Video Signals.

A technical briefing by J. S. Technology.

Introduction.

This document describes how video signals are created and the conversion between different standards. Four different video signals are discussed:

1. RGB (Red, Green, Blue).
2. Component video, also known as YUV and YPbPr
3. S-Video.
4. Composite.

Each of these video signals can be found in modern Home-Cinemas.

Overview.

In a home-cinema, there are various different source of video information – DVD players, VCRs, Laserdisc players and most recently Digital Set-Top boxes. Each of these provides one, two, three or all four possible video formats discussed here.

When a video camera shoots a scene, the light received via the lens is filtered in to three colours, Red, Green and Blue (RGB). Sensors within the camera pick these up, which then produce the three RGB signals. Transmission and storage of these signals is not always via RGB as conversion to component video (YUV) is common place.

A broadcast television picture over the analogue domain is by composite video. This is derived from component video going via what we would call S-Video. Composite and S-Video are very similar systems, with the composite merely being mix of the signals found in S-Video, and hence the “Composite” name.

In a Home-Cinema, composite would be found with standard VHS VCRs (videocassette recorders) and compatible equipment. S-Video can be found on S-VHS VCRs, DVD players and video switching for S-Video is provided in most Audio/Visual (A/V) amplifiers. RGB is a high-quality video format that is typically found on DVD players and Digital Set-Top Boxes. Component video is now being found on some DVD players, and video switching is becoming available on some A/V amplifiers.

This document will demonstrate how the video signal from video camera in RGB is converted through to each type of signal. Finally, the differences between the picture quality of each video signal will be indicated.

RGB – Red, Green, and Blue.

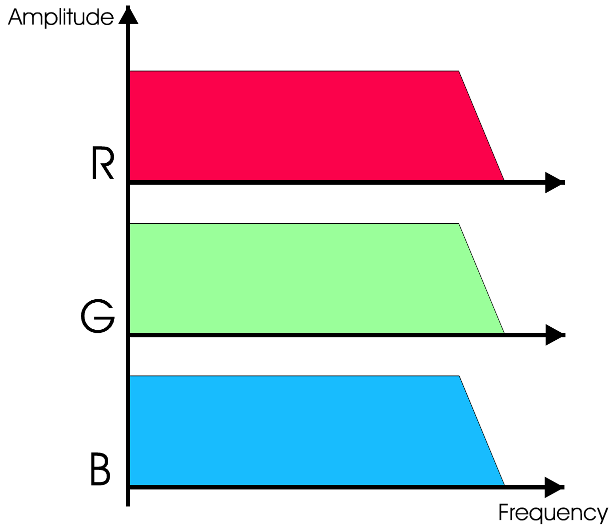


Figure 1: RGB are three distinct signals.

RGB is for the discrete Red, Green, and Blue signals use to create the picture. Each signal corresponds to the filtered colour found on the video camera. As per figure 1, each channel does not share space with another

Component Video (YUV / YPbPr)

Component video, also know as both YUV and YPbPr, is derived via an arithmetic formula from RGB. Strictly speaking the conversion formula is lossless; in practice the colour information is band limited to reduce transmission and storage requirements. Since the human eye isn't as sensitive to colour information as brightness (black & white), this is a justifiable process.

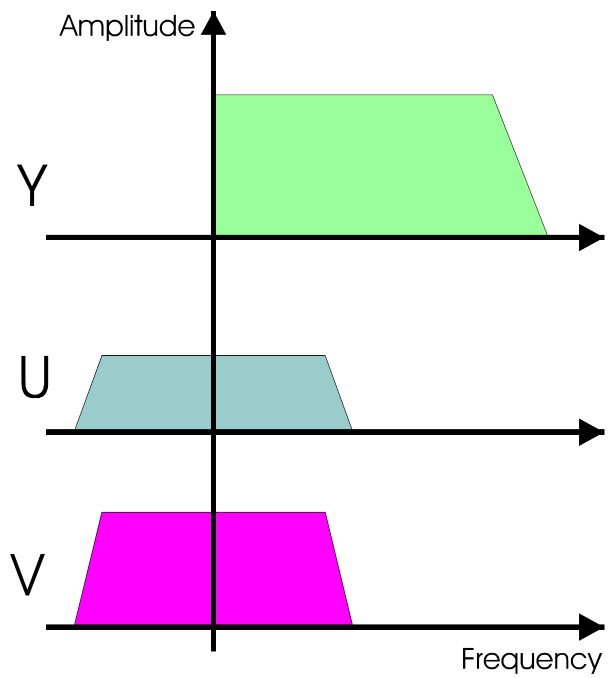


Figure 2. Component video with the brightness (Y) and colour difference signals (U&V).

YUV is derived from:

$$Y = 0.3R + 0.59G + 0.11B$$
$$U = 0.493(B - Y)$$
$$V = 0.877(R - Y)$$

U&V are weighted version of B-Y and R-Y to give the colour difference signals which refer to the Blue and Red colours respectively, green is not described as it can be derived from the above formula. This is shown graphically in Figure 2, where parts of the frequency is shown as being negative, indicating that the colour difference signals can be both positive and negative.

S-Video.

S-Video is derived from component video. The Y, or brightness, remains the same between component and S-Video, but the colour difference signals are combined in to one signal. U&V are quadrature modulated at a frequency chosen to be within the video bandwidth, in the UK this is 4.43MHz. Quadrature modulation is a process where the U&V signals are off-set by 90° and combined using the appropriate carrier frequency. This can later be demodulated to recover both U&V.

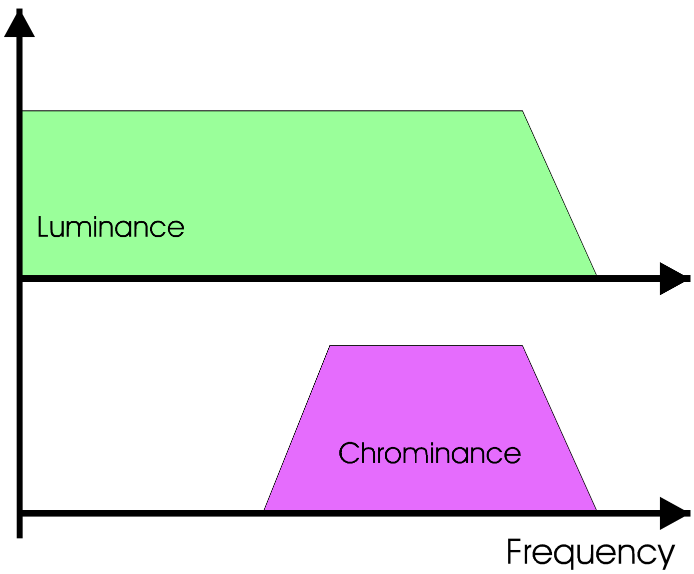


Figure 3a: Frequency Spectrum of S-Video with separated luminance and chrominance.

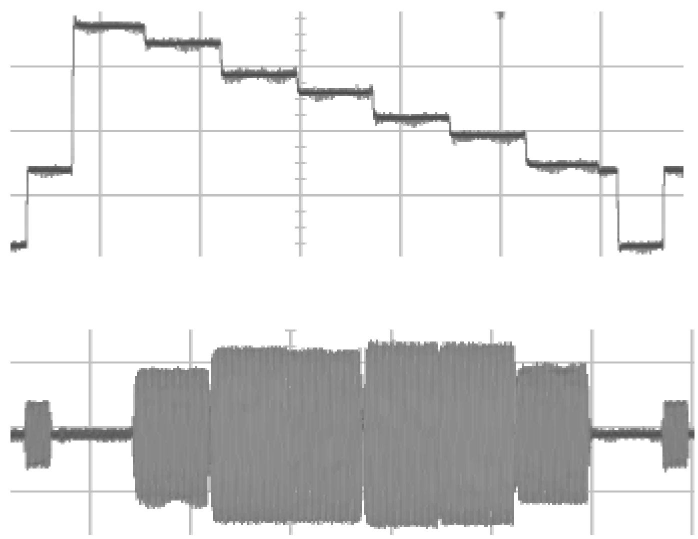


Figure 3b: A scan line of S-Video. Top, luminance and bottom chrominance.

Figure 3a shows the same luminance signal found in Figure 2, but now the colour difference signals of U&V are combined in to the one chrominance signal. Electrically, these give the resulting waveforms shown in Figure 3b. At the top is the luminance stepping down from a white level through grey to black. The final dip is a synchronisation pulse, which is not viewable.

S-Video is very similar to composite, but the luminance and chrominance are kept separate, Figure 3b. Since there is no chrominance signal present in the luminance frequency spectrum, Figure 3a, cross-colour interference does not exist.

Composite Video.

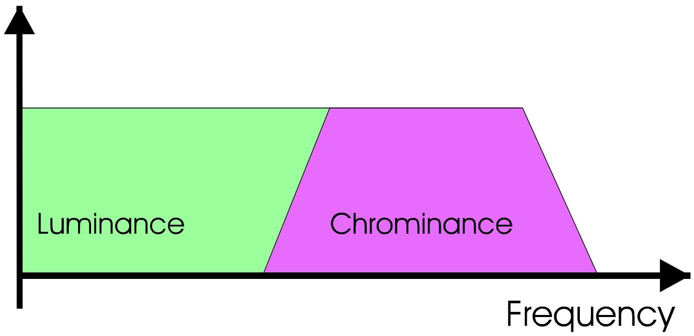


Figure 4a: Frequency spectrum of Composite Video.

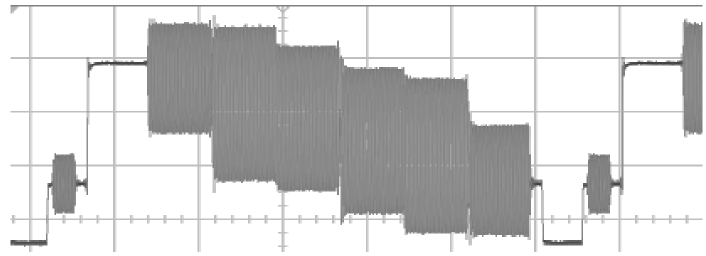
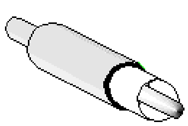


Figure 4b: Time domain of one video scan line.

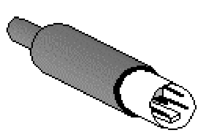
Composite video, as the name suggests, is a mixture of two signals, Figure 4b. Derived by mixing the two signals found in S-Video, both share the same spectrum and medium, Figure 4a. The difficulty with Composite video is when attempting to separate the colour information from the luminance. While it is possible to extract most of the picture information, total separation is not possible. This results in an artefact known as cross-colour interference. Visually cross-colour interference appears at boundaries of sharp colour changes and looks like a hatching pattern overlaid on the boundary.

The Physical Connector.

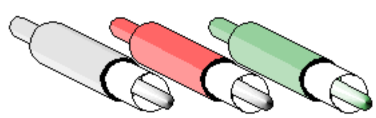
Each video standard typically has their own connector, however composite and S-Video can be carried on the SCART connector **[Sim, J. 2001]**. Composite can be carried on a phono connector, Figure 5, S-Video is via a 4-pin mini DIN connector. Component is typically carried on three phono connectors, but on some systems this may be the lockable BNC type of connector. RGB is typically exclusive to the SCART connector.



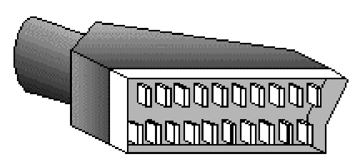
Phono Connector for composite.



4-pin Mini-DIN for S-Video.



Three phono connectors for Component Video



SCART for Composite, S-Video and RGB.

Figure 5. Four different connectors with their video carrying capability.

Conclusions.

Home-Cinemas can have a mixture of connection solutions. Cross-colour interference is inherent in composite video, and as such composite is best avoided in Home-Cinemas. Both S-Video and RGB are high quality video signals that do not suffer from cross-colour interference. Some Home-Cinema equipment requires S-Video. RGB can be used by most modern SCART equipped TVs, but not with all Home-Cinema equipment such as Plasma screens, projectors and especially S-VHS recorders. It is possible to convert RGB to S-Video and to Component video. This later standard is favoured as the resulting quality is similar to that of RGB.

The conversion process of RGB through Component, S-Video and finally to Composite is given in Figure 6. An indication of the relative qualitative output is show.

References:

[Sim, J. 2001] "The SCART Connector." Dr John Sim, J.S. Technology, 2001.

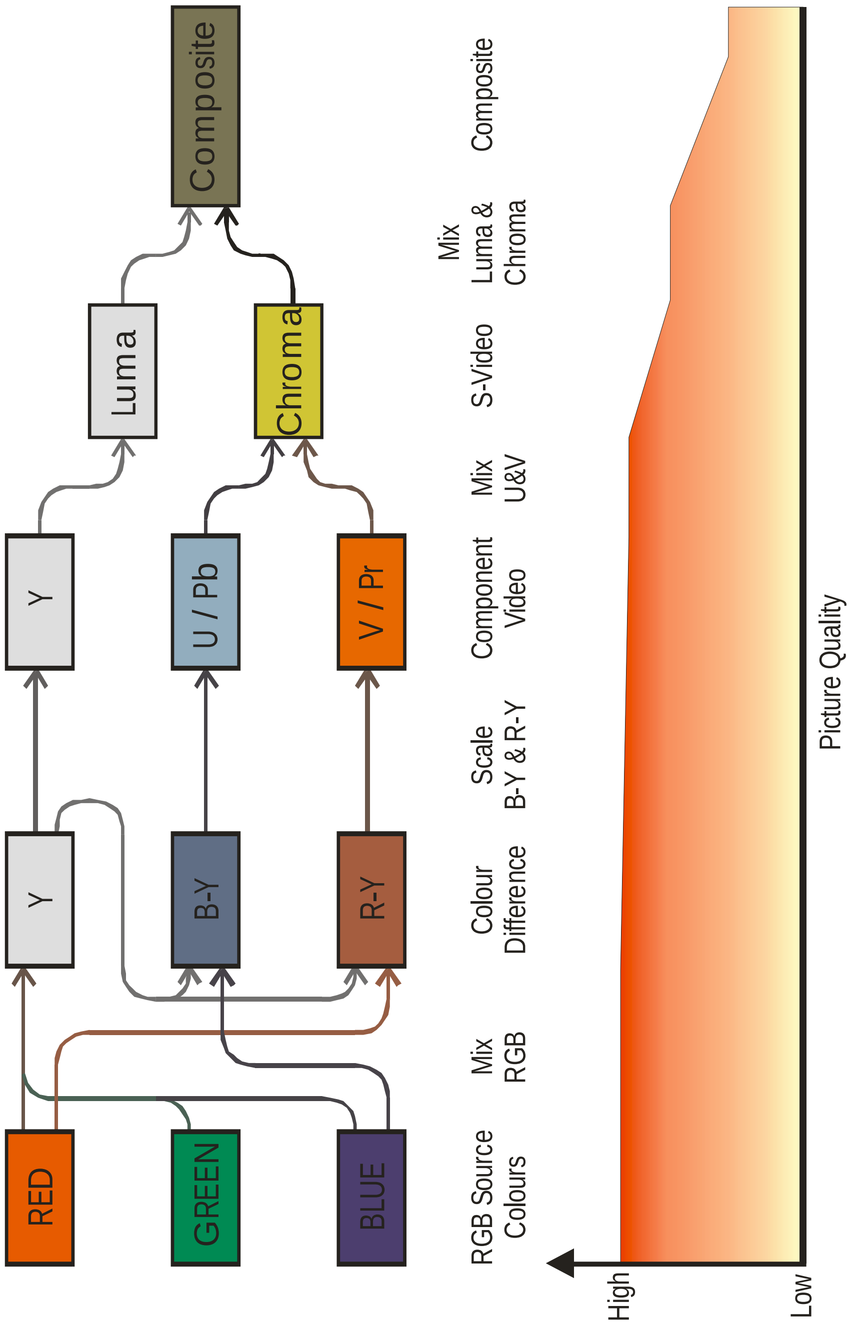


Figure 6. Conversion from RGB, through component, S-Video and finally to Composite. For completion, colour difference signals B-Y and R-Y are shown. Quality index is also show, where RGB and Component video are high quality, composite low quality.

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