APPLICATIONS

THE NTSC COLOR VIDEO SIGNAL

History

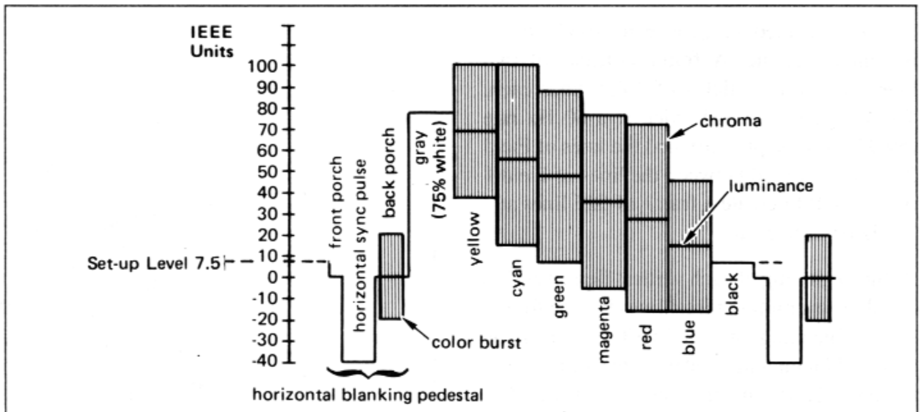
In 1953, the NTSC (National Television Systems Committee) established the color television standards now in use by the television broadcast industry in the United States and many other countries. It was, of course, compatible with the monochrome (black and white) systems that previously existed. The makeup of a composite video signal is dictated by NTSC specifications. These specifications include a 525-line interlaced scan, operating at a horizontal scan frequency of 15,734.26 Hz and a vertical scan frequency of 59.94 Hz. A 3.579545 MHz subcarrier contains the color information. The phase angle of the subcarrier represents the hue; the amplitude of the subcarrier represents saturation.

Horizontal Sync

(See Fig. 49)

The "beginning" of a line of horizontal scan occurs at the leading edge of the horizontal blanking pedestal. In a television receiver, the horizontal blanking pedestal starts as the electron beam of the CRT reaches the extreme right-hand edge of the screen (plus a little overscan in most cases). The horizontal blanking pedestal prevents illumination of the screen during retrace, that is, until the electron beam deflection circuits are reset to the left edge of the screen and ready to start another line of video display. The entire horizontal blanking pedestal is at the blanking level or the sync pulse level. In a television receiver, the blanking and sync pulse levels are the "blacker than black" levels that assure no illumination during retrace.

The horizontal blanking pedestal consists of three discrete parts: the front porch, the horizontal sync pulse, and the back porch. The front porch is a 1.40 microsecond period at blanking level. The front porch is followed by a 4.64 microsecond horizontal sync pulse at the –40 IEEE units level. An explanation of IEEE units follows in the "Amplitude" paragraph. When the horizontal sync pulse is detected in a TV receiver, it initiates flyback, which ends the horizontal scan and rapidly resets the horizontal deflection circuit for the next line of horizontal scan. The horizontal sync pulse is followed by a 4.79 mS back porch at the blanking level. When a color



IEEE Units

LUMINANCE	0	-40	0	77	69	56	48	36	28	15	7.5
CHROMA AMPLITUDE	–	–	40	–	62	88	82	82	88	62	–
VECTOR (FROM B-Y)	–	–	180°	–	167°	284°	241°	61°	104°	347°	–

Fig. 49. One horizontal line of NTSC color bars signal.

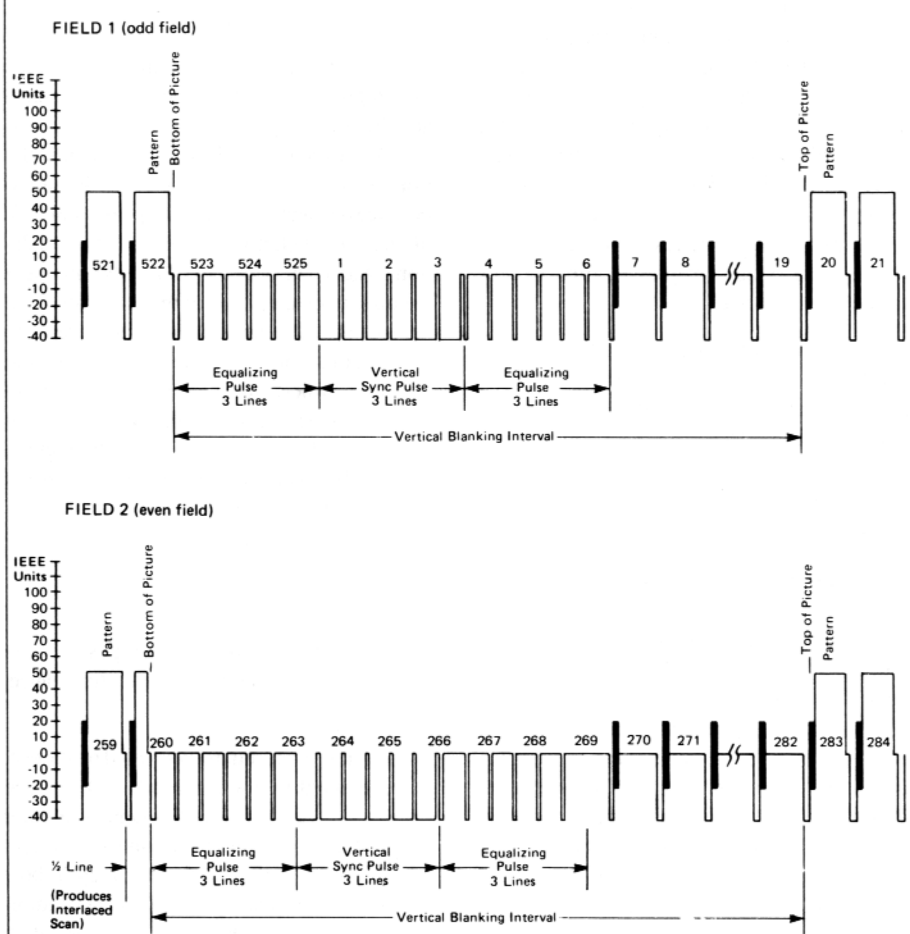


Fig. 50. Composite video signal showing vertical blanking interval.

signal is being generated, 8 to 10 cycles of 3.579545 MHz color burst occur during the back porch. The color burst signal is at a specific reference phase. In a color TV receiver, the color oscillator is phase locked to the color burst reference phase before starting each horizontal line of video display. When a monochrome signal is being generated, there is no color burst during the back porch.

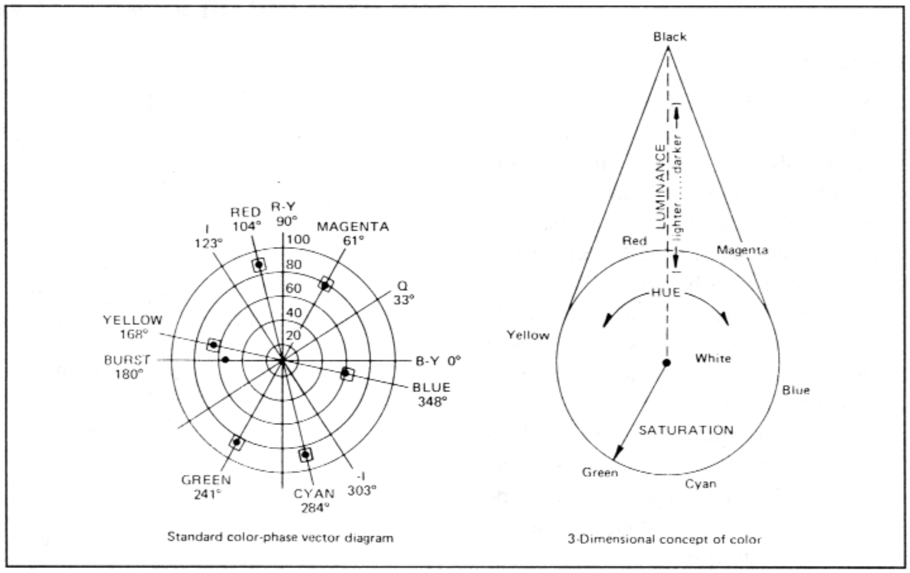


Fig. 51. Elements of color television signal.

Vertical Sync

(See Fig. 50)

A complete video image as seen on a TV screen is called a frame. A frame consists of two interlaced vertical fields of 262.5 lines each. The image is scanned twice at a 60 Hz rate (59.94 Hz to be precise), and the lines of Field 2 are offset to fall between the lines of Field 1 (interlaced) to create a frame of 525 lines at a 30 Hz repetition rate.

At the beginning of each vertical field, a period equal to several horizontal lines is used for the vertical blanking interval. In a TV receiver, the vertical blanking interval prevents illumination of the CRT during the vertical retrace. The vertical sync pulse, which is within the vertical blanking interval, initiates reset of the vertical deflection circuit so the electron beam will return to the top of the screen before video scan resumes. The vertical blanking interval begins with the first equalizing pulse, which consists of six pulses one half the width of horizontal sync pulses, but at twice the repetition rate. The equalizing pulse has an 8% duty cycle. The vertical sync pulse occurs immediately after the first equalizing pulse. The vertical sync pulse is an inverted equalizing pulse at 92% duty cycle. The wide portion of the pulse is at the –40 IEEE units level and the narrow portion of the pulse is at the blanking level. A second equalizing pulse at 8% duty cycle occurs after the vertical sync pulse, which is then followed by 13 lines of blanking level (no video) and horizontal sync pulses to assure adequate vertical retrace time before resuming video scan. The color burst signal is present after the second equalizing pulse.

Note that in Field 1 line 522 includes a full line of video, while in Field 2 line 260 contains only a half line of video. This timing relationship produces the interlace of Fields 1 and 2.

Amplitude

(See Fig. 49)

A standard NTSC composite video signal is 1 volt peak-to-peak, from the tip of a sync pulse to 100% white. This 1 volt peak-to-peak signal is divided into 140 equal parts called IEEE units. The zero reference level for this signal is the blanking level. The tips of the sync pulses are at –40 units, and a sync pulse is approximately 0.3 volt peak-to-peak. The portion of the signal that contains video information is raised to a set-up level of +7.5 units above the blanking level. A monochrome video signal at +7.5 units is at the black threshold. At +100 units the signal represents 100% white. Levels between +7.5 and +100 units produce various shadings of gray. Even when a composite video signal is not at the 1 volt peak-to-peak level, the ratio between the sync pulse and video must be maintained, 0.3 of total for sync pulse and 0.7 of total for 100% white.

There is also a specific relationship between the amplitude of the composite video signal and the percentage of modulation of an rf carrier. A television signal uses negative modulation, wherein the sync pulses (–40 units) produce the maximum peak-to-peak amplitude of the modulation envelope (100% modulation), and white video (+100 units) produces the minimum amplitude of the modulation envelope (12-1/2% modulation). This is very advantageous, because the weakest signal condition, where noise interference can most easily cause snow, is also the white portion of the video. There is adequate amplitude guard band so that peak white of + 100 units does not reduce the modulation envelope to zero.

Color

(See Fig. 51)

The color information in a composite video signal consists of three elements: luminance, hue, and saturation.
Luminance, or brightness perceived by the eye, is represented by the amplitude of the video signal. The luminance component of a color signal is also used in monochrome receivers, in which it is converted to a shade of gray. Yellow is a bright color and has a high level of luminance (is nearer to white), while blue is a dark color and has a low level of luminance (is nearer to black).
Hue is the element that distinguishes between colors, red, blue, green, etc. White, black, and gray are not hues. The phase angle of the 3.58 MHz color subcarrier determines the hue. The three primary video colors of red, blue, and green can be combined in such a manner to create any hue. A phase shift through 360° will produce every hue in the rainbow by changing the combination of red, blue, and green.
Saturation is the vividness of a hue, which is determined by the amount the color is diluted by white light. Saturation is often expressed as a percentage; 100% saturation is a hue with no white dilution, which will produce a very vivid shade. Low saturation percentages are highly diluted by white light and produce light pastel shades of the same hue. Saturation information is contained in the amplitude of the 3.58 MHz color subcarrier. Because the response of the human eye is not constant from hue to hue, the amplitude required for 100% saturation is not the same for all colors.
The combination of hue and saturation is known as chroma, or chrominance. This information is normally represented by a vector diagram. Saturation is indicated by the length of the vector and hue is indicated by the phase angle of the vector. The entire color signal representation is three dimensional, consisting of the vector diagram for chrominance and a perpendicular plane to represent the amplitude of luminance.