REAFFIRMED 2006

SMPTE STANDARD

SMPTE 296M-2001
Revision of
ANSI/SMPTE 296M-1997

for Television — 1280 × 720 Progressive Image Sample Structure — Analog and Digital Representation and Analog Interface

Contents

1 Scope

1.1 This standard defines a family of progressive image sample systems for the representation of stationary or moving two-dimensional images sampled temporally at a constant frame rate and having an image format of 1280 pixels by 720 lines and an aspect ratio of 16:9 as given in table 1. All systems in the table have the common characteristic that all the samples gathered within a single temporal unit, a frame, shall be spatially contiguous and provide a complete description of that frame (4.2) This standard specifies:

– R′G′B′ color encoding;
– R′G′B′ analog and digital representation;
– $Y'P'_BP'_R$ color encoding, analog representation, and analog interface; and
– $Y'C'_BC'_R$ color encoding and digital representation.

Table 1 – Image sampling systems

	System nomenclature	Luma or R′G′B′ samples per active line (S/AL)	Active lines per frame (AL/F)	Frame rate, Hz	Luma or R′G′B′ sampling frequency (fs), MHz	Luma sample periods per total line (S/TL)	Total lines per frame
1	1280 × 720/60	1280	720	60	74.25	1650	750
2	1280 × 720/59.94	1280	720	60/1.001	74.25/1.001	1650	750
3	1280 × 720/50	1280	720	50	74.25	1980	750
4	1280 × 720/30	1280	720	30	74.25	3300	750
5	1280 × 720/29.97	1280	720	30/1.001	74.25/1.001	3300	750
6	1280 × 720/25	1280	720	25	74.25	3960	750
7	1280 × 720/24	1280	720	24	74.25	4125	750
8	1280 × 720/23.98	1280	720	24/1.001	74.25/1.001	4125	750
NOTE – For systems 4 through 8, analog video interface is not preferred. See clause 12.							

Approved
January 4, 2001

Designers should be aware that serial digital interfaces for formats other than $Y'C'_BC'_R$ have not been defined.

A bit-parallel digital interface is incorporated by reference in clause 10.

NOTE – Throughout this standard, references to signals represented by a single primed letter (e.g., R′, G′, and B′) are equivalent to the nomenclature in earlier documents of the form E_R', E_G', and E_B', which in turn refer to signals to which the transfer characteristics in 5.4 have been applied. Such signals are commonly described as being gamma corrected.

1.2 This standard specifies multiple system formats (table 1). It is not necessary for an implementation to support all formats to be compliant with this standard. However, an implementation must state which of the system formats are supported.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards listed below.

SMPTE 274M-1998, Television — 1920 × 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates

SMPTE 291M-1998, Television — Ancillary Data Packet and Space Formatting

SMPTE RP 160-1997, Three-Channel Parallel Analog Component High-Definition Video Interface

SMPTE RP 177-1993 (R1997), Derivation of Basic Television Color Equations

CIE Publication 15.2 (1986), Colorimetry, Second Edition

IEC 60169-8 (1978-01), Radio Frequency Connectors, 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) plus amendments IEC 60169-8-am1 (1996-03) and IEC 60169-8-am2 (1997-11)

ITU-R BT.709-4 (09/00), Parameter Values for the HDTV Standards for Production and International Programme Exchange

3 General

3.1 The specification of a system claiming compliance with this standard shall state:

– which of the 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′ or $Y'C'_BC'_R$ interfaces are implemented; and

– whether the digital representation employs eight bits or 10 bits per sample in its uniformly quantized (linear) PCM coding.

3.2 Digital codeword values in this standard are expressed as decimal values in the 10-bit representation. An eight-bit system shall either round or truncate to the most significant eight bits as specified in 7.10.

4 Timing

4.1 Timing 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 line of equal duration as determined by the sampling frequency (fs) and the samples per total line (S/TL). Samples may be obtained in an optoelectronic conversion process sequentially, simultaneously, or via a combination of both, provided all samples in the frame are contiguous in the image and obtained within the same temporal frame period. The samples within each line shall be uniformly delivered to and collected from the interface in a spatially left-to-right sequence; lines in a frame shall be uniformly delivered to and collected from the interface in a spatially top-to-bottom sequence. 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 11. Each line shall be divided into a number of reference clock intervals, of equal duration, as specified by the column S/TL in table 1. The time between any two adjacent sample instants is called the reference clock interval T. T = 1/fs.

5 System colorimetry

5.1 Equipment shall 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 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
Reference white	0.3127	0.3290

5.3 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:

$$V' = \begin{cases} 4.5L, & 0 \le L < 0.018 \\ 1.099L^{0.45} - 0.099, & 0.018 \le L \le 1.0 \end{cases}$$

5.4 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 7.6 and 12.4, except for overshoots and undershoots due to processing.

5.5 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 – Because the Y′ component is computed from nonlinear R′G′B′ primary components rather than from the linear tristimulus RGB values, it does not represent the true luminance value of the signal, but only an approximation. To distinguish it from luminance, the term luma is used for the Y′ signal. For more information, see e.g. Poynton, *A Technical Introduction to Digital Video*.

5.6 Color-difference component signals P'_B and P'_R, having the same excursion as the Y′ component, shall be computed as follows:

$$P'_B = \frac{0.5}{1 - 0.0722}(B' - Y')$$

$$P'_R = \frac{0.5}{1 - 0.2126}(R' - Y')$$

P'_B and P'_R are filtered and may be coded as C'_B and C'_R components for digital transmission. Example filter templates are given in figure B.2.

6 Raster structure

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

6.2 In a system according to this standard, each frame shall comprise 750 lines including:

– Vertical blanking: lines 1 through 25 inclusive (including vertical sync, lines 1 through 5 inclusive) and lines 746 through 750 inclusive; and

– Picture: 720 lines, lines 26 through 745 inclusive.

6.3 Ancillary signals, as distinct from ancillary data, may be conveyed during vertical blanking, lines 7 through 25 inclusive. The portion within each of these lines that may be used for ancillary data is defined in 9.3. Ancillary signals shall not convey picture information although they may be employed to convey other related or unrelated signals, coded similarly to picture information. Further specification of ancillary signals is outside the scope of this standard.

6.4 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.

6.5 The production aperture defines a region 1280 samples by 720 lines. The horizontal extent of the production aperture shall have the

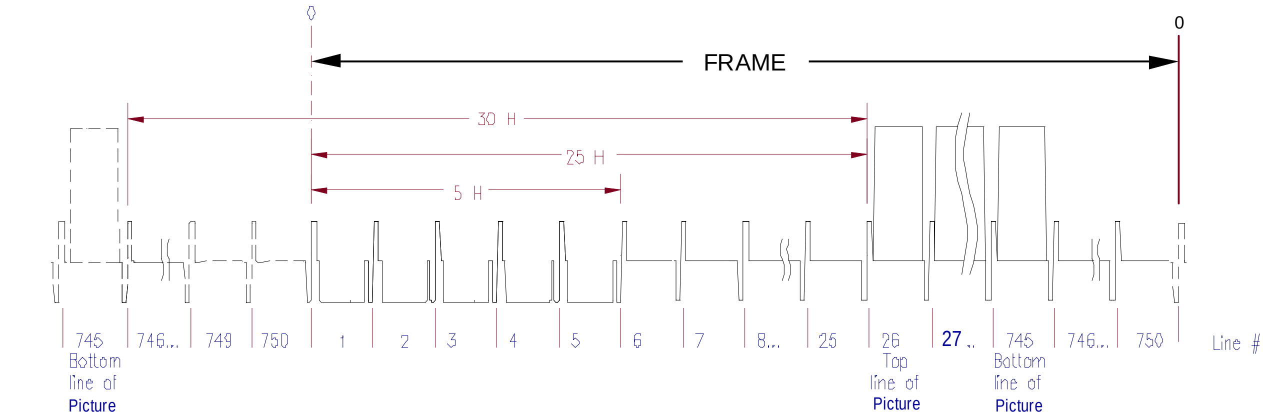


Figure 1 – Vertical timing (analog representation)

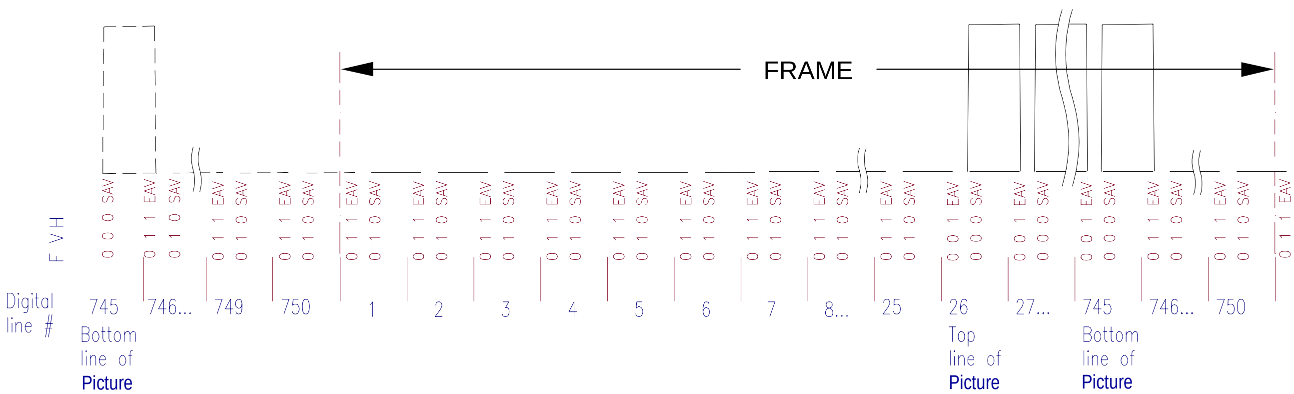


Figure 2 – Vertical timing (digital representation)

50% point of its leading transition at reference luma sample 0 and the 50% point of its trailing transition at luma sample 1279. The production aperture defines the maximum extent of picture information. For further information, consult annex A.

6.6 The aspect ratio of the image represented by the production aperture shall be 16:9. The sample aspect ratio is 1:1 (square pixels).

6.7 The center of the picture shall be located at the center of the production aperture, midway between samples 639 and 640, and midway between lines 385 and 386.

6.8 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 or clause 6, uniformly sampled.

NOTE – Each component is prepared as an individual channel. Combinations of channels may be presented to an appropriate interface for signal interchange. For example, the Y′ channel and the multiplexed C′$_B$/C′$_R$ channel data together comprise a source format for the serial interface specified in SMPTE 292M.

7.2 The digital signals described here are assumed to have been filtered to reduce or prevent aliasing upon sampling. For information regarding filtering, consult annex B.

7.3 The characteristics of the digital signals are based on the assumption that the location of any required sin (x)/x correction is at the point where the signal is converted to an analog format.

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. R′G′B′ samples shall be cosited with each other.

7.5 A luma sampling number in a line is denoted in this standard by a number from 0 through one less than the total number of samples in a line. Luma sample number zero shall correspond to the first active video sample. The luma sample numbering is shown in figure 3. Note that the distance between 0_H and the start of SAV is 256 samples.

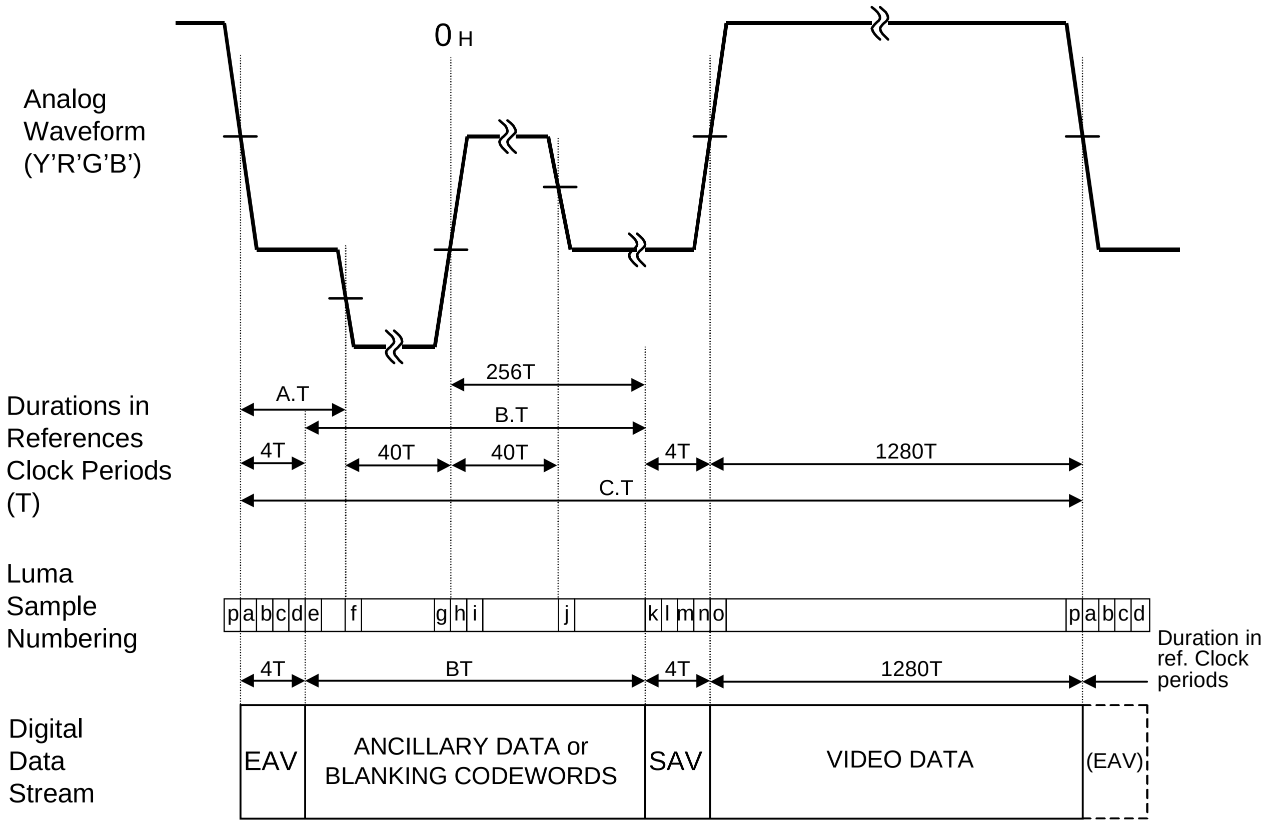
NOTE – The active video digital representation is 1280 clock periods (0-1279) in length.

7.6 Digital R′, G′, B′, and Y′ components shall be computed as follows:

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

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 unary function Floor yields the largest integer not greater than its argument.

NOTE – This scaling places the extrema of R′, G′, B′, and Y′ components at codewords 64 and 940 in a 10-bit representation or codewords 16 and 235 in an eight-bit representation.



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

Figure 3 – Analog and digital timing relationships

7.7 Digital C'_B and C'_R components of the $Y'C'_BC'_R$ set shall be computed as follows:

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

where C′ is the component value in abstract terms from – 0.5 to + 0.5, and C'_D is the resulting digital code. The unary function Floor yields the largest integer not greater than its argument.

NOTE – This scaling places the extrema of C'_B and C'_R at codewords 64 and 960 in a 10-bit representation or codewords 16 and 240 in an eight-bit representation.

7.8 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. The sample number zero of C'_B and C'_R corresponds to the first active video 0 sample. For information regarding filtering, consult annex B.

The subsampled C'_B and C'_R signals shall be time-multiplexed on a sample basis, in the order $C'_BC'_R$. The first data word of an active line shall be a C'_B sample. The multiplexed signal is referred to as C'_B/C'_R.

NOTE – Systems 7 and 8 have 2063 C'_B sample periods and 2062 C'_R sample periods per line. The C'_B/C'_R multiplexer must be reset every line at sample number zero.

7.9 Code values having the eight most significant bits all zero or all one — that is, 10-bit codes 0, 1, 2, 3, 1020, 1021, 1022, and 1023 — are employed for synchronizing purposes and shall be prohibited from video, ancillary signals, and ancillary data.

7.10 A system having an eight-bit interface shall address the conversion of 10-bit video data to eight bits with an appropriate process that minimizes video artifacts such as quantization noise. Ancillary data in 10-bit format shall be converted to eight-bit format by truncating the two least significant bits. In both cases, when converting eight-bit data to 10-bit data, the two least significant bits of the 10-bit word shall be set to 0.

NOTE – SMPTE is addressing rounding for all eight-bit/10-bit digital video standards. SMPTE 291M describes the handling of ancillary data between eight-bit and 10-bit interfaces in annex D.

7.11 For Y′, R′, G′, and B′ signals, undershoot and overshoot in video processing may be accommodated by the use of codewords 4 through 63 and codewords 941 through 1019 in a 10-bit system, or codewords 1 through 15 and codewords 236 through 254 in an eight-bit system.

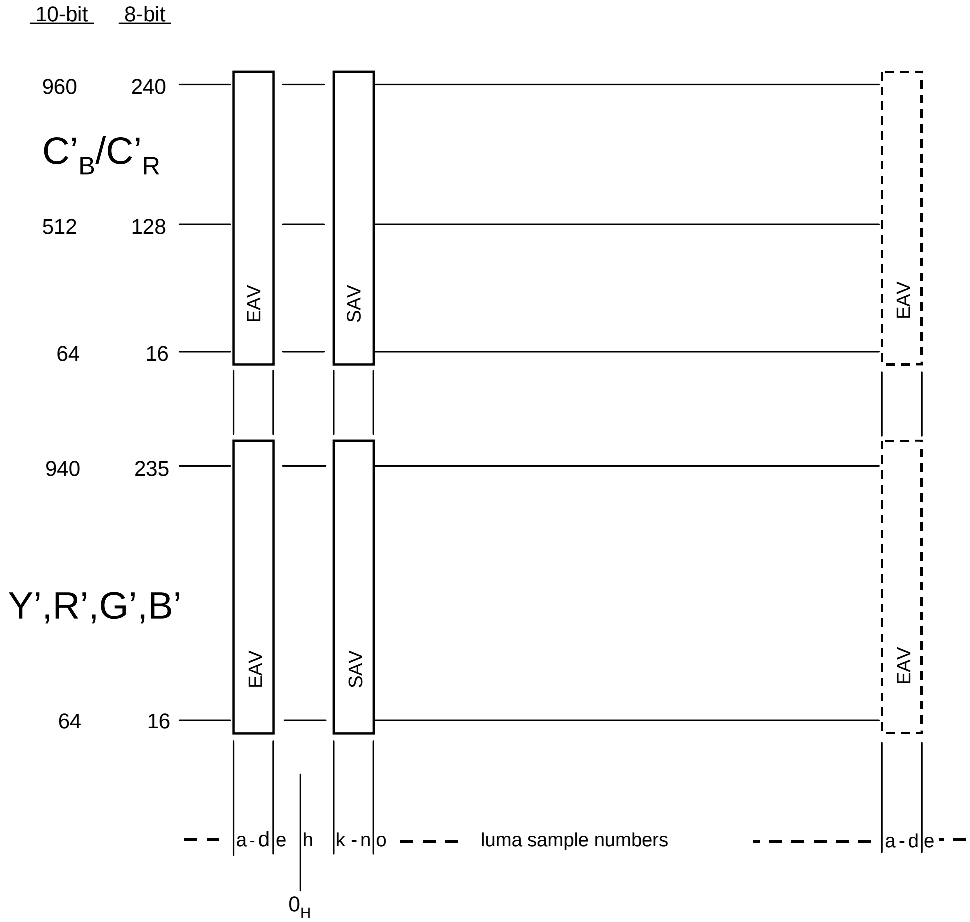
For C'_B and C'_R signals, undershoot and overshoot in video processing may be accommodated by the use of codewords 4 through 63 and codewords 961 through 1019 in a 10-bit system, or codewords 1 through 15 and codewords 241 through 254 in an eight-bit system.

8 Digital timing reference sequences (SAV, EAV)

8.1 SAV (start of active video) and EAV (end of active video) digital synchronizing sequences shall define synchronization across the digital interface. Figures 2, 3, and 4 show the relationship of the SAV and EAV sequences to digital and analog video.

8.2 An SAV or EAV sequence shall comprise four consecutive codewords: a codeword of all ones, a codeword of all zeros, another codeword of all zeros, and a codeword including F (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 3 and 4 show details of the coding).

8.3 When digitized, every line shall include a four-sample EAV sequence commencing 110 clocks prior to 0_H (for systems 1 and 2); 440 clocks prior to 0_H (for system 3); 1760 clocks prior to 0_H (for systems 4 and 5); 2420 clocks prior to 0_H (for system 6);and 2585 clocks prior to 0_H (for systems 7 and 8). When digitized, every line shall include a four-sample SAV sequence commencing 256 clocks after 0_H (for all systems [1, 2, 3, 4, 5, 6, 7, and 8]). The EAV sequence immediately preceding the 0_H datum of line 1 shall be considered to be the start of the digital frame as shown in figure 2.



NOTES
1 Figure 3/table 2 show numbering of luma sample numbers for each of the systems covered in this standard.
2 0_H is the analog horizontal timing reference point.

Figure 4 – Digital representation — Horizontal timing details

Table 2 – Values for figures 3 and 4 and table 5 for different systems

Systems	Luma sample numbering															
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
1,2	1280	1281	1282	1283	1284	1350	1389	1390	1391	1430	1646	1647	1648	1649	0	1279
3	1280	1281	1282	1283	1284	1680	1719	1720	1721	1760	1976	1977	1978	1979	0	1279
4,5	1280	1281	1282	1283	1284	3000	3039	3040	3041	3080	3296	3297	3298	3299	0	1279
6	1280	1281	1282	1283	1284	3660	3699	3700	3701	3740	3956	3957	3958	3959	0	1279
7,8	1280	1281	1282	1283	1284	3825	3864	3865	3866	3905	4121	4122	4123	4124	0	1279

System	Duration in reference clock periods (T)		
	A	B	C
1,2	70	362	1650
3	400	692	1980
4,5	1720	2012	3300
6	2380	2672	3960
7,8	2545	2837	4125

NOTE – Figure 3 and table 2 representations show nominal relationship values between the analog and digital representations. See figure 5 and table 5 for tolerance values for the analog sync including rise and fall tolerances.

Table 3 – Video timing reference codes

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

Table 4 – Protection bits for SAV and EAV

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

8.4 F/V/H flags

– The EAV and SAV of all lines shall have F = 0.

– The EAV and SAV of lines 1 through 25 inclusive and lines 746 through 750 inclusive shall have V = 1.

– The EAV and SAV of lines 26 through 745 inclusive shall have V = 0.

– The EAV of line 1 shall be considered the start of the digital frame.

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

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 The interval between the end of EAV and the start of SAV may be employed to convey ancillary data packets. Designers should be aware that when SMPTE 292M serial interface is employed, the first four samples after EAV are reserved for other usage.

9.3 The interval between the end of SAV and the start of EAV of any line that is outside the vertical extent of the picture (as defined in clause 6.2), and that is not employed to convey digitized ancillary signals, may be employed to convey ancillary data packets.

NOTE – Currently SMPTE is defining the switching point(s) for all serial digital video interfaces. The reader is cautioned to be aware that ancillary data should be placed taking into account the switching point.

9.4 Ancillary data packets may be conveyed across each of the three R′, G′, and B′ channels, or across each of the three Y′, C'_B/C'_R channels.

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

9.6 For specifications of the details of ancillary data, see SMPTE 291M.

10 Bit-parallel interface

The electrical and mechanical parameters of the bit-parallel interface are specified in clauses 10, 11, 12, and 13 of SMPTE 274M, which are incorporated by reference. It is anticipated that in future revisions of SMPTE 274M that auxiliary component A will be eliminated.

11 Analog sync

11.1 Details of analog sync timing are shown in figures 1, 3, and 5 and are summarized in table 5.

11.2 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 40 reference clock intervals, and another negative-going transition follows this instant by 40 reference clock intervals.

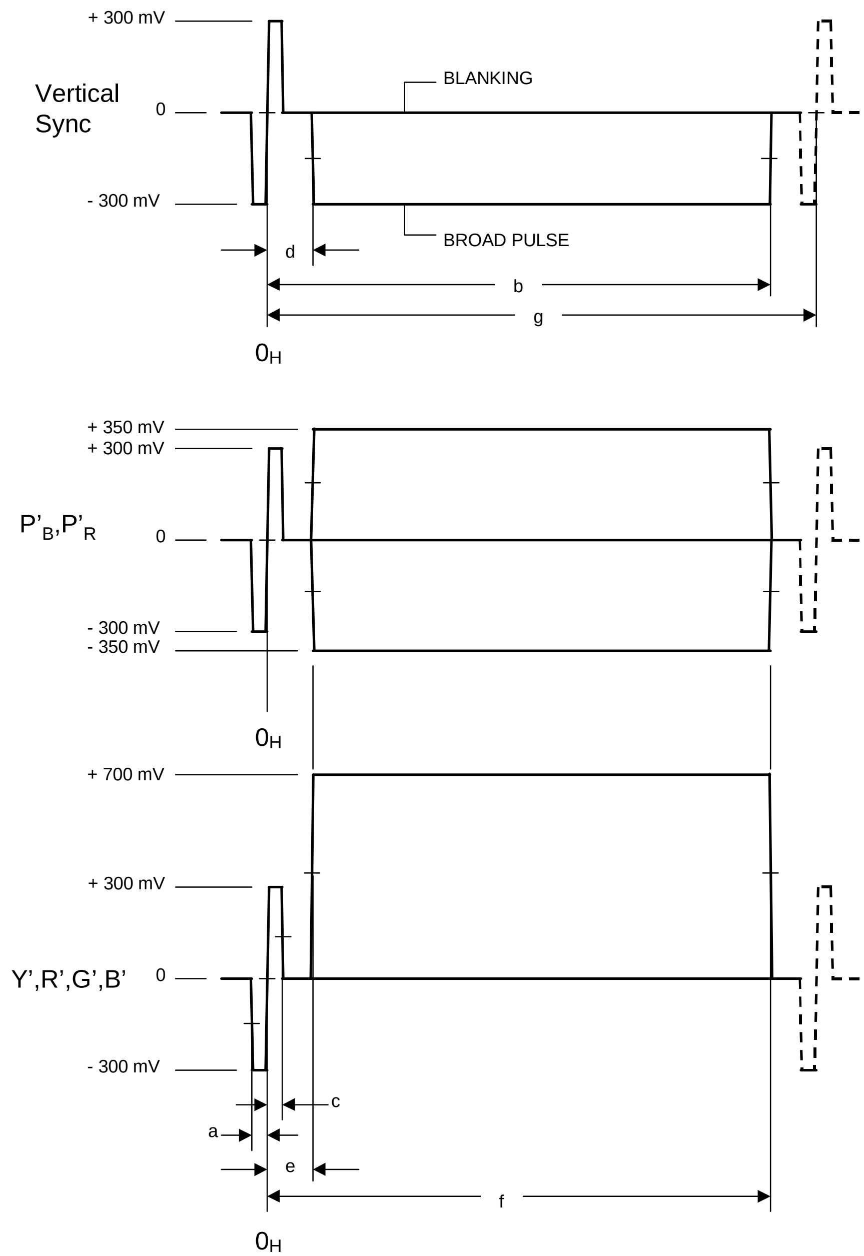


Figure 5 – Analog levels and timing

Table 5 – Analog sync timing (Systems 1 - 8)

		Duration (T)	Tolerance (T)
a	See figure 5	40	± 3
b	See figure 5	1540	– 6 + 0
c	See figure 5	40	± 3
d	See figure 5	260	– 0 + 6
e	See figure 5	260	– 0 + 6
f	See figure 5	1540	– 6 + 0
	Sync rise and fall time	4	± 1.5
g	Total line	Table 2 'C'	
	Active line	1280	– 12 + 0

11.3 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 50% (midpoint) point of each negative transition shall be coincident with its ideal time within a tolerance of ± 3 reference clock periods.

11.4 The trilevel sync pulse shall have structure and timing according to figures 3 and 5. The positive peak of the trilevel sync pulse 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 peaks shall be less than 6 mV.

11.5 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.

11.6 Each frame shall commence with five vertical sync lines, each having a broad pulse. The leading 50% point of a broad pulse shall be 260T after the preceding trilevel zero crossing. The trailing 50% point of a broad pulse shall be 1540T after the preceding trilevel zero crossing.

12 Analog interface

NOTE – This clause applies to all frame rates in table 1. However, direct analog interconnection of slow-rate systems (30 Hz and below) is not preferred, except for synchronizing signals.

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

12.2 R′G′B′ and Y′ channels shall have a nominal bandwidth of 30 MHz.

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

12.4 For the Y′, R′, G′, and B′ components, reference black (zero) in the expressions of 5.5 shall correspond to a level of 0 Vdc, and reference white (unity) shall correspond to 700 mV.

12.5 P'_B and P'_R components are analog versions of the C'_B and C'_R components of 5.6, in which zero shall correspond to a level of 0 Vdc and reference peak level (value 0.5 of equations in 5.6) shall correspond to a level of +350 mV.

12.6 Trilevel sync according to clause 11 shall be added to each analog component.

12.7 Each of the electrical signals in an analog interface employs a connector that shall conform to IEC 60169-8, with the exception that the impedance of the connector may be 75 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 1280 pixels × 720 lines as 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 1280 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 (see figures 3 and 5).

A.2.3 To accommodate a practical implementation of analog blanking within various studio equipment, a tolerance of six clock periods is provided at the start and end of active video. Accordingly, the analog tolerance to parameters b and e of table 5 are as follows:

Parameter	Definition	Nominal value (T)	Tolerance (T)
b	0_H to end of active video	1540	– 6 + 0
e	0_H to start of active video	260	– 0 + 6

Preferred practice is to provide a full production aperture signal at the output of an analog source prior to first digitization, reserving the tolerance for possible subsequent analog processes.

A.2.4 The relationship of the associated analog representation (inclusive of this tolerance) with the production aperture is shown in figure 5.

A.3 Transient regions

A.3.1 This standard defines a picture aspect ratio of 16:9 with 1280 pixels per active line and 720 active lines per frame. 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 Analog transients. 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 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. In order to minimize the effects on subsequent compression or transmission processes, the contaminated area should be confined within 16 pixels and 9 lines of the production aperture edges.

A.4.3 The clean aperture of the picture defines a region 1248 samples in width by 702 lines high, symmetrically located in the production aperture. The clean aperture shall be substantially free from transient effects due to blanking and picture processing. An encroachment of 6 samples maximum on each of the left and right edges of the production aperture is allowed for horizonal blanking errors generated by analog processing. Vertical blanking shall be as specified with zero tolerance.

A.4.4 This yields a minimum clean aperture of 1248 horizontal active pixels by 702 active lines whose quality is guaranteed for final release. The clean aperture lies within the production aperture as shown in figure A.1.

A.4.5 It is good practice to minimize variations in analog blanking and to use techniques in digital processing that minimize or prevent transients in the allowed contaminated area as well as inside the clean aperture.

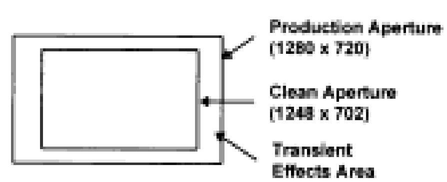


Figure A.1 – Clean aperture

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

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

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

B.3 The value of the amplitude ripple tolerance in the passband is ± 0.05 dB relative to the insertion loss at 100 kHz.

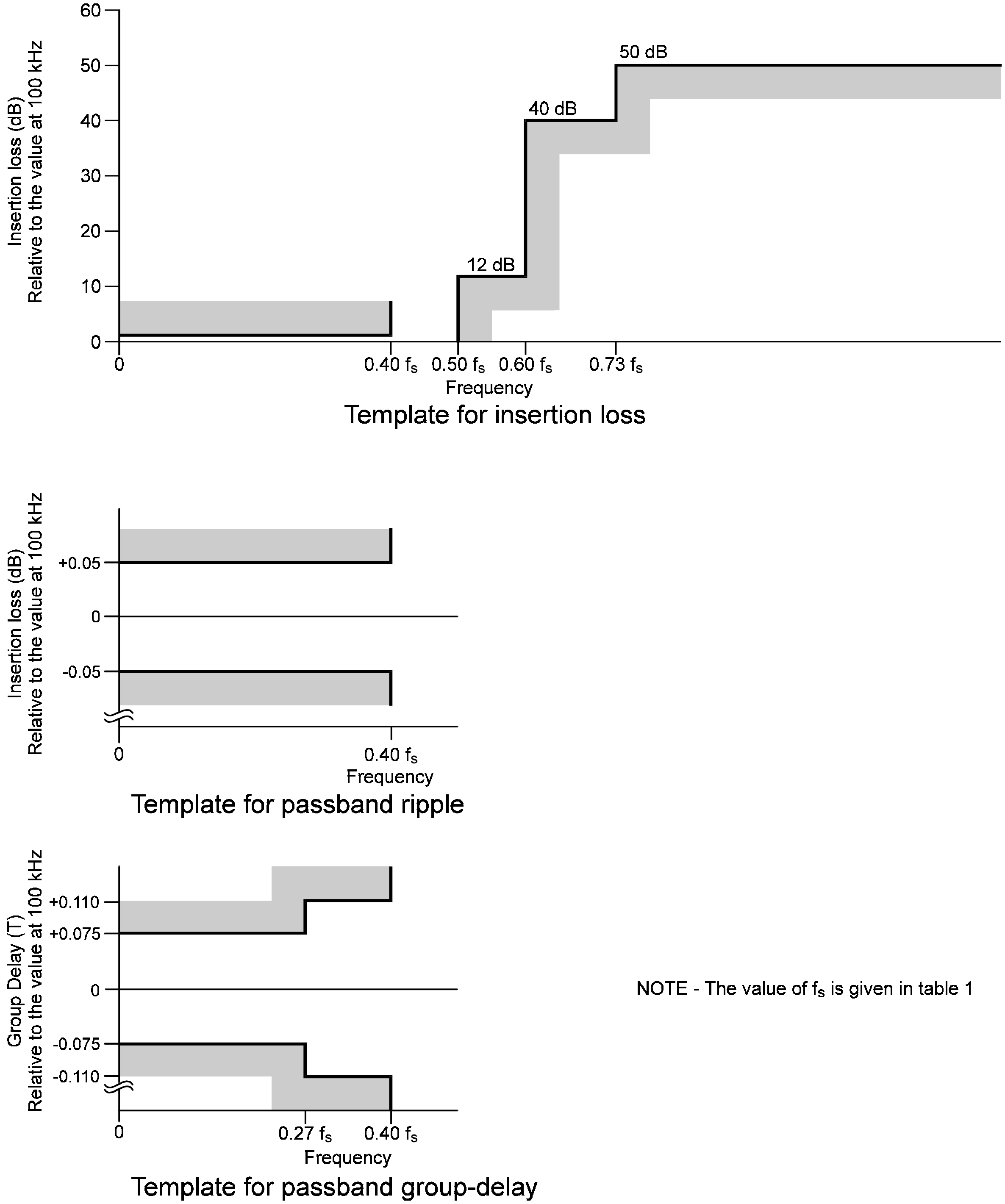


Figure B.1 – Example filter template for Y′ and R′G′B′ components

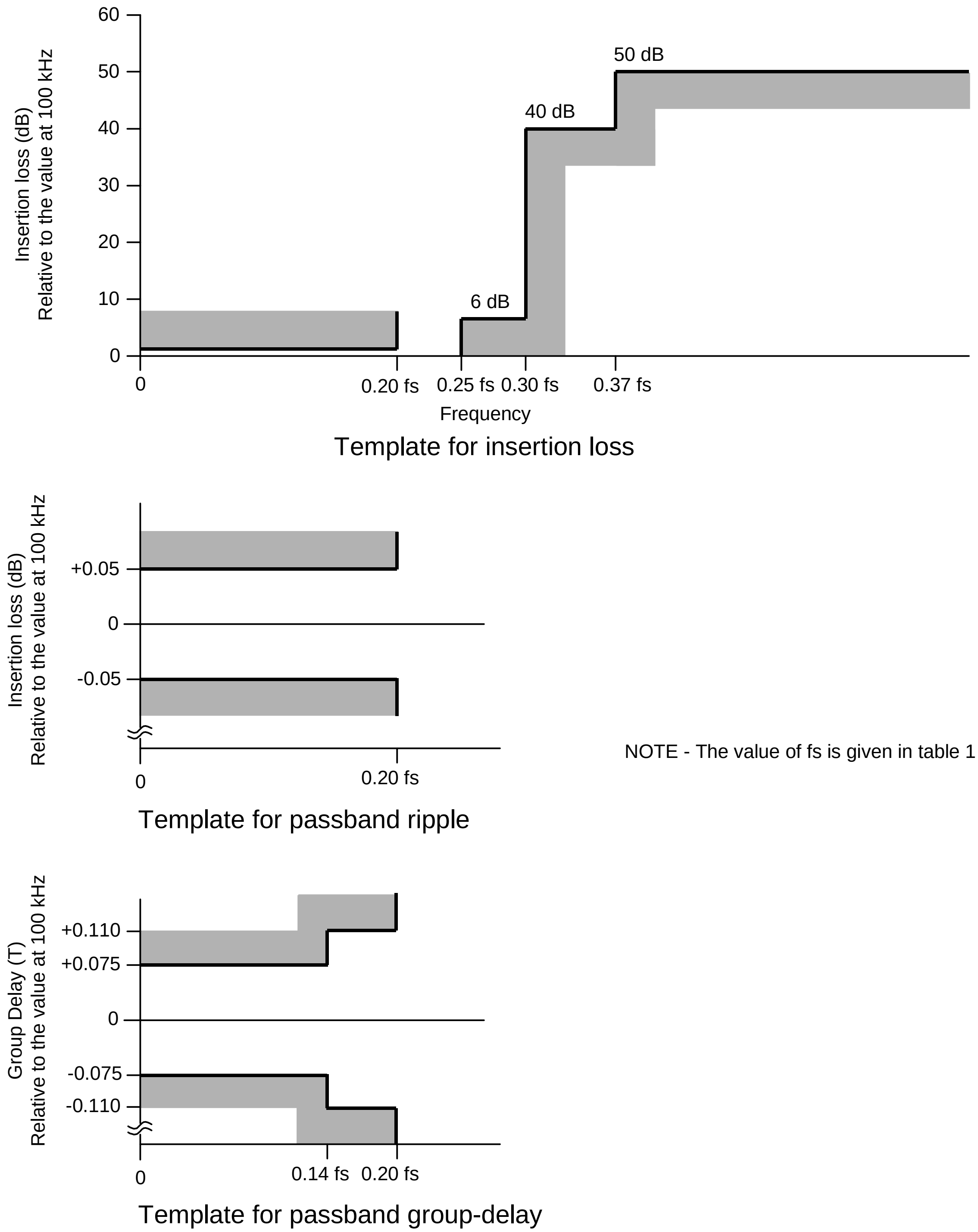


Figure B.2 – Example filter template for P′B and P′R components

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

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

Annex C (informative)
Bibliography

SMPTE 292M-1998, Television — Bit-Serial Digital Interface for High-Definition Television Systems

ITU-R BT.601-5 (10/95), Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios

ITU-R BT.1361 (1998), Worldwide Unified Colorimetry and Related Characteristics of Future Television and Imaging Systems

Poynton, Charles. *A Technical Introduction to Digital Video*. John Wiley & Sons