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tech tips

Understanding The 1VPP Composite Video Signal

One of the most complex waveforms in electronics is the NTSC composite video waveform. This signal includes many different parts: video, horizontal and vertical sync pulses, horizontal and vertical blanking pulses, and special signals that all combine into one waveform. This Tech Tip is dedicated to understanding the details of the composite video signal.

What Is The Composite Video Signal?

The composite video waveform contains all the information needed for the complete CRT picture, line by line and field by field. This signal is used in the picture tube to reproduce the picture on the scanning raster. Composite video consists of video information plus the blanking and sync pulses needed for synchronized re-production.

In producing a picture on the CRT, the raster is scanned twice, 262 1/2 lines for each interlaced field, for a total of 525 lines per frame (a complete picture). Not all 525 lines contain picture information, however. A few horizontal lines of video at both the top and the bottom of the screen are blanked out, and some are "used up" in vertical retrace as we will learn later.

Two important characteristics of the composite video signal are polarity and amplitude. The video signal can have two polarities:

1. A positive sync polarity, with the sync pulses "up", as shown in figure 1a.

2. A negative sync polarity, with the sync pulses "down", as shown in figure 1b.

The signals in 1a and 1b both contain the same picture information, the only difference is the polarity. Negative sync polarity is standard for the input or output signals of video equipment such as TV cameras, video control equipment, and video ports on monitors and VCRs.

For either polarity, the white parts of the video signal are opposite to those of the sync pulses. The black parts of the video are closer to the blanking and sync tip levels, which are considered blacker than black.

The standard input/output amplitude for the video signal in the video equipment mentioned above is 1 VPP into 75 ohms. The requirements for the composite video signal at the inputs for different CRTs, however, varies from 30 to 150 VPP or more for larger tubes.

In relation to time, the composite video signal can be divided into two different parts: the horizontal interval and the vertical interval.

Horizontal Interval

The composite video signal, shown at the horizontal rate in figure 2, consists of a complex series of waveforms. This series of waveforms shown represents one line of picture information which takes 63.5 usec to occur (15,750 Hz).

At the extreme left is a horizontal blanking pulse to cut off the beam of the picture tube during the horizontal retrace period. After one line of video is displayed, the CRT scanning beam must be invisible while it returns to the left side of the CRT. The horizontal blanking pulse is inserted to bring the video signal amplitude to the black level so the retrace cannot be seen. The entire horizontal blanking pedestal is at the 75% level which, not coincidentally, is just blacker than the level for black video.

Riding on top of the blanking pedestal is a horizontal sync pulse. The horizontal sweep oscillator is reset by the leading edge of the sync pulse. The peak-to-peak voltage of the horizontal sync pulse represents 25% of the total waveform.

The "back porch" of the blanking pedestal provides time for the blanked beam to return to the left side of the

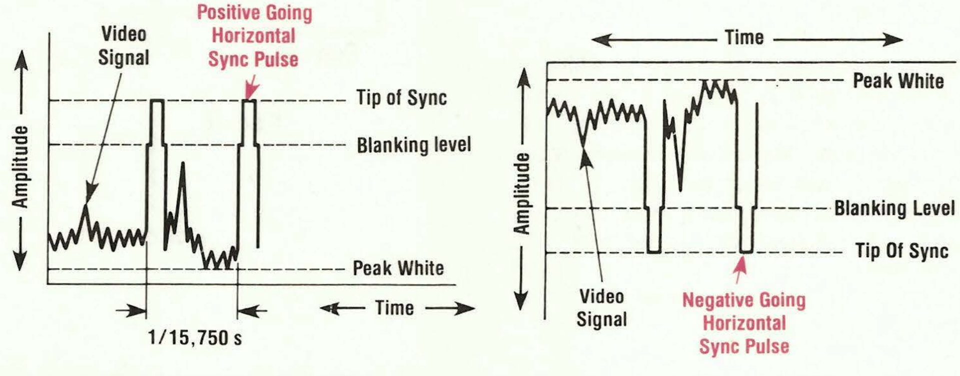

Fig. 1: (a) Two horizontal lines of composite video with positive sync. (b) Same video signal as (a), but with negative sync polarity.

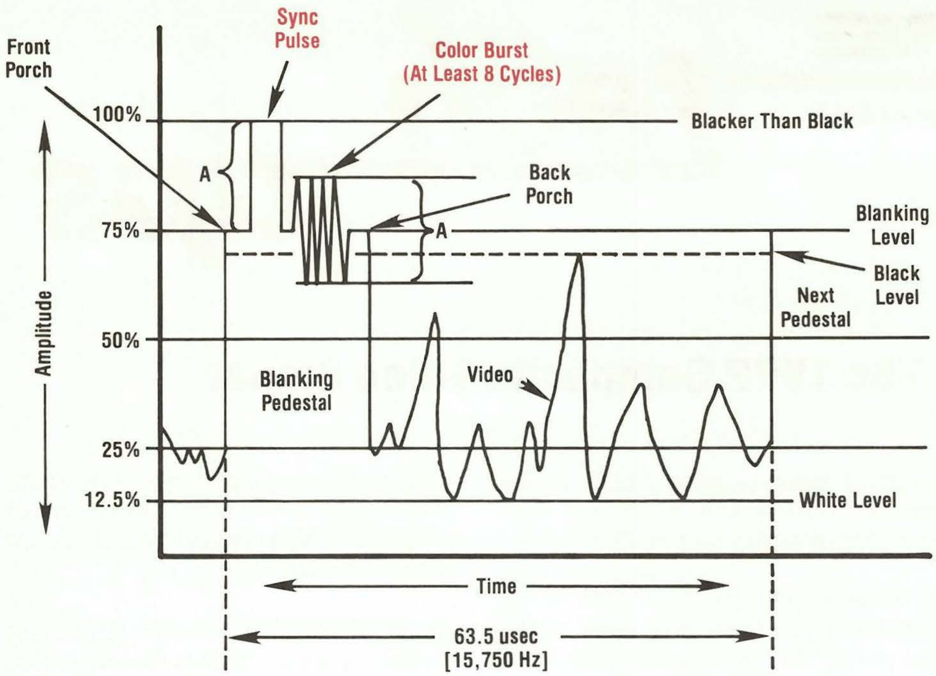

Fig. 2: Detail of one horizontal line and sync (positive sync).

screen. During color transmission a 3.58 MHz sine wave color sync burst signal is added to the ''back porch'' to frequency and phase lock the picture color information. Since the eight to 11 cycles of color burst is symmetrical around the ''back porch'' rather than placed on top of it, the amplitude may appear to be less than that of the sync pulse. This is not the case, however, as both the horizontal sync and the color burst must be 25% of the total waveform amplitude.

The interval immediately following the horizontal blanking pedestal represents one line of video. The video area contains the high-frequency amplitude variations; these give the relative shading from black to white, which the eye interprets as a picture. Video is a constantly changing voltage level unless the signal being transmitted is consistent in nature (such as a bar pattern).

Video levels vary from black to white as shown in figure 2. White is at the 12.5% level while black is just less than the 75% blanking level. Any voltage between these two points will be some shade of gray, depending on the voltage level. Blanking and sync pulses are continuous and repetitious, but the video is always changing in accordance with the image being scanned.

For color television, the composite video includes the 3.58 MHz chrominance signal. As a comparison, figure 3 shows a negative sync video signal with and without color. The relative levels in figure 3a correspond to the relative brightness, or luminance, values for the monochrome information.

In figure 3b, the 3.58 MHz chrominance signal is added to the video signal for the color information. The specific colors in the color signal are not evident because the relative phase angles are not shown. The main point here is that the difference between monochrome and color television is the 3.58 MHz chrominance signal. Note that the luminance levels in figure 3a are the same as the average levels for the signal variations in figure 3b. This means that without the color signal information, the color bars in figure 3b would be reproduced in monochrome as the white, gray, and black bars in figure 3a.

Vertical Interval

After the CRT is filled with lines of video, the scanning beam must return to the top of the screen so it can start all over again. This repositioning time, called the vertical blanking interval, is composed of 21 horizontal lines which are not displayed (see figure 4). This portion of the composite video waveform is extremely important since it contains timing pulses, FCC regulated test signals, source identification codes, reference signals, and information regarding caption availability for the deaf during a broadcast.

The first six pulses, known as equalizing pulses, synchronize video information in fields one and two. These pulses occur at twice the horizontal sync rate and assure that vertical triggering occurs at the same time for odd and even fields.

Next is the vertical sync pulse. The three-line-wide pulse tells the scanning circuits to start over again at the top of the CRT. It contains serrations at half-line intervals so the vertical sync pulses for successive fields are timed for odd-line interlaced scanning.

Following the vertical sync is a group of six more equalizing pulses. This second set of pulses ensure field frequency regularity.

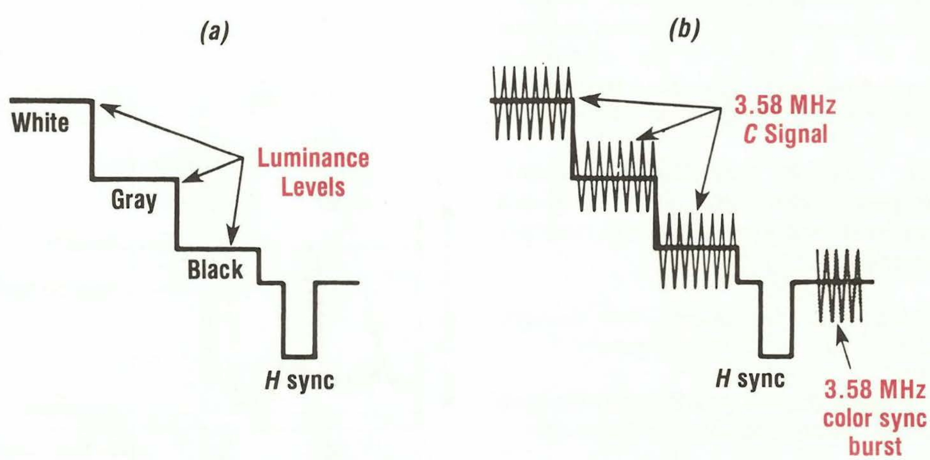

Fig. 3: Video signal with and without color. (a) Monochrome signal alone, for white, gray and black picture information. (b) Same signal combined with the 3.58 MHz chrominance signal for color information.

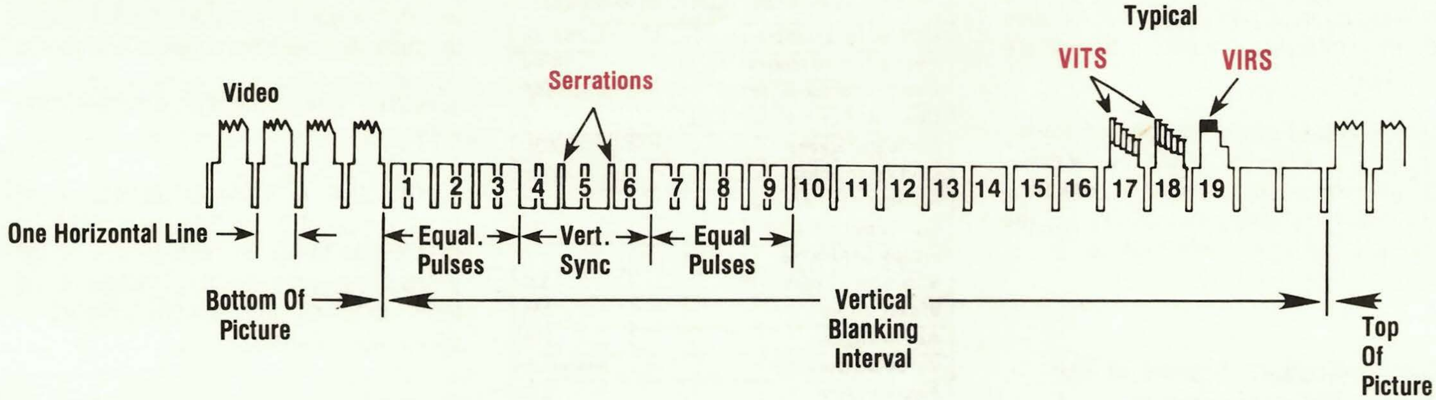

Fig. 4: Detail of the vertical blanking interval.

The scanning beam does not reset to the top of the screen at the start of vertical sync because the sync pulse must build up a charge in a capacitor to trigger the scanning circuits. Typically, vertical flyback starts with the leading edge of the third serration. This means the time of one line passes during vertical sync before vertical flyback starts. So, three lines (equalizing pulses) + one line (vertical sync charge time) equals four lines that are blanked at the bottom of the picture. Also, as the scanning beam retraces from bottom to top of the raster, five complete invisible horizontal lines are produced.

With four lines blanked at the bottom before flyback and five lines blanked during flyback, 12 lines remain of the total 21 during vertical blanking. These 12 blanked lines are at the top of the raster at the start of the vertical trace downward. The FCC regulates these lines which include special reference signals and communication signals.

Test Signals In The Vertical Blanking Interval

Most TV stations transmit special reference signals during the vertical blanking interval. The two most common signals are the VITS (vertical interval test signal) and VIRS (vertical interval reference signal).

VITS

The VITS are used by the networks to assist in evaluation of various parameters of their broadcast system's performance. The VITS are transmitted during active operation to ensure continuous quality and accuracy in terms of color and distortion. In regard to transmitter performance, the quality of the VITS frequently determines if a problem warrants a trip to the transmitter site.

The VITS is typically located on line 17 and 18 during vertical blanking (see figure 4). The type of test signal is determined by individual networks or the FCC and depends on transmitter operation, area served, etc.

VIRS

The VIRS is used to establish the correct values of chroma amplitude and phase, luminance, and black setup levels. The

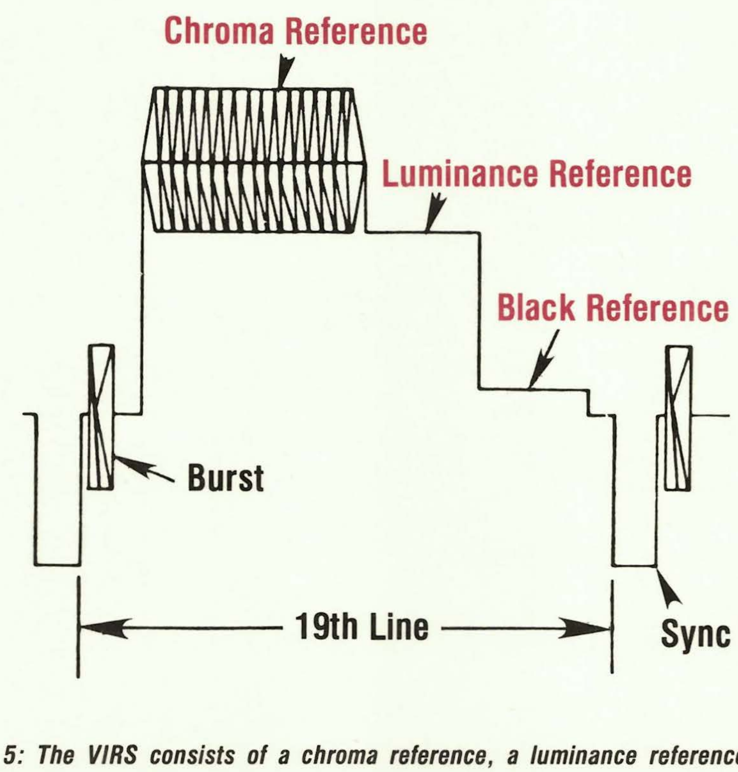

Fig. 5: The VIRS consists of a chroma reference, a luminance reference and a black reference.

VIRS, transmitted on line 19 of the vertical blanking interval (see figure 5), includes special reference values for these parameters.

Since it is part of the transmitted signal, the VIRS is available at the TV receiver. Circuits have been developed to detect the VIRS reference, and automatically set the receiver levels to the correct values.

Communications Signals In The Vertical Blanking Interval

Of the 21 lines in vertical blanking, the first nine are for vertical sync and equalizing pulses. Lines 17, 18, and 19 are normally reserved for VITS and VIRS, although the individual network may switch these signals to different lines. The remaining lines have become extremely useful for special communications systems.

Summary of NTSC Television Standards	
Horizontal scan frequency, Hz	15,734.26
Vertical scan frequency, Hz	59.94
Color Subcarrier, MHz	3.579545
Channel Band width, MHz	6
Lines per frame	525
Lines per field	262.5
Frames per second	30
Fields per second	60
Fields per frame	2
Video Band width, MHz	4.2
Video signal	AM
Audio signal	FM
Video Modulation	Negative
Aspect ratio	4:3

Fig. 6: National Television Systems Committee (NTSC) standards.

One of the recent additions to the vertical blanking interval has been closed-caption information for the hearing-impaired. This signal is digitally encoded for superimposed captions that can be displayed on the TV picture. A special decoder at the TV sorts out the lines used to carry data for the captions. Then the data are processed to form alpha-numerical symbols, which include numbers and letters.

Another system similar to captions is the transmission of a much larger quantity of data words to permit reproduction of full pages of alpha-numerical characters in text form. Graphics with simple pictures or graphs can be included.

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