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PALplus Overview

Introduction

PALplus is the result of a cooperative project (started in 1990) undertaken by European broadcasters. By 1995, they wanted to provide an enhanced definition television system (EDTV) compatible with existing receivers, as an interim solution to HDTV. PALplus has been transmitted by several broadcasters since 1994.

A PALplus picture has a 16:9 aspect ratio. On conventional TVs, it is displayed as a 16:9 letterboxed image with 432 active lines. On PALplus TVs, it is displayed as a 16:9 picture with 574 active lines, with extended vertical resolution. The full bandwidth (5.0MHz for PAL systems B and G, 5.5MHz for PAL system I) is available for luminance detail. Cross color artifacts are reduced by clean encoding.

Wide Screen Signaling

Line 23 is devoted to a Widescreen Signalling (WSS) control signal, defined by Recommendation ITU-R BT.1119, used by PALplus TVs (see Application Note AN9716). PALplus is defined as being Letterbox 16:9 center, camera mode or film mode, helper signals present using modulation, and clean encoding used. Teletext subtitles may or may not be present, and open subtitles may be present only in the active picture area.

In addition, during a PALplus transmission, the last 21µs of line 23 contains a 10µs black level followed by 48 cycles of the -U phase subcarrier. This is provided to fine-tune the helper-line demodulation phase and gain. During PALplus transmissions, line 623 also carries a 9.5µs black level followed by a 10µs white level for setting the levels in the letterbox processing circuits.

A PALplus TV has the option of deinterlacing a Film Mode signal and displaying it on a 50Hz progressive-scan display or using field repeating on a 100Hz interlaced display.

Ghost Cancellation

An optional ghost cancellation signal (defined by ITU-R BT.1124) on line 318 allows a suitably adapted TV to measure the ghost signal and cancel it. A PALplus TV may or may not support this feature.

Processing Overview

All PALplus sources start out as 16:9 images, occupying all 576 active scan lines of the standard 625 line PAL video signal. The format of the signal at this point is ITU-R BT.601 YCbCr.

Vertical Filtering

Before transmission, the 576 active scan lines of the 16:9 image are squeezed into 432 scan lines. To avoid aliasing problems, the vertical resolution is reduced by lowpass filtering. For luminance, vertical filtering is done using a Quadrature Mirror Filter (QMF) highpass and lowpass pair. Using the QMF process allows the highpass and lowpass information to be resampled, transmitted, and later recombined with minimal loss.

The luminance QMF lowpass output and the chrominance lowpass output are resampled into three-quarters of their original heights; little information is lost to aliasing. After clean encoding, it is the letterboxed signal that non-PALplus TVs display.

The luma highpass output of the QMF process contains the rest of the original luma vertical frequency. It is used to generate the helper signal and is transmitted using the “black” scan lines not used by the letterbox picture.

Helper Signal: Film Mode

A film mode broadcast has both fields of a frame coming from the same image, as is usually the case with a movie scanned on a telecine.

In film mode, the maximum vertical resolution per frame is 288 cycles per active picture height (cph), limited by the 576 active scan lines per frame.

The vertical resolution of the luminance image is reduced to 216cph so it can be transmitted using only 432 active lines. The QMF lowpass and highpass filters split the luma vertical information into DC-215cph and 216-288cph. The color difference signals are lowpass filtered to about 80cph.

The luma lowpass information is re-scanned into 432 lines to become the letterbox image. Since the vertical frequency is limited to a maximum of 216cph, no information is lost.

The luma highpass output is decimated so only one in four lines are transmitted. These 144 lines are used to transmit the helper signal. Because of the QMF process, no information is lost to decimation.

The 72 lines above and 72 lines below the central 432-line of the letterbox image are used to transmit the 144 lines of the helper signal. This results in a standard 576 active line picture, but with the original image in its correct aspect ratio, centered between the helper signals. The scan lines containing helper signal are companded and modulated using the U subcarrier so they look black and are not visible to the viewer.

The 576 scan lines are transmitted as a standard interlaced PAL image.

Helper Signal: Camera Mode

Camera (or video) mode assumes the fields of a frame are independent of each other, as would be the case when an electronic camera scans a scene in motion. Therefore, the image may have changed between fields. Only intra-field processing is done.

In camera mode, the maximum vertical resolution per field is 144 cycles per active picture height (cph), limited by the 288 active scan lines per field.

The vertical resolution of the luma image is reduced to 108cph so it can be transmitted using only 216 active lines. The QMF lowpass and highpass filter pair split the luma vertical information into DC-108cph and 108-144cph. The color difference signals are lowpass filtered to about 40cph. The luma lowpass information is re-scanned into 216 lines to become the letterbox image. Since the vertical frequency is limited to a maximum of 108cph, no information is lost.

The luma highpass output is decimated so only one in four lines is transmitted. These 72 lines are used to transmit the helper signals. Because of the QMF process, no information is lost to decimation.

The 36 lines above and 36 lines below the central 216-line of the letterbox image are used to transmit the 72 lines of the helper signal. This results in a standard 288 active line picture, but with the original image in its correct aspect ratio, centered between the helper signals. The scan lines containing helper signal are companded and modulated using the U subcarrier so they look black and are not visible to the viewer.

The 288 scan lines are transmitted as a standard field of a PAL image.

Clean PAL Encoding

Only the letterboxed portion of the PALplus signal is clean encoded. The helper signals are not actual PAL video. However, they are close enough to video to pass through the transmission chain and remain fairly invisible on standard TVs.

Fixed ColorPlus

Film Mode uses a fixed ColorPlus technique, making use of the lack of motion between the two fields of a frame. Fixed ColorPlus transmits the same chroma and high-frequency luma (luminance above 3MHz) on lines N and N+312 during the letterboxed portion of a frame.

During decoding, each line is split into a low-frequency component and a high-frequency component.

Adding the high-frequency portions of lines N and N+312 cancels the chroma, leaving luminance (if they are subtracted, the luminance cancels, leaving the chrominance).

Luma above 3MHz is vertically limited to 108cph since it occupies 216 lines (per field) within the letterboxed image, and there is no contribution from the helper signal. The PALplus system allows this since fine diagonal frequencies are not very visible.

Luma below 3MHz is processed differently. Since it is clear of interference from the chroma, it may have different information on lines N and N+312. This allows the full vertical resolution of 288cph to be reconstructed with the aid of the helper signal (which is limited to a 3MHz bandwidth).

Motion Adaptive ColorPlus (MACP)

Camera Mode uses a motion adaptive version of ColorPlus.

The encoder tests for a match of chrominance on lines N and N+312. If they match, the same chrominance and high-frequency luminance (luminance above 3MHz) on lines N and N+312 during the letterboxed portion of a frame are transmitted.

If the chrominance doesn't match, it is transmitted separately for lines N and N+312. High-frequency luminance for lines N and N+312 is not transmitted.

At the decoder, a standard PAL decoder processes the video signal, and its output is saved for possible use later. The decoded U and V signals from lines N and N+1 are delayed and averaged with the U and V signals one field later (from lines N+312 and N+313). They are lowpass filtered, yielding a “reference” color difference signal for each frame.

The U and V signals from the PAL decoder are compared with the “reference” U and V signals for every pixel in the image. If there is a match, the decoder assumes Fixed ColorPlus encoding was used, so addition and subtraction is used to separate the luminance and chrominance. If there is not a match, then Motion Adaptive ColorPlus encoding must have been used, in which case the original U and V signals from the PAL decoder are used for the display.

Summary

This Application Note reviewed the PALplus technique of transmitting 16:9 information over the standard PAL transmission system, for use on both 16:9 and standard PAL televisions.

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