[redacted]

2.3 Component Video

Component video describes a system in which a color picture is represented by a number of video signals, each of which carries a component of the total video information. In a component video facility, the component video signals are processed separately and, ideally, encoding into a composite video signal occurs only once, prior to transmission. There are two choices of studio component video signal sets that can be selected. These are

- G, B, R signals: This requires the generation, distribution, and processing of three signals of equal bandwidth. These signals are readily available with all cameras.
- Y, B-Y, R-Y signals: This requires the generation, distribution, and processing of three signals obtained by matrixing the primary G, B, R signals. Usually the Y signal has a wider bandwidth than the B-Y and R-Y (color-difference) signals. These signals are readily available with some cameras.

There have been limited attempts at standardizing analog component video signals. Currently, a number of de facto "standards" coexist, making interconnection of equipment difficult.

Components, in some form, are the basic ingredients of any color television system. Since practical color cameras generally have three separate sensors, one for each primary color, a green, blue, red (GBR) system will exist at some stage inside the camera, even if it does not emerge in that form. GBR consists of three signals, each having the same bandwidth. It is used where the highest accuracy is needed, often for the production of still pictures. Examples of this are paint systems and computer-aided design (CAD) displays.

Some savings in bandwidth can be obtained by using color-difference signals. The human eye relies on luminance to convey picture detail, and much less resolution is needed in the color information. GBR signals are matrixed together to form a luminance (and monochrome compatible) signal Y, which has full bandwidth. The matrix also produces two color-difference signals, B-Y and R-Y, which do not need to have the same bandwidth as the Y signal. One half or one quarter of the Y bandwidth is usually acceptable, depending on the application.

2.3.1 The GBR signals

GBR component signals are essentially three monochrome video signals, each representing one of the primary colors. Possible sources of GBR signals include cameras, telecines, composite video decoders, character generators, and graphics systems.

2.3.1.1 Signal characteristics. Figure 2.78 presents several sets of GBR signals encountered in practice and their characteristics. The signal amplitudes are typical of 100% color bars. All signals are shown with sync added. Some sets of signals have sync added to the green component only, whereas others carry sync on a separate (fourth) wire.

The first column shows the characteristics of the "NTSC-related" GBR signals generally available at the output of an NTSC camera. Setup is usually added in the NTSC encoder, so these signals do not have setup but have a 714-mV peak amplitude and, if sync is added, −286 mV of sync.

The second column shows the characteristics of NTSC-related GBR signals such as would be available at the output of an NTSC decoder. They are similar to the signals in column 1 except for the presence of setup.

The third column shows the characteristics of SMPTE/EBU signals. Note the

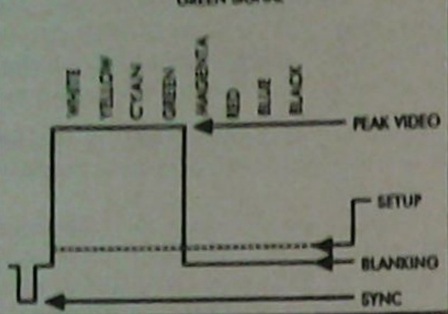
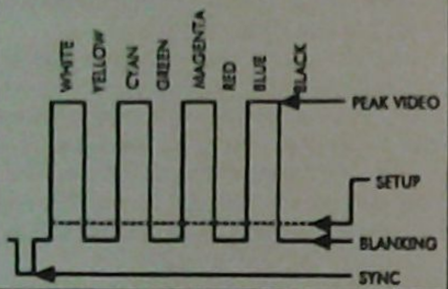
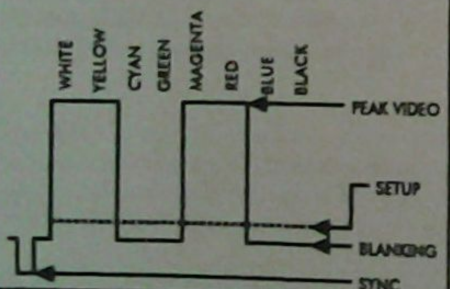
WAVEFORM	NTSC RELATED	NTSC RELATED WITH SETUP	SMPTE 253 M
GREEN SIGNAL 			
PEAK VIDEO	714.3 mV	714.3 mV	700 mV
SETUP	0 mV	53.57 mV	0 mV
BLANKING	0 mV	0 mV	0 mV
SYNC	-285.7 mV	-285.7 mV	-300 mV
BLUE SIGNAL 			
PEAK VIDEO	714.3 mV	714.3 mV	700 mV
SETUP	0 mV	53.57 mV	0 mV
BLANKING	0 mV	0 mV	0 mV
SYNC	-285.7 mV	-285.7 mV	-300 mV
RED SIGNAL 			
PEAK VIDEO	714.3 mV	714.3 mV	700 mV
SETUP	0 mV	53.57mV	0 mV
BLANKING	0 mV	0 mV	0 mV
SYNC	-285.7 mV	-285.7 mV	-300mV

Figure 2.78 Analog component G,B,R signal characteristics—100% color bars.

absence of setup, 700-mV peak signal, and −300 mV of sync. A similar set of signals would be available at the output of a PAL decoder.

These "standards" are similar but not strictly compatible. In extreme cases, white clipping and noticeable errors in displayed light levels will occur when

noncompatible equipment is interconnected. It is, therefore, essential to normalize each GBR feed to the input specifications of the equipment into which it is fed.

2.3.2 The Y, B-Y, and R-Y signals

Y, B-Y, and R-Y signal components are linear combinations of signals representing the three primary colors: green, blue, and red. Possible sources of Y, B-Y, and R-Y signals are cameras, analog component videocassette recorders, and composite video decoders.

2.3.2.1 Signal characteristics. The luminance signal has the following mathematical expression:

$$E'_Y = 0.587E'_G + 0.114E'_B + 0.299E'_R$$

This expression is identical to that used with all composite (NTSC, PAL, and SECAM) as well as component systems.

The color-difference signals are different from the NTSC, PAL, and SECAM color-difference signals in terms of peak-to-peak signal amplitude and bandwidth. In NTSC and PAL the color-difference scaling factors were aimed at limiting the encoded signal amplitude to 130.8 IRE (+935 mV) for the cyan and yellow components of a 100% color-bar signal. This signal amplitude results in severe transmitter overload. The developers of the NTSC system relied on the fact that saturated 100% yellow and cyan colors are not commonly encountered in nature and assumed, therefore, that transmitter overmodulation would never occur in practice. The advent of character generators and other digital equipment resulted in synthetic component signals that, when encoded into NTSC or PAL, could result in composite signals that will overload a transmitter.

Figure 2.83 presents several sets of Y, B-Y, and R-Y signals encountered in practice. The signal amplitudes are typical for 100% color bars. Normally the Y (luminance) signal has sync added.

The first column shows the characteristics of the NTSC-related Y, B-Y, and R-Y signals as would be obtained at the output of an NTSC decoder. Note that the luminance signal has a 714-mV nominal peak amplitude, 53.55 mV of setup, and −286 mV nominal of sync. The color-difference signals are bipolar and have unequal peak-to-peak amplitudes: 611.52 mV for B-Y and 860.6 for R-Y. This is a result of the peculiar amplitude scaling of the NTSC color-difference signals as per the expressions below:

$$E'_{B\text{-}Y} = 0.493\,(E'_B - E'_Y)$$

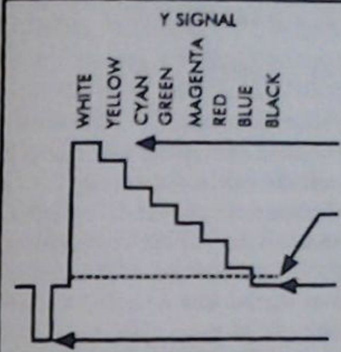
$$E'_{R\text{-}Y} = 0.877\,(E'_R - E'_Y)$$

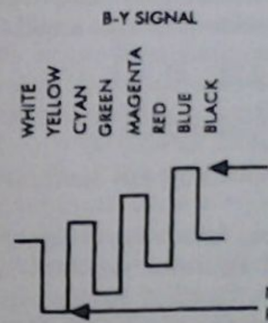
The second column shows the characteristic component signals conforming to the EBU N10 standard. There is no equivalent official SMPTE standard. However, EBU N10 is a de facto SMPTE standard. Note that the luminance signal has a 700-mV peak-to-peak amplitude, no setup, and −300 mV of sync. The color-difference signals are bipolar, symmetrical, and have identical 700-$mV_{p\text{-}p}$ signal amplitudes. To differentiate them from the NTSC or PAL color-difference signals, they are called P_B and P_R, respectively. Their identical peak-to-peak signal amplitudes result from the modified scaling factors as in the expressions below:

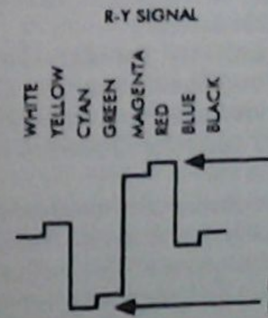
$$P_B = 0.564\,(E'_B - E'_Y)$$

$$P_R = 0.713\,(E'_R - E'_Y)$$

The third column shows the characteristics of the component video signals obtained at the output of a Sony Betacam SP videocassette recorder (VCR) as marketed in North America, when a 100% color bar signal is played back. The







WAVEFORM	NTSC	EBU N10	BETACAM	M II
Y SIGNAL				
PEAK WHITE	714.3 mV	700 mV	714.3 mV	700 mV
SETUP	53.57 mV	0 mV	53.57 mV	52.5 mV
BLKG	0 mV	0 mV	0 mV	0 mV
SYNC	-285.7 mV	-300 mV	-285.7 mV	-300 mV
B-Y SIGNAL				
POSITIVE PEAK	+313.54 mV	+350 mV	+466.65 mV	+324 mV
	0 mV	0 mV	0 mV	0 mV
NEGATIVE PEAK	-313.54 mV	-350 mV	-466.65 mV	-324 mV
R-Y SIGNAL				
POSITIVE PEAK	+438.5 mV	+350 mV	+466.65 mV	+324 mV
	0 mV	0 mV	0 mV	0 mV
NEGATIVE PEAK	-438.5 mV	-350 mV	-466.63 mV	-324 mV

Figure 2.83 Analog component Y, B-Y, R-Y signal characteristics—100% color bars

luminance signal has a peak-to-peak amplitude of 714 mV, 53.57 mV of setup, and −285.7 mV of sync. The color-difference signals are bipolar, symmetrical, and have an identical peak-to-peak amplitude of 933.3 mV. With a 75% color bar signal, the luminance has a peak-to peak amplitude of 535.72 mV and the