RECOMMENDATION ITU-R BT.709-1

BASIC PARAMETER VALUES FOR THE HDTV STANDARD FOR THE STUDIO AND FOR INTERNATIONAL PROGRAMME EXCHANGE

(Question ITU-R 27/11)

(1990-1994)

The ITU Radiocommunication Assembly,

considering

a) that the parameter values of an HDTV studio standard need to be chosen to facilitate:

- the production of HDTV programmes,
- the international exchange of HDTV programmes,
- the introduction of HDTV broadcasting services, and
- the use of HDTV for non-broadcast purposes;

b) that this work is the subject of Question ITU-R 27/11;

c) that there are large benefits to programme producers and broadcasters in the adoption of a single world-wide standard for HDTV programme production and international programme exchange;

d) that broadcasters and programme producers have a requirement for joint, international production in HDTV;

e) that the HDTV studio standard must be harmonized with those of current and developing television systems and with those of existing motion-picture film,

recommends

1. that the following parameters be used in the generation of signals in high-definition television studios and for international exchange of HDTV programmes.

Note 1 – In this Recommendation, the processing model noted below is assumed. The parameters are thus expressed as components using a digital representation concept. Analogue parameters are derived.

Processing model

- Representation of the optical image as a set of three conceptual images in electrical form.
- Sampling of these conceptual images and arrangement of the samples.
- Conversion of the samples into a set of three electrical signals (RGB).
- Formatting of the RGB signal set.
- Analogue scaling, insertion of blanking intervals and addition of sync signals.
- Digital scaling, multiplexing and addition of timing references.

1. Opto-electronic conversion

Item	Characteristics			
	Parameter	Value		
1.1	Opto-electronic transfer characteristics before non-linear precorrection	Assumed linear		
1.2	Overall opto-electronic transfer characteristics at source	$V = 1.099\, L^{0.45} - 0.099$ for $1 \geq L \geq 0.018$ $V = 4.500\, L$ for $0.018 > L \geq 0$ where: L: luminance of the image $0 \leq L \leq 1$ V: corresponding electrical signal		
1.3	Chromaticity coordinates (CIE, 1931) – *For reference primaries, see Note 1* – For interim primaries related to current display technology	Primary	Coordinates	
			x	y
		red	0.640	0.330
		green	0.300	0.600
		blue	0.150	0.060
1.4	Assumed chromaticity for equal primary signals $E_R = E_G = E_B$ (Reference white)	D_{65}		
			x	y
			0.3127	0.3290

Note 1 – Studies to establish the parameter values for the reference primary colours, non-linear video processing and video matrixing are in progress to improve future display colour-rendition and to optimize transformation between HDTV, film, graphics and colour hard-copy (see Annex 1).

2. Picture characteristics

Item	Characteristics	
	Parameter	Value
2.1	Aspect ratio	16:9
2.2	Samples per active line	1920
2.3	Sampling lattice	Orthogonal

2.4 The sample distribution and the number of active lines are interrelated and are still under study (see Annex 1). The results of this study may also lead to the wish to reconsider the number of samples per active line.

3. Picture scanning characteristics

Item	Characteristics	
	Parameter	Value
3.1	Order of sample scanning	Left to right top to bottom
3.2	Interlace ratio	See below

The objective for the system is defined to be progressive scanning, i.e., 1:1 interlace ratio.

For current implementations, an interlace ratio of 2:1, or an equivalent sample-rate reduction process, may be used.

3.3 The picture rate depends on a number of well-known factors (see Annex 1).

4. Signal format

Item	Characteristics	
	Parameter	Value
4.1	Conceptual non-linear pre-correction of primary signals	$\gamma = 0.45$ (See complete specification in § 1.2)
4.2	Derivation of luminance signal E'_Y – *Equation for systems related to reference primaries see Note 1* – Equation for interim systems related to current display technology and conventional coding	$E'_Y = 0.2125\ E'_R +$ $0.7154\ E'_G +$ $0.0721\ E'_B$
4.3	Derivation of colour-difference signals (analogue coding) E'_{P_B}, E'_{P_R} – *Equation for system related to reference primaries, see Note 1* – Equation for interim systems related to current display technology and conventional coding	$E'_{P_B} = 0.5389\ (E'_B - E'_Y)$ $E'_{P_R} = 0.6349\ (E'_R - E'_Y)$
4.4	Derivation of colour-difference signals (digital coding) C_1, C_2	Digitally scaled from the values of 4.3

Note 1 – Studies to establish the parameter values for the luminance and colour-difference equations are in progress to improve system performance and optimize transformations between HDTV, film graphics and colour hard-copy (see Annex 1).

5. Analogue representation

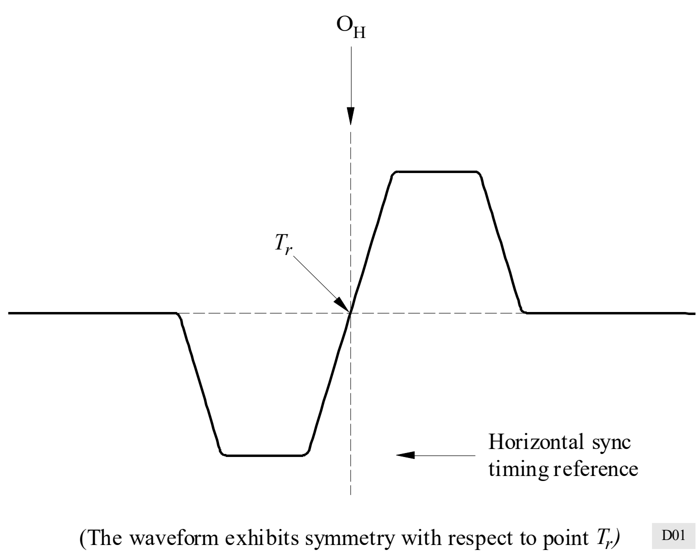
Levels are specified in millivolts measured across a matched 75 Ω termination.

Item	Characteristics	
	Parameter	Value
5.1	Nominal level – E'_R, E'_G, E'_B, E'_Y	Ref. Black: 0 Ref. White: 700
5.2	Nominal level – E'_{P_B}, E'_{P_R}	± 350
5.3	Format of synchronizing signals	Tri-level bipolar (see Fig. 1)
5.4	Timing reference	(see Fig. 1)
5.5	Sync level[(1)]	± 300 sync on all components (see Fig. 2)

(1) Some administrations may wish to consider the use of sync on all components as optional.

FIGURE 1

Format of synchronizing signal

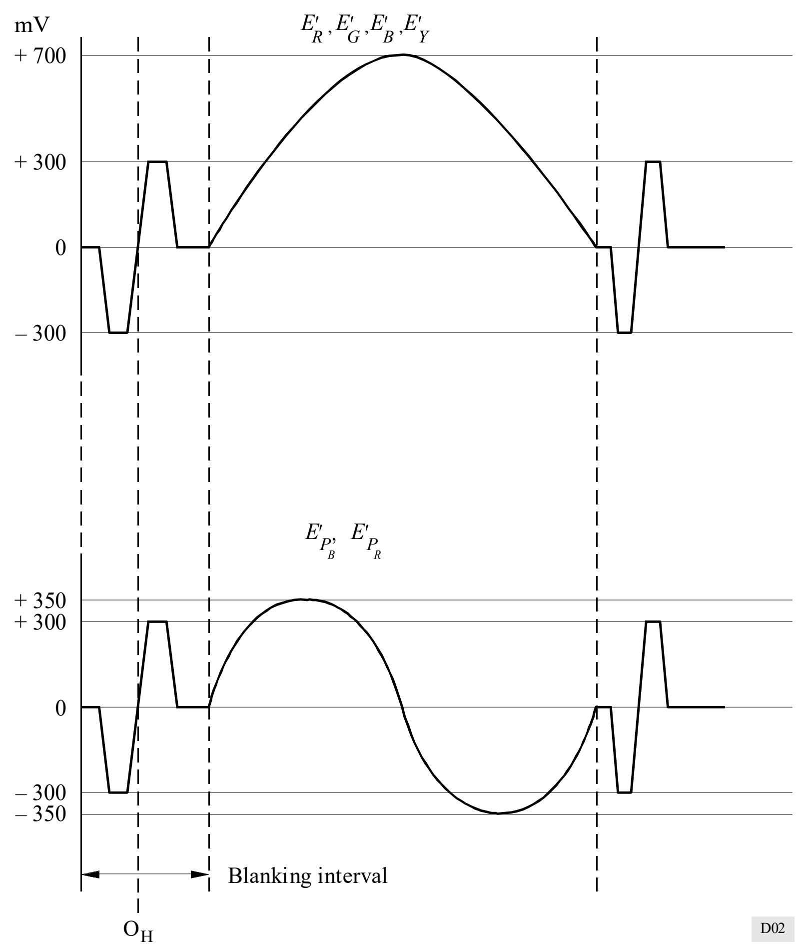


(The waveform exhibits symmetry with respect to point T_r)

5.6 The horizontal and vertical blanking intervals will be derived from the studies concerning the parameters in § 2 and 3 (see Annex 1).

FIGURE 2

Sync level on component signals



6. Digital representation

Item	Characteristics	
	Parameter	Value
6.1	Coded signals	R, G, B or Y, C_1, C_2
6.2	Sampling lattice R, G, B, Y	Orthogonal, line and picture repetitive
6.3	Sampling lattice C_1, C_2	Samples co-sited with each other and with alternate luminance samples
6.4	Sampling frequency R, G, B, Y	Sampling frequency is an integer multiple of 2.25 MHz
6.5	Sampling frequency C_1, C_2	Colour-difference sampling frequency to be 1/2 luminance sampling frequency

6.6 The parameters for the samples per full line for the R, G, B, Y, C_1 and C_2 signals, the signal coding, nominal levels and synchronizing words, possibly together with video-related data (video index signal), are still under study (see Annex 1).

6.7 The bit rate of the HDTV signal is expected to be in the range 0.8 to 1.2 Gbit/s for current implementations and in the range 2.0 to 3.0 Gbit/s for some future implementations (see Annex 1).

ANNEX 1*

Notes on the outstanding HDTV studio parameter values

1. Opto-electronic conversion

Three approaches are included in the studies concerning the parameter values for the reference primary colours for the worldwide HDTV studio standard:

– an extension of the colour gamut based on the values shown in § 1.3, through adjustment of the allowable video-signal ranges,

– adoption of the values shown in Table 1,

– adoption of the values shown in Table 2.

TABLE 1

	Primary	Coordinates	
		x	y
Assumed chromaticity coordinates (CIE 1931) for reference primaries	red green blue	0.6915 0.0000 0.1440	0.3083 1.0000 0.0297

TABLE 2

	Primary	Coordinates	
		x	y
Assumed chromaticity coordinates (CIE 1931) for reference primaries	red green blue	0.640 0.168 0.150	0.330 0.731 0.060

* In Annex 1, the notes on the outstanding HDTV studio parameter values are given. Pending the completion of the Recommendation, an HDTV studio system based on 1125/60/2:1 or 1250/50/2:1 should use signal parameters conforming to those of Annex 2. Many of these parameter values are identical to those already specified in the Recommendation.

Some administrations believe that the use of the first approach could provide a simple and compatible path from the interim to the reference system.

An alternative coding uses an opto-electronic transfer characteristic with a logarithmic/linear law ($V = 0.2675 \ln (1 + 41.15\,L)$). It is stated to offer benefits of reduced visibility of noise and quantization artefacts compared to that achievable with the "gamma" law of the interim system.

2. Picture characteristics

There has been extensive discussion of those aspects of a standard that are related to the way in which the television picture is to be constructed to achieve a single worldwide studio standard as desired by all administrations.

The difficulty lies in a determination as to a means of reaching that goal, particularly because of the problems associated with the field or picture frequency.

In addition to the direct one-step approach to a single standard, contributions have been presented suggesting two conceptual approaches to the above problems. One of these is a "common image format" concept which could be used at a picture or field frequency to suit the application. The other is based on the "common data rate" concept inherent in Recommendation ITU-R BT.601. A new approach has been suggested based on the concept of "common image part" whereby a sampling lattice with common sample density is used to define pictures of different sizes, resulting in different numbers of pixels per frame. The two previous approaches can be made special cases of this latter approach.

3. Picture scanning characteristics

There are two major factors to be considered in the selection of a picture rate:

– motion portrayal; and

– the relationship with film and with current and future TV systems.

Motion portrayal is influenced mainly by the picture rate selected and dynamic resolution is improved by the introduction of shuttering in the camera.

Both the picture rate and the interlace ratio are significant for a number of well known reasons.

4. Signal format

Studies have suggested that an interim HDTV system should use conventional $YC_1\,C_2$ coding which is used in currently available HDTV production systems. In addition, it was suggested that augmented conventional or constant-luminance coding approaches may offer more accurate signal rendition or reconstruction.

Studies are in progress to evaluate more thoroughly possible system performance improvements using constant-luminance coding. A decision then will be made as to whether constant-luminance coding will be included in HDTV system design.

It has been pointed out that the reduction of the bandwidth of the colour difference signals to a greater degree than that of the luminance signal, can cause errors in colour reproduction. A "pre-equalization" method (PEQ) has been proposed to reduce these errors, which offers the advantage of compatibility with the existing system while requiring additional circuitry only in the picture source.

5. Analogue representation

It may be possible to vary the blanking intervals at appropriate interfaces in the overall HDTV system.

6. Digital representation

6.1 Parameters for the studio standard

In addition to the number of samples per digital active line, the number of samples per full line in the analogue-to-digital horizontal timing relationship, further agreements are being sought on the following items:

6.1.1 Form of coding

6.1.2 Correspondence between video signal levels and quantization levels:

– scale,

– luminance signal,

– each colour-difference signal.

Studies are continuing in this area. There is agreement that at least 8 bits are required for R, G, B, Y, C_1 and C_2, and that 10 bits will be required for some applications. Therefore, both 8-bit and 10-bit representations are required.

The operational margin of the dynamic range is still subject to further study even in the case of Recommendation ITU-R BT.601.

One possible solution is to use the same relationship between video signal levels and quantizing levels as that in Recommendation ITU-R BT.601 for 8-bit signals, and for the 10-bit signal, to simply add two bits of lower significance.

Several other proposals are under consideration. One takes the Recommendation ITU-R BT.601 approach mentioned above but adds possibilities of variable dynamic range in the case of 10-bit signals. Another family of proposals uses part of the 8 or 10-bit dynamic range to extend the permissible signal level above nominal peak white and below normal black level.

6.1.3 Video index

The studio standard parameters could embrace the definition of a “video index” signal. Such a signal would include information concerning the origin, coding and prior processing of the signal.

To finalise § 6.1.1 and 6.1.2 above, further studies are necessary to complete the definition of the form of coding (linear and non-linear). Reaching a conclusion to these studies may be aided if the video index signal included the values of selected parameters.

6.1.4 Code word usage

It may be reasonable to reserve some levels when a similar structure of the interface to that described in Recommendation ITU-R BT.656 is used, particularly for synchronization data.

6.2 Some considerations on bit rates

The source bit rate can be fixed as the result of the choices on relevant parameter values of the studio standard. Transmission of this bit rate in Level 16 of the Synchronous Hierarchy (2 488.320 Mbit/s)* appears to be technically feasible.

Various bit-rate reduction techniques for HDTV signals are being developed, and the quality obtainable with them is under examination in reference to user requirements which are yet to be established. Many people interested in the possibility of achieving contribution quality with a bit rate of 140 Mbit/s. Further comparative study with a unified test method is most desirable before method(s) of bit-rate reduction are recommended.

Bit-rate reduction techniques may permit the use of bit rates for network transmission such as Level 4 (622.080 Mbit/s)* or Level 1 (155.520 Mbit/s)* of the Synchronous Hierarchy or possibly lower bit rates.

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* See ITU-T Recommendation G.707.

ANNEX 2*

Additional information to support the practical application of the Recommendation

Introduction

The work to complete a single worldwide standard for HDTV studio production and for the international exchange of HDTV programmes continues and the need to complete Recommendation ITU-R BT.709 urgently is recognized. However, some administrations and organizations have an immediate need to carry out production, international programme exchange and broadcasting and thus require comprehensive specifications to ensure the necessary compatibility in equipment and systems. Already, HDTV studio systems based on 1125/60/2:1 or 1250/50/2:1 have been implemented and are in use as sources for both broadcast and non-broadcast services.

To guide the orderly development of HDTV studio systems, the parameter values of these two systems are reproduced below to enable the practical application of this Recommendation.

It should be noted that many of these parameter values are identical to those already specified in the Recommendation.

Signal parameter values for the 1125/60/2:1 system and the 1250/50/2:1 system

1. Opto-electronic conversion

Item	Characteristics		
	Parameter	Value	
		1125/60/2:1	1250/50/2:1
1.1	Opto-electronic transfer characteristics before non-linear precorrection	Assumed linear	
1.2	Overall opto-electronic transfer characteristics at source(1)	$V = 1.099\,L^{0.45} - 0.99$ for $1 \geq L \geq 0.018$ $V = 4.500\,L$ for $0.018 > L \geq 0$ where: L: luminance of the image $0 \leq L \leq 1$ V: corresponding electrical signal	
1.3	Chromaticity coordinates (CIE 1931) Primary – Red – Green – Blue	Coordinates x 0.640 0.300 0.150	 y 0.330 0.600 0.060
1.4	Assumed chromaticity for equal primary signals $E_R = E_G = E_B$ (Reference white)	D_{65} x 0.3127	 y 0.3290

(1) The Gamma law is limited in gain at low signal levels to obviate noise-in-black problems.

* The Administration of the United States of America does not support approval of Annex 2 and must therefore take a reservation because approval will be viewed as support of interim standards which will impede progress towards the completion of Recommendation ITU-R BT.709 as a single worldwide standard for studio production and international programme exchange.

2. Picture characteristics

Item	Characteristics		
	Parameter	Value	
		1125/60/2:1	1250/50/2:1
2.1	Aspect ratio	16:9	
2.2	Sample per active line	1920	
2.3	Sampling lattice	Orthogonal	
2.4	Active lines per picture	1035	1152

3. Picture scanning characteristics

Item	Characteristics		
	Parameter	Value	
		1125/60/2:1	1250/50/2:1
3.1	Order of sample scanning	Left to right, top to bottom	1st line of Field 1 above 1st line of Field 2
3.2	Interlace ratio	2:1[(1)]	
3.3	Picture rate (Hz)	30	25
3.4	Total number of lines	1125	1250
3.5	Field frequency (Hz)	60	50
3.6	Line frequency (Hz)	$33\,750 \pm 10 \times 10^{-6}$	31 250

(1) For 1250/50/2:1 - Some administrations may consider future compatible extensions based on progressive scanning.

4. Signal format

The terms R, G, B, Y, C_1/C_B , C_2/C_R, are often used and are generally understood to refer to the signals E'_R, E'_G, E'_B, E'_Y, E'_{P_B}/E'_{C_B}, E'_{P_R}/E'_{C_R} respectively (i.e. they correspond to gamma pre-corrected signals).

Item	Characteristics		
	Parameter	Value	
		1125/60/2:1	1250/50/2:1
4.1	Conceptual non-linear precorrection of primary signals	$\gamma = 0.45$	
4.2	Derivation of luminance signal E'_Y [(1)]	$E'_Y = 0.2125\, E'_R + 0.7154\, E'_G + 0.0721\, E'_B$	$E'_Y = 0.299\, E'_R + 0.587\, E'_G + 0.114\, E'_B$
4.3	Derivation of colour-difference signal (analogue coding) E'_{P_B}, E'_{P_R} or E'_{C_B}, E'_{C_R}	$E'_{P_B} = 0.5389\, (E'_B - E'_Y)$ $E'_{P_R} = 0.6349\, (E'_R - E'_Y)$	$E'_{C_B} = 0.564\, (E'_B - E'_Y)$ $E'_{C_R} = 0.713\, (E'_R - E'_Y)$
4.4	Derivation of colour-difference signal (digital coding) C_1, C_2 or C_B, C_R	Digitally scaled from the values of 4.3	

(1) For 1250/50/2:1 – The use of prime denotes gamma-corrected signals; this non-constant luminance derivation is advised pending further studies. These values differ from those in the main body of this Recommendation for reasons of compatibility with present HD equipment and simplicity of conversion to conventional standards and encoding of HD-MAC.

5. Analogue representation

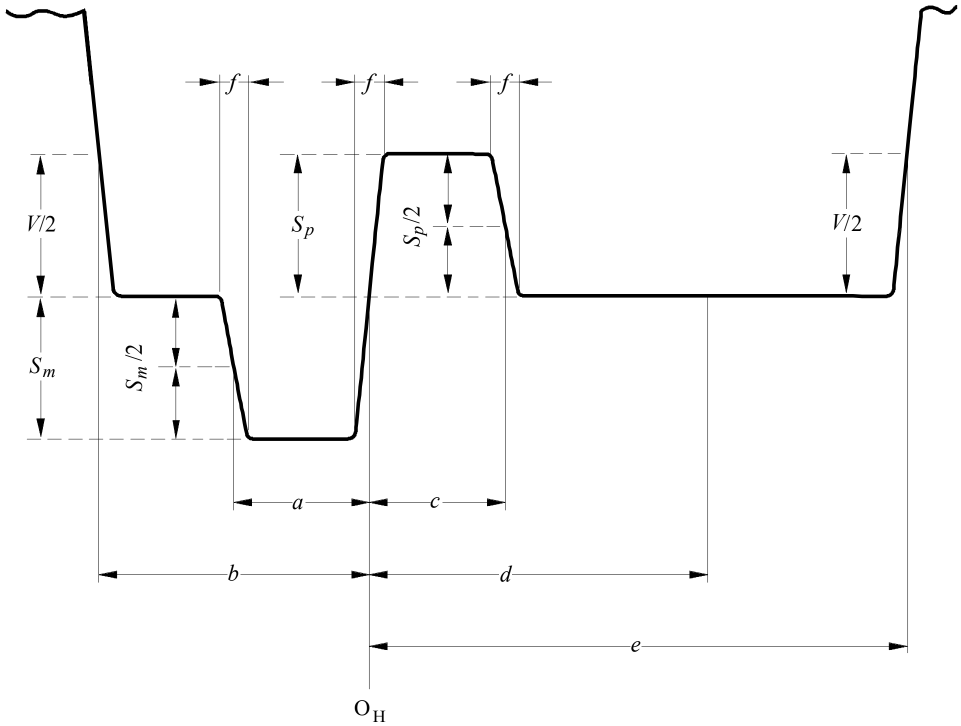
Levels are specified in millivolts measured across a matched 75 Ω termination.

Item	Characteristics		
	Parameter	Value	
		1125/60/2:1	1250/50/2:1
5.1	Nominal level E'_R, E'_G, E'_B, E'_Y	Reference black: 0 Reference white: 700	
5.2	Nominal level E'_{P_B}, E'_{P_R} or E'_{C_B}, E'_{C_R}	± 350	
5.3	Form of synchronizing signal	Tri-level bipolar (see Fig. 3)	(see Fig. 4)
5.4	Line sync timing reference	O_H (see Fig. 3)	(see Fig. 4)
5.5	Sync level	± 300 (See Table 1) sync on all components	± 2% – rise time 50 ns ± 10 ns (10%-90%) – see also[(1)]
5.6	Inter-component timing accuracy	Not applicable	± 2 ns
5.7	Blanking interval	(see Table 3 and Fig. 5)	(see Tables 4 and 5)
5.8	Nominal signal bandwidth (MHz)	30 (for all components)	

(1) When using R, G, B signals, the use of syncs on at least the green channel is advised; transmission of separate syncs is also acceptable. When using Y, C_B, C_R signals the Y signal at least carries sync.

FIGURE 3

Line synchronizing signal waveform for the 1125/60/2:1 system



Line sync timing references

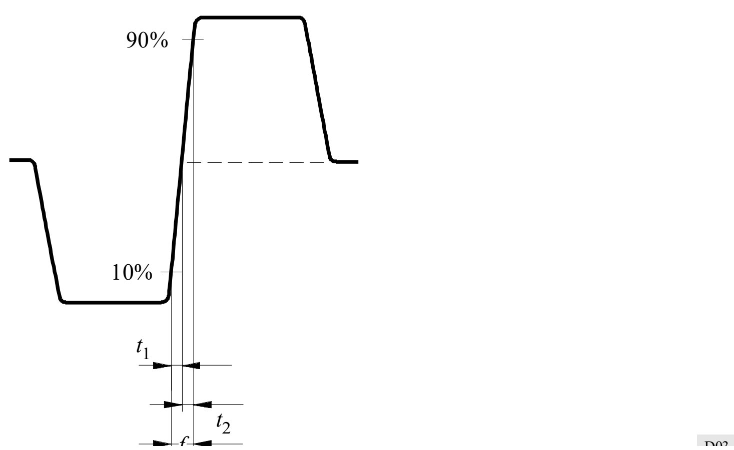


FIGURE 4

Line synchronizing signal waveform for the 1250/50/2:1 system

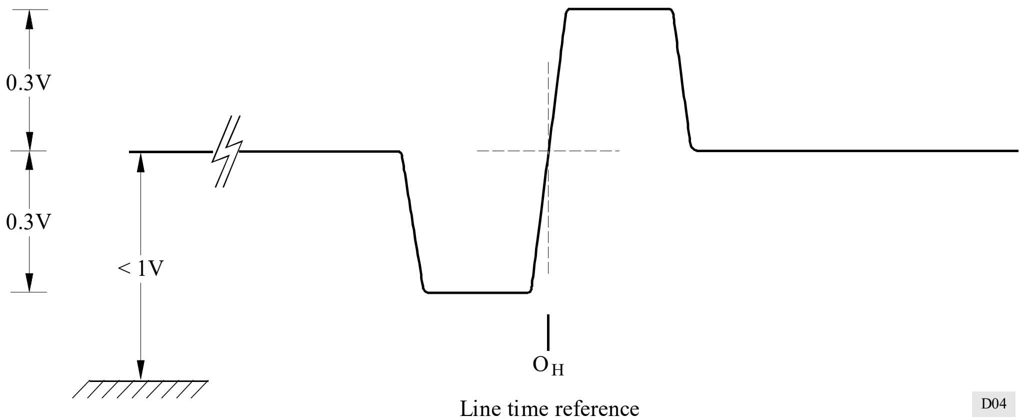


TABLE 3

Level and timing specification of synchronizing signal of the 1125/60/2:1 system (see Figs. 3 and 5)

Symbol	Parameter	Nominal value	Reference clock intervals	Tolerance (µs)
a	Negative line sync width	0.593 µs	44	± 0.040
b	End of active video	1.185 µs	88	+ 0.080 – 0.000
c	Positive line sync width	0.593 µs	44	± 0.040
d	Clamp period	1.778 µs	132	± 0.040
e	Start of active video	2.586 µs	192	+ 0.080 – 0.000
f	Rise/fall time	0.054 µs	4	± 0.020
t_2–t_1	Symmetry of rising edge	–	–	± 0.002
S_m	Amplitude of negative pulse	300 mV	–	–
S_p	Amplitude of positive pulse	300 mV	–	–
V	Amplitude of video signal	700 mV	–	–
–	Field-blanking interval	45 *H*/field	99000	–

FIGURE 5

Field synchronizing signal waveform for the 1125/60/2:1 system

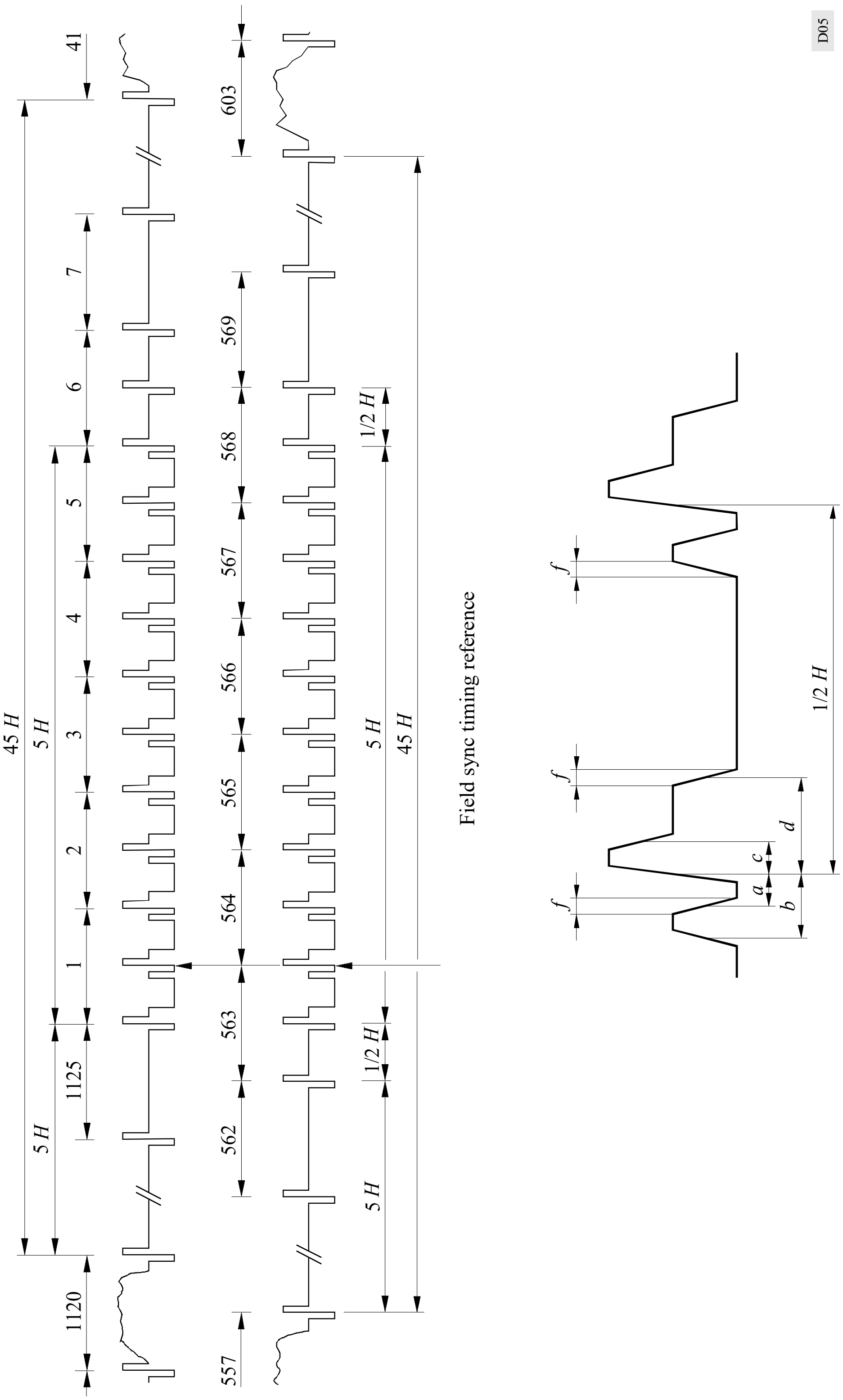


TABLE 4

Line timing details for the 1250/50/2:1 system
(see Figs. 4, 6 and 7)

Item	Parameters	Time (μs)	2.25 MHz samples	72 MHz samples
1	Total line length	32	72	2304
2	Active line length(1) – digital – analogue	 26.67 26.00	 60 (58.5)	 1920 1872
3	Line blanking(2) – digital – analogue	 5.33 6.00	 12 (13.5)	 384 432
4	Front porch(2)	0.89	2	64
5	Back porch(2)	2.67	6	192
6	Tri-level synchronisation half width	0.89	2	64
7	Field pulse	8.00	18	576

(1) Relative disposition of analogue and digital active lines assumed to be as per scaled version of Recommendation ITU-R BT.601 (i.e. symmetrical). Analogue active line measured from the half-height of signal after line blanking. Rise and fall times assumed to be 15 ns but subject to ratification. Analogue blanking should preferably be applied at the studio or playout output.

(2) Front porch is defined at the interval between the end of active video and the half-height of the leading negative edge of the tri-level sync pulse. Similarly back porch is the interval between the half-height of the trailing negative edge of the tri-level sync and the start of active video (see Fig. 6).

TABLE 5

Field timing details for the 1250/50/2:1 system
(see Figs. 7 and 8)

Item	Parameter	Value/Description
1	Total number of lines per frame	1250
2	Total number of lines per field	625
3	Active lines per frame	1152
4	Active lines per field	576
5	Frame reference O_V	O_H on line 1
6	Frame indication	Line 1250
7	Field indication	Line 625
8	Active lines field 1	Lines 45 ... 620 inclusive
9	Active lines field 2	Lines 670 ... 1245 inclusive
10	Field blanking	Lines 1246 ... 44 and 621 ... 669 inclusive

FIGURE 6

Line sync timing references for the 1250/50/2:1 system after *D/A* conversion and before final analogue blanking

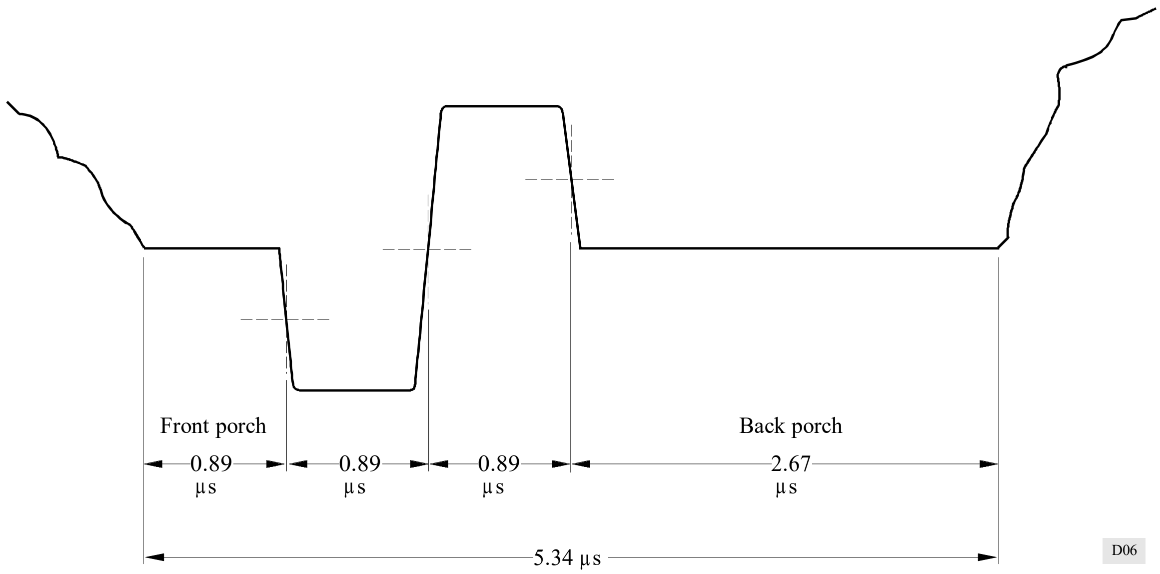


FIGURE 7

Frame and field identification for the 1250/50/2:1 system

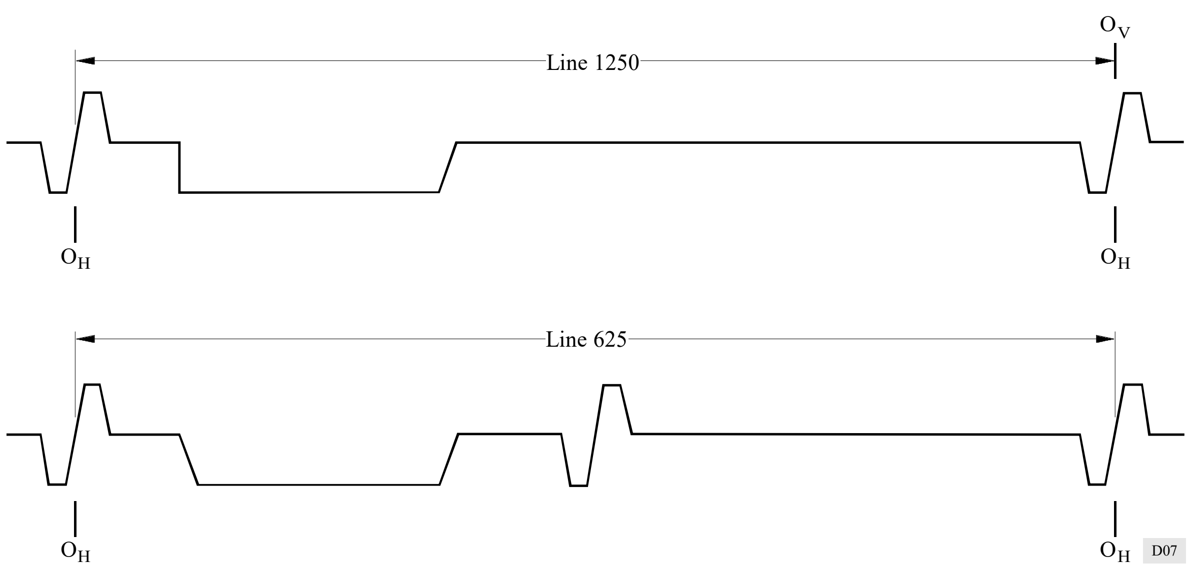
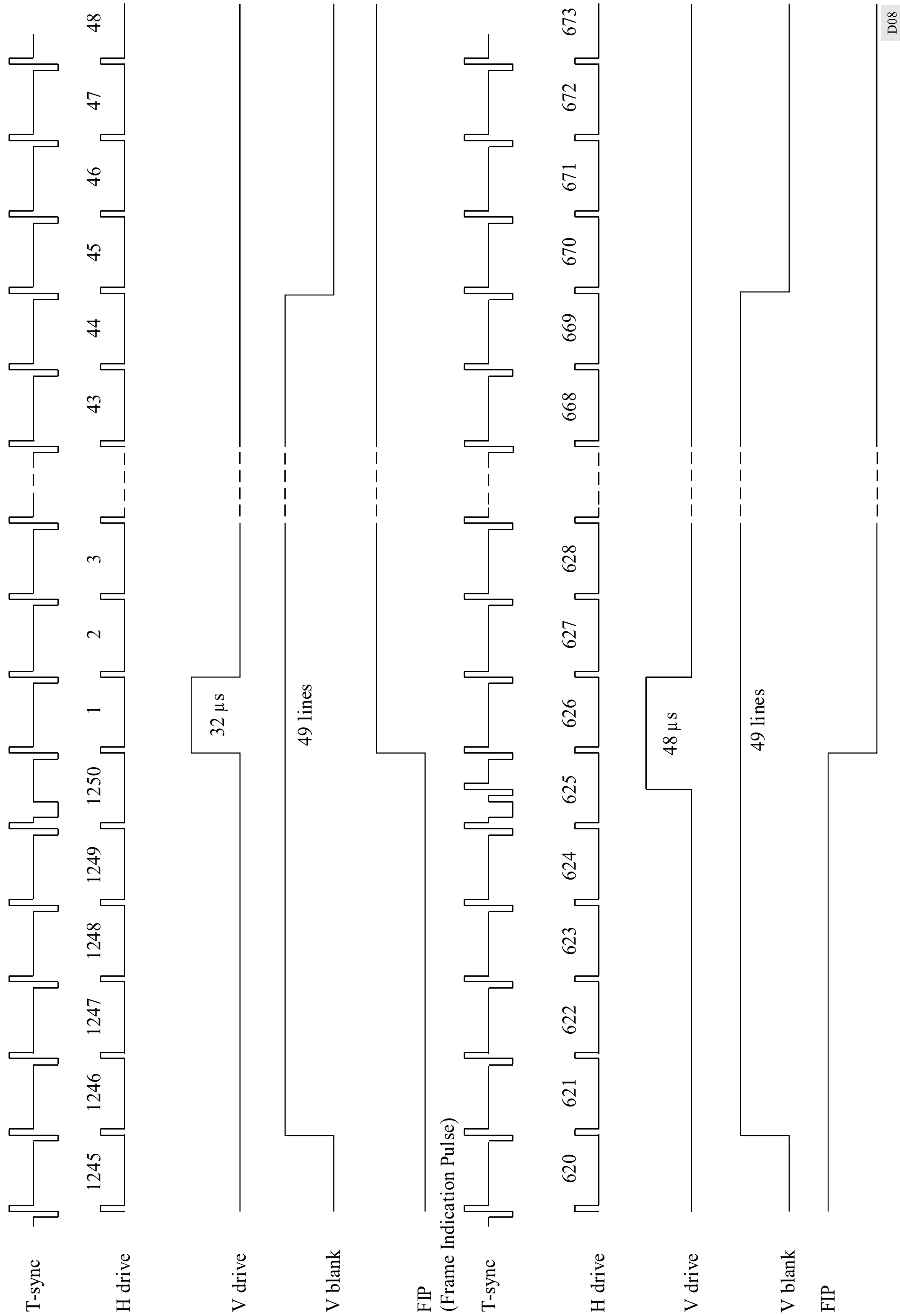


FIGURE 8

Timing of signals during the field-blanking interval for the 1250/50/2:1 system



6. Digital representation

Item	Characteristics		
	Parameter	Value	
		1125/60/2:1	1250/50/2:1
6.1	Coded signal	R, G, B, or Y, C_1/C_B, C_2/C_R	
6.2	Sampling lattice – R, G, B, Y	Orthogonal, line and picture repetitive	
6.3	Sampling lattice signal – C_1/C_B, C_2/C_R	Orthogonal, line and picture repetitive co-sited with each other and with alternate(1) Y samples	
6.4	Sampling frequency (MHz) – R, G, B, Y	$74.25 \pm 10 \times 10^{-6}$ (33 × 2.25)	72 (32 × 2.25)
6.5	Sampling frequency (MHz) – C_1/C_B, C_2/C_R	$37.125 \pm 10 \times 10^{-6}$ (33/2 × 2.25)	36 (16 × 2.25)
6.6	Number of samples per full line – R, G, B, Y – C_1/C_B, C_2/C_R	2200 1100	2304 1152
6.7	Active number of samples per line – R, G, B, Y – C_1/C_B, C_2/C_R	1920 960	
6.8	Coding format	Linear, 8 or 10 bits/component	
6.9	Timing relationship between the analogue synchronizing reference O_H and video data (in clock periods)	192	256
6.10	Quantization levels(2) – Black level R, G, B, Y – Achromatic C_1/C_B, C_2/C_R – Nominal peak – R, G, B, Y – C_1/C_B, C_2/C_R	8 bit coding 16 128 235 16 and 240	
6.11	Quantization level assignment(3) – Video data – Timing references(2)	8 bit coding 1 through 254 0 and 255	
6.12	Filter characteristics(4) – R, G, B, Y – C_1/C_B, C_2/C_R	See Fig. 9A See Fig. 9B	See Fig. 10A See Fig. 10B

(1) The first active colour-difference samples being co-sited with the first active luminance sample.

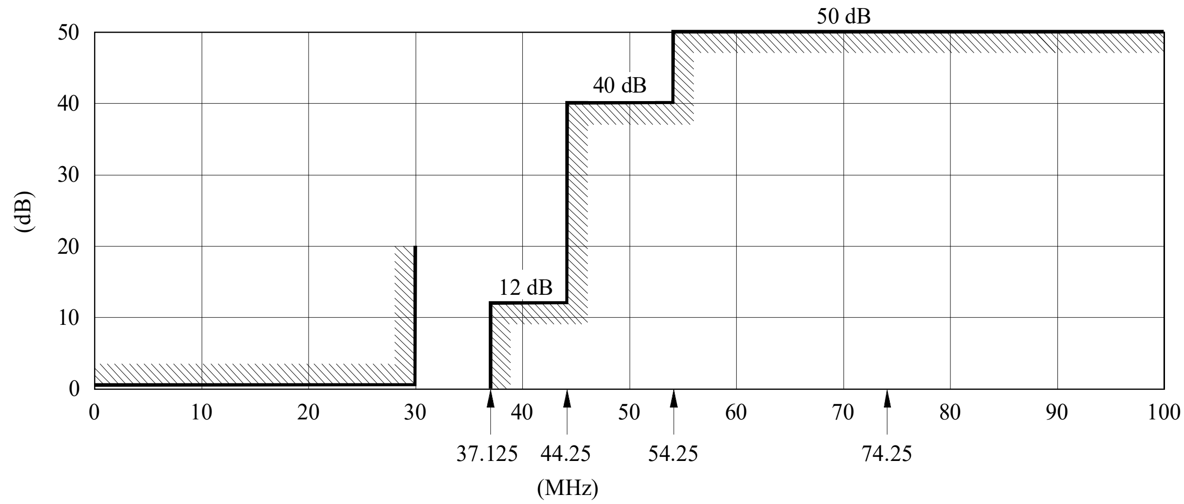
(2) For 1125/60/2:1 – In the case of 10 bit representation the two LSBs are ignored.

(3) For 1125/60/2:1 – For 10 bit coding two LSBs are added to the 8 bit code words.
For 1250/50/2:1 – 10 bit representation is under study.

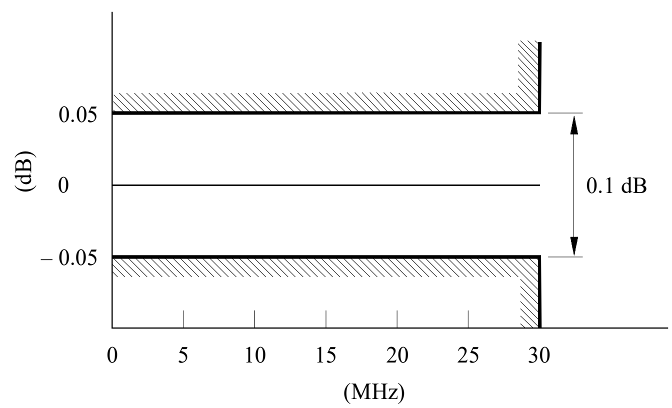
(4) These filter templates are defined as guidelines.

FIGURE 9A

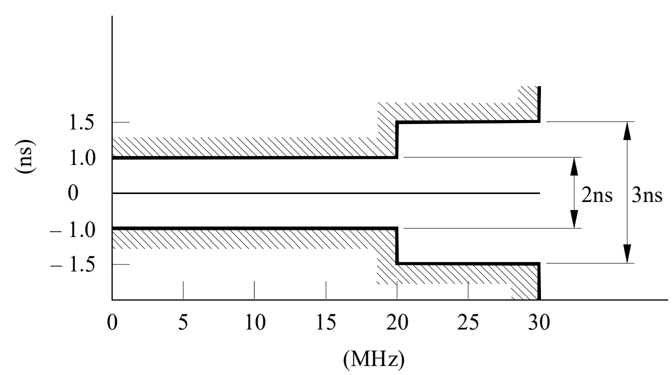
Filter characteristics for *R*, *G*, *B* and *Y* signals for the 1125/60/2:1 system



a) Template for insertion loss/frequency characteristic



b) Passband ripple tolerance



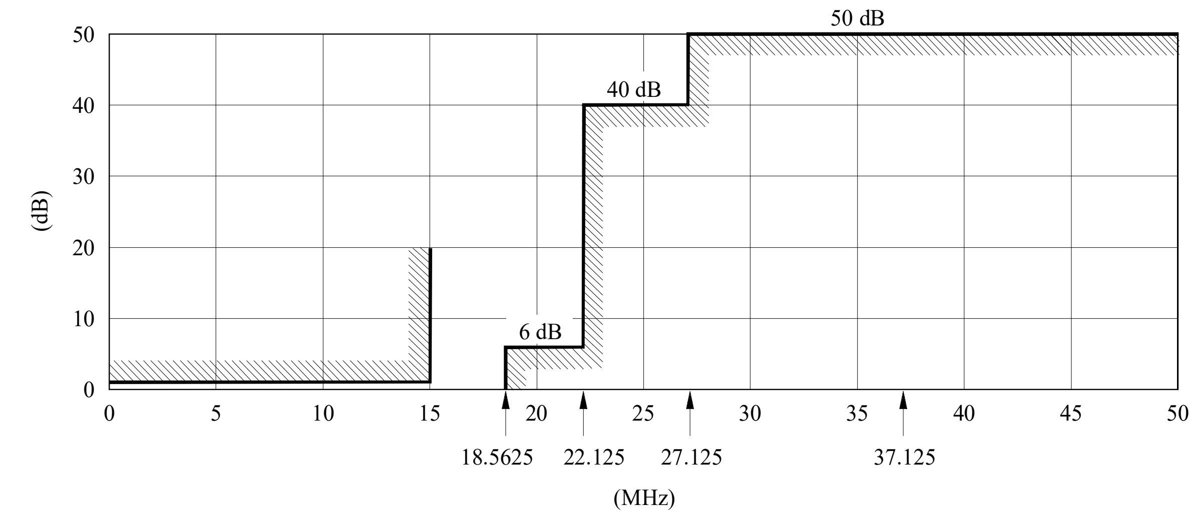
c) Passband group-delay tolerance

Note 1 – The lowest frequency value in b) and c) is 100 kHz (instead of 0 MHz).

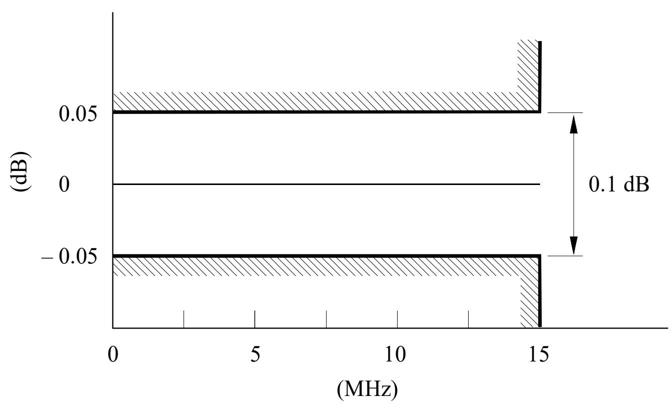
D09

FIGURE 9B

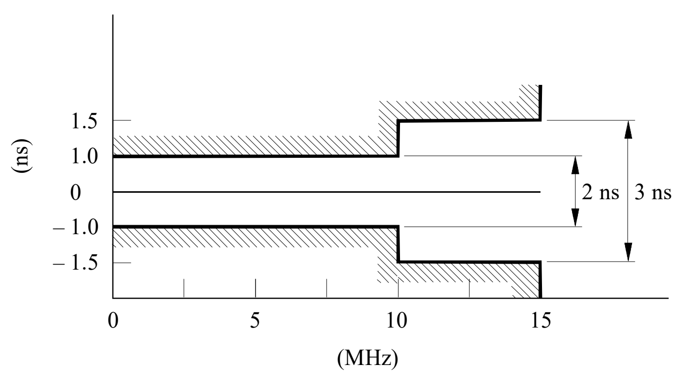
Filter characteristics for P_B and P_R signals for the 1125/60/2:1 system



a) Template for insertion loss/frequency characteristic



b) Passband ripple tolerance



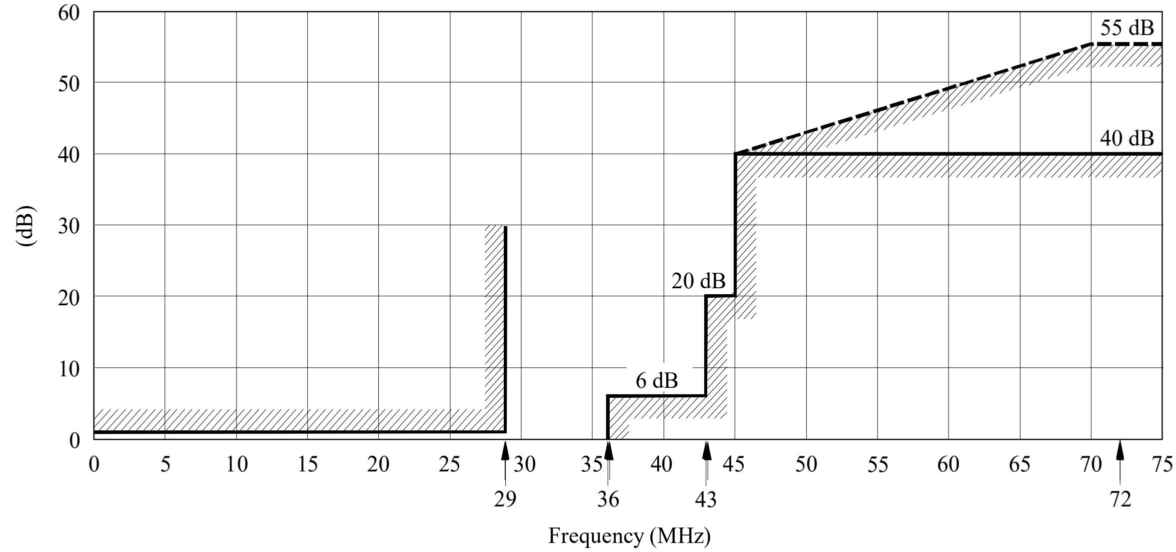
c) Passband group-delay tolerance

Note 1 – The lowest frequency value in b) and c) is 100 kHz (instead of 0 MHz).

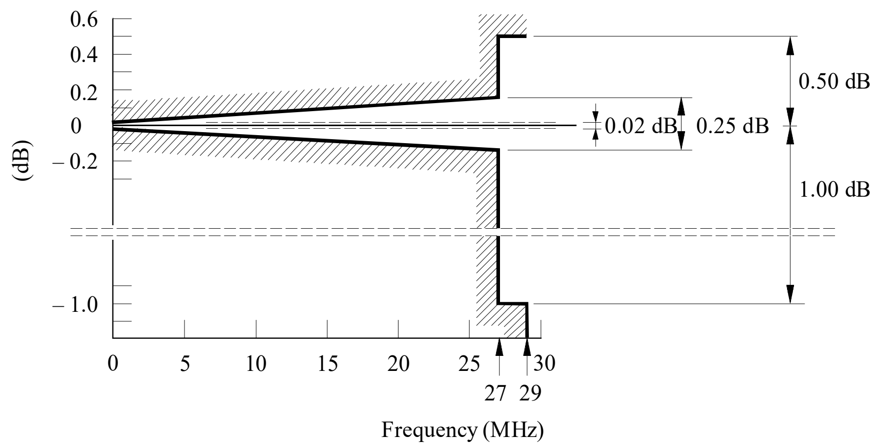
D10

FIGURE 10A

Filter characteristics for *R*, *G*, *B* and *Y* signals for the 1250/50/2:1 system



a) Template for insertion loss/frequency characteristic



b) Passband ripple tolerance

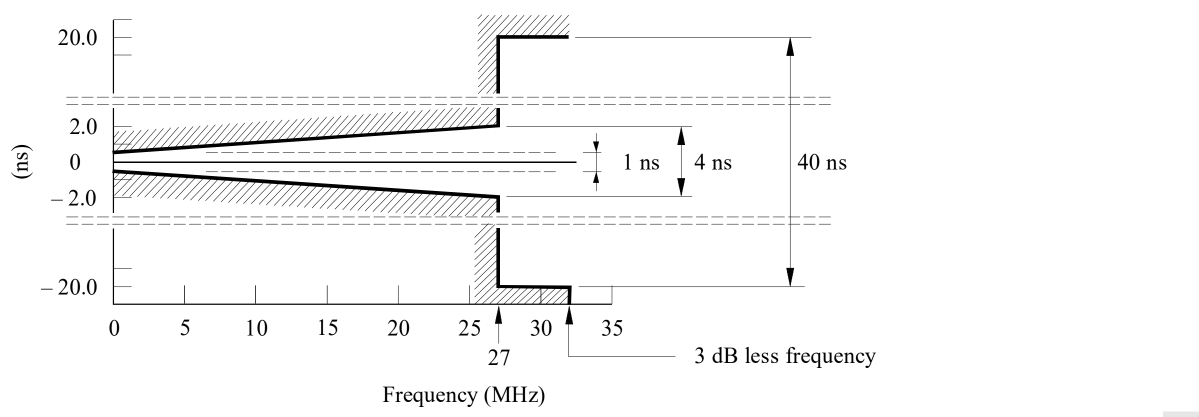
Note 1 – In a digital implementation:

– the insertion loss should be at least 55 dB above 70 MHz (dashed-line template);

– the amplitude/frequency characteristic (on linear scales) should be skew-symmetric about the nail amplitude point;

– the group delay distortion should be zero by design.

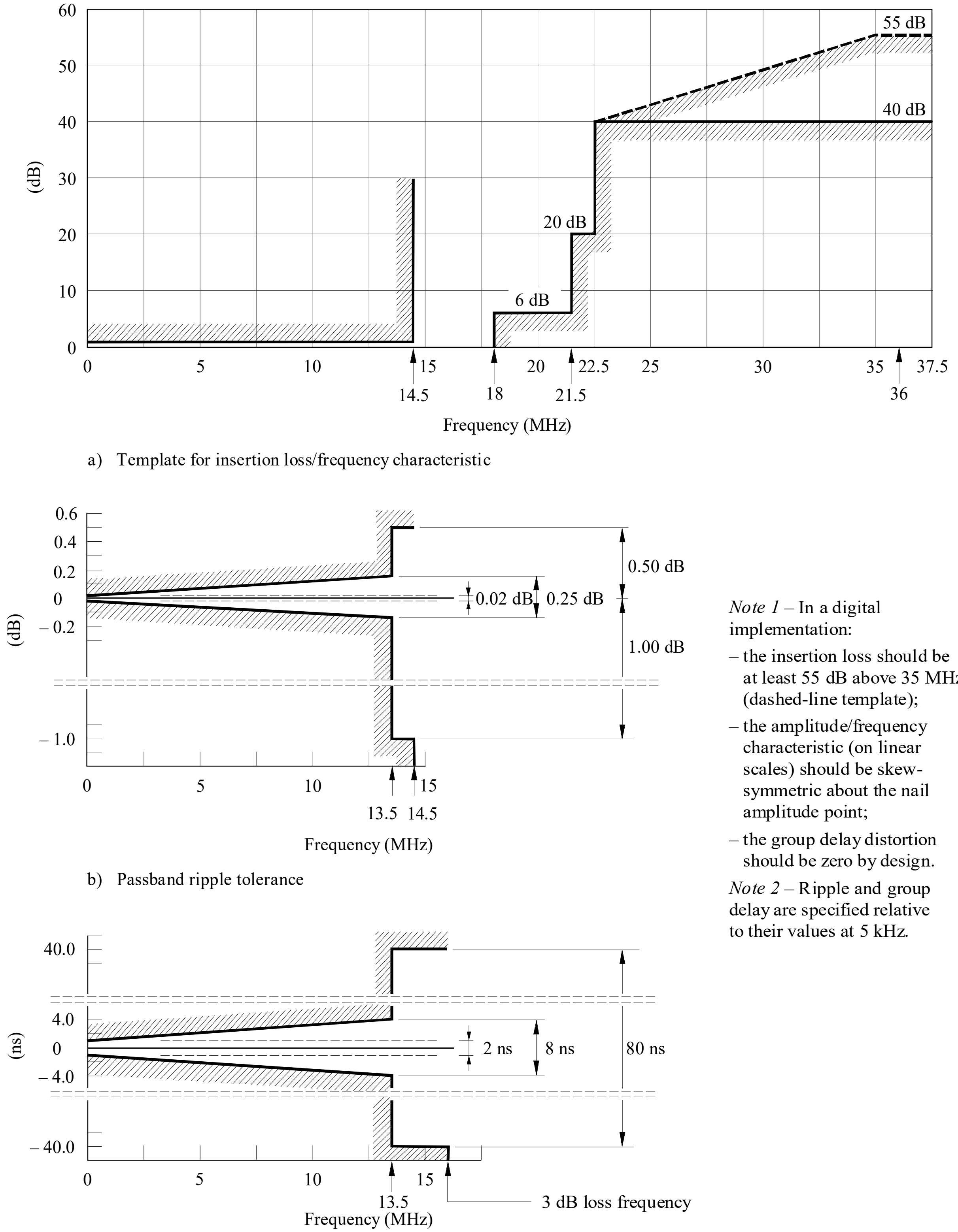
Note 2 – Ripple and group delay are specified relative to their values at 5 kHz.



c) Passband group delay tolerance

FIGURE 10B

Filter characteristics for C_B and C_R signals for the 1250/50/2:1 system



a) Template for insertion loss/frequency characteristic

b) Passband ripple tolerance

c) Passband group delay tolerance

Note 1 – In a digital implementation:

– the insertion loss should be at least 55 dB above 35 MHz (dashed-line template);

– the amplitude/frequency characteristic (on linear scales) should be skew-symmetric about the nail amplitude point;

– the group delay distortion should be zero by design.

Note 2 – Ripple and group delay are specified relative to their values at 5 kHz.