) of the horizontal sync waveform is 88 clock intervals.
Correspondence between video signal levels and quantization levels	8 bit system: E_G', E_B', E_R', Luminance signal E_Y', Auxiliary channel	220 quantization levels with the black level corresponding to level 16 and the peak white level corresponding to level 235.
	Each color difference signal (E_{PB}', E_{PR}')	225 quantization levels symmetrically distributed about level 128, which corresponds to the zero signal.
NOTE—These values refer to precise nominal video signal levels. Signal processing may occasionally cause the signal level to deviate outside this range.	10 bit system: E_G', E_B', E_R', Luminance signal E_Y', Auxiliary channel	877 quantization levels with the black level corresponding to level 64 and the peak white level corresponding to level 940.
	Each color difference signal (E_{PB}', E_{PR}')	897 quantization levels symmetrically distributed about level 512, which corresponds to the zero signal.
Quantization level assignment	8-bit system	254 of the 256 levels (digital levels 1 through 254) of the 8-bit word shall be used to express quantized values. Data levels 0 and 255 shall be reserved to indicate timing references.
NOTE—These values refer to precise nominal video signal levels. Signal processing may occasionally cause the signal level to deviate outside this range.	10-bit system	1016 of the 1024 levels (digital levels 4 through 1019) of the 10-bit word shal be used to express quantized values. Data levels 0 to 3 and 1020 to 1023 shall be reserved to indicate timing references.

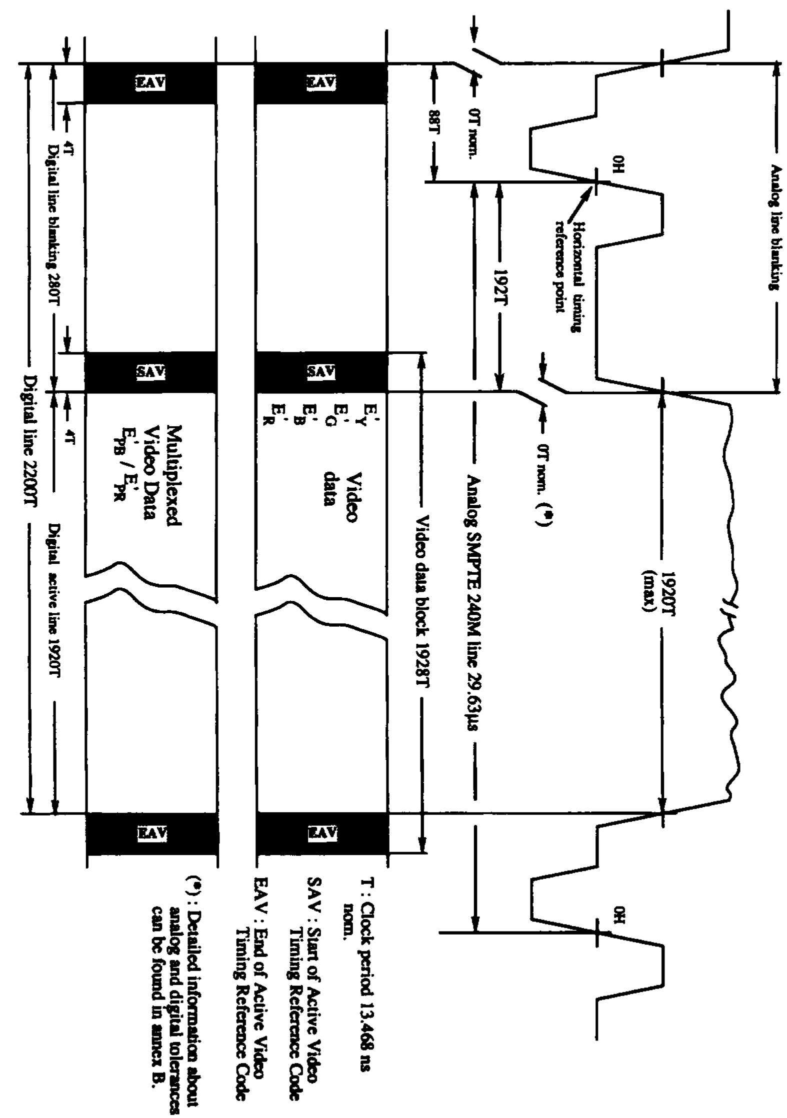


Figure 1 – Data format and timing relationship to analog SMPTE 240M waveform

– the black level (0 mv) shall correspond to level 64 in a 10-bit system or to level 16 in an 8-bit system.

4.3 Common signal format for digital interfaces

4.3.1 General description

The digital interface provides a unidirectional interconnection between a single source and a single destination. A signal format common to both parallel and serial interfaces is described below. The data signals shall be in the form of binary information coded in 8- or 10-bit words. These signals are:

- video data;
- timing reference codes;
- ancillary data;
- identification codes.

The characteristics of the data word at the interface shall be based on the assumption that the location of any required sin(x)/x correction is at the point where the digital signal is converted to an analog format.

4.3.2 Video data

4.3.2.1 Coding characteristics

The video data is in compliance with SMPTE 240M and with the *field blanking definition shown in table 2.*

4.3.2.2 Video data format

For a 10-bit system the data levels 0 to 3 and 1020 to 1023 (000_h to 003_h and $3FC_h$ to $3FF_h$ in the hexadecimal representation) shall be reserved for timing identification purposes. Consequently, data levels 4 through 1019 (004_h through $3FB_h$) shall be used to express quantized signal values.

For an 8-bit system, data levels 0 and 255 (00_h and FF_h) shall be reserved to indicate timing references. Digital levels 1 through 254 (01_h through FE_h) shall be used to represent quantized signal values.

The video data words shall be conveyed across the digital interface using multiple bit-parallel channels; luminance E_Y' and time-multiplexed color-difference signal E_{PB}'/E_{PR}' or the three primary color signals E_G', E_B', E_R'. Each parallel channel consists of 8 or 10 bits and the transmission rate shall be 74.25 Mwords/s. Co-sited samples of the two color-difference signals shall be time-multiplexed in the order E_{PB}' and E_{PR}'.

4.3.2.3 Timing relationship between video data and the analog synchronizing waveform

4.3.2.3.1 Line interval

Figure 1 depicts the timing relationship between the digital video and the analog line sync waveform. The digital active line shall begin 192 clock periods after the rising edge of the analog, tri-level, line sync pulse (the zero crossing point is labelled 0H in figure 1). The precise timing shall be specified between half-amplitude points. Lines shall be numbered from 1 through 1125 as shown in figures 2A and 2B.

4.3.2.3.2 Field interval

The start of the digital field shall be determined by the position specified by the start of the digital line. The digital field shall start coincident with the end of active video (EAV) timing reference code of the lines indicated in table 2. Field blanking in the digital interface shall be in full-line increments.

4.3.2.4 Video timing reference codes (SAV, EAV)

There shall be two timing reference codes, one at the beginning of each video data block (start of active video, SAV) and another at the end of each video data block (end of active video, EAV). These codes are shown in figure 1. The timing reference codes shall be

Table 2 — Field interval definition

V: Digital field blanking		
Field 1	Start (V=1)	Line 1121
	Finish (V=0)	Line 41
Field 2	Start (V=1)	Line 558
	Finish (V=0)	Line 603
F: Digital field identification		
Field 1	F = 0	Line 1
Field 2	F = 1	Line 564

Notes –
1 Signals F and V shall change state synchronously with the end of active video (EAV) timing reference code, *at the beginning of the digital line.*
2 Definition of line numbers is given in SMPTE 240M. Digital line numbers shall change state prior to the horizontal timing reference point (0H), as shown in figure 1.

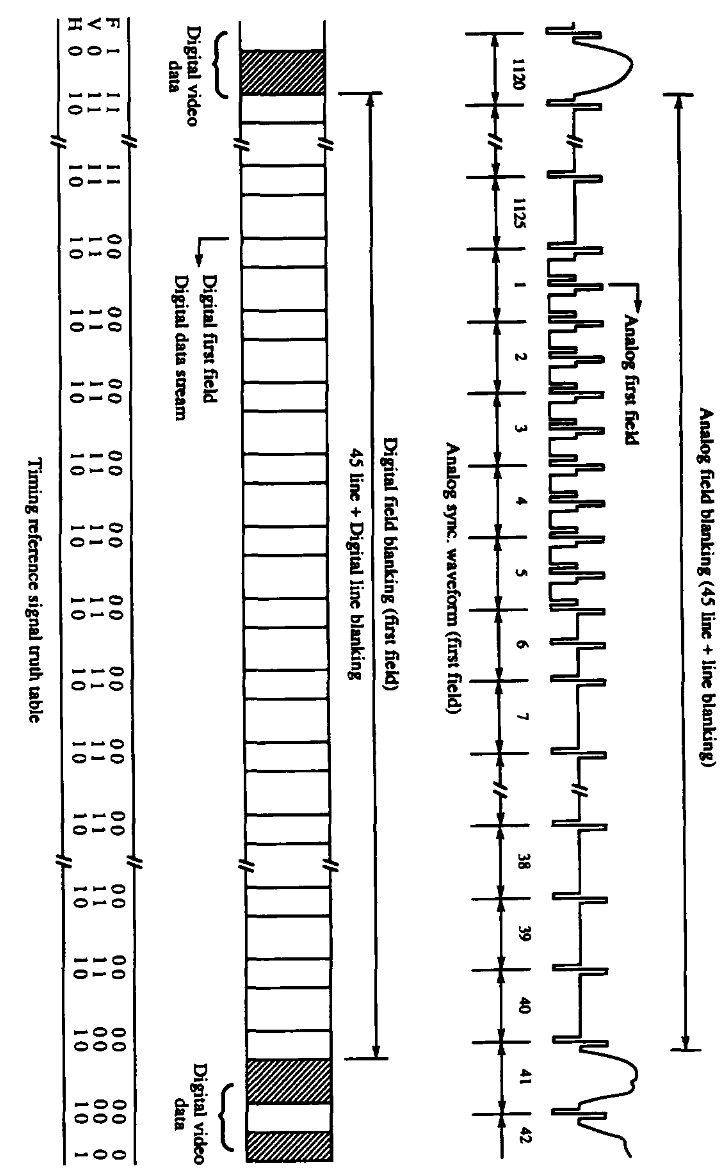


Figure 2A – First digital field (F = 0)

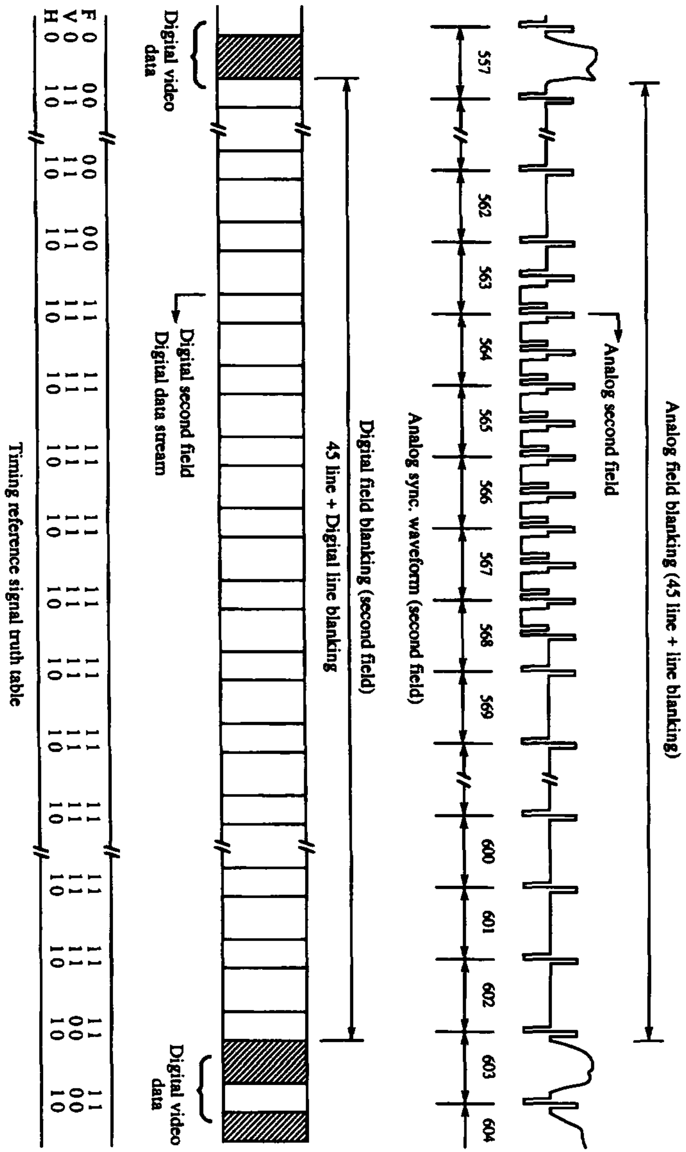


Figure 2B – Second digital field (F=1)

contiguous with the video data, when present, and continue through the field blanking interval. The SAV and EAV codes shall be the digital interface line synchronization signals and shall be carried on every line by all component signals, namely, E_Y', E_{PB}', E_{PR}', and E_G', E_B', E_R'. The interval starting at EAV and ending with SAV shall be the digital line blanking period as shown in figure 1.

Each timing reference code shall consist of a four-word sequence in the following format for a 10-bit system: $3FF_h$, 000_h, 000_h, XYZ_h (in hexadecimal notation). The first three words shall be a fixed preamble. The fourth word contains information defining:

- field 2 identification;
- state of field blanking;
- state of line blanking.

The assignment of bits within the timing reference codes shall be as shown in table 3.

For an 8-bit system, the bits of each timing reference word are selected starting from the MSB of each of the words specified in table 3 (note that FF_h and 00_h are reserved for use in timing reference codes).

Bits P0, P1, P2, P3 in table 3 have logic values that depend on the states of the bits F, V, and H and are shown in table 4. At the receiver this arrangement permits one-bit errors to be corrected and two-bit errors to be detected.

4.3.2.5 Ancillary data

NOTE — The precise location of the ancillary data blocks and the coding of words 3, 4, and 5 (see figure 3) requires further study.

Table 3 — Video timing reference codes

Word	Bit Number									
	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
First	1	1	1	1	1	1	1	1	1	1
Second	0	0	0	0	0	0	0	0	0	0
Third	0	0	0	0	0	0	0	0	0	0
Fourth	1	F	V	H	P3	P2	P1	P0	0	0

F= 0 during field 1; 1 during field 2 — V= 0 elsewhere; 1 during field blanking — H= 0 in SAV; 1 in EAV

NOTES –
1 P0, P1, P2, P3; protection bits (see table 4).
2 MSB; most significant bit.
3 LSB; least significant bit.
4 Table 2 defines the logic state of the V and F bits.

Table 4 — Protection bits for SAV and EAV

Bit No.	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

Ancillary data may be inserted synchronously into the *video/data multiplex during the blanking intervals at a* rate of 74.25 Mwords/s. Figure 3 shows the configuration of the ancillary data block. It shall consist of the ancillary timing reference signal code (ANC) and the data field. The wordlength of both the code and the data is 10 bits.

Small blocks of data, less than (or equal to) 272 words in total length, including the ANC sequence (as described below) may be carried within the line blanking period of each video component on every line (following the EAV timing reference code).

For the luminance EY' and E_G', E_B', E_R' channels, large blocks of data, up to 1920 words in total length (including the ANC sequence), may be carried within the interval starting with the end of SAV and terminating with the beginning of EAV, on the 90 lines contained in the digital field blanking periods. The time-multiplexed E_{PB}'/E_{PR}' channel may also provide 1920 words of transmission capacity for each of these lines. Ancillary data may be optionally carried in the active portion of any of the other lines that comprise *the field interval.*

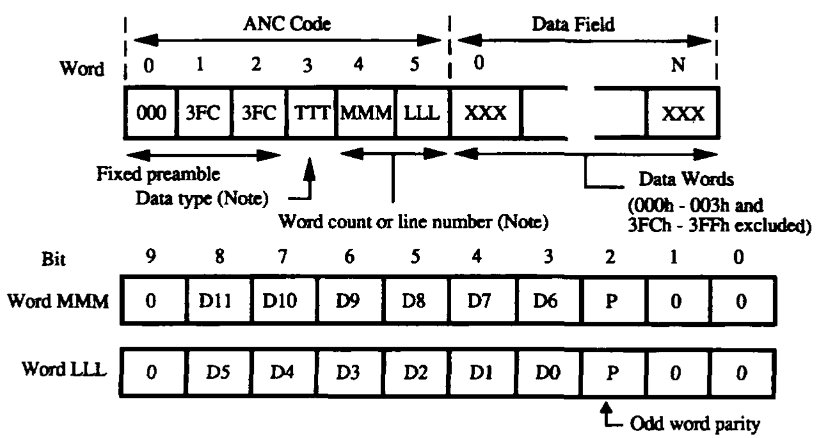
4.3.2.5.1 Ancillary data signal format

Further studies are needed for a final decision on the signal format of the ancillary data.

4.3.2.5.2 Timing reference signal for ancillary data (ANC)

Each ancillary data block shall be preceded by the ancillary timing reference signal code (ANC), shown in figure 3.

The first three words shall be a fixed preamble. The fourth word, noted as "TTT," shall contain data identification codes which will be determined at a future time as part of the studies required to complete the specification of the ancillary data signal format. Words 4 (MMM) and 5 (LLL) shall contain either the line number or the data word count. When ANC is used to transmit the video line number, the line number shall be carried by the two words shown as "MMM" and



NOTE – "Word count" shall specify the length of the data field and shall lie in the range 1 – 1914. If word TTT indicates a video line number then D11 to D0 shall contain the binary equivalent of the line number and the word count shall be zero. The ancillary blocks may be transmitted when time is available during line or field blanking following the EAV timing reference code.

Figure 3 — Ancillary data block

"LLL" and no ancillary data shall follow. Each word shall consist of six bits of data and a parity bit (odd parity). The two least significant bits and bit 9 shall be set to zero. ANC can occur multiple times per line period if different blocks of data are carried. The ANC and its associated data block shall not occupy the intervals reserved for EAV, SAV, or active video.

4.3.2.6 Data transmission during blanking intervals

In an 8-bit system, the data words occurring during digital blanking intervals, that are not used for the timing reference codes SAV, EAV, and ANC or for ancillary data, shall be filled with the sequence 10_h, 10_h, . . ., which corresponds to the blanking level of the luminance E_Y' (or E_G', E_B', E_R') or 80_h, 80_h, . . ., which corresponds to the blanking level of the time-multiplexed color-difference signals E_{PB}'/E_{PR}'.

In a 10-bit system, the digital blanking intervals are filled with the sequence 040_h, 040_h, . . ., which corresponds to the blanking level of the luminance E_Y' (or E_G', E_B', E_R') or 200_h, 200_h, . . . , which corresponds to the blanking levels of the time-multiplexed color-difference signals E_{PB}'/E_{PR}'.

5 Bit-parallel interface

5.1 General description of the interface

This section specifies a bit-parallel digital interface for the interconnection of digital television equipment operating in the production system specified in SMPTE 240M.

5.1.1 E_Y', E_{PB}', E_{PR}' system

The bits of the digital code words that describe the signal, which consists of the luminance E_Y' and two time-multiplexed color-difference components E_{PB}'/E_{PR}', shall be transmitted in parallel by means of 8 or 10 shielded conductor pairs for each of the components. Each conductor pair shall carry a stream of bits at a rate of 74.25 Mwords/s. The conductor pairs may also carry ancillary data that may be time-multiplexed into the data stream during video blanking intervals. An additional conductor pair shall carry a synchronous clock signal at 74.25 MHZ.

The signals on the interface shall be transmitted using balanced conductor pairs for a distance of up to 20 m (65.6 ft) without equalization (see annex D).

The digital bit-parallel interconnection uses a 93 multi-pin connector equipped with a locking mechanism (see 5.5.3). The interface shall consist of one transmitter and one receiver in a point-to-point connection.

The bits of the data word (8 or 10 bits) shall be denoted as data YD0 to data YDn for luminance and data CD0 to data CDn for the multiplex color-difference signals. The entire word is designated as data YD(0—n) and data CD(0—n). Data YDn and data CDn shall be the most significant bit (n = 7 or n = 9).

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

5.1.2 E_G', E_B', E_R' system

The bits of the digital code words that describe the E_G', E_B', E_R' components shall be transmitted in parallel by means of 8 or 10 shielded conductor pairs. Each conductor pair shall carry a stream of bits at a rate of 74.25 Mwords/s. The conductor pairs may also carry ancillary data that shall be time-multiplexed into the data stream during video blanking intervals. An additional conductor pair shall carry a synchronous clock signal at 74.25 MHz.

The signals on the interface shall be transmitted using balanced conductor pairs for a distance of up to 20 m (65.6 feet) without equalization (see annex D).

The digital bit-parallel interconnection shall use a 93 multi-pin connector equipped with a locking mechanism (see 5.5.3). The interface shall consist of one transmitter and one receiver in a point-to-point connection.

The bits of the data word (8 or 10 bits) shall be denoted as data GD0, BD0, RD0 to data GDn, BDn, RDn for the E_G', E_B', E_R' signals respectively. The entire word is designated as data GD(0—n), BD(0—n) and RD(0—n). Data GDn, BDn, and RDn shall be the most significant bit (n = 7 or n = 9).

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

5.2 Data signal format

The recommended data format is described in 4.2 and 4.3.

5.3 Clock signal

5.3.1 General description

The clock signal shall be a 74.25 MHz square wave in which the low level to high level transition shall represent the data transfer timing (see figure 4). This signal shall have the following characteristics:

NOTE - All digital signal time intervals are specified at the half-amplitude points. All transitions are specified between the 20% and 80% amplitude points.

- Clock pulse width (t) = 6.734 ns ± 1.5 ns;
- Clock jitter — The peak-to-peak jitter between rising edges shall be within ± 0.5 ns of the average time of the rising edge computed over one field.

5.3.2 Clock to data timing relationship

The positive transition of the clock signal shall occur midway between data transitions as shown in figure 4.

5.4 Electrical characteristics of the interface

5.4.1 General description

For the transmission of a luminance E_Y', and the time-multiplexed color-difference signal E_{PB}'/E_{PR}', the interface shall have 21 balanced signal pairs (along with their corresponding line drivers and receivers). For the transmission of E_G', E_B', E_R', or E_Y', E_{PB}'/E_{PR}', and the auxiliary channel, the interface shall have 31 balanced signal pairs.

Each line driver (source) shall have a balanced output and the corresponding line receiver (destination) shall have a balanced input (see figure 5).

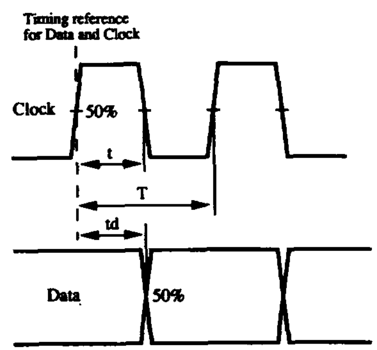
Although the use of ECL technology is not specified, the line driver and receiver shall be ECL compatible; i.e., they shall permit the use of standard ECL (10KH series) for either or both ends.

Each parallel channel of the interface shall have 10 balanced signal pairs. In the case of an 8-bit system, the 8 most significant pairs shall be used with the LSB and second LSB of the 10-bit word connected to logic zero at the source, and terminated to the line impedance (110 ohms) at the destination.

5.4.2 Signal convention

The signalling polarity of the voltage appearing across the interconnecting cable shall be positive binary and defined as follows (refer to figure 5):

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



Line frequency: fh= 33.75 kHz (nominal)
Clock period: T= 1/(2200 fh)= 13.468 ns (nominal)
Clock pulse width: t= 6.734 ns ± 1.5 ns

Figure 4 - Clock to data timing (at sending end)

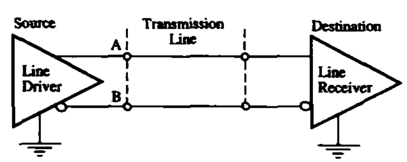


Figure 5 - Line driver and receiver interconnection

5.4.3 Line driver characteristics (source)

5.4.3.1 Output impedance

The line driver shall have a balanced output with a maximum impedance of 110 ohms.

5.4.3.2 Common mode voltage

The average of the voltages on the two terminals of the line driver shall be −1.29 V ± 15% with reference to the ground terminal.

5.4.3.3 Signal amplitude

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

5.4.3.4 Rise and fall times

Rise and fall times shall be no greater than 2.0 ns measured between the 20% and the 80% amplitude points across a 110 ohm resistive load. The difference between rise and fall times shall not exceed 1.0 ns.

5.4.4 Line receiver characteristics (destination)

5.4.4.1 Terminating impedance

The cable shall be terminated by 110 ohms ± 10 ohms.

5.4.4.2 Maximum input signal

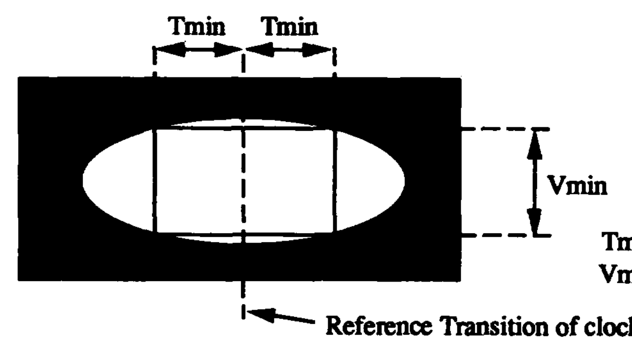
The maximum input signal shall be 2.0 V peak-to-peak.

5.4.4.3 Minimum input signal

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

5.4.4.4 Maximum common mode signal

The receiver shall operate correctly in the presence of common mode noise (comprising interference in the range 0 to 33 kHz with both terminals to ground) having a maximum amplitude of 0.3 V.



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. Figure 6 assumes 2.5 ns propagation skew, 1.0 ns data source skew, and 0.5 ns clock jitter 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. Background information about timing issues can be found in annex E.

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

Table 5 — Description of multi-channel cable

21-pair multi-channel cable		31-pair multi-channel cable		31-pair multi-channel cable	
EY', EPB'/EPR'		EG', EB', ER'		EY', EPB'/EPR' and auxiliary channel	
EY'	74.25 Mwords/s 10-bit parallel	EG'	74.25 Mwords/s 10-bit parallel	EY'	74.25 Mwords/s 10-bit parallel
EPB'/EPR'	74.25 Mwords/s 10-bit parallel	EB'	74.25 Mwords/s 10-bit parallel	EPB'/EPR'	74.25 Mwords/s 10-bit parallel
Clock	74.25 MHz	ER'	74.25 Mwords/s 10-bit parallel	Auxiliary channel	74.25 Mwords/s 10-bit parallel
		Clock	74.25 MHz	Clock	74.25 MHz

5.4.4.5 Differential delay

Data shall be correctly sensed when the relative differential delay between the received clock and the received data is in the range of 4 ns (see figure 6).

5.5 Mechanical characteristics – Connector and cable structure

5.5.1 Outline of connector and cable

The specification of a twisted-pair, multi-channel cable and a 93-pin connector, which shall be used for the bit-parallel transmission at 74.25 Mwords/s of the component signals described in this standard, is given below.

5.5.2 Interconnecting cable

The multi-channel cable shall consist of a multitude of twisted-pairs with individual shields. The nominal characteristic impedance of each twisted pair shall be 110 ohms (to comply with the specifications given in 5.4.3 and 5.4.4).

Depending on the type of application, there are two types of interconnecting cables. They are described in table 5.

5.5.2.1 Cable length

The interconnecting cable shall be for use in indoor environments where the physical length of the cable is up to a maximum of 20 m (65.6 ft) (see annex D). Within this range, the transmitted digital data shall be correctly detected satisfying the conditions of the eye diagram of figure 6, without the need for equalization of the cable characteristics. Cable with reduced differential delay (compared to the example value specified in annex D) can be used for longer transmission distances.

5.5.2.2 Cable structure

The multi-channel cable shall consist of either 21 or 31 twisted-pairs of conductors with individual shielding of each pair.

The optimum cable shall be one constructed to minimize the differential delay between any two conductor pairs.

The cable shall contain an overall shield, to minimize radiation (EMI), carried through the cable assembly and connectors via the cable shield and the connector body at each end.

5.5.3 Connector characteristics

5.5.3.1 Connector description

The connector specified in this section shall be a 93 pin, multi-pin connector.

The cable assembly shall be provided with connectors containing pin contacts at both the sending end and receiving end of the cable.

Each source equipment shall be provided with a receptacle connector containing socket contacts for the digital components generated by the equipment. Each receiver equipment shall be provided with a receptacle connector containing socket contacts for the digital components received by the equipment.

Figures 7, 8, and 9 respectively show the mechanical drawings and dimensions of the multi-pin connector (plug), the multi-socket connector (receptacle), and the connector metal hood and locking mechanism.

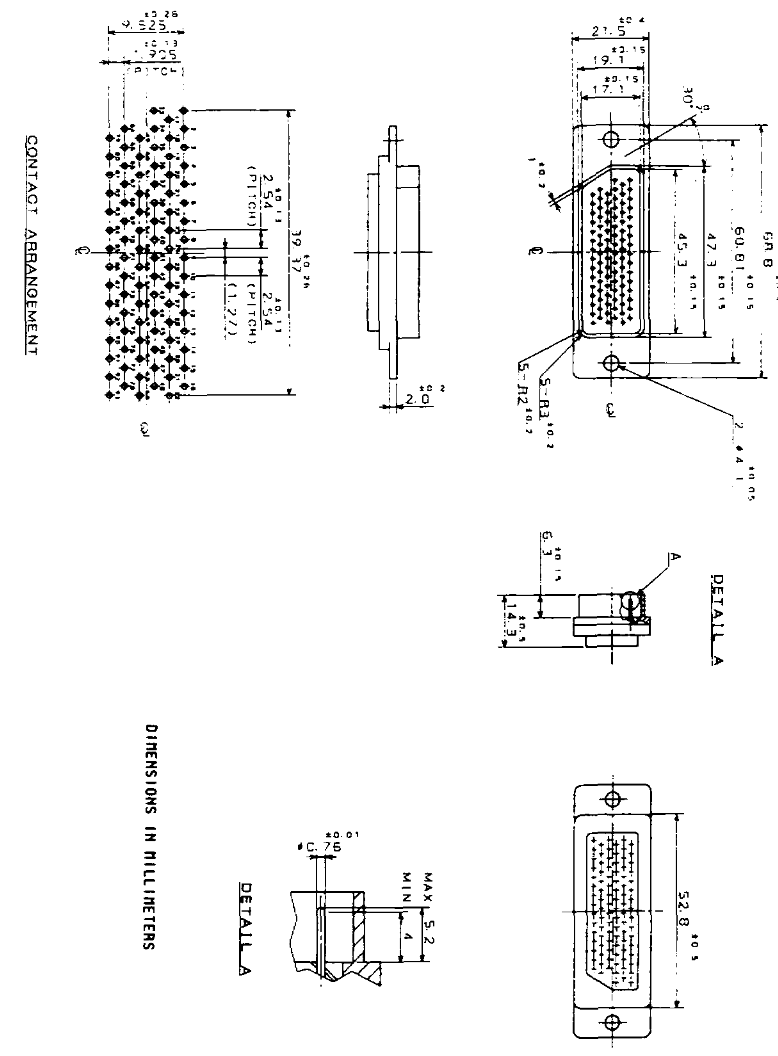
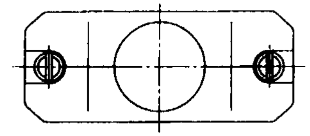


Figure 7 – 93-pin multi-pin connector (plug)



NOTE 1. A SCREW PROJECTING OUT FROM THE PLUG CONNECTOR.
DIMENSIONS IN MILLIMETERS.

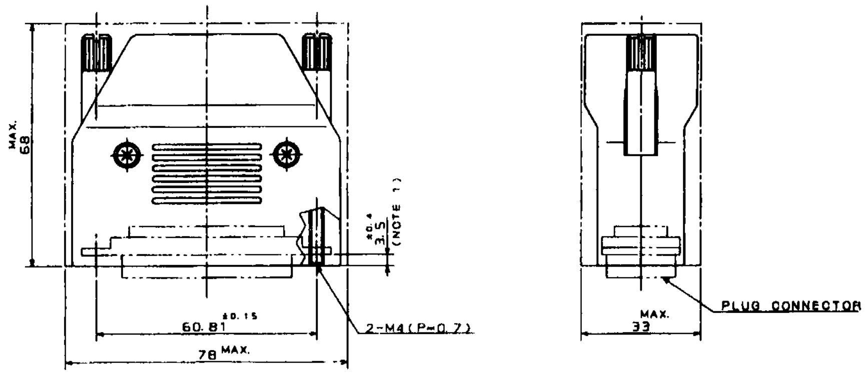
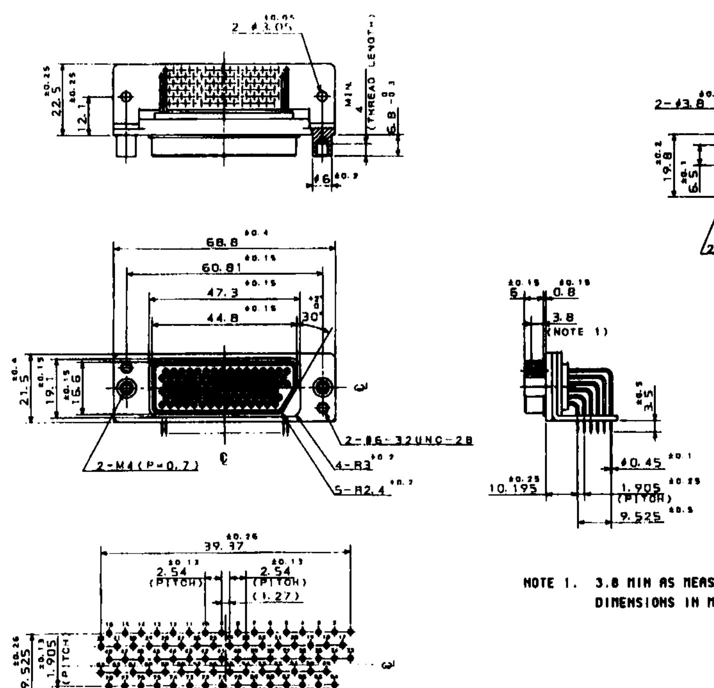
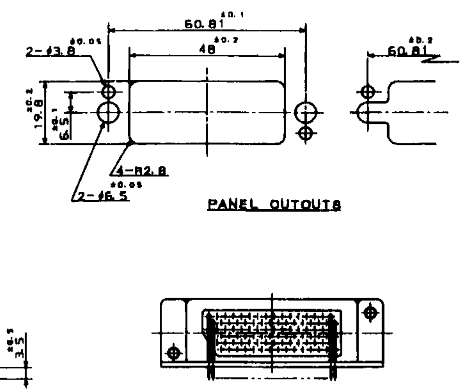


Figure 9 – 93-pin multi-pin connector hood





NOTE 1. 3.8 MIN AS MEASURED WITH A SQUARE ENDED TEST PIN.
DIMENSIONS IN MILLIMETERS.

1. Ey', EPB'/EPR' System (XD2 - XD9 are used in an 8 bit System)

	No.		No.		No.		No.		No.		No.	
	1	CK+	17	GND	33	CK-						
MSB	2	YD9+	18	GND	34	YD9-	49	AuxD4+	64	GND	79	AuxD4-
	3	YD8+	19	GND	35	YD8-	50	AuxD3+	65	GND	80	AuxD3-
	4	YD7+	20	GND	36	YD7-	51	AuxD2+	66	GND	81	AuxD2-
	5	YD6+	21	GND	37	YD6-	52	AuxD1+	67	GND	82	AuxD1-
	6	YD5+	22	GND	38	YD5-	53	AuxD0+	68	GND	83	AuxD0-
	7	YD4+	23	GND	39	YD4-	54	CD9+	69	GND	84	CD9-
	8	YD3+	24	GND	40	YD3-	55	CD8+	70	GND	85	CD8-
	9	YD2+	25	GND	41	YD2-	56	CD7+	71	GND	86	CD7-
	10	YD1+	26	GND	42	YD1-	57	CD6+	72	GND	87	CD6-
LSB	11	YD0+	27	GND	43	YD0-	58	CD5+	73	GND	88	CD5-
	12	AuxD9+	28	GND	44	AuxD9-	59	CD4+	74	GND	89	CD4-
	13	AuxD8+	29	GND	45	AuxD8-	60	CD3+	75	GND	90	CD3-
	14	AuxD7+	30	GND	46	AuxD7-	61	CD2+	76	GND	91	CD2-
	15	AuxD6+	31	GND	47	AuxD6-	62	CD1+	77	GND	92	CD1-
	16	AuxD5+	32	GND	48	AuxD5-	63	CD0+	78	GND	93	CD0-

2. EG', EB', ER' System (XD2 - XD9 are used in an 8 bit System)

	No.		No.		No.		No.		No.		No.	
	1	CK+	17	GND	33	CK-						
MSB	2	GD9+	18	GND	34	GD9-	49	BD4+	64	GND	79	BD4-
	3	GD8+	19	GND	35	GD8-	50	BD3+	65	GND	80	BD3-
	4	GD7+	20	GND	36	GD7-	51	BD2+	66	GND	81	BD2-
	5	GD6+	21	GND	37	GD6-	52	BD1+	67	GND	82	BD1-
	6	GD5+	22	GND	38	GD5-	53	BD0+	68	GND	83	BD0-
	7	GD4+	23	GND	39	GD4-	54	RD9+	69	GND	84	RD9-
	8	GD3+	24	GND	40	GD3-	55	RD8+	70	GND	85	RD8-
	9	GD2+	25	GND	41	GD2-	56	RD7+	71	GND	86	RD7-
	10	GD1+	26	GND	42	GD1-	57	RD6+	72	GND	87	RD6-
LSB	11	GD0+	27	GND	43	GD0-	58	RD5+	73	GND	88	RD5-
	12	BD9+	28	GND	44	BD9-	59	RD4+	74	GND	89	RD4-
	13	BD8+	29	GND	45	BD8-	60	RD3+	75	GND	90	RD3-
	14	BD7+	30	GND	46	BD7-	61	RD2+	76	GND	91	RD2-
	15	BD6+	31	GND	47	BD6-	62	RD1+	77	GND	92	RD1-
	16	BD5+	32	GND	48	BD5-	63	RD0+	78	GND	93	RD0-

Table 6 — Bit-parallel interface pin assignments

5.5.3.2 Connector contact assignment

The 93 pin/socket connector shall be used with either the 21-pair or the 31-pair multi-channel cables. These cables are described in 5.5.2. The pin/socket assignment for both types of cable shall be as given in table 6.

In the case of transmission of EY', time-multiplexed EPB'/EPR' components and auxiliary channel (with either 8 or 10 bits), the EPB'/EPR' multiplexed signal shall be carried on the pins specified for the red component; i.e., pins 54 through 63 for the data signals (terminal A in figure 4) and 84 through 93 for the return signals (terminal B in figure 4). The bits describing the auxiliary channel (e.g., a key or alpha signal) shall be carried on those pins specified for the blue channel; i.e., pins 12 - 16 and 49 - 53 for the data signals and 44 - 48 and 79 - 83 for the return signals.

The shield for each conductor pair shall use the ground pin located between the pins for that signal pair in table 6 (e.g., pin 17 shall be used for the shield of the clock signal).

5.5.3.3 Cable connector assembly

The structure of cable and equipment connectors shall be as shown in figure 10.

The individual signal and shield wires of the multi-channel cable should be connected to pin contacts by pressure. Deviation in cable lengths between twisted pairs of the cable assembly shall be minimized in order to prevent data skew due to differential delays.

The structure of the connector hood prevents unnecessary radiation of electromagnetic interference.

The overall shield of the multi-channel 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.

5.5.3.4 Connector locking mechanism

There shall be electrical conduction between the overall cable shield and the connector hood and equipment frame.

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

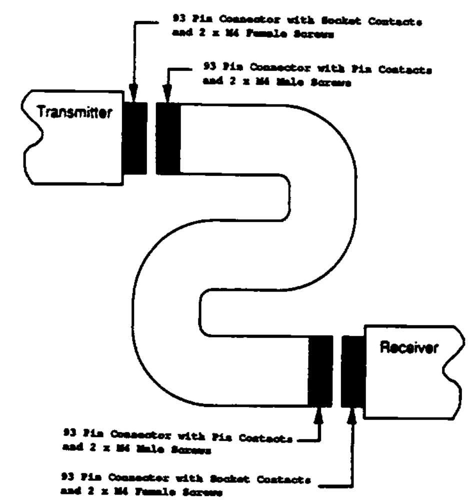


Figure 10 – Cable connector assembly

Annex A (informative)

Pre- and post-filtering characteristics

Figures A.1 and A.2 depict examples of filter characteristics for pre- and post-filtering of E_Y', E_G', E_B', E_R' and for E_{PB}', E_{PR}' component signals respectively.

The following points have been taken into account in the design of these filter templates:

- The passband frequency of the component signals complies with the specifications of SMPTE 240M E_G', E_B', E_R' and luminance E_Y' = 30 MHz E_{PB}', E_{PR}' = 15 MHz;

- The value of the amplitude ripple tolerance in the passband is 0.1 dB peak-to-peak, for both the luminance and color-difference components;

- The insertion loss characteristics of the filters are *scaled up versions* (5.5 times) of the characteristics of CCIR Rec. 601-1. There is an attenuation of more than 12 dB at the frequency of 37.125 MHz for the E_Y', E_G', E_B', E_R' *components* and an attenuation of more than 6 dB at 18.5625 MHz for the color-difference components E_{PB}', E_{PR}'.

The filter templates also show the following attenuation values:

40 dB attenuation	E_Y', E_G', E_B', E_R'	at 44.25 MHz
	E_{PB}', E_{PR}'	at 22.125 MHz
50 *dB attenuation*	E_Y', E_G', E_B'	at 54.25 MHz
	E_{PB}', E_{PR}'	at 27.125 MHz

The *group-delay tolerance* in the passband is specified as follows:

E_Y', E_G', E_B', E_R'	2 ns *peak-to-peak (up to 20 MHz)*
	3 ns peak-to-peak (20 to 30 MHz)
E_{PB}', E_{PR}'	2 ns peak-to-peak (up to 10 MHz)
	3 *ns peak-to-peak (10 to 15 MHz)*

In CCIR Rec. 601-1 the group-delay tolerance is specified as follows:

E_Y', E_G', E_B', E_R'	2 ns to 6 ns peak-to-peak
E_{PB}', E_{PR}'	4 ns to 12 ns peak-to-peak.

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

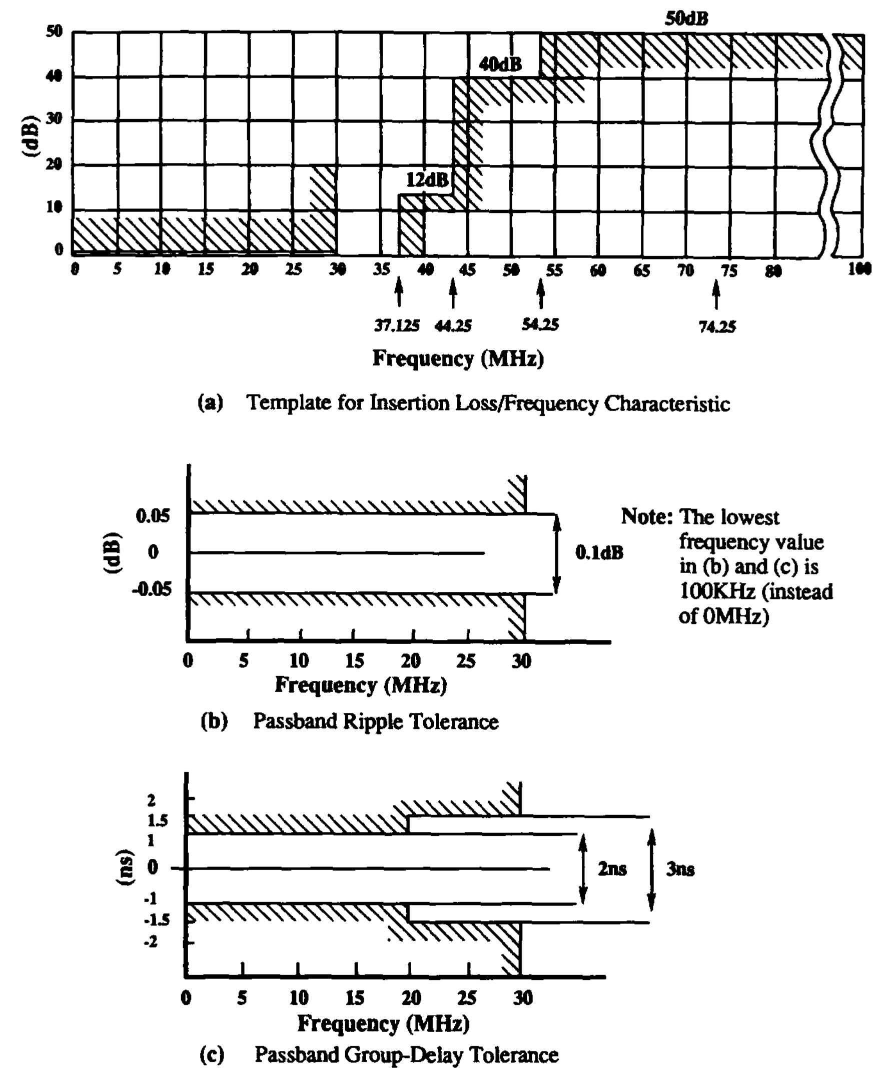


Figure A.1 — Filter specification for luminance E_Y' or E_G', E_B', E_R' signal when using a sampling frequency of 74.25 MHz

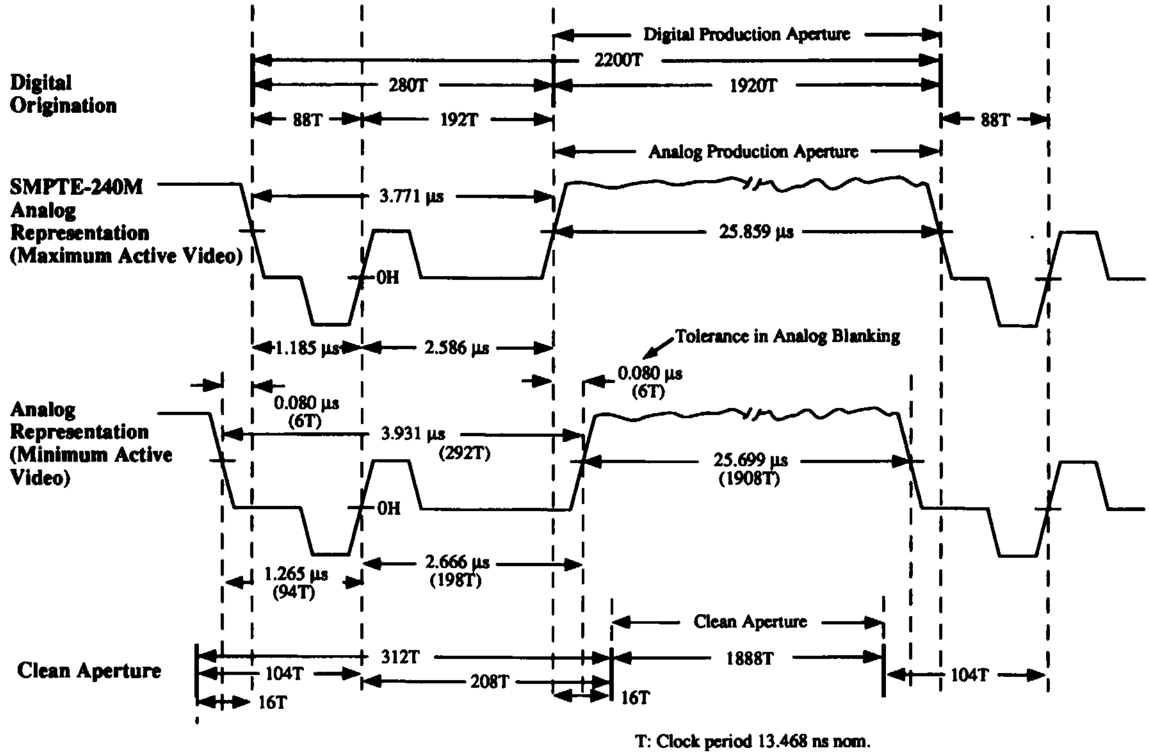


Figure B.1 — Timing relationship between production aperture and clean picture

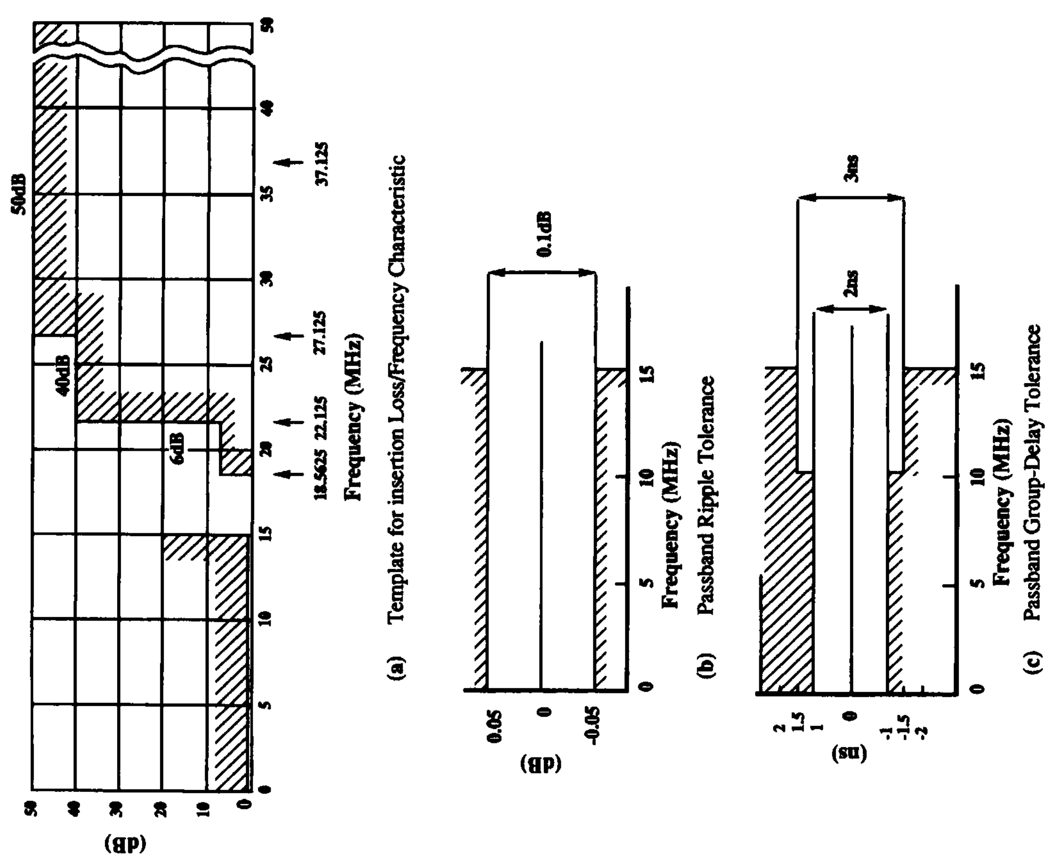


Figure A.2 — Filter specification for color-difference signals when using a sampling frequency of 37.125 MHz

Annex B (informative)

Production aperture issues

B.1 Production aperture

A production aperture for the digital signal defines an active picture area of 1920 pixels by 1035 lines, produced by signal sources conforming to SMPTE 240M such as cameras, telecines, digital videotape recorders, and computer generated pictures. This digital standard recommends that all of this video information be carefully produced, stored, and properly processed by subsequent digital studio equipment. In particular, digital blanking in all studio equipment should rigorously conform to this specified digital production aperture.

B.2 Analog blanking tolerance

The width of the maximum active analog video of the signal described in SMPTE 240M is defined by the 1920 clock periods. This value is measured at the 50% points of the analog video signal. However, the analog blanking period can differ from equipment to equipment and the digital blanking may not coincide with the analog blanking in actual implementation.

To maximize the active video 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 B.1).

To accommodate a practical implementation of analog blanking within various studio equipment, a horizontal region of 6 clock periods (or 80 ns) is introduced at the start and end of active video.

This analog blanking tolerance window introduces the following tolerance to parameters "b" and "e" of figure 1(c) shown in SMPTE 240M-1988.

Parameter	Definition	Nominal value	Tolerance
"b"	End of Active Video	1.185 μs	−0.000, +0.080 μs
"e"	Start of Active Video	2.586 μs	−0.000, +0.080 μs

The relationship of the associated analog representation (inclusive of this tolerance) with the production aperture is shown in figure B.1.

B.3 Transient regions

SMPTE 240M precisely defines a picture aspect ratio of 16:9 with 1920 pixels per active line and 1035 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 this standard.

Among the factors that can contribute to such effects, the following describes some of the more important:

- bandwidth limitation of component analog signals (most noticeably, the ringing of 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
- tolerance in analog blanking.

In order to accommodate realistic tolerances for analog and digital processes during post-production operations, the following information is given in the form of a technical guideline.

B.4 Clean aperture

It is recognized that 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.

The concept of a clean aperture defines an inner picture area within which the picture information is subjectively uncontaminated by all edge transient distortions. This 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.

This gives rise to a possible picture area, the clean aperture, of 1888 horizontal active pixels by 1017 active lines within the digital production aperture, whose quality is guaranteed for final release (see figure B.2).

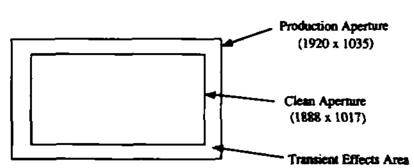


Figure B.2 – Production and clean apertures

Annex C (informative)

Electrical characteristics of the interface

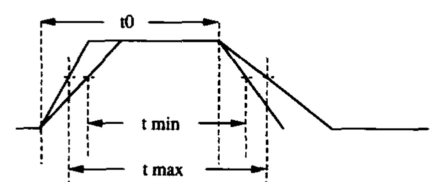
C.1 Clock signal

The following information relates to the selection of the parameters that specify the electrical characteristics of the parallel digital interface described in this standard. These characteristics are described following the presentation style of CCIR Rec. 656 for ease of comparison of the parameter values.

C.1.1 Width (6.734 ns ± 1.5 ns)

The specification 6.734 ns ± 1.5 ns has been decided taking into consideration the following points:

(1) The maximum pulse width (t_{max}) and the minimum pulse width (t_{min}) of the clock have been calculated using acceptable tolerances on the rise (tr) and fall (tf) time of the ECL 10KH series (see figure C.1 and note 4).



$t0 = 1/2$ period of the clock
$t_{max} = t0 + (tf_{max}/2) - (tr_{min}/2)$
$= t0 + (1.7/2) - (0.5/2)$
$= t0 + 0.6$ ns
$t_{min} = t0 + (tf_{min}/2) - (tr_{max}/2)$
$= t0 + (0.5/2) - (1.7/2)$
$= t0 - 0.6$ ns

Figure C.1 — Clock pulse width

(2) It is desirable that the tolerance of the pulse width be set as small as possible to avoid shifting of the clock phase that could be caused by using cable with degraded frequency characteristics.

(3) It is desirable that the clock waveform be generated not only from an oscillator of double frequency followed by a frequency divider, but also from a fundamental frequency oscillator. There is an example in practical use of the fundamental frequency oscillation technique whose duty factor is (50 ± 5)%. The corresponding tolerance becomes 13.468 ns × (±5%) = ± 0.67 ns. Thus the total tolerance is obtained by adding this and the value in (1) above.

C.1.2 Jitter (± 0.5 ns)

In consideration of the following, the specification value of ± 0.5 ns has been recommended.

(1) Any possible disturbances to the variable frequency oscillator as well as any disturbances caused by the shaping of the ECL signal waveform should be considered.

(2) The external synchronizing signal should be sufficiently stabilized; its variation should not be included in the jitter specification.

C.1.3 Data timing (6.734 ns ± 1.0 ns)

The specification 6.734 ns ± 1.0 ns has been decided taking into account the following conditions:

(1) After latching, each word of the data sequence is transmitted from the output terminal of an ECL 10KH line driver. The clock signal is transmitted in the same manner, but only after passing through a constant delay line. The duration of this delay consists of the typical propagation delay of the latch in use plus a fixed time of 6.734 ns.

(2) The time delay tolerance is defined as the sum of the tolerances listed below:
1. Propagation delay of the latches used
2. Propagation delay of line drivers
3. Delay time of the delay line for the clock signal

The time delay tolerance includes variations caused by temperature drifts and hardware setting.

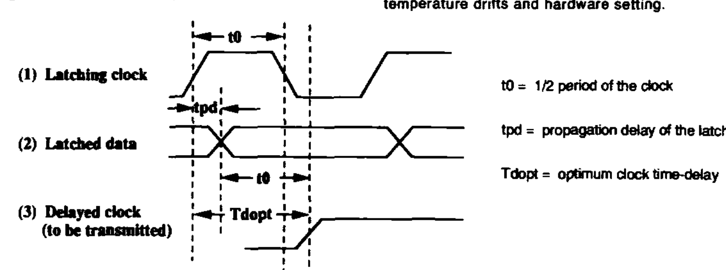


Figure C.2 – Timing characteristics between clock and data

(3) A faster ECL device, like MC10E151, can provide a propagation delay in the order of 0.47 ns to 0.8 ns. Hence, the tolerance can be calculated to be 0.17 ns.

(4) The propagation delay of a line driver device (ECL 10KH family), such as MC10H116, can be found distributed in the range of 0.4 ns to 1.45 ns. The tolerance can then be calculated to be ± 0.53 ns.

(5) The variations in time delay for the delay line used for the clock signal can be found to be less than ± 0.1 ns.

(6) The maximum tolerance is therefore calculated to be ± 0.8 ns, which is less than the value adopted in this standard for the total tolerance; i.e., ± 1.0 ns.

(7) In practice, ECL devices from the 10KH family can be used to satisfy the total tolerance specification of ± 1.0 ns. This is because the delay variations found in latch devices of this ECL family do not experience large time delays (see figure C.2).

C.2 Line driver characteristics (source)

C.2.1 Output impedance (110 ohms max)

The value 110 ohms has been chosen in conformity with the characteristic impedance of the cable to be connected. From the viewpoint of waveform transmission, the use of a series termination might be desirable, where the resistor value to be inserted depends on the electrical characteristics of the output circuit of the sending end. However, this has been *specified with only the maximum value to maintain a sufficient* noise immunity of the system. This specification is the same as CCIR Rec. 656.

C.2.2 Common mode voltage (–1.29 V ± 15%)

This has been specified considering the range of common mode voltage that may appear at the output of the device, and which is derived from the output characteristics of ECL 10KH (see note 1). The value is the same as CCIR Rec. 656.

C.2.3 Signal amplitude (0.6 V to 2.0 V peak-to-peak)

The minimum signal amplitude has been specified with the minimum value that can be obtained from the ECL 10KH driver (see note 2).

The maximum signal amplitude has been specified with the maximum value that the ECL 10KH receiver can accept. The allowable range of input common mode voltage for ECL 10KH is -2.85 V to -0.8 V. In the worst case, under the maximum common mode voltage of -0.8 V and the maximum signal amplitude of 2.0 V peak-to-peak, the input voltage at the receiver could become +0.2 V, which exceeds the allowable maximum input voltage of ECL. However, it has been confirmed through measurements that this does not cause any problems. The maximum signal amplitude of 2.0 V peak-to-peak is the same as CCIR Rec. 656.

C.2.4 Rise and fall times (less than 2.0 ns)

The ECL reference (10KH series) guarantees this specification even in the worst case.

C.2.5 Difference between rise and fall times (not to exceed 1.0 ns)

Based on the values shown in note 3, the maximum difference between rise and fall times is calculated to be 1.2 ns in the extreme case. Measurements have confirmed, however, that all differences in rise and fall times were not more than 1.0 ns.

C.3 Line receiver characteristics

C.3.1 Terminating impedance (110 ohms ± 10 ohms)

The value has been chosen in conformity with the characteristic impedance of the cable. The same value as CCIR Rec. 656 is taken for the tolerance.

C.3.2 Maximum input signal (2.0 V peak-to-peak)

This has been set within the range in which the receiver (ECL 10KH) can operate without any problem, even when the input voltage of the receiver exceeds maximum input rating specified by the ECL reference (see C.2.3). The value is the same as CCIR Rec. 656.

C.3.3 Minimum input signal (183 mV peak-to-peak)

Considering the input-output characteristics of the ECL line receiver, this has been specified as the sufficient value of differential input voltage that produces a full output swing. This is the same as in CCIR Rec. 656.

C.3.4 Maximum common mode signal (± 0.3 V)

The value has been specified considering that the input common mode voltage of the ECL line receiver does not exceed the allowable range specified in the ECL reference. This consideration gives rise to an asymmetric range in common mode signal of –1.37 V to +0.3 V (see note 4). However, in order to guarantee the correct operation of the receiver in the presence of common mode noise, the amplitude of the noise (AC component) should be limited to less than the smaller value of 0.3 V.

C.3.5 Differential delay (± 4.0 ns)

This value is the maximum variation of data time-delay in reference to the clock at the receiving end, and is obtained by adding the following values. It also corresponds to the scaled value of that in CCIR Rec. 656 (27 MHz clock, 11 ns differential delay).

Clock jitter: ± 0.5 ns
Data timing at sending end: ± 1.0 ns
Differential delay between pairs of cable: ± 2.5 ns

C.4 Eye diagram (T min = 4.0 ns, V min = 100 mV)

Each eye diagram can be displayed by selecting one line of each conductor pair on the oscilloscope (assuming no common mode noise, no clock jitter, and no data timing jitter).

The value of T min has been calculated as shown in annex E.

The value for V min is the same as that in CCIR Rec. 656.

NOTES to Annex C —

1 The following are included in the specification of ECL 10KH (MC10H116):

0°C

V_{OH} max –0.84V
V_{CM} max = –1.24V (–1.29V + 4%)
V_{OH} min –1.02V
V_{OL} max –1.63V — V_{CM} min = –1.48V (–1.29V –15%)
V_{OL} min –1.95V

25°C

V_{OH} max –0.81V
V_{CM} max = –1.22V (–1.29V + 5%)
V_{OH} min –0.98V
V_{OL} max –1.63V — V_{CM} min = –1.47V (–1.29V –14%)
V_{OL} min –1.95V

75°C

V_{OH} max –0.735V
V_{CM} max = –1.17V (–1.29V + 9%)
V_{OH} min –0.92V
V_{OL} max –1.60V — V_{CM} min = –1.44V (–1.29V –11%)
V_{OL} min –1.95V

2 The following are included in the specification of ECL 10KH (MC10H116):

0°C

V_{OH} min –1.02V
0.61 V
V_{OL} max –1.63V

25°C

V_{OH} min –0.98V
0.65V
V_{OL} max –1.63V

75°C

V_{OH} min –0.92V
0.68V
V_{OL} max –1.60V

3 The following are included in the specification of ECL 10KH (MC10H116):

0°C

tr max/tf max 1.5 ns
1.0 ns
tr min/tf min 0.5 ns

25°C

tr max/tf max 1.6 ns
1.1 ns
tr min/tf min 0.5 ns

75°C

tr max/tf max 1.7 ns
1.2 ns
tr min/tf min 0.5 ns

4 The following are included in the specification of ECL 10KH (MC10H116):

Input Common Mode Range $VCMR_{max}$ –0.8V
0.3V
–1.10V
Output Common Mode Range –1.29V ± 15%
–1.48V
1.37V
Input Common Mode Range $VCMR_{min}$ –2.85V

Annex D (informative)

Example of cable implementation

As an example of the design of the interconnecting multi-channel cable, the technical characteristics of a possible implementation are shown in table D.1 and figure D.1.

In this design example, the differential delay between twisted-pairs is within 2.5 ns for the case in which the cable length is 20 m (65.6 ft). However, it is possible to obtain longer interconnections if the transmission characteristics of the cable are such that guarantee the overall differential delay to remain within the 2.5 ns range.

Table D.1 — Example of cable implementation

Item		Unit	Value	
			21-pair cable	31-pair cable
Number of pairs		Pairs	21	31
Number of wires		Conductors	42	62
Conductor	Material		Tin plated copper	
	AWG Size		28	28
	Structure	strands/mm	7/0.127	
	Outer diameter	mm	0.381	
Dielectric	Thickness	mm	0.32	
	Outer diameter	mm	1.021	
	Pitch	mm	Left hand lay 20	
	Outer diameter	mm	Approx. 2.0	
Inner shield	Material		Tin plated copper	
	Structure	strands/mm	41/0.12 nominal	
	Density	%	More than 90	
	Outer diameter	mm	2.28	
Inner sheath	Thickness	mm	0.2	
	Outer diameter	mm	2.68	
Outer diameter of twisted cables		mm	Approx. 14.3	Approx. 17.1
Inner cable fixing			Taped	
Outer shield	Material		Tin plated copper	
	Structure	Carr/Piece/mm	24/14/0.14	32/12/0.14
	Density	%	More than 80	
	Outer diameter	mm	15.3	18.1
Outer sheath	Material		Heatproof vinyl	
	Thickness	mm	1.4	1.7
Diameter of cable	Nominal	mm	18.1	21.5
	Maximum	mm	19.9	23.7
Conductive resistance		Ω/km	Less than 242	
Voltage-proof test		Vrms for 1min	1000	
Insulation resistance		MΩ/km	More than 1500	More than 1000
Impedance		Ω	110 nominal between signals when measured with the balance method. (100 nominal between signals when measured with TDR method).	
Delay time of signal transfer (propagation)		ns/m	4.8 nominal	

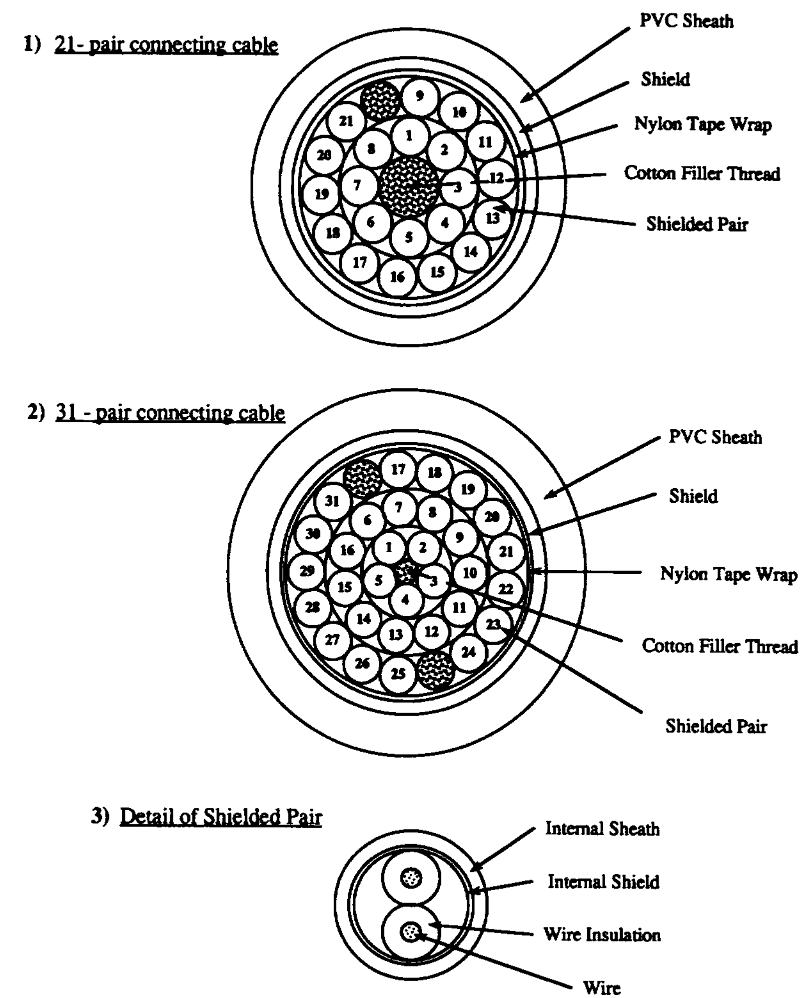


Figure D.1 — Example of cable cross-sections for 21- and 31-pair multi-channel cables

Annex E (informative)

Information on eye diagrams

Figure E.1 shows fully opened eye diagrams, one ideally positioned and two extremely shifted relative to the clock. When there is no clock jitter, no variance of data timing, no differential propagation delay between cables, and also when the frequency characteristics of the cable and interface electronics are ideal, the ideal eye pattern (full open) is observed at the receiving end (figure E.1(a)).

When clock jitter, data timing, and cable propagation delay are all delayed by the maximum extent relative to the clock, while the frequency characteristics of the cable and interface electronics are still ideal, the eye pattern of figure E.1(b) is observed at the receiving end. On the other hand, when clock jitter, data timing, and cable propagation delay are all advanced by the maximum extent relative to the clock, while the frequency characteristics of the cable and interface electronics are still ideal, the eye pattern of figure E.1(c) is observed at the receiving end.

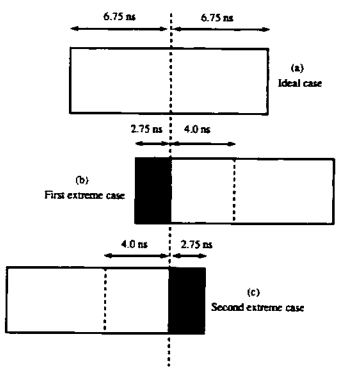


Figure E.1 — Eye diagrams for ideal and extreme timing

In the case of figure E.1(b), the time region of 2.75 ns on the left-hand side, which is indicated by the shaded area, is considered to be a time margin during which the actual eye opening may close. This closing of the eye opening can be due to non-ideal conditions such as frequency characteristics of the cable, rise and fall times of the line driver, etc. In the case of figure E.1(c), the reasons for the existence of the shaded area on the right-hand side are the same.

For any one data bit at the receiving end, variations in cable propagation delay and data timing values are uncertain. They may take either one of the two extreme cases shown in figure E.1(b) or E.1(c), when replacing the cable and/or interface electronics. Therefore, a maximum margin value of 2.75 ns can be allocated on both left and right sides, where the actual eye opening may close. This is shown in figure E.2, which also indicates that the receiver can and should sense the data correctly within this minimum eye opening.

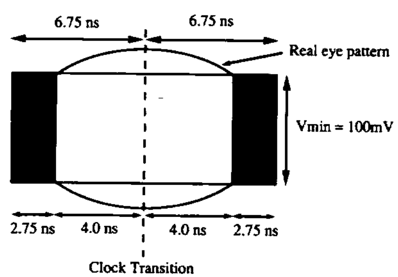


Figure E.2 — Minimum eye opening receiver should sense correctly

PROPOSED SMPTE STANDARD

SMPTE 185

Revision of ANSI/SMPTE 185-1987

for Motion-Picture Film (70-mm) — Six Magnetic Records on Release Prints — Position, Dimensions, Reproducing Speed and Identity

1 Scope

1.1 This standard specifies the position, dimensions, reproducing speed, identity, and use of the six magnetic audio records on 70-mm motion-picture release prints.

1.2 The standard also specifies the longitudinal picture-audio displacement on the film.

2 Audio records

2.1 The lateral location and width of the six magnetic audio records shall be as specified in figure 1 and table 1.

2.1.1 The records shall be referred to by number, as shown in figure 1, with record No. 1 nearest the reference edge. The left and right channel apply to a listener facing the screen. Record No. 1 shall be used for the left loudspeaker channel. Record No. 2 shall be used for the left center loudspeaker channel. Record No. 3 shall be used for the center loudspeaker channel. Record No. 4 shall be used for the right center loudspeaker channel. Record No. 5 shall be used for the right loudspeaker channel. Record No. 6 shall be used for the surround and auditorium loudspeakers.

2.1.2 Audio records No. 4 and 5 shall be adjacent to the frameline identifier.

2.2 The recordings shall be made so that the azimuth of the record is at an angle of 90° ± 2' to the reference edge of the film.

2.3 With the direction of film travel as shown in figure 1, the magnetic striping shall be on the surface of the film facing the projector lens.

2.4 The audio records shall be recorded in such a manner that they can be reproduced properly by reproducing heads whose gaps are positioned in a straight line within the film plane and conforming in orientation to 2.2.

3 Reproducing speed

The recording shall be made so that the audio records will reproduce properly at 120 perforations per second (approximately 112 ft [34 m] per minute or 22.4 in [569 mm] per second) which is 24 frames (5 perforations each) per second.

4 Picture-audio displacement

The magnetic audio records on the film shall lag behind the center of the corresponding picture by a distance of 23 frames ± 1/2 frame (see annex A).

THIS PROPOSAL IS PUBLISHED FOR COMMENT ONLY

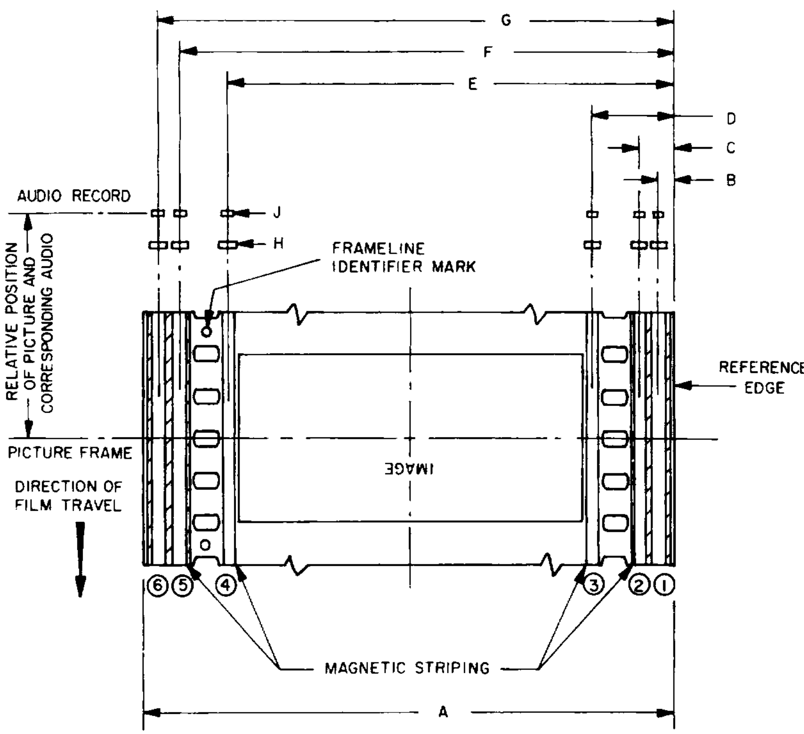


Figure 1 – Record location and width

Table 1 – Record dimensions

Dimensions	Inches	Millimeters
A	2.754 (see note 1)	69.95 ref
B	0.050 ± 0.002	1.27 ± 0.05
C	0.115 ± 0.002	2.92 ± 0.05
D	0.323 ± 0.002	8.20 ± 0.05
E	2.331 ± 0.002	59.21 ± 0.05
F	2.539 ± 0.002	64.49 ± 0.05
G	2.654 ± 0.002	67.41 ± 0.05
H (recording gap width)	0.075 ± 0.002	1.90 ± 0.05
J (reproducing gap width)	0.070 ± 0.002	1.78 ± 0.05

NOTES

1 Locations and width dimensions of magnetic stripes and recording gaps of magnetic heads are chosen on the assumption that the lateral film shrinkage is within range of 0% to 0.2% at the time of striping and/or recording.

2 The locations of reproducing gaps of magnetic heads for projectors are chosen on the assumption that the lateral film shrinkage at the time of presentation is 0.2% greater than at the time of striping. The locations of reproducing gaps of magnetic heads in the equipment used for the production of release prints should be the same as those for the recording heads.

Annex A (informative)
Projector thread path

As a working procedure, the accuracy of picture-audio displacement in a projection print is frequently judged by screening in a review room. It is important that the standard thread path in this review room projector be set accurately to the value specified in this standard plus one frame for every 50 ft (15 m) separating the loudspeaker from the observer. Otherwise, nonstandard prints may be produced.

Annex B (informative)
Bibliography

ANSI/SMPTE 119-1988, Motion-Picture Film (70-mm) — Perforated 65-mm, KS-1870

ANSI/SMPTE 152-1989, Motion-Picture Film (70-mm) — Projectable Image Area

ANSI/SMPTE 221-1987, Motion-Picture Film (70-mm) — Magnetic Striping —Six-Track Audio Release Prints