RECOMMENDATION ITU-R BT.1197-1*

Enhanced wide-screen PAL TV transmission system (the PALplus system)

(Question ITU-R 10/6)

(1995-1998)

The ITU Radiocommunication Assembly,

considering

a) that the 16:9 aspect ratio provides an enhanced viewing experience, particularly on large screen receivers, and is likely to be adopted for new digital services;

b) that there are indications that the public interest in the new 16:9 aspect ratio is growing;

c) that PAL services are likely to continue for several decades, whatever new services are introduced;

d) that evaluations, summarized in Appendix 1 to Annex 1, have shown that the PALplus system can provide high quality 16:9 pictures for wide-screen receivers whilst maintaining compatibility with existing 4:3 receivers (using 16:9 letterbox);

e) that the signalling system required by PALplus for receiver control has been recommended in Recommendation ITU-R BT.1119;

f) that Recommendation ITU-R BT.1118 recommends that when enhancements to existing television systems are made, some or all of the modular enhancements and features listed in Annex 1 to that Recommendation should be used;

g) further that two of these modules are:

– coder requirements for accommodating wide aspect ratio signals, and

– coder requirements for reducing cross-effects and optimal use of the signal spectrum;

h) that the PALplus system can provide for the two modules listed in § h) above;

j) that although the PALplus system does not permit open subtitling in the black band below the letterbox PALplus signal, this can be mitigated by use of the MACP picture enhancement technique of PALplus which allows open subtitling to be included anywhere within the transmitted image,

recommends

1 that where administrations or broadcasters wish to enhance the delivery of conventional definition PAL (see Note 1) television with:

– compatible 16:9 wide-screen,

– compatible encoding to reduce cross-effects

* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2002 in accordance with Resolution ITU-R 44.

and make optimum use of the video signal spectrum, the PALplus system, as specified in Annex 1, should be used.

NOTE 1 – In the case of PAL systems B, G, H, I, D and K;

2 that where one of these two enhancement modules is required individually for the enhancement of the delivery of conventional PAL (see Note 1) television, the relevant module of the PALplus system (see Note 2), as specified in Annex 1, should be used.

NOTE 1 – In the case of PAL systems B, G, H, I, D and K.

NOTE 2 – The term "PALplus" identifies a system for transmissions in which all modules of the system described in Annex 1 are used (see also Table 1).

ANNEX 1

PALplus system specification

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1 Introduction

PALplus is an enhanced transmission system which has been designed to allow existing PAL broadcasters to offer wide-screen pictures with greatly reduced levels of conventional PAL artefacts, whilst retaining a high level of compatibility with the PAL transmission infrastructure and with existing PAL receivers.

The format of the primary encoder input and decoder output signals for PALplus is 625/50/2:1, with an aspect ratio of 16:9. A 1250/50/2:1 HDTV source may be used after downconversion to 625/50/2:1.

The wide-screen picture is transmitted in letterbox format to achieve compatibility with existing 4:3 receivers. Loss of vertical resolution (as compared to the 576 active line source picture) is minimized in the PALplus receiver by making use of a vertical helper signal transmitted in the black bands above and below the letterbox picture.

The PALplus system has two modes of operation. These are called “film mode”, which is used only with film sources, and “camera mode” which is used with normal 50 Hz video sources. Both the vertical conversion (to the letterbox picture) and the motion adaptive colour plus (MACP) method of improved chrominance/luminance separation make use of a camera mode and a film mode to give optimum system performance.

Starting from a 625/50/2:1 4:2:2 digital component input signal (in accordance with Recommendation ITU-R BT.601, based on 13.5 MHz sampling (see Note 1)) with 576 active lines per frame and an aspect ratio of 16:9, a conversion to 430 active picture lines is first carried out. When the source provides 50 Hz motion (camera mode), this conversion must be performed intra-field in order to avoid motion artefacts but, when the source is known to have only 25 Hz motion (i.e., in film mode), then an intra-frame conversion (using samples taken from the two fields of a frame) is used. The letterbox picture signal used for transmission has only three quarters of the number of active picture lines as the source; in order to minimize loss of vertical resolution in the PALplus display, the black bands are used to transmit a vertical helper signal.

An enhanced PAL encoding and decoding technique known as “motion adaptive colour plus” is used to reduce PAL luminance/chrominance crosstalk artefacts and to maximize horizontal resolution. In film mode, the system takes advantage of the known temporal redundancy of the signal and uses an intra-frame PAL encoding technique (fixed colour plus). In camera mode, the same technique is applied to appropriate areas of each picture frame. However, in areas containing moving saturated colour (usually representing only small parts of typical pictures), there is likely to be a significant amount of movement between the adjacent fields of a source picture frame, which could lead to occasionally visible colour judder if colour plus processing were applied. To minimize this problem, in such areas of the picture, the system reverts adaptively to a simpler form of PAL encoding, making use of motion detectors in both the encoder and decoder to identify areas of fast colour motion between adjacent frames.

Ghost cancellation is an optional enhancement. The parameters of the ghost cancellation reference signal are given in Recommendation ITU-R BT.1124, Annex 1, § 1.3.

NOTE 1 – All references to Recommendation ITU-R BT.601 in this Recommendation refer to the 13.5 MHz sampling variant specified in Part A.

2 Essential features of a PALplus transmission

A PALplus signal is derived according to the processes illustrated in Fig. 1. These are summarized below and defined further in § 3. The vision signal should be described as “PALplus” only when *all* of the following processes are implemented:

– **Vertical conversion (QMF process) to 430-line letterbox picture**

This is the conversion of the 16:9 aspect ratio source picture with 576 active lines to a 16:9 aspect ratio letterbox picture with 430 active lines. The QMF (quadrature mirror filter) format conversion process also yields vertical luminance resolution information that can be encoded and transmitted in the black bands.

– **Vertical helper encoding**

This is the method of processing and modulating the vertical luminance information derived from the QMF format conversion process, resulting in the “vertical helper” signal that is transmitted in the black bands above and below the active letterbox picture.

– **Motion adaptive colour plus (MACP)**

This is the encoding technique that makes possible improved separation of chrominance and luminance in the PALplus receiver.

Furthermore, PALplus makes use of a wide-screen signalling system (Recommendation ITU-R BT.1119) in order to convey essential information about the content of the transmitted signal to the decoder.

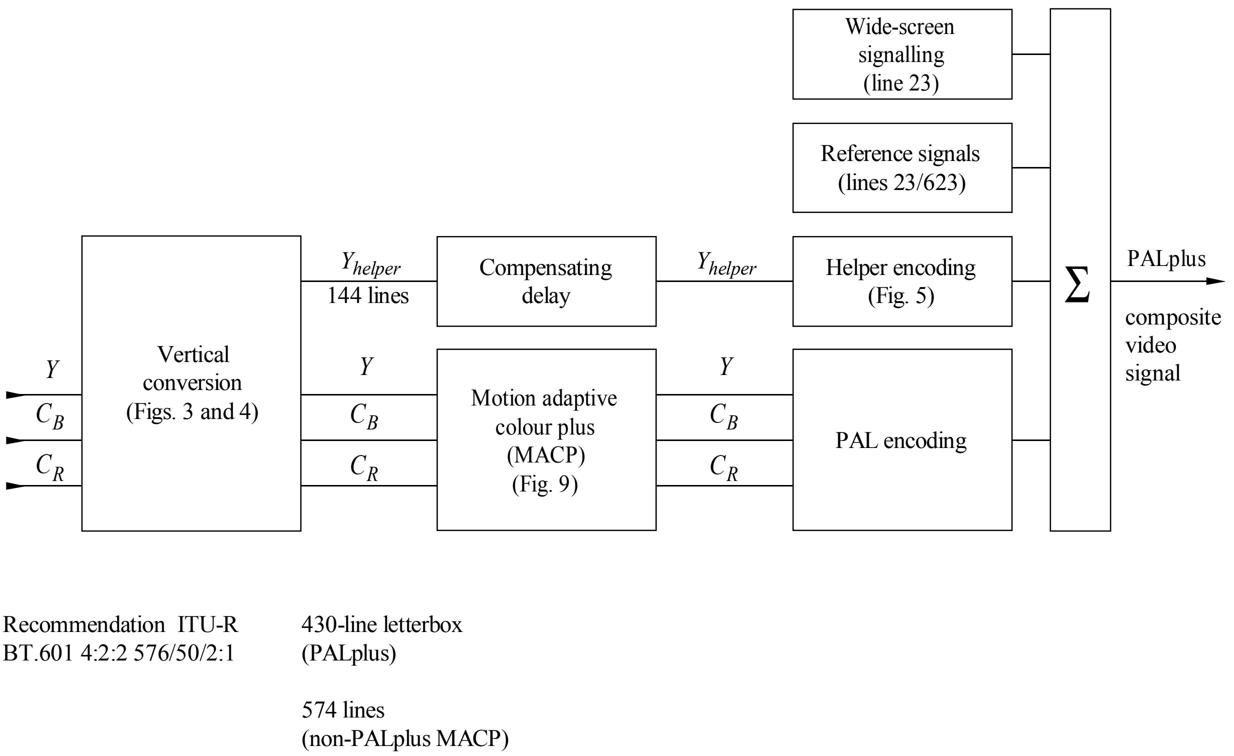
The encoded PALplus signals also contains reference signals that may be used by the PALplus receiver for the accurate setting of the levels of the incoming luminance and vertical helper signals.

The MACP encoding technique, without the transmission of vertical helper information, but with appropriate use of wide-screen signalling to indicate an aspect ratio of either 4:3 or 14:9, may also be applied to component source pictures with 576 (nominal) active picture lines. Such a transmission is referred to as “non-PALplus MACP”. This gives the PALplus receiver the potential to display pictures of enhanced quality from a wide range of component-sourced programme material, in addition to transmissions in PALplus.

The PALplus signal at the output of the encoder consists of the combination of the PAL encoded MACP pre-processed letterbox picture, the modulated helper signal resulting from the QMF vertical conversion process, the reference signals, and the signalling bits (see Fig. 1).

FIGURE 1

Outline of PALplus encoding processes



Note 1 – Helper not used with non-PALplus MACP.

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The essential features of a PALplus transmission are summarized in Table 1.

TABLE 1

The enhancement features incorporated in a PALplus transmission

Enhancement	Essential for PALplus?
Format conversion (QMF) from Recommendation ITU-R BT.601 source with 16:9 aspect ratio to 430-line letterbox	Yes
Vertical helper encoding	Yes
Motion adaptive colour plus	Yes
Reference signals (lines 23/623)	Yes
Wide-screen signalling	Yes
Ghost cancellation reference signal (line 318)	Optional

2.1 The PALplus signal

2.1.1 Input picture signal to the PALplus encoder

The input to the PALplus encoder is a component digital 625-line, 50 field/s interlaced 4:2:2 YC_BC_R signal (according to Recommendation ITU-R BT.601, minimum 8-bit resolution), with 576 (nominal) active picture lines and an aspect ratio of 16:9. Field 1 shall be the dominant field at all times in the case of material to be PALplus encoded in film mode.

2.1.2 The encoded composite PALplus signal

The output of the PALplus encoder is an analogue PAL composite signal containing 430 active picture lines in letterbox format, together with helper information contained in the black bands above and below the visible letterbox picture area (see Figs. 12, 13 and 17). In addition, signalling bits are contained in the first half of line 23 (see § 3.5), and reference signals for use by the PALplus decoder are inserted into the second half of line 23 and the first half of line 623 (see § 3.4 and Figs. 14 and 15).

All general characteristics of the encoded PALplus signal conform to the parameters listed in Recommendation ITU-R BT.470. These include all aspects of the standard PAL colour burst, which are retained on the same lines as for a standard PAL signal.

All operations in the encoder are performed in digital form. Prior to digital-to-analogue conversion at the output of the encoder, the encoded PALplus signal has the following characteristics:

– Sampling rate: 13.5 MHz (or multiple thereof), quantizing range: 0.00_{10} to 255.75_{10} (unsigned), 10-bit resolution (see Note 1), black level = 64.00_{10}, peak-white level = 192.00_{10}.

– The quantizing range is illustrated in Fig. 16.

– Permitted signal data levels for this 10-bit signal are in the range 1.00_{10} to 254.75_{10} for compatibility with the signal data levels of Recommendation ITU-R BT.601. (All vision signals lie within this range.)

– Using the above quantizing scale, the maximum peak-to-peak amplitudes of the modulated chrominance signals are: $U = 112.00_{10}$, $V = 157.50_{10}$.

Each active line of letterbox picture and of helper is formed from 702 digital active samples, and the structure of the PALplus frame is as shown in Fig. 17.

It should be noted that, for convenience, the sampling clock period numbers are indicated as being in the range 1 to 864, where clock period 1 represents the leading edge of line syncs, half amplitude reference (see Fig. 17). Sampling clock period 1 therefore corresponds to Recommendation ITU-R BT.601 luminance sample number 732. The first active sample of each line is in clock period 143, which corresponds to the 11th sample of the digital active luminance line of Recommendation ITU-R BT.601 (luminance sample No. 10).

The frequency spectrum occupied by the chrominance signal is 4.43 MHz ± 1.3 MHz at –3 dB.

The amplitude/frequency characteristic of the luminance signal should be substantially uniform from 0 to 5.5 MHz. The horizontal bandwidth of the luminance signal is limited principally by the use of digital processing with 13.5 MHz sampling according to Recommendation ITU-R BT.601 and, unlike standard PAL encoding, should not be modified by the use of a notch filter in the region embracing the subcarrier frequency.

The transmitted luminance and chrominance bandwidths may be restricted by the characteristics of the transmission system; for example, the luminance bandwidth will be limited to 5 MHz in the case of System B/G, and to 5.5 MHz in System I (see Recommendation ITU-R BT.470).

The total delay in the encoding process should preferably be the same in both camera mode and in film mode. The exact delay will depend on the encoder implementation, but could be expected to be of the order of 30 ms (see Note 2). A nominally equivalent compensating delay should be applied to associated audio paths prior to transmission.

NOTE 1 – *Nomenclature:* Within this specification, the contents of digital words are expressed in decimal form. To avoid confusion between 8-bit and 10-bit unsigned representations, the eight most significant bits are considered to be an integer part while the two additional bits, if present, are considered to be fractional parts. (For example, the bit pattern 10010001 would be expressed as 145_{10} and 1001000101 as 145.25_{10}.) Where no fractional part is shown, it should be assumed to have binary value 00.

NOTE 2 – *Time delay in encoder:* The modular description of the encoding processes given in § 3 will result in a longer time delay than this. Although it is possible to combine some elements so as to reduce the time delay, a fully modular approach to the description of the formation of a PALplus signal has been adopted for reasons of clarity.

3 The PALplus encoding processes

3.1 Vertical conversion

The incoming 576-active line YC_BC_R signals are converted to a central 430-line letterbox picture, together with 144 lines of a vertical helper signal representing additional luminance vertical information (see Fig. 17). The conversion is carried out intra-frame in film mode, and is carried out intra-field in camera mode. The processes are illustrated in Figs. 3 and 4. (Reciprocal processes to those described for the encoder are carried out by the PALplus decoder to reconstruct a wide-screen display with 576 active picture lines.)

The entire contents of lines 23 and 623 of the input signals to the encoder are set to black, overwriting any active video in these lines, prior to vertical conversion.

In film mode, field memories M4A (luminance) and M5A (C_B, C_R) together with the associated line memories (M4B for luminance, M5B for C_B, C_R) and switches perform field insertion during the second input field (see Fig. 4). This results in a sequential frame for processing at the rate of 27 MHz for luminance, and 13.5 MHz for each of C_B and C_R.

3.1.1 Encoder vertical conversion of luminance

For luminance, a special QMF technique is used to generate two sub-bands as illustrated in the two nominal filter plots ENC_Y_QMF (see Note 1) for camera mode and film mode respectively (see Fig. 2). These sub-bands contain the 430-line letterbox luminance, and 144 lines representing vertical detail information that would otherwise be lost by the vertical filtering to 430 lines. The QMF technique is essentially loss-free, and has the advantage that in the decoder there is cancellation of alias components in the main and helper signals.

As illustrated in Figs. 3 and 4, the luminance QMF (ENC_Y_QMF) operates at 13.5 MHz in camera mode, and at 27 MHz in film mode (during the period of one field only). In film mode, memories M1, M2, M3, M4 and M5 are used to change sample rates from the input/output rates to the double speed used in the luminance QMF and chrominance vertical sample rate conversion processes.

Following the QMF, some further memories and field-rate switches are required. This is because although the filters and the QMF have produced the correct number of lines for the letterbox signal, these lines are in the form of a multiplex of letterbox picture and helper lines (three lines of letterbox picture followed by one line of helper) spread out across the period of the input field (camera mode) or frame (film mode).

Referring to Figs. 3 and 4, M2A and M2B store the two fields of each letterbox luminance frame. M3A and M3B hold the first and second fields of the colour-difference signals. M1A and M1B perform a similar function for the helper lines, storing them as they are output from the QMF. The frame memory sizes shown in Fig. 3 for M1A, M2A and M3A ensure that the camera mode processing time delay is identical to that of film mode.

NOTE 1 – A guide to filter name abbreviations is given in Appendix 3.

3.1.2 Encoder vertical conversion of chrominance

The colour-difference signals undergoes vertical sample rate conversion to produce a central 430-line letterbox picture signal, carried out intra-field in camera mode, and intra-frame in film mode.

Referring to Fig. 3, camera mode colour-difference signals are converted as illustrated by the nominal filter plot ENC_UV_C_VSRC, giving separate conversion of each field.

Referring to Fig. 4, 215 lines of intra-frame averaged colour difference signal are generated by a single intra-frame downconversion operation illustrated by the nominal filter plot ENC_UV_F_VSRC. The output from the vertical filter ENC_UV_F_VSRC is a single field of film mode colour-difference signal. In field memories M3A and M3B, the colour difference signal is stored with 64 μs output lines in the two successive fields of the output frame. This ensures that the colour-difference signal in the two fields is identical.

FIGURE 2

Nominal filter characteristics

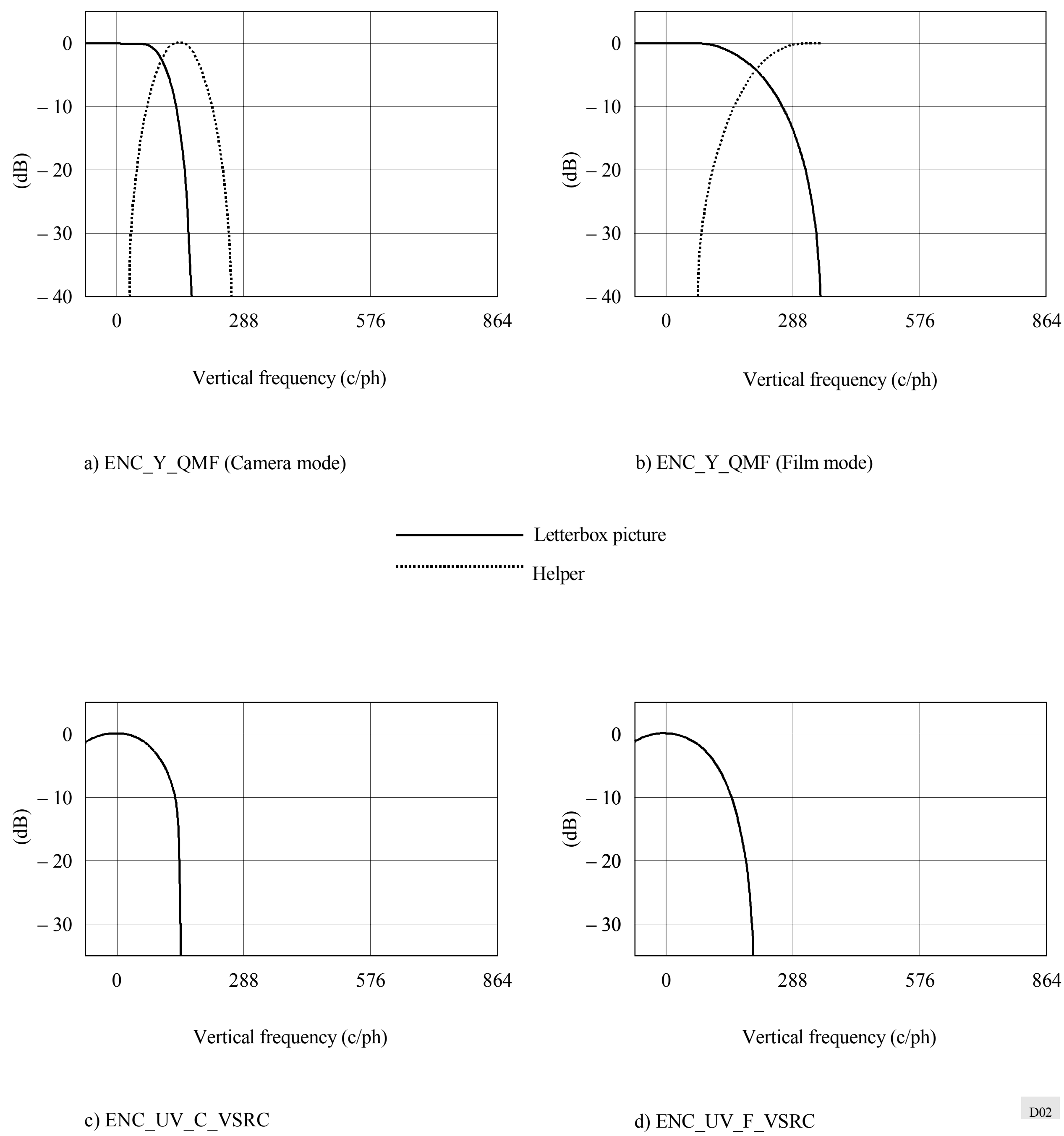


FIGURE 3

Encoder vertical conversion (camera mode)

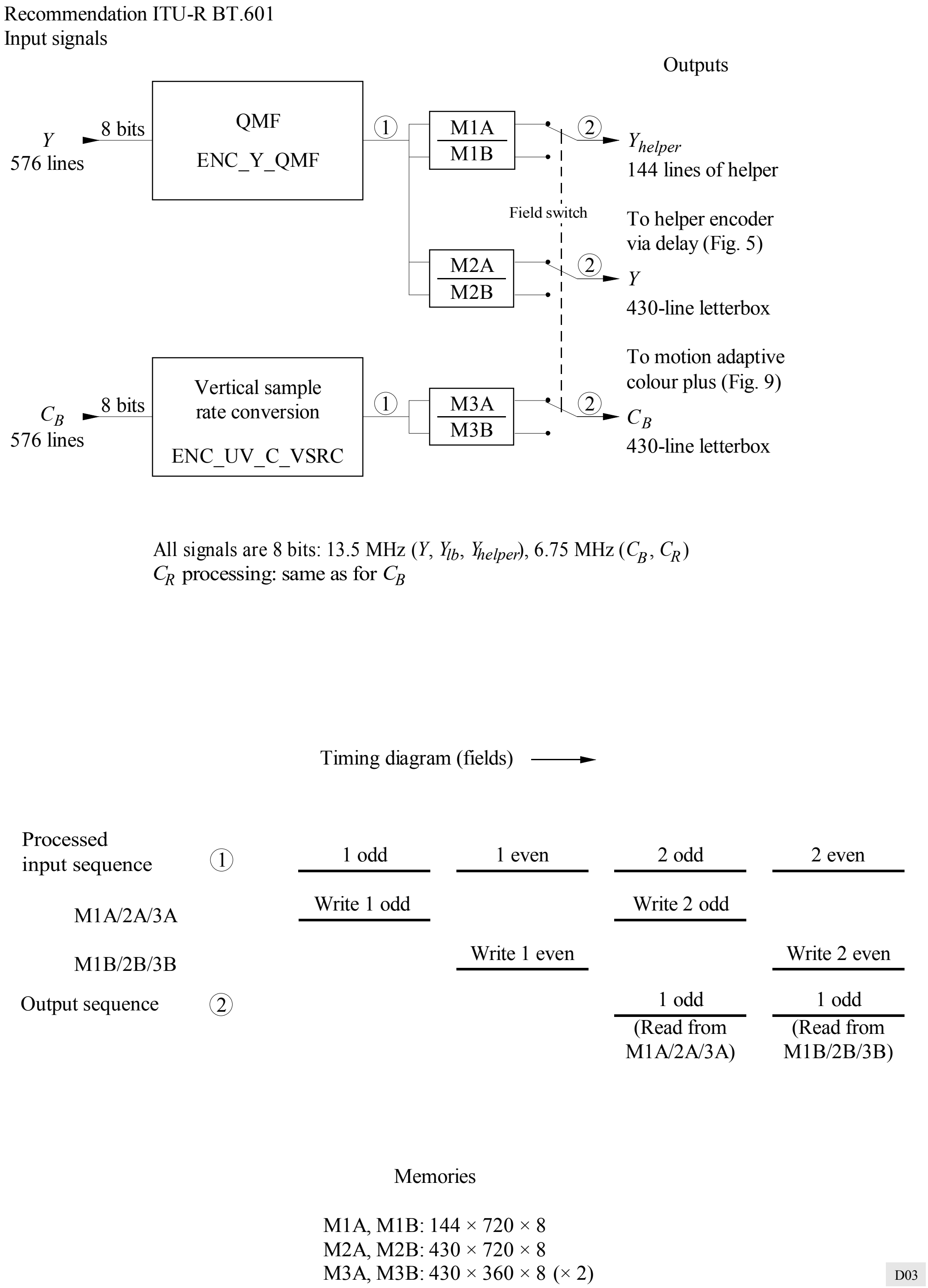
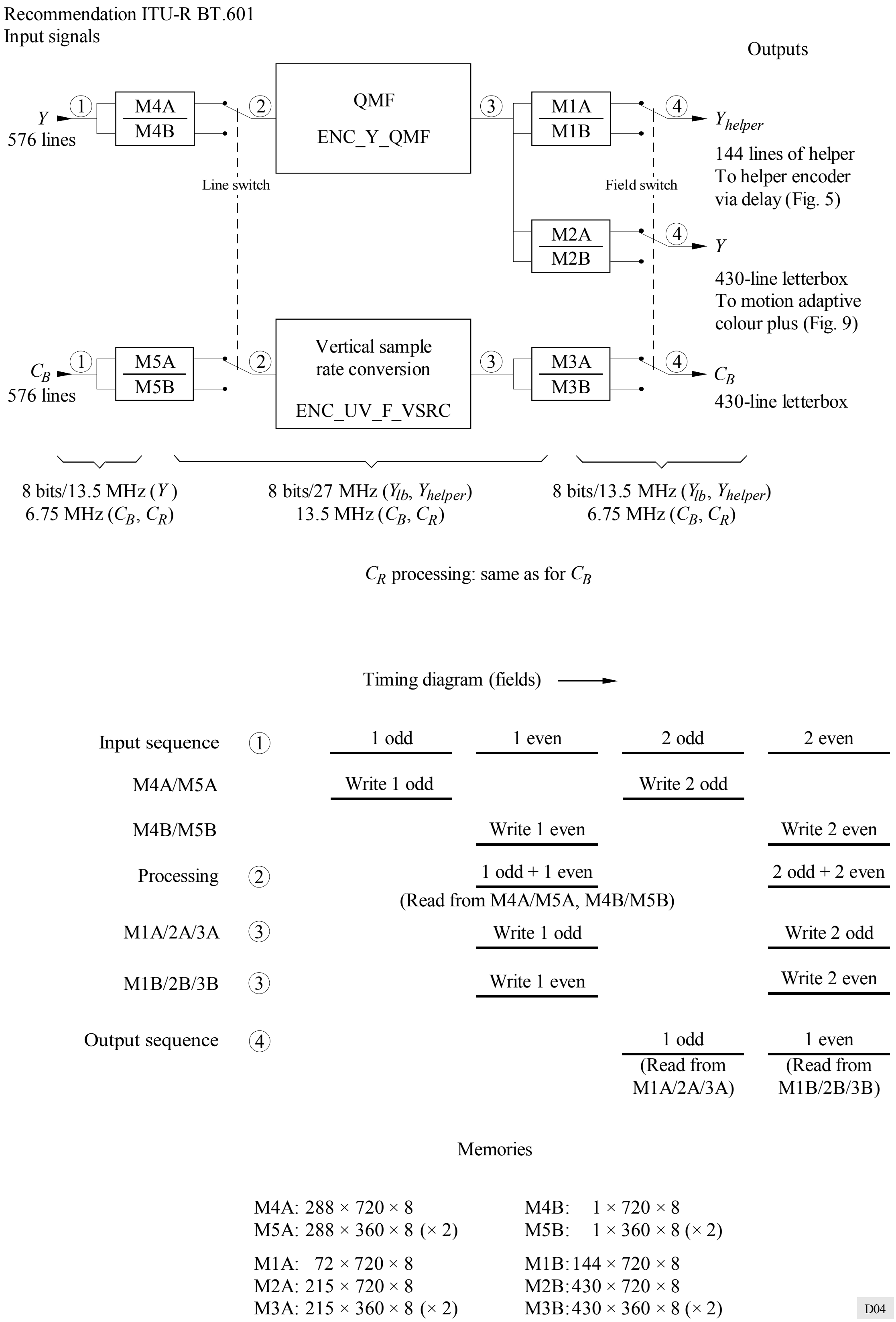


FIGURE 4

Encoder vertical conversion (film mode)



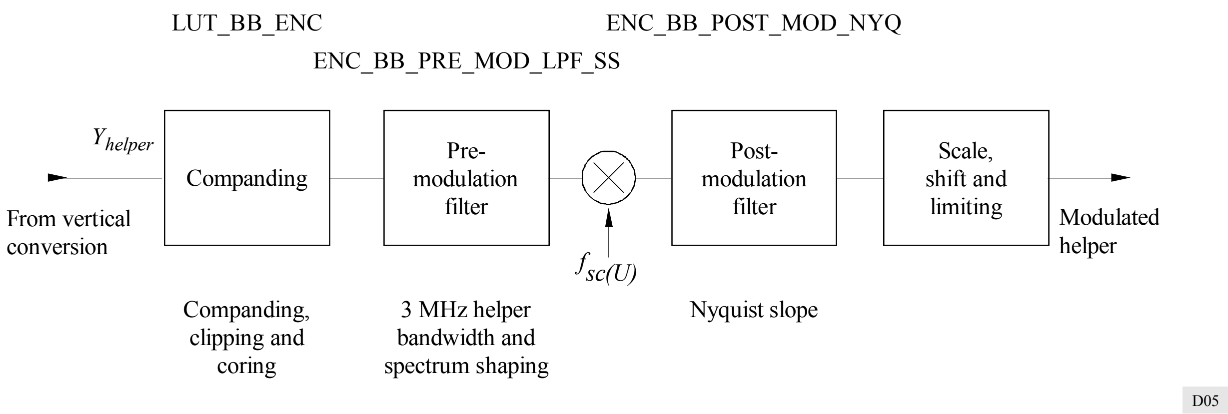
3.2 Vertical helper encoding

The vertical helper signal in the black bands is transmitted symmetrically around black level, with a maximum amplitude of 300 mV peak-to-peak, and makes use of vestigial sideband suppressed carrier modulation of the *U* phase of the colour subcarrier (see Figs. 12 and 13).

The vertical helper encoding scheme is indicated in Fig. 5.

FIGURE 5

Helper encoding

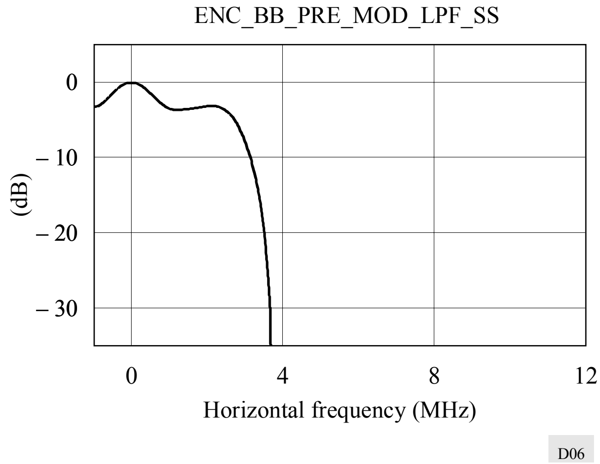


A combination of companding, clipping and coring is applied prior to modulation as illustrated in Fig. 18. Different companding curves are used for camera and film mode, and reciprocal processes are incorporated in the decoder.

A "shaped" full Nyquist filtering system is used in order to help minimize the visibility of the helper signal on the compatible picture and to optimize noise performance.

Low-pass filtering and spectrum shaping prior to modulation is carried out according to the nominal filter shape illustrated for pre-modulation filter ENC_BB_PRE_MOD_LPF_SS:

FIGURE 6
Nominal filter characteristic



Following the low-pass filtering and spectrum shaping referred to above, vestigial sideband suppressed carrier amplitude modulation takes place on the *U* phase of the colour subcarrier.

Following modulation, the helper undergoes full Nyquist filtering (–6 dB at f_{sc}).

Limiting is applied to ensure that the modulated helper cannot exceed ± 150 mV.

The resulting nominal spectral occupancy of the modulated helper signal is shown in Fig. 13, which shows the maximum possible amplitude versus frequency.

The vertical helper encoding processing uses signal paths with a minimum resolution of 8 bits. Signal paths with higher precision may be used.

3.3 Motion adaptive colour plus

The enhanced PAL encoding and decoding processes used in PALplus have been designed to cause minimal cross effects between luminance and chrominance at the output of the PALplus decoder. The technique is known as "motion adaptive colour plus". It encompasses the "fixed" colour plus processing that is used in film mode only, and enables the benefits of colour plus processing to be obtained over most areas of pictures in camera mode.

"Fixed" colour plus uses the fact that points in a PAL signal separated by exactly 312 lines have almost exactly opposite subcarrier phase. Considering a line, say "*n*", in the first field, then the line $n + 312$ is the line in the second field which is immediately above line *n* in the frame. If these two lines carry the same luminance and chrominance information, the luminance and chrominance can be separated by adding and subtracting the composite signals from each other. Adding yields luminance because the anti-phase colour subcarrier cancels. Subtracting yields modulated chrominance because the anti-phase colour subcarrier adds and the luminance cancels. C_B and C_R colour-difference signals free from cross-effects may alternatively be recovered by intra-frame averaging following chrominance demodulation. It is this latter approach that is the preferred method of implementation for the PALplus decoder.

In practice, only high horizontal frequency luminance (above approximately 3 MHz) is intra-frame averaged, because only this part of the luminance signal shares spectrum with the modulated chrominance.

"Fixed" colour plus works well in film mode. However, simply averaging samples 312 lines apart would occasionally cause unacceptable artefacts in camera mode, where there may be some movement between adjacent fields of a frame. A particular problem can occur in fast moving coloured areas: since all of the chrominance signal is averaged, motion artefacts are sometimes visible in the form of colour judder. In camera mode, therefore, motion adaptive colour plus is used, in which a motion detector in both the encoder and decoder detects movement in the chrominance signal.

The output of the motion detector is a control signal which selects between "fixed" colour plus encoding and decoding, and conventional colour encoding and decoding using only low-frequency luminance (up to 3 MHz). In areas of saturated moving colour, the spectrum of the encoded PALplus signal above 3 MHz is occupied solely by chrominance, with no vertical or temporal constraints. The system has been designed such that the motion detectors in the encoder and decoder make similar decisions independent of the amount of motion detected in the encoder.

In film mode, there is no need for the motion adaptive processing, and the colour encoding and decoding processes remain in "fixed" colour plus.

3.3.1 Pre-processing in the encoder

The encoder luminance processing is shown in Fig. 9a).

The luminance is divided into high and low frequency components Y_{HF} and Y_{LF} respectively, as shown by the nominal filter plot Y_BSPLIT in Fig. 7.

The high-pass signal Y_{HF} undergoes vertical pre-filtering and is in addition intra-frame averaged in the following manner, where n is the line number:

$0 \leq n \leq 214$ (PALplus 430-line letterbox picture)

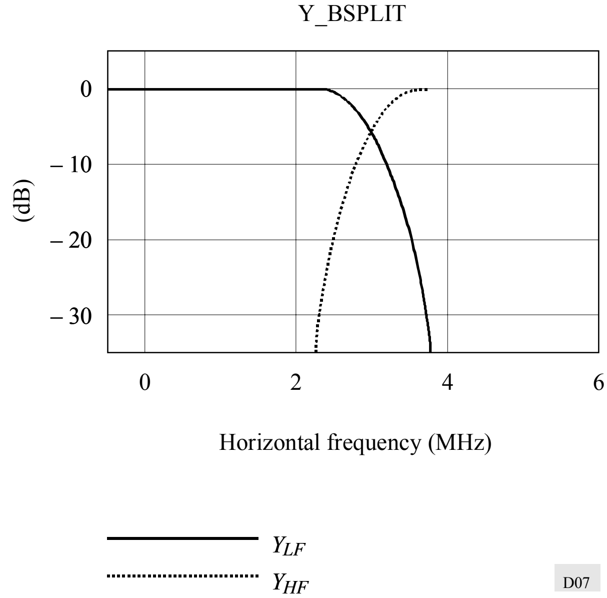
$-36 \leq n \leq 250$ (non-PALplus MACP)

$$Y_{IFA}(60 + n) = 1/2\ (Y_{HF}(372 + n) + Y_{HF}(60 + n))$$

$$Y_{IFA}(372 + n) = Y_{IFA}(60 + n)$$

FIGURE 7

Nominal filter characteristic



The intra-frame averaged signal Y_{IFA} is added back to the low frequency component Y_{LF}, but in camera mode the amplitude of the intra-frame averaged signal Y_{IFA} is first adjusted under control of the motion detector signal *L* (see § 3.3.2). This results in a contribution at reduced amplitude in areas of colour motion in camera mode.

The chrominance processing is shown in Fig. 9b).

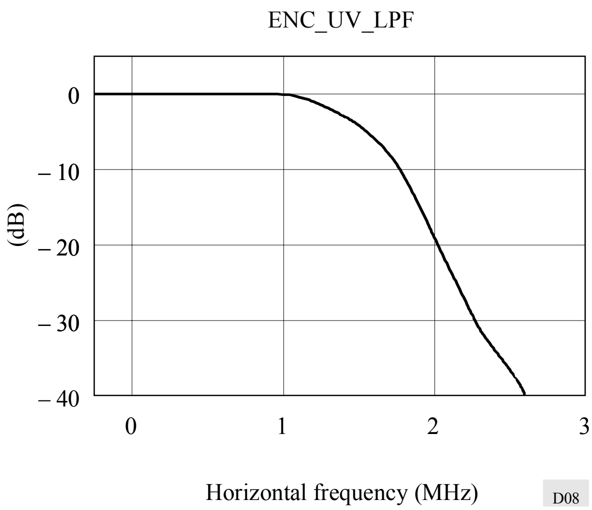
Chrominance low-pass pre-filtering (ENC_UV_LPF) is necessary for motion adaptive colour plus in order to provide sufficient attenuation of colour-difference frequencies higher than nominally 1.4 MHz.

Greater attenuation of high colour-difference frequencies is required than the minimum needed to comply with the normal PAL specification (Recommendation ITU-R BT.470) so as to avoid the introduction of unacceptable cross-luminance artefacts in the PALplus receiver.

The horizontal bandwidths of the colour-difference signals prior to intra-frame averaging is therefore slightly more constrained than referred to in Recommendation ITU-R BT.470, according to the nominal filter plot, ENC_UV_LPF, illustrated in Fig. 8.

FIGURE 8

Nominal filter characteristic



The intra-frame averaging process of each of the chrominance signals C_B and C_R is applied in the following manner, where n is the line number:

$0 \leq n \leq 214$ (PALplus 430-line letterbox picture)

$-36 \leq n \leq 250$ (non-PALplus MACP)

$C_{B(IFA)}(60 + n) = 1/2\ (C_B(372 + n) + C_B(60 + n))$

$C_{B(IFA)}(372 + n) = C_{B(IFA)}(60 + n)$

In camera mode, the outputs of either direct (C_B/C_R) or intra-frame averaged ($C_{B(IFA)}/C_{R(IFA)}$) signals are selected under control of the motion detector signal C as described in § 3.3.2.

In film mode, the chrominance outputs consist of the intra-frame averaged ($C_{B(IFA)}/C_{R(IFA)}$) signals.

In the case of PALplus, the motion adaptive colour plus process is carried out on the 430-line letterbox picture as shown in Fig. 17.

Motion adaptive colour plus may be applied to other Recommendation ITU-R BT.601 input sources, regardless of the aspect ratio, without transmission of helper signals. This is referred to as "non-PALplus MACP". In such cases, motion adaptive colour plus processing in both the encoder and the decoder takes place on all 574 full active picture lines (lines 24-310 and 336-622), whatever the exact picture aspect ratio or setting of the wide-screen signalling aspect ratio bits. For such signals, the PALplus encoder either sets both the second half of line 23 and the first half of line 623 to black level, or, alternatively, may include both the reference signals described in § 3.4.

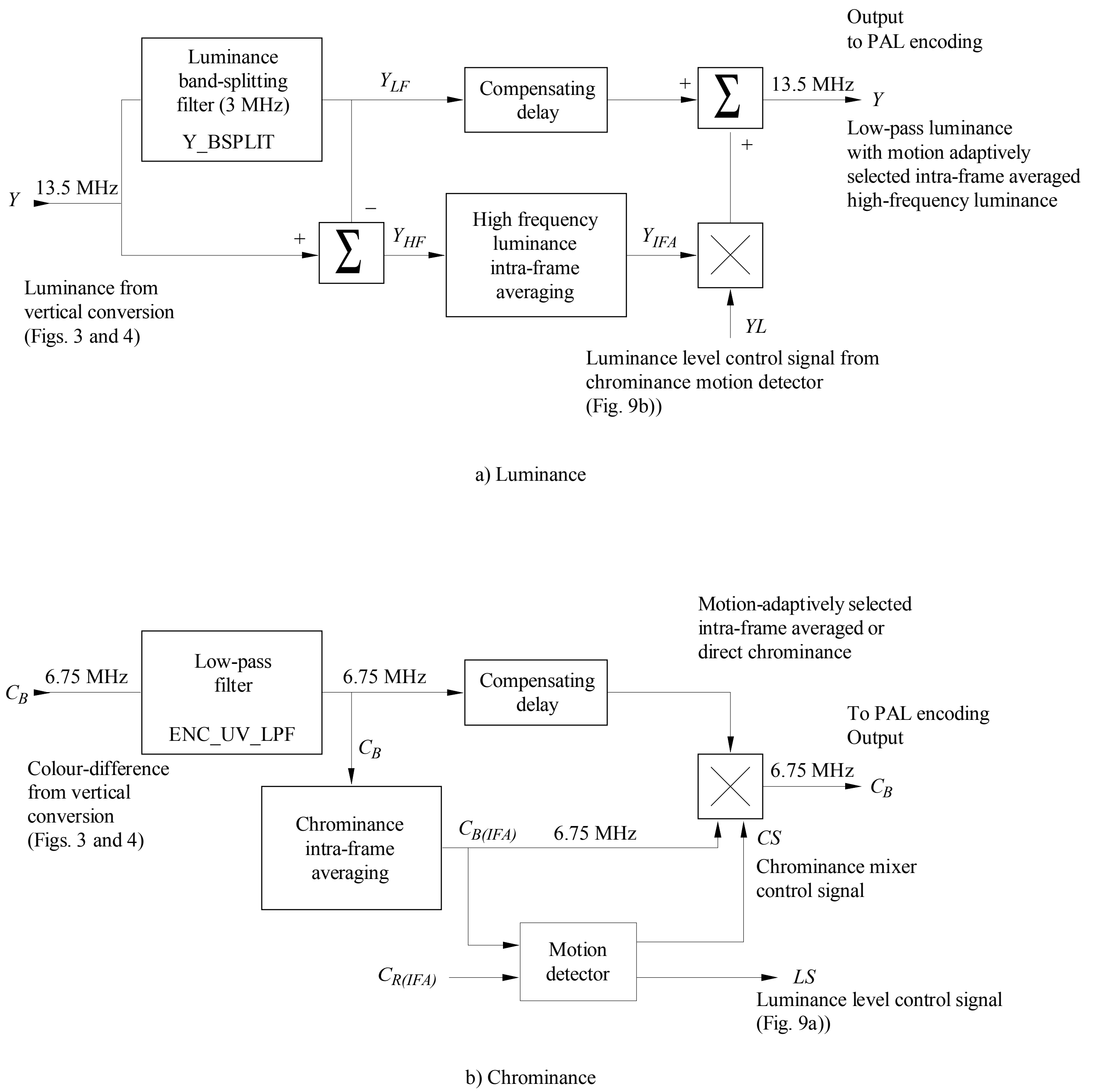
The luminance and chrominance signals resulting from the motion adaptive colour plus process are used to form a composite PAL signal as described in § 2.1.2.

3.3.2 Motion detector operation

A motion detector (see Fig. 9) provides control signals *LS* and *CS* to determine in camera mode whether the spectrum above nominally 3 MHz carries both intra-frame averaged high-frequency luminance and intra-frame averaged chrominance, or non-intra-frame averaged chrominance. (The latter can be considered as sharing of this band between intra-frame averaged and intra-frame difference chrominance.)

FIGURE 9

Motion adaptive colour plus encoding



Note 1 – Processing of C_R is identical to that of C_B.

Note 2 – The motion detector is common to both C_B and C_R processing.

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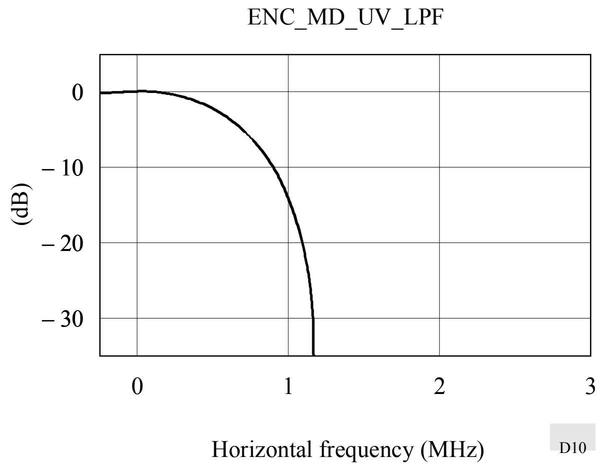
The motion detector makes use of the intra-frame averaged chrominance signals $C_{B(IFA)}$ and $C_{R(IFA)}$ which shall first be low-pass filtered according to the nominal filter plot, ENC_MD_UV_LPF, illustrated in Fig. 10.

FIGURE 10

Nominal filter characteristic

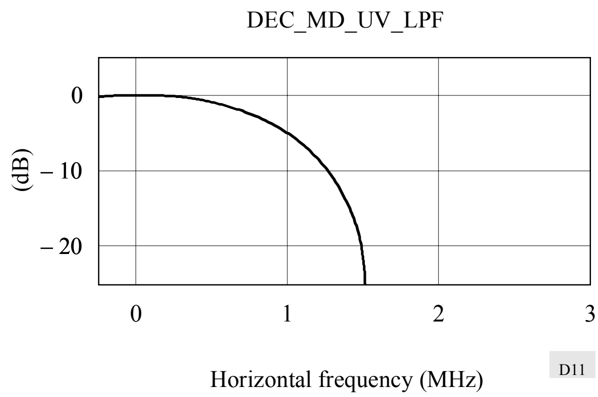


For the system to work correctly, it is important that the same motion signal is generated in both the encoder and the decoder. This means that the encoder must not use information that is not available to the decoder.

The decoder motion detector should operate with intra-frame averaged chrominance signals $C_{B(IFA)}$ and $C_{R(IFA)}$ that have been low-pass filtered according to the nominal characteristics illustrated for DEC_MD_UV_LPF. This ensures that the motion detector operates on signals with comparable bandwidths in both the decoder and the encoder (see Fig. 11).

FIGURE 11

Nominal filter characteristic



3.4 Reference signals

When the transmission contains a modulated helper signal (i.e., when WSS bit $b_6 = 1$, see Table 4) reference signals are inserted into the second half of line 23 as defined in Fig. 14, and into the first half of line 623 as defined in Fig. 15.

The rise-and-fall times (and tolerances) of the helper reference burst in the second half of line 23 are the same as those of the PAL colour burst.

The helper reference burst in line 23 is colour subcarrier with phase of minus *U*, corresponding to the peak amplitude of the modulated helper signal.

The required reference signals in line 23 (see Fig. 14) are preferably generated by applying appropriate baseband signals at the input to the helper encoder (Fig. 5). This is in order to maximize commonality of processing between the helper references and helper signals, and to allow for the compensation of any non-ideal characteristics in the helper encoder. The rise-and-fall times are the same as those of line blanking given in Recommendation ITU-R BT.470.

These reference signals may optionally be included in transmissions of non-PALplus MACP (i.e., when $b_5 = 1$ and $b_6 = 0$).

Table 2 summarizes the contents of the second half of line 23 and first half of line 623, with respect to information signalled by the wide-screen signalling (WSS) system (see § 3.5):

TABLE 2

Summary of contents of second half of line 23 and first half of line 623 with respect to information contained in the WSS

b_6b_5	Contents second half line 23, first half line 623
1X	Reference signals (see Figs. 14 and 15)
01	Black
00	Active picture

3.5 Signalling

The WSS system (Recommendation ITU-R BT.1119) is used. This makes use of data inserted into the first half of line 23 by the PALplus encoder.

The information required specifically for PALplus is to indicate the use of motion adaptive colour plus encoding, and to indicate the presence of the modulated vertical helper signal.

This information is conveyed by two bits within Group 2 ("enhanced services") of the WSS as follows:

TABLE 3

Use of bit b_5 to indicate motion adaptive colour plus encoding

b_5	Colour coding process
0	Standard PAL
1	Motion adaptive colour plus

NOTE 1 – In film mode ($b_4 = 1$) motion adaptive colour plus is set to "fixed" colour plus operation, i.e., is not motion adaptive.

TABLE 4

Use of bit b_6 to signal the presence of the modulated helper signal

b_6	Helper signal
0	No helper
1	Modulated helper

NOTE 1 – A helper signal may be present only when the aspect ratio is a 16:9 centre letterbox (i.e., if $b_0 = 1$, $b_1 = 1$, $b_2 = 0$, and $b_3 = 0$) or ">16:9 letterbox centre" (i.e., if $b_0 = 1$, $b_1 = 0$, $b_2 = 1$, and $b_3 = 1$), and only with ≤ = 430 active picture lines (see also § 3.5.1.1).

A PALplus transmission carries appropriate information in film bit b_4 to signal the presence of camera mode or film mode:

TABLE 5

Use of film bit b_4

b_4	Film bit
0	Camera mode
1	Film mode

A PALplus transmission makes use of the appropriate aspect ratio label bits ($b_0 = 1$, $b_1 = 1$, $b_2 = 0$, $b_3 = 1$) carried in WSS Group 1 in order to signal the presence of a central 16:9 letterbox.

3.5.1 Signalling examples

The following are examples of line 23 wide-screen signalling (WSS) system signalling options that may be provided by the PALplus encoder:

3.5.1.1 PALplus

$b_0 = 1, b_1 = 1, b_2 = 0, b_3 = 1, b_4$ = camera/film bit, $b_5 = 1, b_6 = 1$.

NOTE 1 – It is recommended that PALplus decoders should *not prevent* the use of PALplus processing in the case of transmissions having a “>16:9 letterbox centre” aspect ratio label. There would be no change to helper or MACP processing,

$b_0 = 1, b_1 = 0, b_2 = 1, b_3 = 1, b_4$ = camera/film bit, $b_5 = 1, b_6 = 1$.

3.5.1.2 Non-PALplus motion adaptive colour plus

Motion adaptive colour plus can be used with component picture sources having any of the eight possible combinations of aspect ratio and letterbox position defined by the three aspect ratio label bits (and associated parity bit) of the WSS, such that:

$b_0 = X, b_1 = X, b_2 = X, b_3$ = odd parity bit, b_4 = camera/film bit, $b_5 = 1, b_6 = 0$.

For example, for studio applications, anamorphic 16:9 aspect ratio non-PALplus MACP may be used:

$b_0 = 1, b_1 = 1, b_2 = 1, b_3 = 0, b_4$ = camera/film bit, $b_5 = 1, b_6 = 0$.

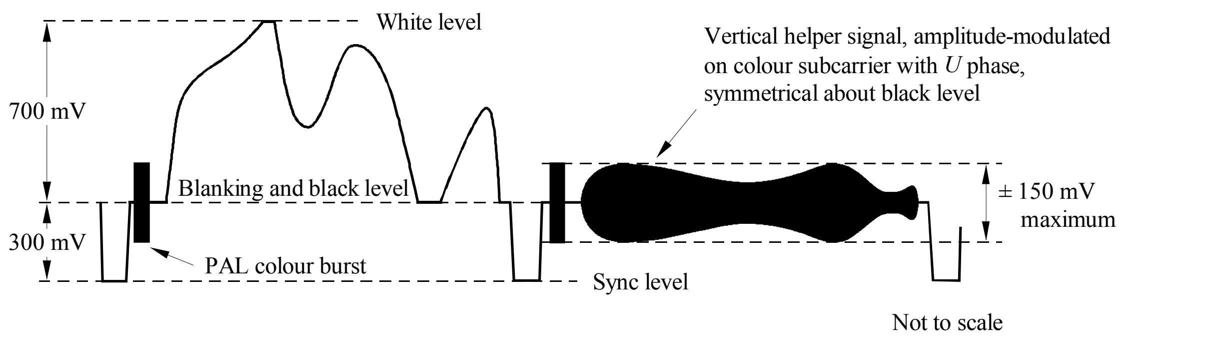
3.5.1.3 Conventional PAL

Where WSS data is included, bits b_0, b_1, b_2 may be used to indicate various aspect ratios of a conventional PAL transmission, as defined in the WSS. Similarly, the film bit b_4 may also be used by receivers to perform optimum upconversion, even with transmissions using standard PAL coding:

$b_0 = X, b_1 = X, b_2 = X, b_3$ = odd parity bit, b_4 = camera/film bit, $b_5 = 0, b_6 = 0$.

FIGURE 12

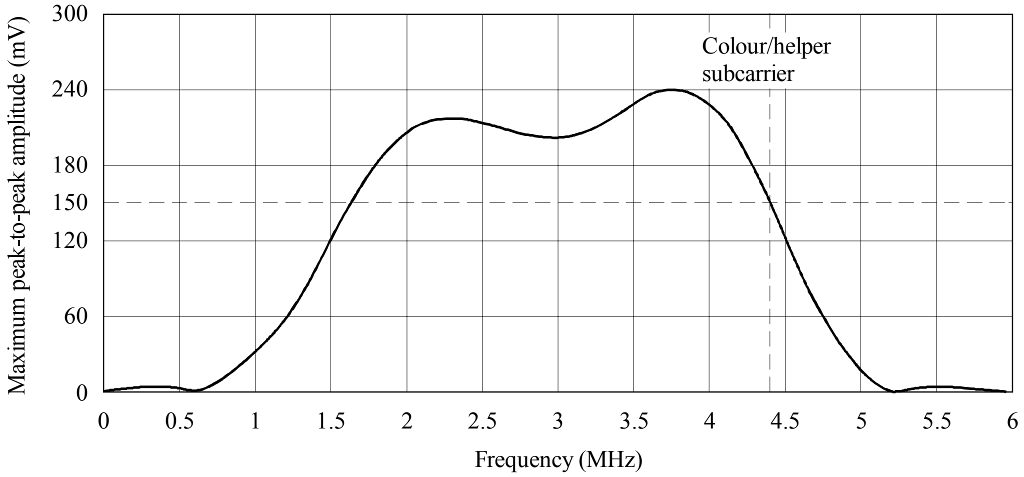
Waveforms showing typical lines of PALplus letterbox picture and vertical helper signals



Note 1 – Standard PAL horizontal blanking applies in lines carrying the vertical helper signal. Burst blanking is identical to that of a standard PAL signal.

FIGURE 13

The frequency spectrum occupied by the modulated helper signal

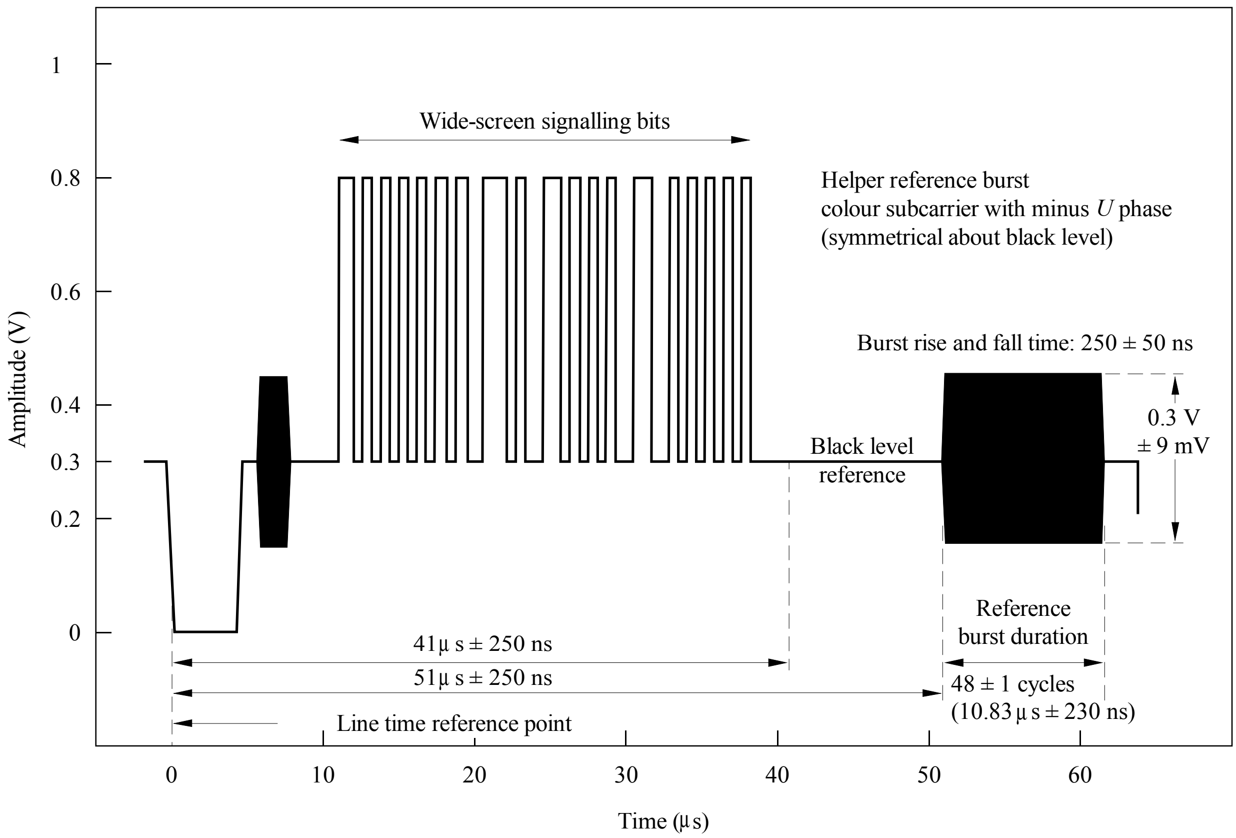


Note 1 – Maximum permissible time-domain helper amplitude is 300 mV peak-to-peak.

D13

FIGURE 14

Reference signals in line 23

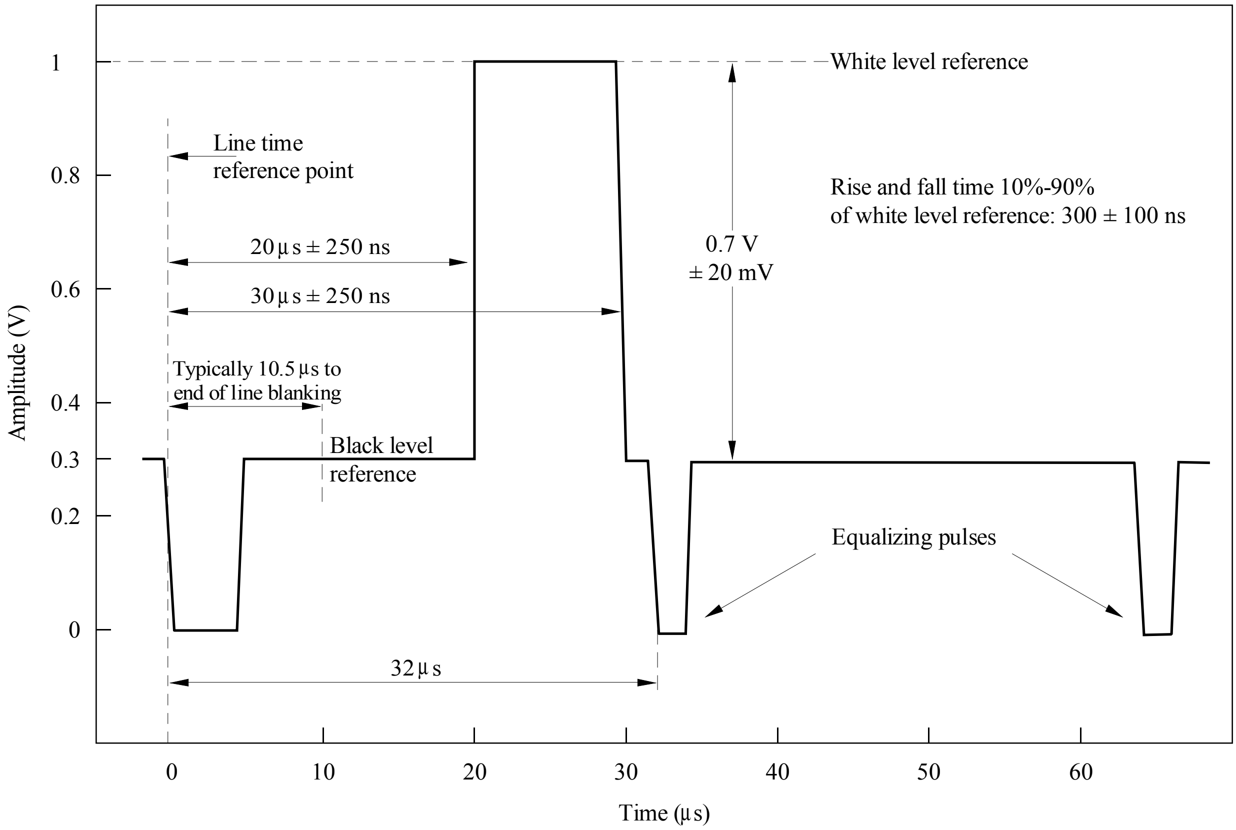


Note 1 – It is recommended that the reference signals be generated by applying appropriate baseband signals to the helper encoder.

D14

FIGURE 15

Reference signals in line 623

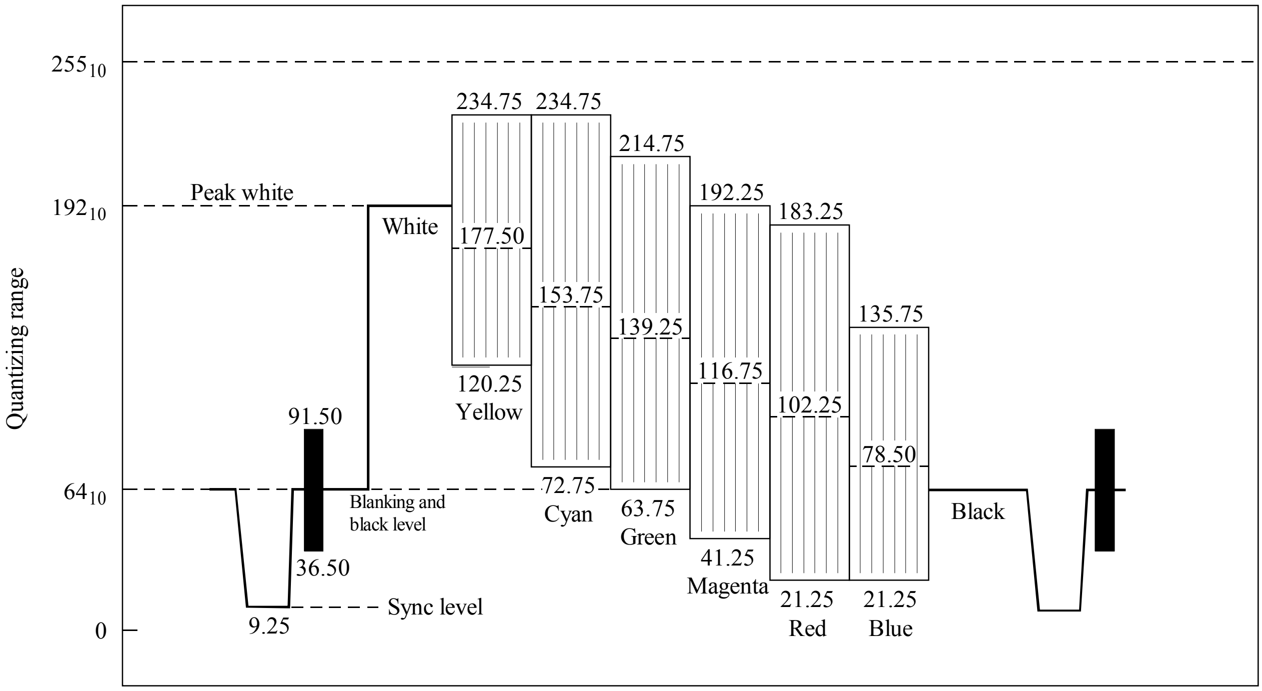


Note 1 – There is no burst in line 623.

D15

FIGURE 16

Digital representation of the PALplus signal at the output of the encoder, showing the quantizing range



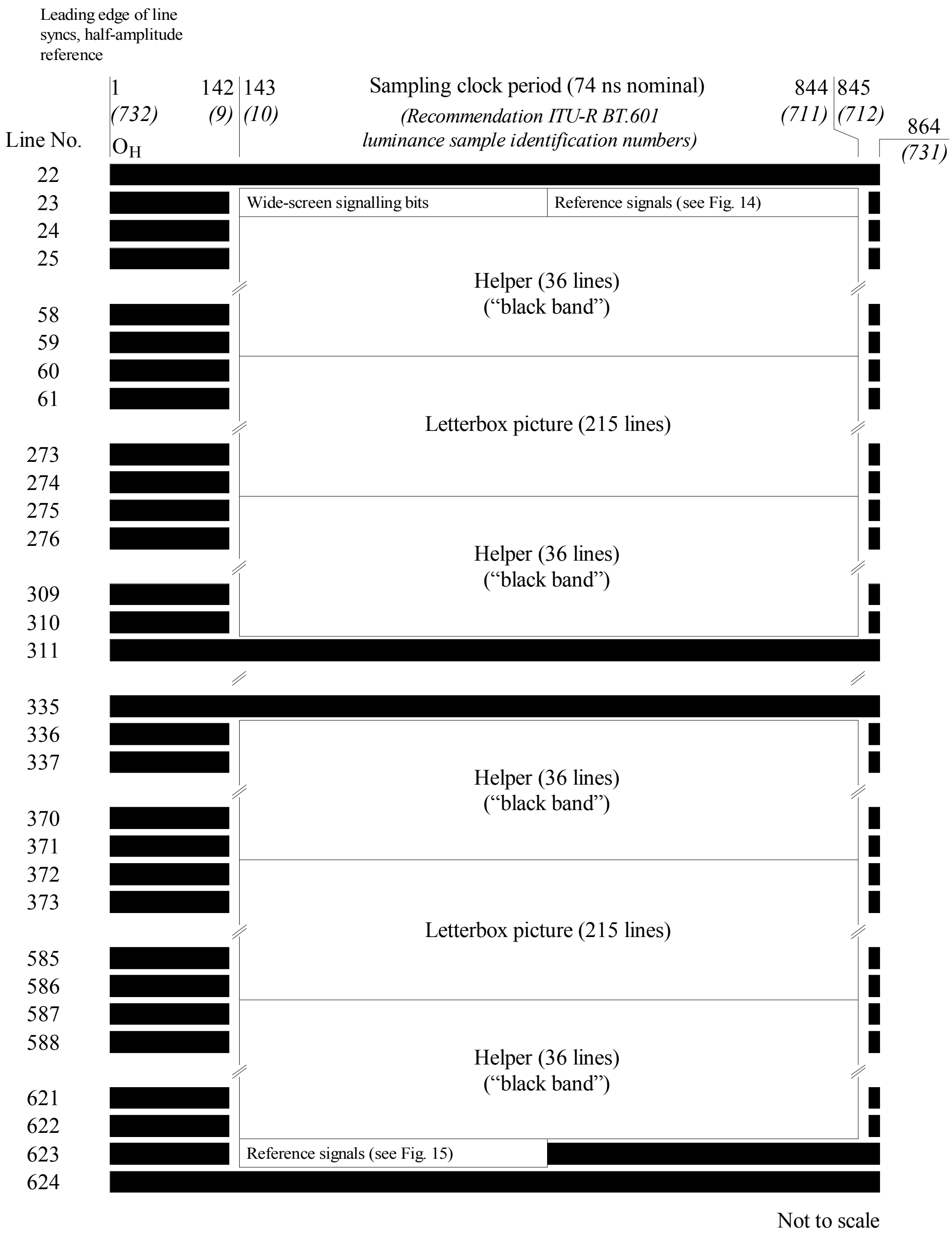
Note 1 – Permitted values: 1.00_{10} - 254.75_{10}
Protected values : 0.00, 0.25_{10}, 0.50_{10}, 0.75_{10},
255.00_{10}, 255.25_{10},
255.5_{10}, 255.75_{10}.

Note 2 – Nominal values are shown for the line waveform for 100% amplitude, 100% saturation colour bars. The signal is coded with 10-bit resolution.

D16

FIGURE 17

Format of the PALplus frame

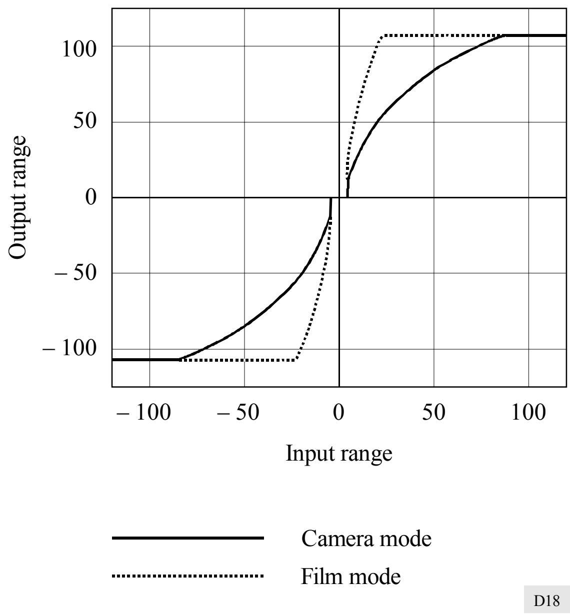


Note 1 – Sampling clock periods correspond to those of Recommendation ITU-R BT.601 (sampling frequency: 13.5 MHz) as indicated above. Active lines contain 702 samples for letterbox picture or helper.

D17

FIGURE 18

Illustration of the effects of helper companding



APPENDIX 1

TO ANNEX 1

Report on the European Broadcasting Union (EBU) evaluation of the PALplus system

This Appendix describes the enhanced wide-screen PALplus system performance, and the features and facilities which distinguish it from normal PAL.

1 Basic picture quality

1.1 EBU quality requirements

The picture quality achievable on an enhanced PAL receiver with adequate received signal strength must be better than available from state-of-the-art letterbox (see Note 1) PAL services (i.e. without helper signals, viewed on a 16:9 display, and with the scan height expanded to fill the screen), and should be about equivalent to that available from 16:9 4:2:2. It should be evaluated in the light of the quality guidelines set out in Recommendation ITU-R BT.1127 on relative quality.

Subjective evaluations (performed using the double stimulus continuous quality scale method (DSCQS) (Recommendation ITU-R BT.500) at 4 *H*) with a 4:2:2 signal as reference which included:

– PALplus,

– letterbox PAL,

need to show that PALplus lies between the 16:9 4:2:2 reference and letterbox PAL for picture material, including that chosen to be "critical but not unduly so". As a guideline the 4:2:2 to enhanced PAL difference should be up to about 12% on the DSCQS scale.

NOTE 1 – "Letterbox" means, in this context, that there is no precoding at the transmitter or helper signals to improve resolution.

1.2 Subjective tests

These tests have been conducted using the full specification reference PALplus encoding and decoding equipment with no interconnecting simulated or real channel.

1.2.1 Test set-up

Subjective programme material comprising eight sequences (two of which were film material) was presented on a 16:9 display in tests to determine relative evaluation of 4:2:2, decoded PALplus and letterbox PAL picture quality.

The DSCQS test method was employed with viewing at 4 *H*. The eight sequences were chosen to specifically stress, but not unduly so, the known properties of the PALplus system. A complication in testing arose by reason of the 4:2:2 and decoded PALplus signals being full 576 active picture lines whereas the letterbox PAL pictures were accommodated in 430 active lines. It was therefore necessary to arrange that the displays used could remotely expand the vertical scans without disturbance during presentation of the letterbox pictures in order to fill the full screen height.

The majority of tests (78 observers) were conducted on 20" 4:3 professional monitors masked down to 16:9. Separate tests with six observers were conducted on a 16:9 professional monitor using a commercial 28" CRT. Further separate tests, 12 observers, used a 38" HDTV display, the test signals being up-converted from 576 or 430 lines as appropriate.

1.2.2 Subjective test results

– Results from individual laboratories tests showed a high level of consistency despite the different test conditions and set-up used (see Fig. 19). Variations of assessments in each test covered a wide range.

– With the film sequences, PALplus achieved a quality about equivalent to 16:9 4:2:2 (less than 3% different) although with the same sequences with letterbox PAL, there was visible impairment (10-35%) relative to 16:9 4:2:2.

– With camera pictures PALplus achieved a considerable reduction in picture impairment, compared to letterbox PAL.

– Some camera sequences, two overall and four from one laboratory, just failed to achieve less than 12% impairment as required by EBU.

– Overall results showed a 8.5% difference on the DSCQS scale between PALplus and anamorphic 4:2:2. The difference between PAL letterbox and anamorphic 4:2:2 reached 31%.

1.3 Expert evaluation

These tests have been conducted using the full specification reference PALplus encoding and decoding equipment with no interconnecting simulated or real channel.

1.3.1 Viewing conditions

To represent existing displays, a range of domestic and professional monitors was used varying from 17" to 38".

Some of these used 625-line, 2:1 interlace, others used higher line-rates and were fed via two professional up-converters and an experimental circuit. In one test, the display was switched from 625-line 1:1 to 1250-line 2:1. One domestic display worked at 100 Hz using an internal converter.

To represent larger displays, an HDTV projection produced an image of 4 m diagonal and was driven using a professional up-converter.

The expert viewers were encouraged to use a range of viewing distances from 3 *H* to 10 *H*. In one test, the viewing distances necessary to render differences between different presentations were used to quantify visible picture differences.

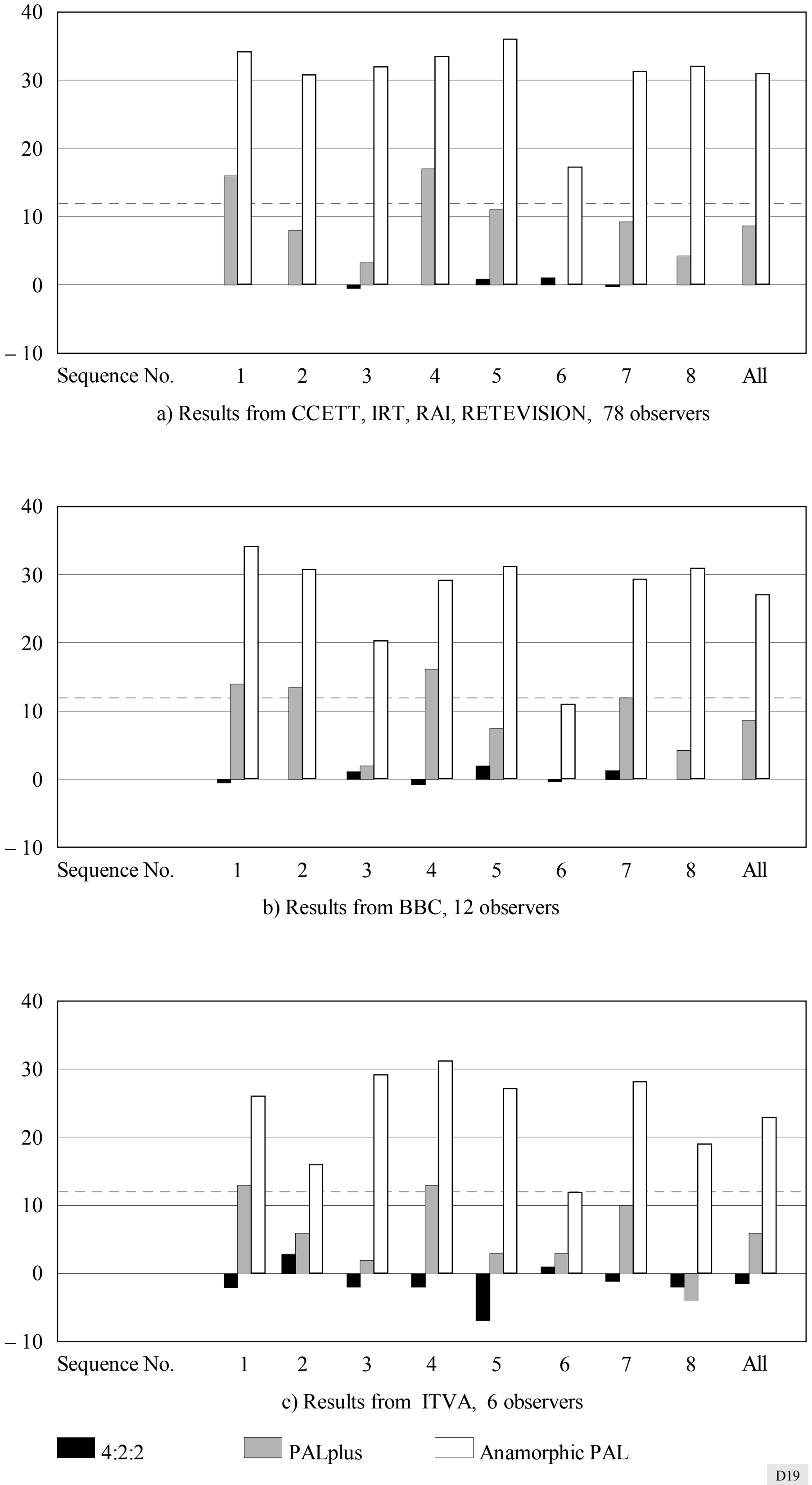
1.3.2 Test material

A very wide range of picture material was used which was mainly derived from HDTV programme recordings via a professional down-converter. A test programme, recorded in the Netherlands, using modern CCD 625-line 2:1 cameras represented the best of current programme material.

A series of critical sequences processed using MPEG-2 MP@ML (at 6 and 9 Mbit/s) were used for informal comparisons.

FIGURE 19

PALplus basic picture quality at 4 *H* (normalized)



1.3.3 Conclusions on expert assessments

The conclusions drawn included the following:

– After viewing a range of picture material with baseband tests, the specialists concluded that, overall, the system gave a quality close to 4:2:2 picture quality (576 active lines) for nearly all natural programme material from different sources at viewing distances of 4 *H* or more.

– The PALplus system removes the quality ceiling on PAL which is mainly set by luma-chroma cross effects. PALplus and PAL have similar colour-difference bandwidths. In PALplus, the MACP can also influence the portrayal of moving details. This means most impairments are limited to pictures with moving detail. PALplus' own quality ceiling is probably set by the limited signal bandwidths, particularly for high saturation moving coloured areas when the luminance bandwidth is also reduced.

– The limit on delivering the potential quality to the home will be set by the capabilities of home receivers and the characteristics of the transmission system. 16:9 display systems currently available to the consumer do not allow the delivery of the full capabilities of the system. PALplus would benefit from better quality displays.

– The use of down-converted HDTV source material, and modern high quality 625-line 16:9 CCD cameras, can be a significant benefit to the PALplus (and PAL) picture quality.

– PALplus would not be out of place in an HDTV environment at viewing distances of 4 *H* or more.

1.4 Evaluation of elements of the system

1.4.1 Evaluation of the contribution of MACP

The conclusion was as follows:

– There are clearly visible benefits, in both up-converted and non-up-converted receivers, from MACP. The impact of PAL on a 16:9 display and/or a large display is to magnify the degree of annoyance caused by PAL artefacts. Thus, the benefit of the MACP processing becomes more important with 16:9 displays and larger displays.

1.4.2 Evaluation of the contribution of the helper signal

The conclusions drawn included the following:

– The helper provides the means of reconstructing the full 576 active picture lines for the display from the transmitted 430-line letterbox.

– The contribution of the helper to picture quality for video camera originated material (camera mode) is greater than for film material (film mode). This is not because there is necessarily less detail in the film source, but because the helper conveys only the higher spatial frequencies in this mode.

– When the display is 1250-line interlace, the presence of the helper improves the picture quality, when high vertical detail is present in the source, in two ways. Firstly, it provides more vertical detail, and secondly it makes field based alias (interline twitter, line crawl) less visible. High vertical details can be expected in areas of the picture, from down-converted HDTV, and modern high-quality 625-line 16:9 CCD cameras, and from electronically generated captions and graphics.

– For the 625-line interlaced display, the most significant assistance from the helper is the reconstruction of the full 576 active picture lines which reduces the visibility of the line structure. The helper thus allows a more efficient way of reducing line structure than either expensive line standards conversion with its own separate artefacts or the much simpler vertical scan expansion. The other improvements due to the helper, as described above, are perceptible for the 625-line display but may not be so obvious to the non-expert.

1.4.3 Contributions of the different elements

– In overall terms, in the PALplus system, the improvement provided by MACP predominates, particularly in the 16:9 large screen (≥ 32") environment at viewing distances of about 4 *H*. In this case, it provides most of the quality gain of the PALplus system. This is because the overall ceiling on PAL quality (at 6 *H* or more) is set by cross effects rather than resolution. However, the helper system does provide some benefit which becomes more important with increasing screen size. Importantly, the helper system seems to be the cheapest (and possibly best) route to line-structure-free 16:9 large screen display, although it would be more expensive to implement than a simple zoom system.

– 16:9 systems which use zooming or line-rate 4:3 interpolation both have shortcomings. For systems with zooming the line-structure is visible. For systems with line-rate doubling up-conversion, additional artefacts are introduced.

– Motion adaption artefacts are visible on specially constructed sequences with horizontally moving captions and on horizontally moving coloured bars against a detailed background. This indicates that failure of MACP encoding is possible, but no other sequences were found where the effect was perceptible and disturbing.

2 Compatible picture quality

2.1 EBU compatible picture quality requirements

The picture quality available on a conventional PAL receiver when enhanced PAL is being broadcast needs to be acceptable to viewers with conventional PAL receivers. The fact that enhanced PAL is being broadcast should not make the broadcast less attractive or less likely to be watched on 4:3 receivers. The possibility of using open subtitling must be taken into account in making this judgement. Given that the system is a letterbox system there should be no significant difference in quality when compared to conventional letterbox.

In precise terms, as a guideline, this would mean that subjective evaluations (performed using the DSCQS method at 6 *H*), with a 4:2:2 letterbox signal as reference, should give an enhanced PAL compatible quality not more than 12% different from the letterbox PAL quality on existing receiver.

Enhanced PAL receivers should be arranged to display letterbox PAL services without additional artefacts in full-screen format.

The subjective picture quality should not be degraded by an increased visibility of the helper signal when displaying compatible enhanced PAL pictures on a conventional PAL receiver.

2.2 Subjective tests

These tests have been conducted using the full specification reference PALplus encoding equipment.

A state-of-the-art delay-line and notch-filter PAL decoder with no interconnecting simulated or real channel was used.

2.2.1 Test set-up

Subjective programme material comprising the same eight sequences as used for the basic quality tests was presented on a standard 20" 4:3 professional monitor to determine the relative qualities of a 4:2:2 letterbox, encoded PALplus, and encoded PAL letterbox. The encoded PALplus signals were naturally in 430-line letterbox format, the 4:2:2 pictures were down-converted from full frame 576 lines to 430-lines letterbox, and also encoded to PAL for the PAL letterbox. No monitor switching was required, however to isolate the subjective effects of helper visibility of the encoded PALplus pictures, some monitors were masked off to cover the black-band helper regions.

2.2.2 Subjective test results

– Tests with top and bottom of screen taped over (no visible helper) showed a high level of consistency with generally small differences between the different presentations (see Fig. 20).

– Film sequences (with no visible helper) showed bigger differences with PALplus presentations than camera sequences although there was no significant failure of compatibility.

– When the masking tapes were removed (see Fig. 21), the assessments of compatibility showed general overall bigger differences than with no helper visible. There was no consistent difference between film and camera pictures. The assessment of sequences known to generate largest helpers tended to be worse, showing that visibility of the helper may have an effect on compatibility. But the differences were still 10% or less and therefore not significant.

2.2.3 Expert evaluation

2.2.3.1 Helper visibility

– An appraisal was made of the visibility of the helper signal on 4:3 receivers. When used on a well adjusted monitor, the helper signal was practically invisible at normal viewing distances (6 *H* or more).

– If the black level was "sat up" (i.e. mis-adjusted), and chrominance was increased, the helper was perceptible at the same viewing distances. The visibility of the helper varied significantly with picture content, but rarely became sufficiently conspicuous to be annoying.

– The limit on visibility will be set by practical home receiver adjustment, rather than the transmission system.

– Captions with high luminance set against a black background seem to give rise to the most noticeable helper artefacts.

2.2.3.2 MACP

The reception of pictures with MACP on 4:3 PAL professional monitors (notch filter decoder) was such that no additional impairments were observed. The pictures were the same or better quality than they would otherwise have been with standard PAL encoding and decoding. The system can be considered PAL-compatible.

3 Transmission

The following sections refer to information gathered from the PALplus consortium.

3.1 Terrestrial transmission

The current terrestrial networks are suitable to transmit and broadcast the PALplus signals. Depending on the technology used in the radio links and transmitters networks, different performances can be expected.

3.1.1 Links

Analogue links will, in general, exhibit a similar performance with PALplus signals. Some type of digital links may require new interfaces to convey PALplus signals.

3.1.2 Transmitters

Transmitters do not need, in general, any modification to manage the PALplus signals. Only some pulsed klystron type transmitters may require some special adjustment, or circuit modification, to achieve a proper performance with the new signals.

FIGURE 20

Compatible PALplus, helper masked at 6 *H* (normalized)

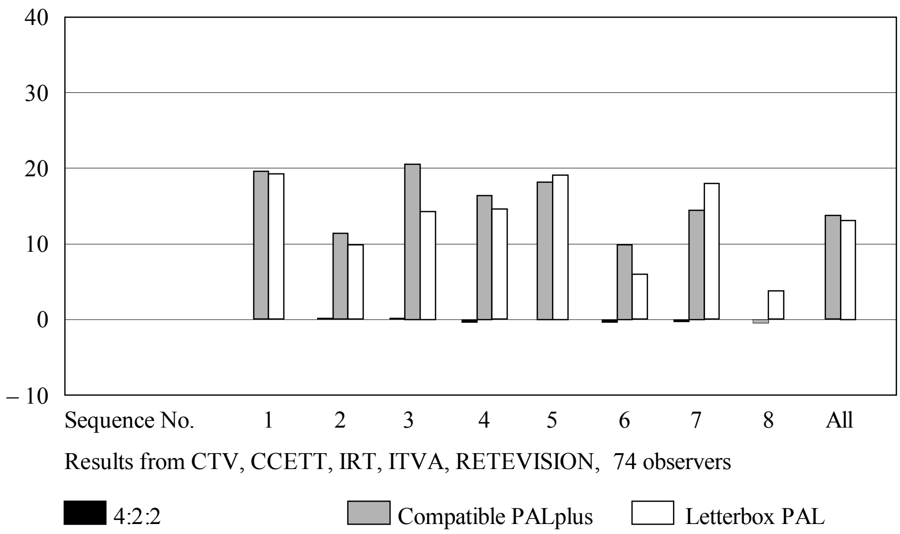
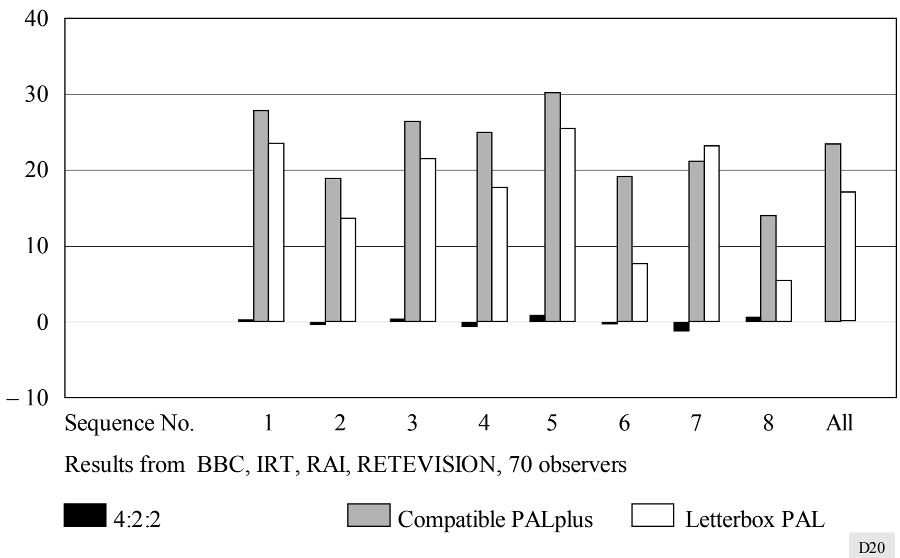


FIGURE 21

Compatible PALplus, with visible helper masked at 6 *H* (normalized)



3.2 Cable networks

An extensive measurement campaign in the Dutch cable networks, using PALplus signals, has shown a generally high level of performance with no impairment affecting PALplus differently from PAL.

3.3 Satellite

The overall quality achieved by PALplus via satellite tends to be limited by the performance of cheap satellite domestic equipment. With high quality equipment good PALplus quality is achieved.

With camera pictures PALplus can input visible noise when the smaller size dishes are used. Film pictures do not suffer in this way.

4 Reception

4.1 *C*/*N* requirements

In the normal service area, PALplus and PAL have similar noise performances.

In the fringe area, the PALplus signal displays more noise than a normal PAL signal. The noise penalty increases as the *C*/*N* reduces (up to 2-3 dB).

4.2 Interferences

4.2.1 PALplus as wanted signal

Initial tests made with a professional PALplus receiver have shown that the PALplus signal can be up to 2 or 3 dB more sensitive than PAL against interferences. Additional measurements with domestic PALplus receivers are needed to get definitive figures.

4.2.2 PALplus as unwanted signal (PAL as wanted)

For all channel combinations (co-channel, adjacent and image channel), and for all offset situations, the PALplus signal shows the same performance as PAL. As a consequence, no modification of the protection ratio figures of Recommendation ITU-R BT.655 is needed.

4.2.3 PALplus as unwanted signal (SECAM as wanted)

PAL and SECAM performances against interferences, as they are gathered in Recommendation ITU-R BT.655, are quite similar. It may be expected that protection ratio figures for “SECAM signals interfered by PALplus” be similar to those for “SECAM signals interfered by PAL”, but this should be verified by measurements.

4.3 Scrambling tests (information provided by the PALplus consortium)

PALplus tests have been performed with five different scrambling systems currently used in Europe.

These systems were examined in a closed circuit, some of them also over a satellite and cable path.

No fundamental problems occurred during this test phase. PALplus is working with all five systems. A good picture quality could be achieved.

The wide-screen signalling could be transmitted as all systems are transparent to line 23.

5 Receiver complexity

5.1 EBU requirements

Enhanced PAL receivers should be financially within reach of the general public no more than two years after their production. Different cost/quality formulae prove attractive in different parts of Europe. However, as a general guideline, experience has shown that a cost increment of more than about 30% compared to an equivalent height conventional receiver will severely discourage receiver sales.

The system should enable the economic integration of decoders within commonly purchased domestic recorders and displays and not be limited to high-end products.

5.2 Information gathered from the PALplus consortium

The receiver manufacturers within the PALplus consortium (Philips, Grundig, Thomson, Nokia and Sony) are committed to come to the market with the first PALplus receivers by the end of 1994. The first generation of PALplus sets is expected to carry a cost increment of up to about 30% compared to equivalent existing PAL 16:9 receivers. Dedicated Silicon PALplus decoders will not be available for this first generation of receivers. The PALplus decoders used by these sets will be based on digital programmable video processors. Dedicated Silicon PALplus decoders are expected to become available within the next two years, and should considerably reduce the cost increment. The PALplus receivers manufacturers have decided to introduce PALplus into the marketplace via 28" and 32" high-end equipment. The view of the above-mentioned manufacturers is that integration of PALplus decoders into smaller, cheaper sets will be determined by market demand.

6 Recording

6.1 EBU requirements for professional recording

The enhanced signal must be capable of transparent recording on existing professional recorders.

6.2 Tests results on D2 and D3

D2 and D3 digital composite professional video-recorders have been used extensively during the course of transmission tests by broadcasters within the PALplus consortium. With only a minor modification (switching off the clipping below black level during playback) these recorders are capable of transparent PALplus recording and playback.

6.3 EBU requirements for home recording

Current home video-recorders must be able to make compatible 4:3 letterbox recordings with a quality potential equivalent to that available with conventional PAL on these recorders.

Domestic recording facilities must become available economically to deliver a satisfactory off-air recording to a 16:9 display, comparable in quality to that available from prerecorded media.

6.4 Information gathered from the PALplus consortium

VCR manufacturers associated with the PALplus consortium intend to launch first generation home-recorders at IFA '95. These will be based on the VHS and S-VHS format and will incorporate line 23 signalling and helper processing. The cost increment is expected to be small compared to equivalent conventional PAL VCRs. MACP will not be incorporated in these first generation PALplus VCRs. It is hoped that continuing studies will lead to the benefit of MACP being included in future generation of consumer VCRs, together with the ability to record teletext subtitles.

7 Open subtitling

This issue has been duly considered. Options have been identified which could potentially mitigate the open-subtitling issue.

Some aspects are common to any letterbox broadcast where subtitling or logo could be involved.

These options could not be tested as the corresponding PALplus equipment was not available.

8 Overall conclusions

The EBU having set up an ad hoc Group (V/EPS) to investigate enhanced compatible wide-screen television recommends that where there is a requirement for delivery of an enhanced compatible wide-screen television system based on PAL, the PALplus system should be used.

APPENDIX 2

TO ANNEX 1

Informative note on receivers for the PALplus system

The recovered luminance signal from a PALplus decoder can be expected to have a horizontal bandwidth limited principally by the characteristics of the transmission system: for example, 5 MHz in the case of System B/G, or 5.5 MHz with System I.

The horizontal bandwidth of the decoded chrominance signals can be expected to be approximately 1.0 MHz (–3 dB), depending on filtering chosen in the decoder, and the characteristics of the transmission system.

Receivers should have a good, reasonably flat, IF vision response up to 4.43 MHz, and should exhibit no significant band-edge distortions up to 5.0 MHz in the case of Systems B/G and preferably up to 5.5 MHz for System I. In the case of System I and where a wider IF bandwidth is used than for System B/G, it should be noted that additional filtering should preferably be applied to the modulated helper signal so as to avoid the introduction of noise above nominally 5 MHz.

The standard method of display of a PALplus signal is in 625-line interlaced (50 Hz) form, with 576 active picture lines, although other display formats (for example, 50 Hz progressive or 100 Hz interlace) are receiver options.

PALplus receivers shall make use of a wide-screen display with an aspect ratio of 16:9.

Delays may be incorporated in the audio paths to compensate for the delay in the vision processing. The vision delay will depend on the receiver implementation, but might in practice be expected to be of the order of 30 ms.

PALplus receivers make use of the aspect ratio label bits b_0, b_1,and b_2 (and parity bit b_3) carried in WSS Group 1, and bits b_4, b_5 and b_6 in WSS Group 2, and are preferably able to deal with both PALplus and non-PALplus MACP.

It is recommended that PALplus decoders should not make use of the helper signal for transmissions signalled as having "subtitles out of active image area" (WSS bits $b_9 = 0$, $b_{10} = 1$).

There may be circumstances in which PAL/PALplus signals are transcoded directly into SECAM, with no attempt to alter the signalling information carried by the WSS. Therefore, in the case of receivers designed for operation in a SECAM environment, it is advisable to ensure that use of the PALplus helper signal is made only when a transmission is being received in the PAL system, regardless of the status of bit b_6 as signalled by the WSS.

Correct operation of the MACP process used by the PALplus system relies on the fact that points separated by 312 lines within a frame have a precise phase relationship. In order to avoid disturbing this relationship, any changes to the equalization of the signal applied by a ghost canceller located in either the transmission or reception chain should be made during the period of lines 624 to 22.

APPENDIX 3

TO ANNEX 1

Filter name abbreviations

The following is a guide to the short-form notation used to construct system coefficient names:

BB: black bands

BPF: band-pass filter

BSPLIT: band-splitting filter

C: camera mode

CS: motion detector chrominance switching control signal

DEC: decoder

ENC: encoder

F: film mode

HF: high-frequency component

IFA: intra-frame averaging

LF: low-frequency component

LPF: low-pass filter

LUT: look-up table

LS: motion detector luminance level control signal

MACP: motion adaptive colour plus

MD: motion detector chain

NYQ: Nyquist

POST_MOD: post-(de)modulation

PRE_MOD: pre-(de)modulation

QMF: quadrature mirror filter

SS: spectrum shaping

U: present in C_B path

UV: present in both colour-difference signal (C_B and C_R) paths

V: present in C_R path

VSRC: vertical sample-rate conversion

Y: luminance signal

YL: motion detector luminance level control

APPENDIX 4

TO ANNEX 1

Studio production guidelines for transmissions to be encoded into PALplus and guidelines for handling PALplus encoded signals

1 General

PALplus is an enhanced 16:9 aspect ratio letterbox transmission format, and is not designed as a format for programme production or contribution.

Programme material intended for PALplus transmission should be sourced and post-produced using component studio equipment operating in the full-height wide-screen aspect ratio of 16:9 (i.e., anamorphic, with nominal 576 active lines), and able to deliver a 4:2:2 625/50/2:1 16:9 aspect ratio digital component input signal (in accordance with Recommendation ITU-R BT.601; Part A, § 1) to the input of the PALplus encoder.

NOTE 1 – Down conversion to letterbox for transmission is an integral function performed within a PALplus encoder.

In the case of film, for a transmission to be referred to as "PALplus", the aspect ratio of the image area scanned should be no greater than 1.90:1. (This corresponds to the wider limit of the definition of "16:9" in Recommendation ITU-R BT.1119.)

For film scanned to give an aspect ratio > 1.90:1, the PALplus encoding process should be used with the WSS aspect ratio label set to "> 16:9 letterbox centre" instead of "16:9 letterbox centre". Such a transmission should be referred to as "coded in PALplus quality" rather than "PALplus".

NOTE 2 – Film scanned to give an image area aspect ratio > 16:9 (> 1.78:1) should be input to a PALplus encoder as an anamorphic letterbox, i.e., should be treated as a 16:9 aspect ratio source (nominal 576 active lines) containing black bands. When viewed on 4:3 receivers, the join between the black bands within the 16:9 letterbox picture area and the black bands of the PALplus letterbox can be visible, unless care is taken to match the film black to the electronically generated true black of the PALplus black bands.

2 Constraints of the composite PALplus signal

No picture information should be added (either by superimposing or mixing) to the black bands of the composite PALplus signal. The black bands are occupied by the helper signal, so that addition of other picture information (such as subtitles or station identification logos) would result in the generation of visible artefacts on PALplus receivers.

A composite PALplus signal should not be cross-faded or wiped with a PAL signal (see Section 4 which refers to switching between PAL and PALplus signals).

It may be possible to cross-fade or wipe horizontally between two PALplus signals, provided identical line 23 WSS information is maintained. The two signals should both be in film mode, or both in camera mode.

NOTE 1 – The mixer used to perform such a cross-fade or wipe should be capable of handling the entire contents of line 23 and the first half of line 623, and should not perform clipping of low-frequency luminance signals below black-level.

Studio or distribution equipment used to convey the composite PALplus signal should be transparent to the whole of line 23 and the first half of line 623, and should not introduce clipping of low-frequency luminance signals below black-level.

NOTE 2 – The PALplus helper signals carried in the black bands are modulated on the colour subcarrier with a maximum amplitude of 300 mV peak-to-peak. However, these helper signals are wider in bandwidth than standard PAL chrominance signals and, within the aforementioned permitted signal amplitude range, contain energy within the composite signal between approximately 1 MHz and 5 MHz.

A composite PALplus signal cannot be recorded correctly via the composite input of a component video tape recorder designed for standard PAL operation.

A PALplus signal can be recorded on a composite digital video tape recorder.

NOTE 3 – For a correct recording to be made on a composite digital video tape recorder, any circuits that would otherwise introduce clipping of low-frequency luminance signals below black-level should be disabled.

A composite PALplus signal should not be passed through equipment that incorporates decode/encode functions, or which includes processes in the spatial or temporal domain, and which are optimized only for standard PAL.

Synchronizers and other studio or distribution equipment should retain the correct PAL eight-field sequence, and should not introduce horizontal or vertical picture shifts. Care should be taken to avoid the introduction of inter-field jitter, as this can lead to cross-luminance following MACP decoding.

Cascading of the PALplus encoding and decoding process is possible, but can result in some loss of quality.

PALplus signals can be distributed via 140 Mbit/s composite digital circuits designed for standard PAL operation.

Where it is required to distribute a composite PALplus signal via a 34 Mbit/s digital contribution/distribution circuit, or a 140 Mbit/s codec incorporating PAL decode/encode processes, particular attention should be given to the design of the codec interface in order to ensure effective transparency.

Scrambling systems used for transmission have been found to be generally compatible, but should be evaluated individually for their transparency and picture quality.

Picture quality monitoring of a PALplus signal should be carried out using a correctly decoded PALplus picture, and should not rely only on viewing the PALplus letterbox picture.

3 Camera mode and film mode

In the case of programme material to be transmitted in film mode, field 1 should be dominant at all times.

It is technically possible to switch between camera mode and film mode within a single programme encoded in PALplus. However, receivers cannot necessarily be expected to react sufficiently quickly to avoid visible picture disturbances, since the WSS “detection time” target of 8 frames applies to detection of any changes in WSS status, not just for detection of changes in aspect ratio. It is therefore preferable to avoid switching between camera mode and film mode within a programme.

If a programme contains a mixture of camera material and film material, or if field dominancy of part of the film material is incorrect or is in doubt, then camera mode should be selected. If it is nevertheless wished to switch directly between camera mode and film mode, then it is desirable that the encoder should blank the helper signal for a period of 8 frames immediately following the first transmission of the changed WSS data.

In the case of rolling titles inserted electronically onto film-sourced material which is transmitted in film mode, the originating character generator should change the vertical position of each row of titles only at frame boundaries. Otherwise, visible artefacts may result, in which case camera mode should be used.

4 Programme junctions between transmissions in PALplus and PAL

It is advisable to use the line 23 WSS to signal that a transmission is in standard 4:3 PAL, and not to rely on the fact that absence of the WSS, by default, indicates a transmission to be in standard 4:3 PAL. Otherwise, PALplus receivers are likely to take longer to detect the change of transmission format, and this could result in pictures being processed and displayed incorrectly.

At a junction between a transmission in PALplus and a transmission in another format, it is advisable to transmit full-frame black in the newly signalled format for a period of 8 frames following the first transmission of the changed line 23 WSS status. This period represents the nominal time expected for receivers to detect that a change of WSS status has occurred, during which the receiver display mode will remain unchanged.

It is advisable to ensure that the transmission of a change of wide-screen signalling status is neither advanced nor delayed with respect to the related change in picture format.

5 Open subtitles and logos

To minimize the likelihood of loss of important picture information due to the effects of receiver overscan on wide-screen receivers, open subtitling or station identification logos should be placed within the following “safe” picture area, which excludes the top and bottom edges each representing nominally 5% of the full height of the 16:9 aspect ratio picture:

a) prior to PALplus encoding (the preferred method), on the 16:9 aspect ratio component source picture:

   lines 35-294 and 348-607 (inclusive);

b) on the PALplus letterbox picture:

   lines 68-262 and 381-575 (inclusive).

NOTE 1 – If inserted directly into the composite PALplus letterbox picture, subtitles or logos should not contain chrominance information.

NOTE 2 – Insertion of subtitles or logos directly into the composite PALplus letterbox picture can give rise to visible artefacts on PALplus receivers.

In addition, it is advisable to avoid insertion of subtitles within the left-hand and right-hand edges each representing 10% of the full width of the 16:9 aspect ratio picture.

6 Non-PALplus use of Motion Adaptive Colour Plus

For the handling, recording and distribution of non-PALplus MACP signals, and programme junctions between transmissions of non-PALplus MACP and other formats, the same general constraints apply as for signals encoded in PALplus; these are outlined in earlier paragraphs.

NOTE 1 – Unlike PALplus, non-PALplus MACP (which does not include the vertical helper signals of PALplus) does not contain low-frequency energy below black level.

In the case of non-PALplus Motion Adaptive Colour Plus encoding of component picture sources that have been cropped electronically to give a letterbox picture (for example, in an aspect ratio of 14:9) it is desirable that pairs of lines at the top of the letterbox picture, and also at the bottom of the letterbox picture, are partner lines for MACP intra-frame averaging.

The top line of the letterbox picture should therefore be taken from an even field, and the bottom line of the letterbox picture from an odd field.