

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 21 μ s of line 23 contains a 10 μ s 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 9.5 μ s black level followed by a 10 μ s 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 Mir-

ror 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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
 2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
 3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
 4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
 5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
 6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
 7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
 8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
 9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
 10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
 11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
 12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.
- (Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
- (Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852-2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886-2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338