SUBCOURSE
SS 0606

EDITION
8

ANALYZING COLOR VIDEO AND VIDEO TEST SIGNALS

THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

AIPD

READINESS/PROFESSIONALISM THRU GROWTH

US ARMY RADIO/TELEVISION SYSTEMS SPECIALIST
MOS 26T SKILL LEVEL 1, 2 & 3 COURSE

ANALYZING COLOR VIDEO AND VIDEO TEST SIGNALS

SUBCOURSE SS0606

US Army Signal Center and Fort Gordon
Fort Gordon, Georgia

EDITION 8
5 CREDIT HOURS
REVISED: 1988

General

The Analyzing Color Video and Video Test Signals subcourse requires a basic understanding of television electronics, television systems operation, and television transmissions. This subcourse is designed to teach you the knowledge and the basic applications used in color television transmission and television test signals. Information is provided on the fundamentals of color, color transmission, color test signals, and basic television test signals. The subcourse is presented in three lessons, each lesson corresponding to a terminal objective as indicated below.

Lesson 1: DESCRIBE THE FUNDAMENTALS OF COLOR

TASK: Describe the fundamentals of color used in television transmission.

CONDITIONS: Given the information and illustrations relating to the fundamentals of color.

STANDARDS: Demonstrate competency of the task skills and knowledge by correctly responding to 80 percent of the multiple-choice test questions covering the fundamentals of color used in television transmission.

Lesson 2: DESCRIBE THE COLOR BAR TEST SIGNALS

TASK: Describe and identify the four basic color bar test signals.

CONDITIONS: Given information and illustrations relating to the four basic color bar test signals.

STANDARDS: Demonstrate competency of task skills and knowledge required for identification of the color bars signals discussed in this lesson by correctly responding to 80 percent of the multiple-choice test questions covering the four basic color bar test signals.

Lesson 3: DESCRIBE THE BASIC ELECTRONIC TELEVISION TEST SIGNALS

TASK: Describe and identify five basic electronic television test signals.

CONDITIONS: Given information and illustrations pertaining to the basic television test signals.

STANDARDS: Demonstrate competency of task skills and knowledge required for identification of the test signals discussed in this lesson, by correctly responding to 80 percent of the multiple-choice test questions covering five basic electronic television test signals.

This subcourse is designed to provide the reader a good understanding of the fundamentals of color video and the basic applications of video test signals. It is not designed to instruct on equipment repair.

This subcourse supports the following MOS 26T tasks:
STP 11-26T13-SM-TG, September 1985

113-575-0021	Troubleshoot and Repair a Television Receiver
113-575-0038	Troubleshoot and Repair Video Pulse Distribution Amplifiers
113-575-0043	Troubleshoot a Color Television Camera
113-575-0044	Troubleshoot a 3/4-inch Video Cassette Recorder/Reproducer
113-575-0045	Troubleshoot a Television Transmitter
113-575-0046	Troubleshoot a Television Video Switcher
113-575-0049	Troubleshoot a Time Base Corrector
113-575-2040	Perform Functional Check of a Color Television Film Camera Chain
113-575-2041	Perform Functional Check of a Color Television Camera System

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Whenever pronouns or other references denoting gender appear in this document, they are written to refer to either male or female unless otherwise noted.

INTRODUCTION TO ANALYZING COLOR VIDEO AND VIDEO TEST SIGNALS

The Federal Communication Commission (FCC) standards for broadcast television are based on the work of the National Television System Committee (NTSC). The term "NTSC Color" is often used because the specific details of the television transmission system were designed and developed by NTSC. NTSC sets the standards which are used in the United States and in the various countries that use this system.

Once the guidelines were established for black and white and color television transmission, test equipment had to be designed to maintain the specifications of the signal being transmitted. The NTSC joined in collaboration with the Electronics Industries Association (EIA), the Society of Motion Picture and Television Engineers, and the Institute of Electrical and Electronic Engineers (IEEE) to develop various television test signals.

This subcourse explains the fundamentals behind the development of the color signal and how it is transmitted. The subcourse identifies and discusses various applications of the television test signals such as: Color bars, Multiburst, Gray-scale Linearity, Vertical Interval Test, Vertical Interval Reference, and Sin2 Window test signals. The information contained in this subcourse will provide knowledge necessary to enhance your competence in the field of television engineering.

Lesson 1
DESCRIBE FUNDAMENTALS OF COLOR

TASK

Describe the fundamentals of color used in television transmission.

CONDITIONS

Given the information and illustrations relating to the fundamentals of color.

STANDARD

Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the fundamentals of color used in television transmission.

REFERENCES

None

Learning Event 1:
DESCRIBE COLORIMETRY

1. General. To learn the color TV system you must have a basic background in the fundamentals of color. The entire concept of color television is based upon how the eyes react to light frequencies. From studies conducted on how people see, it was determined that the color signals would occupy a certain amount of space in the frequency bandwidth for color television. The process of specifying and determining colors had to be accomplished before the color television system could be developed. This is a science in itself and is known as colorimetry.

2. Colorimetry. The science and practice of determining and specifying colors is referred to as colorimetry. The science of colorimetry was especially important to the color engineers who contributed to the design of the present color television system. Since the system had to be designed to reproduce things as they are seen in nature, the characteristics of light, vision, and color were taken into consideration.

a. Colorimetry is a very complex subject. It is not necessary to be an expert colorimetrist in order to understand the takeup of the color picture signal and the way in which it is used in the color receiver. However, a better understanding of the color television system is attained if the most important fundamentals of colorimetry are known. The principles of color as applied to television are slightly different from those which many of us have been taught in connection with other types of color reproduction.

b. The properties of light and vision must be understood before studying the principals of color. Light is the basis of color and the eye must be able to convey picture sensation to the brain. But the eye has certain visual limits.

3. Limits of vision. The limits of vision are chiefly determined by four factors; intensity threshold, contrast, visual angle, and time threshold.

a. Intensity threshold. This is the lowest brightness level that can stimulate the eye. It is very much dependent upon the recent exposure of the eye to light. When a person enters a darkened room it takes the eye a long time to reach maximum sensitivity. The required time, which is usually about an hour, differs among individuals. When a person returns to a lighted area the time it takes for the eye to reach maximum is very short, actually just a matter of minutes.

b. Contrast. This represents a difference in the degree of brightness and in the intensity between black and white elements of the reproduced picture. The range of contrast should be great to produce a strong picture, with bright white and dark black for the extreme intensity values.

c. Visual angle. As an object is made smaller or is placed further from the eye, the angle formed by the light rays from the extremities of the object to the eye becomes smaller. This angle is referred to as the visual angle. In order for the eye to respond, the visual angle must be such that the image covers a definite area on the retina. If this area is decreased, a point at which the eye could no longer see the object is reached. This principle is used in eye tests. The minimum visual angle is dependent upon the contrast and brightness of the image. For example, an object with sharp contrast can be distinguished at a narrow visual angle, while the same size object with a lower contrast might not be visible.

d. Time threshold. There is a minimum time during which a stimulus must act in order to be effective. This is called the time threshold. If the exposure interval is too short, the rods and cones of the eye do not have time to respond to the image on the retina. The time threshold is also dependent upon the size, brightness, and color of the object. These four factors are all important factors that were taken into consideration in development of the color system for television. Now, light sources must be discussed.

4. Light Sources. To see, we must have a source of light, just as in the process of hearing we must have a source of sound before we can hear. When we speak of light, we usually think of light coming from the sun or the light which is emitted from some artificial lighting source such as electrical light. This type of light is referred to as direct light. Another type of light is indirect or reflected light, given off by an object when direct light strikes it. Direct light falling on an object is either absorbed or reflected. If all the light is reflected, the object appears white. If direct light is entirely absorbed, the object appears black. The larger the amount of light that is reflected by an object, the brighter the object will appear to the eye. In addition, the brighter the light source, the brighter the object will become. This can be demonstrated by casting a shadow on a portion of an object and noting the difference in brightness of the two areas. The portion without the shadow will appear brighter.

5. The visible light spectrum. Light is one of many forms of radiant energy. Any energy that travels by wave motion is considered radiant energy. Classified in this group along with light are sound waves, X-rays, and radio waves. As shown in Figure 1-1, light which is useful to the eye occupies only a small portion of the radiant energy spectrum. Sound is located at the lower end of the spectrum; cosmic rays are at the upper end. Light falls just beyond the middle of the spectrum. Along the top of the spectrum is the frequency scale, and along the bottom is the Angstrom unit scale (fig 1-1).

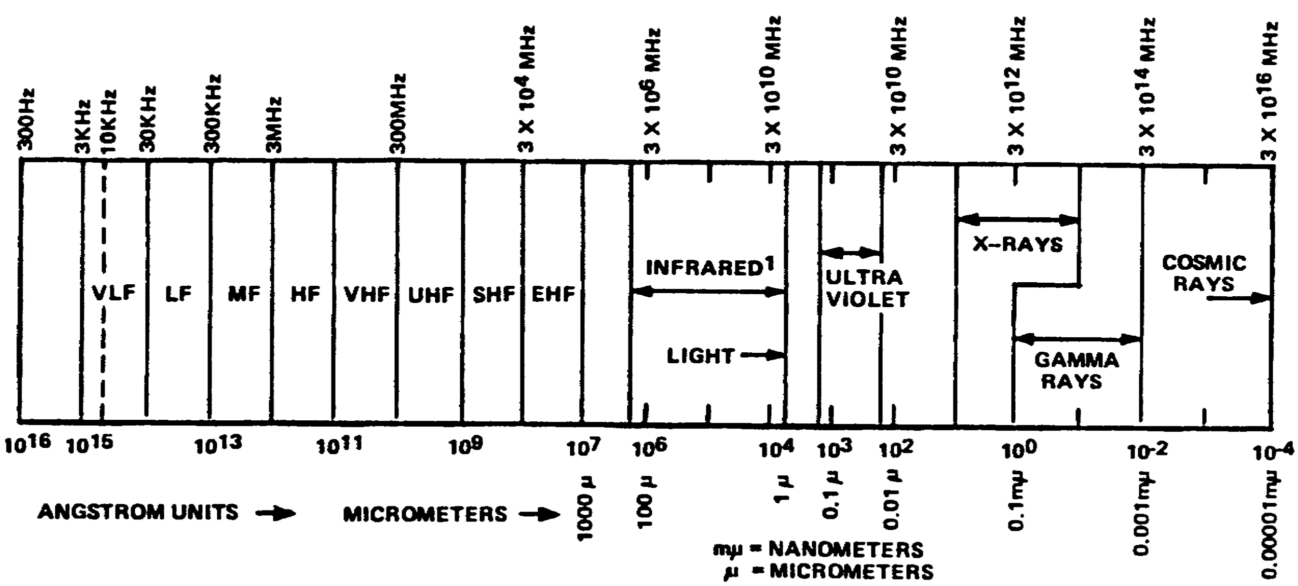


Figure 1-1. Radiant energy spectrum

a. Wavelengths in the region of light are measured in millimicrons. These units are also shown along the bottom of the spectrum in the illustration. Visible light is made alp of that portion of the spectrum between 380 and 780 nanometers (fig 1-2). The usable portion of the light spectrum for television falls between 400 and 700 nanometers (fig 1-3).

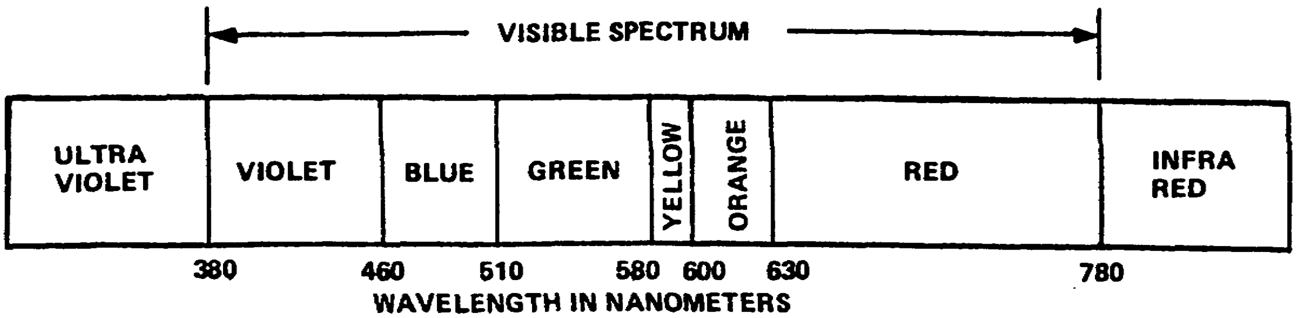


Figure 1-2. Visible light spectrum

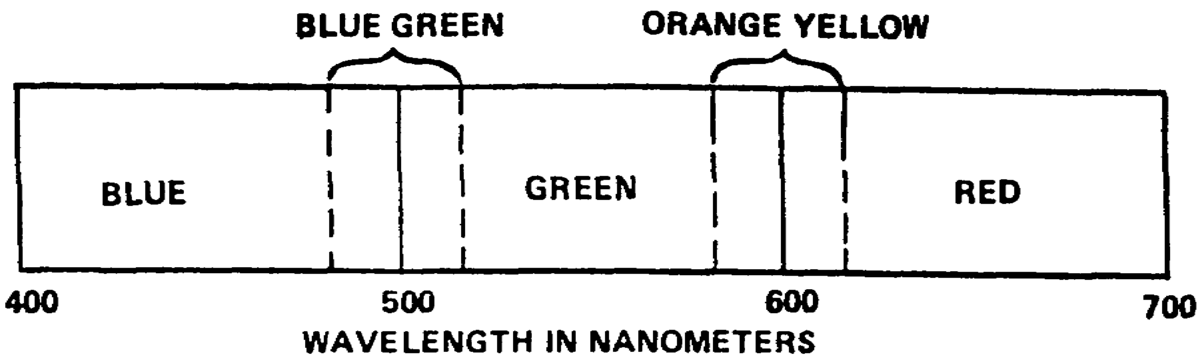


Figure 1-3. Visible light spectrum used for color television

b. When all of the light spectrum from 400 to 700 nanometers is presented to the eye in nearly equal proportions, white light is seen. This white light is made up of various wavelengths which represent different colors. Passing light through a prism will show the composition of the visible light spectrum, (fig 1-4). The light spectrum is broken up into various wavelengths, with each wavelength representing a different color. The ability to disperse the light with a prism results because light with shorter wavelengths travels slower through glass than does light of longer wavelengths. Six distinct colors are visible when passing white light through a prism. Since the colors of the spectrum pass gradually from one to the other, the theoretical number of colors becomes infinite. It has been determined that about 125 colors can be identified in the visible spectrum.

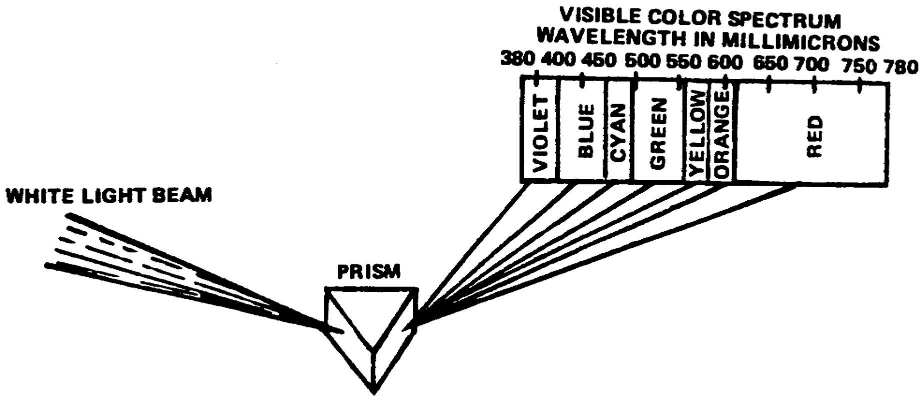


Figure 1-4. Effect of prism on white light

Learning Event 2:
DESCRIBE LUMINOSITY AND THE ADDITIVE METHOD OF COLOR MIXING

1. Luminosity curve. The fact that the human eyes do not perceive each color with equal efficiency is due in some way to the physical construction of the eye. It is believed that the cones of the retina respond to color stimuli and that each cone is terminated by three receptors. Each receptor is believed to respond to a different portion of the spectrum, with peaks occurring in the red, blue, and green regions. An average can be taken of the color response of a number of people, and a standard for the average person can be derived.

a. This standard response is called the luminosity curve for the standard observer (fig 1-5).

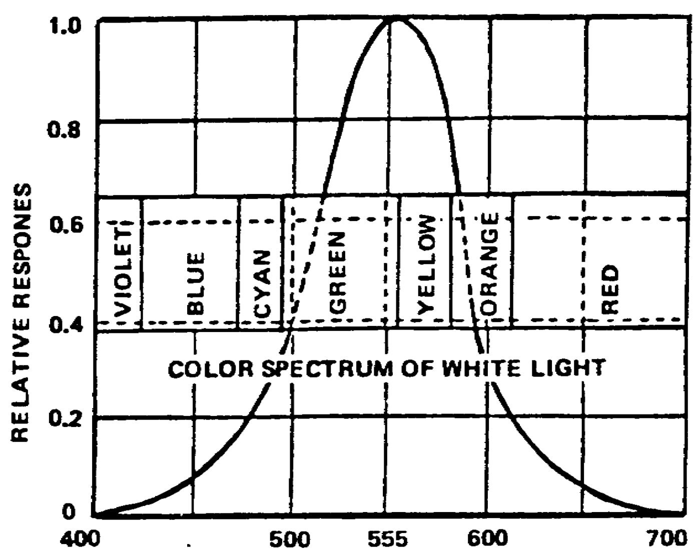


Figure 1-5. Luminosity curve

b. The curve is a plot of the response verse wavelength. We can look at the luminosity curve and see that maximum response occurs at a wavelength of approximately 555 nanometers and that less response is indicated on either side of that point. From this information, it can be seen that the average person's eye is most sensitive to yellow-green light.

2. Qualities of color. There are three qualities which are used to describe any one color. These are hue, saturation, and brightness.

a. Hue is a quality which is used to identify any color under consideration, such as red, blue, or yellow. Hue, which defines the wavelength of the color, would be synonymous with frequency, which defines the wavelength of the radio wave.

b. Saturation is a measure of the absence of dilution by white light and can be expressed with terms such as rich, vivid, or pure. Saturation defines the purity of the color, and is synonymous with signal to noise ratio, which defines the purity of the radio wave. A 100-percent saturated color contains no white light.

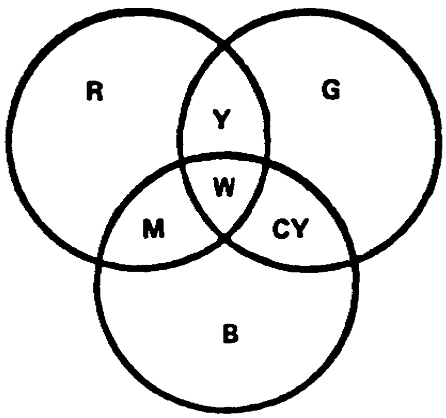
c. Brightness defines the amount of light energy which is contained within a given color. It is synonymous with amplitude, which defines the amount of energy in the radio wave. Brightness is a characteristic of both white light and color. Hue and saturation are characteristics of color only. The brightness level of a color can be changed without changing the saturation. The converse is also true.

3. Any given color, within limitations, can be reproduced or matched by mixing three primary colors. This applies to large areas of color only. Color vision for small objects or small areas is much simpler because only two primary colors are needed to produce any hue. This is because, as the color area is reduced in size, it become more difficult to differentiate between hues. For small areas every hue appears as gray. At this point a change in hue is not apparent; only a change in brightness level can be seen. For example, a large area of blue can be easily distinguished from a large area of blue-green. However, when these areas are reduced in size, it becomes more difficult to distinguish between the colors.

4. Color mixing. In color television, the additive process of color mixing is used. It uses colored lights for the production of colors. The colors in the additive process do not depend upon an incident light source; self-luminous properties are characteristics of additive colors. Cathode ray tubes contain self-luminance properties, so it is logical that the additive process would be employed in color television.

a. The three primaries for the additive process of color mixing are red, blue, and green. Two requirements for the primary colors are that each primary be different and that the combination of any two primaries do not produce the third. Red, green, and blue were chosen for the additive primaries because they fulfilled these requirements, and the greatest number of colors could be matched by the combination of these three colors. Three additive primaries are combined in a definite proportion (fig 1-6). White has been produced through the addition of all three primaries. Red and green combine to make yellow. The combination of red and blue produces magenta (bluish-red), while blue and green combine to make cyan (greenish-blue).

b. Yellow, magenta, and cyan are the secondary colors and are the complements of blue, green, and red, respectively. When a secondary color is combined with its complementary primary, white is produced. For example, combining yellow with blue produces white. Cyan added to red produces white and magenta plus green produces white. Carrying this one step further, the complementary colors when added together produce white. The expression circles in Figure 1-6 relate to color mixing.



R + B + G = WHITE
R + B = MAGENTA
M + G = WHITE
R + G = YELLOW
Y + B = WHITE
G + B = CYAN
CY + R = WHITE

Figure 1-6. The expression circles of color mixing

c. Since yellow + blue = white, and red + green = yellow, then red + green + blue = white. Because the addition of the three primaries can produce white, the addition of the correct proportions of the three complementaries which are made up of the three primaries can also produce white. Therefore cyan + magenta + yellow = white.

d. It is not necessary to overlap the primary colors in the additive process to produce a different color. Two sources of color may be placed near each color, and at a certain viewing distance the two colors will blend and produce the new color. The eye actually performs the additive process. The screen of a color kinescope contains hundreds of thousands of phosphorous dots arranged in triangular patterns (fig 1-7). Each dot is excited by its own electron beam. The cluster of dots will emit a white light or any other color depending on the strength of the various electron beams. Due to the limits of vision of the human eyes and the process discussed above, we are actually seeing an illusion when we watch our television receiver.

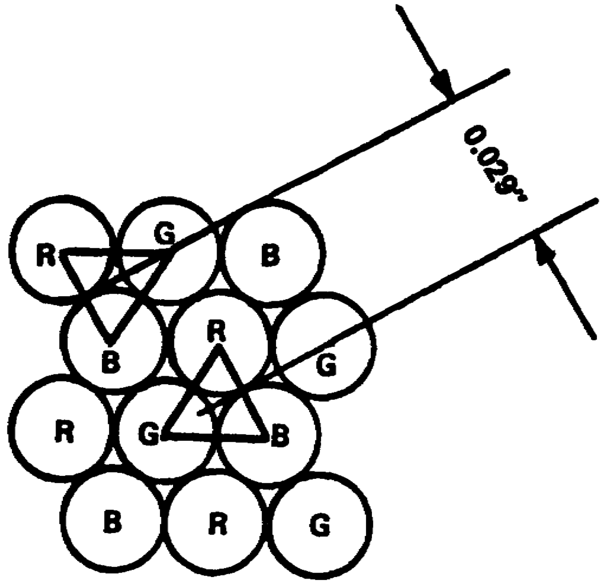


Figure 1-7. Phosphorous dots

e. Each additional primary color contributes a certain percentage of brightness in the mixture of white. Green is the brightest of the three primaries, red is the second brightest, and blue is the dimmest. This has been determined through experimentation with the response of the eye. The eye responds more to green than any other of the primary colors. With the total brightness of white considered as unity, green contributes 59 percent of the total, red 30 percent, and blue 11 percent. Therefore, when combining green with red we have yellow with a brightness level of 89 percent. Cyan has a brightness value of 70 percent. The third complementary color, magenta, has a brightness value of 41 percent. It obtains 30 percent from red and 11 percent from blue. The order of brightness for each color is known as the luminance stairstep (fig 1-8).

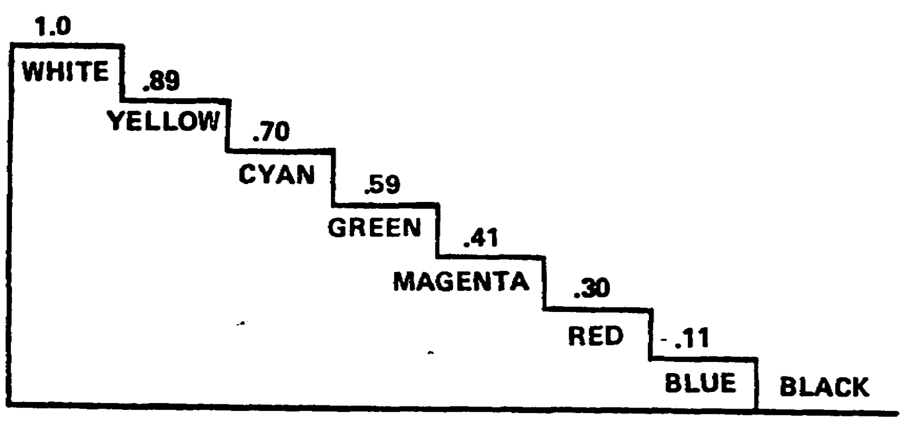


Figure 1-8. Luminance stairstep

5. The Commission Internationale de l'Eclairage (CIE) chromaticity diagram and the NTSC triangle. In the development of a color matching and specification system, extensive color matching tests on many observers were conducted using a device known as a colorimeter. In order to establish an average which could be considered as that of the standard observer, many persons were used, with each performing similar tests. The results of these tests are known as tristimulas values for the color mixture curves.

a. By the use of mathematical equations, the information contained in the color mixture curves has been converted to a graphical representation of the color on a three-dimensional plane and is referred to as the Maxwell Triangle. For practical purposes the three-dimensional Maxwell triangle has been converted to a two-dimensional drawing and designated as the CIE chromaticity diagram.

(1) Examining the diagram in Figure 1-9, you see that the horseshoe curve, which is known as the spectrum locus, is graduated into numerals ranging from 400 in the left-hand corner to 700 at the extreme right. These figures represent the wavelengths of the various colors in nanometers. The blues extend from approximately 400 to 490 nanometers, the greens from approximately 550 to 580 nanometers, and the reds (including orange) extend from 580 to 700 nanometers.

(2) Since fully saturated colors contain no white light, the spectrum colors which lie directly on the horseshoe curve are 100-percent saturated. At point E in Figure 1-9, only white light is present, so there is zero percent saturation. This same principle applies when observing the vectorscope, which is a device used for measuring relationships between the various color signals being transmitted as well as the amount of saturation present.

(a) Various percentages of saturation fall along a straight line drawn between any point on the spectrum locus and point E (fig 1-9). As you move towards point E, the saturation is decreased.

(b) Conversely, as you move toward the curve, the saturation is increased. Thus, you can see that a 100-percent saturated color is one that has 100-percent purity or freedom from white and that a desaturated color is a color which contains some amount of white light.

b. When primary colors were selected for color television work, it was found that those primaries were limited by color phosphors that were available for the picture tube. Figure 1-9 shows the actual location of the primaries (red, blue and green) that are used in color television. These points represent the primaries selected by the NTSC, and define a triangle within the boundaries of the chromaticity diagram.

(1) NTSC is a research group set up by leading equipment manufacturers and broadcasters. The group examines all aspects of television, such as frequency, bandwidth, quality, power, color, and methods of transmission.

(2) The area within the triangle represents the range of colors that are obtainable when these primaries are used. In the NTSC triangle, red has a wavelength of approximately 610 nanometers, green is approximately 540 nanometers, and blue is approximately 470 nanometers. At first glance, this triangle appears much smaller than the spectrum of colors obtainable when ideal primaries are used. But, if you give Figure 1-9 a close inspection, you see that the NTSC primaries fall very close to saturated colors on the chromaticity curve. The red primary, for example, is actually on the curve.

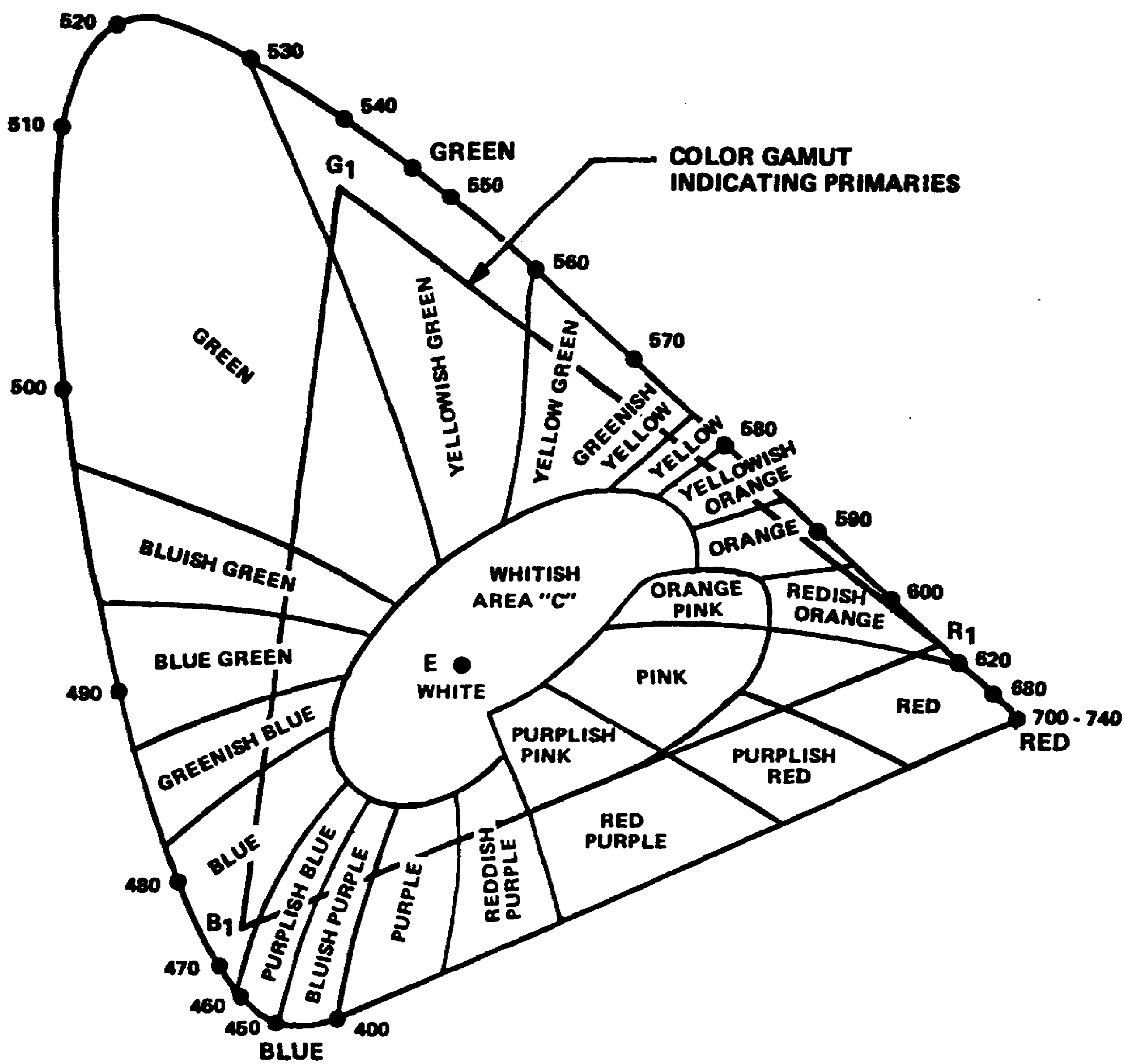


Figure 1-9. CIR chromaticity diagram and the NTSC triangle

Learning Event 3:
DESCRIBE THE NTSC COLOR TRANSMISSION SYSTEM

1. Compatibility is one of the primary requirements of the color television system. Compatibility provides a high definition black and white picture for present standard black and white receivers without any modifications to the TV receiver. This means that the following must apply:

a. First, a color telecast must provide a full 6-MHz black and white signal with the same amplitude modulation, sync, and blanking characteristics as does any ordinary standard monochrome telecast.

b. Second, the chrominance information, which includes the hue and saturation variable of color, must be transmitted within the standard 6-MHz television channel.

c. Third, the transmitted chrominance information must not in any way cause objectionable interference with the black and white signal (the brightness variable of color).

d. At first glance it seems to be a difficult task since the 6-MHz channel is apparently already well filled. However, you will learn that it is not impossible to transmit the chrominance information along with the monochrome signal within the standard 6-MHz television channel.

2. As previously stated, color television programs must be transmitted so they can be faithfully reproduced by black and white receivers. This feature is known as compatibility (fig 1-10).

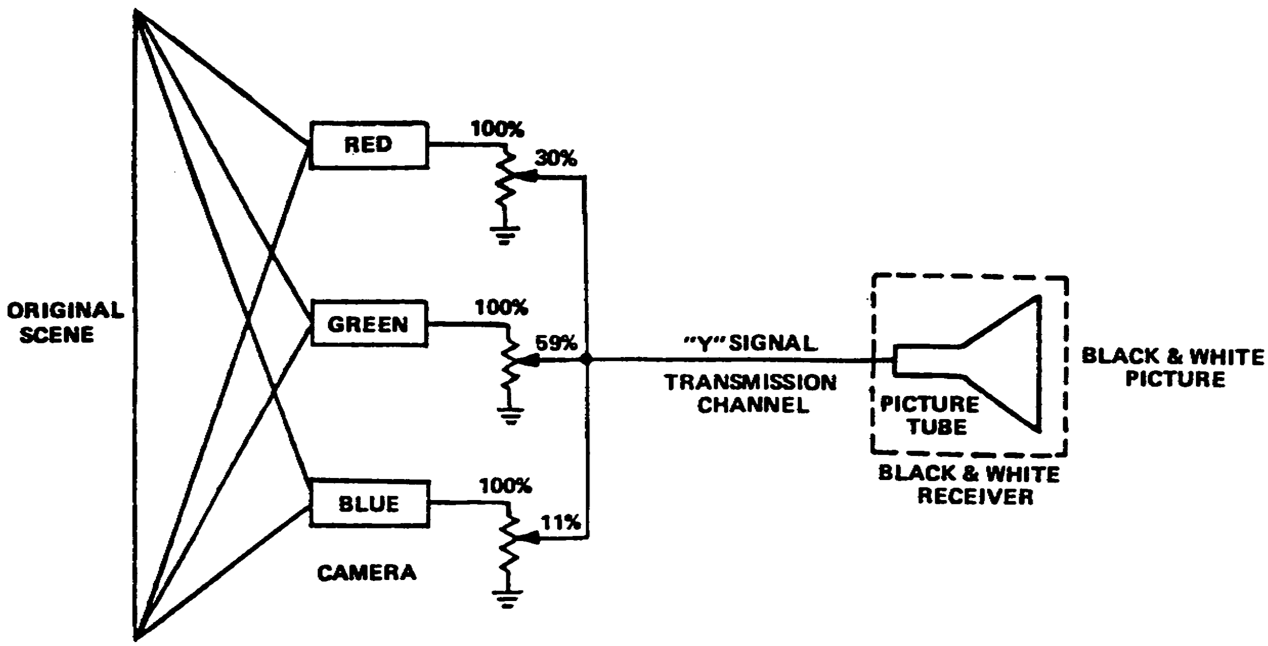


Figure 1-10. Compatibility

3. Reverse compatibility (fig 1-11) or black and white reception on a color receiver is the next requirement. A black and white signal' transmitted by a monochrome system is split three ways and is applied to the red, blue and green electron gun cathodes of a tricolor kinescope. Before the signal is applied to its electron guns, the tricolor tube is adjusted to produce a white raster. After a white raster is obtained, the signal is applied to all three guns and the black and white signal being transmitted produces a monochrome picture on the tricolor kinescope. In the process of producing a white screen, the kinescope automatically separates the brightness signal into a ratio of 30 percent red, 11 percent blue, and 59 percent green as the signal is applied to the electron guns.

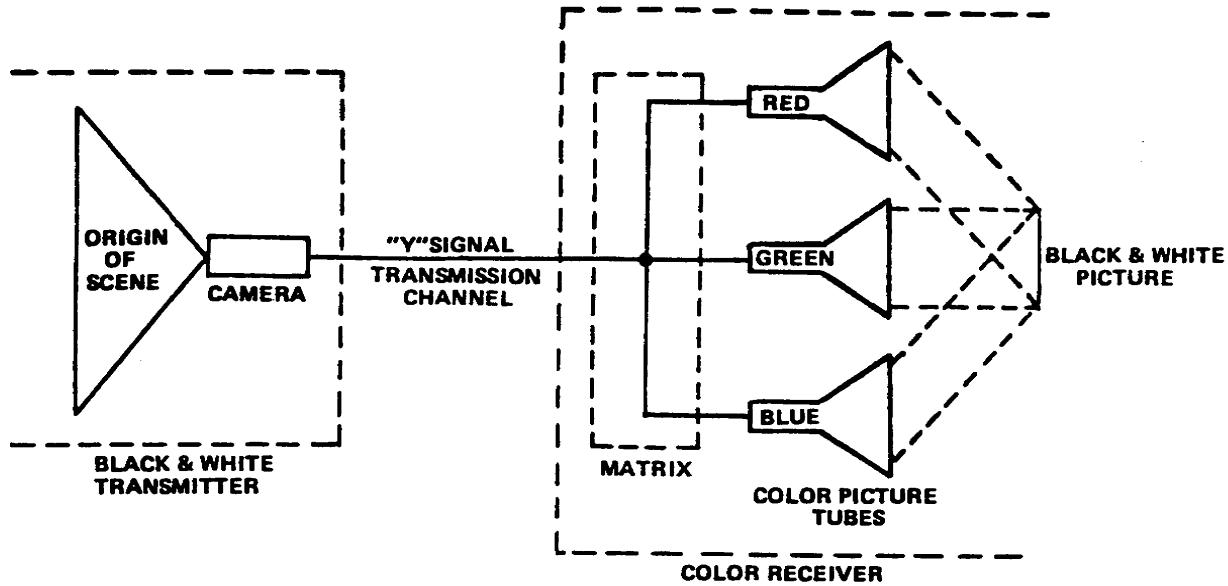


Figure 1-11. Reverse compatibility

4. A review of the standard bandwidth breakdown of a TV channel is presented in figure 1-12, so you can associate it with the bandwidth of the color signal. The bandwidth is 6 MHz, the video carrier is placed 1.25 MHz above the vestigial sideband, video information is compressed within the 4.2 MHz band above the video carrier, and for compatibility the monochrome and chrominance information is placed within the same 4.2 MHz band (fig 1-12).

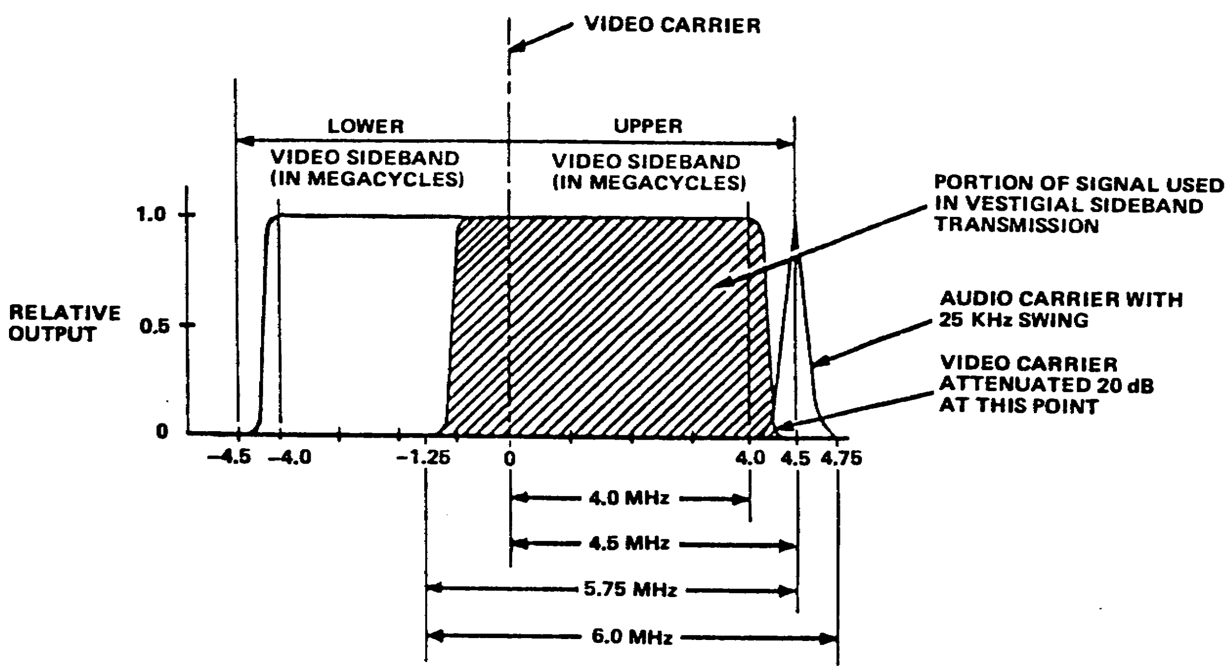


Figure 1-12. Standard television bandwidth

a. The color information is contained within the same 4.2 MHz band as the monochrome signal. It was discovered that a monochrome 4 MHz video signal does not occupy every cycle of the 4 MHz assigned to it. Rather, this signal appears in forms of clusters or "bursts" of energy located in harmonics of the 15750 Hz line-scanning frequency.

b. Figure 1-13 indicates that in a TV scene, the electrical signal consists of bursts of signal energy at the line harmonics with harmonics of 30 Hz (frame rate) and 60 Hz (field rate) clustered on either side. Other frequencies are attenuated so much that the space in between is considered to be unoccupied by any electrical signal. From Figure 1-13 it can be seen that half of the video spectrum is unused. Since the scanning rate for the chrominance and for the luminance signals are the same, the concentrations of energy produced by both are spaced at the same intervals. It is feasible, therefore, that the bands of concentrated energy of the chrominance signal could be spaced between the bands of the luminance signal. As seen in Figure 1-13, the spaces in the frequency occur at odd multiples of one-half the line frequency.

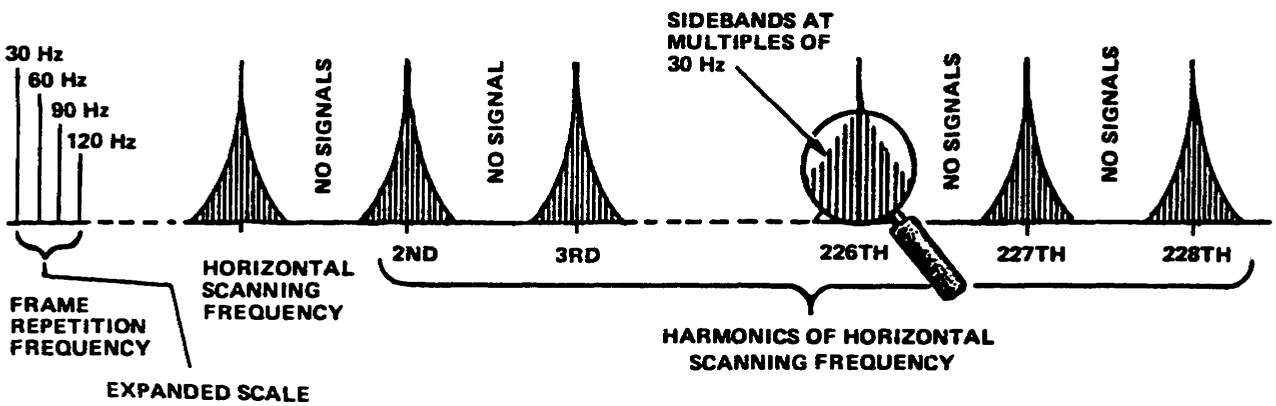


Figure 1-13. Distribution of energy in the frequency spectrum of a standard monochrome signal

c. If a subcarrier frequency equal to an odd multiple of one-half the line scanning frequency is chosen, the chrominance and luminance signals are interleaved. This practice is followed today (fig 1-14).

5. Color signal components. A color signal consists of two components; a monochrome signal and the signal which carries information concerning color. Each component will be examined separately.

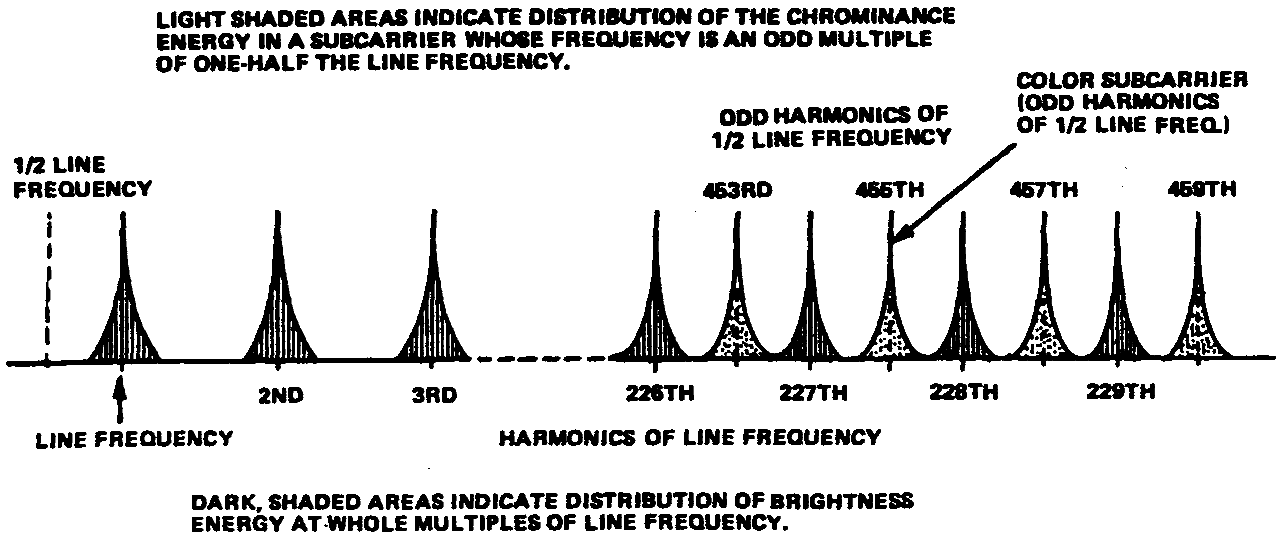


Figure 1-14. Interleaving of color with luminance signals

a. The monochrome signal (luminance or black and white), portion of the total color signal is equivalent in all respects to the present monochrome signals. It is formed by combining the red, blue and green signals from their respective color camera pickup tubes in these proportions:

Y (luminance) = Q.59G + Q.30R + Q.11B

Where:

Y = a mathematical symbol representing the luminance signal
G = green signal
R = red signal
B = blue signal

(1) This particular proportion was chosen because it closely follows the color sensitivity of the human eye. That is, if you take equal amounts of red, blue, and green light and superimpose the rays from these lights on a screen, you will see white. However, if you then look at each light separately, the green will appear twice as bright as the red, and from 6 to 10 times as bright as the blue. This is because the eye is more sensitive to green than to red and more sensitive to red than to blue.

(2) Thus, the luminance signal is composed of 59 percent green signal (that is, 59 percent of the output of the green camera pickup tube), 30 percent red, and 11 percent blue, and contains frequencies from 0 to 4.2 MHz.

(3) The terms monochrome and luminance are synonymous. They are also often referred to as the brightness signal. Every monochrome signal contains nothing but the variations in amplitude of the picture signal, and these amplitude variations at the picture tube produce changes in light intensity at the screen.

b. The second component of the television signal is the color signal itself, which is interleaved with the black and white signal. To determine what information this portion of the total signal must carry, we will examine how the eye reacts to color, since it is in the eye where the color image is formed. The color-discerning characteristics of the human eye have been thoroughly studied and, briefly, here is what is known:

(1) The typical human eye sees a full color range only when the area or object is relatively large. When the size of the area or object decreases, it becomes more difficult for the eye to distinguish colors. Thus, where the eye required three primary colors, now it finds that it can get along very well with only two. That is, these two colors will, in different combinations, provide the limited range of colors that the eye needs or can see in these medium-sized areas.

(2) When the detail become very small, all that the eye needs to (or can) discern are changes in brightness. Colors cannot be distinguished from gray, and in effect the eye is color blind.

(3) These properties of the eyes are put to use in the NTSC color system. First, only the large- and medium-sized areas are colored; the fine detail is fendered in black and white. Second, even the color information is regulated according to bandwidth; that is, the larger objects receive more of the green, red, and blue than the medium sized objects.

(4) The color signal takes the form of a subcarrier and an associated set of sidebands. The subcarrier frequency is 3.579545 MHz or rounded off to 3.58 MHz. This represents a figure which is the product of 7875 Hz multiplied by 455. The value 7875 Hz is one-half the line frequency of 15750 Hz, and if we use an odd multiple of 7875 Hz as a carrier, the frequency falls midway between the harmonics of 15750 Hz. If we use even multiples of 7875, we would end up with 15750 Hz or one of its harmonics, and this would place the color signal at the same points throughout the band as those occupied by the black and white signal (fig 1-14). By taking an odd multiple of 7875 Hz, we cause the signal to fall in between the bundles of energy produced by the first signal, and the two do not interfere.

(a) It is highly desirable to have the color subcarrier frequency as high above the picture carrier as possible in order to minimize the interference with the black and white video information (fig 1-15).

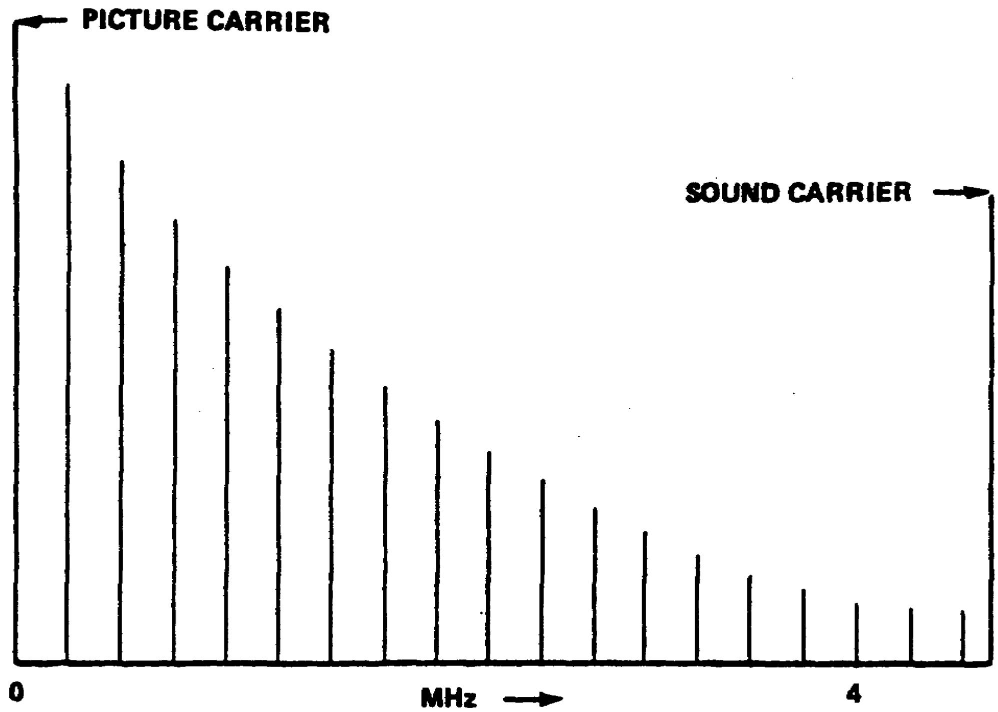


Figure 1-15. Black and white video energy distribution

(b) The energy level of the black and white video falls very rapidly with increasing video frequencies. By placing the color subcarrier as high as possible the different energy levels minimize possible interference (fig 1-16). Practical limits set the upper limit to 3.6 MHz.

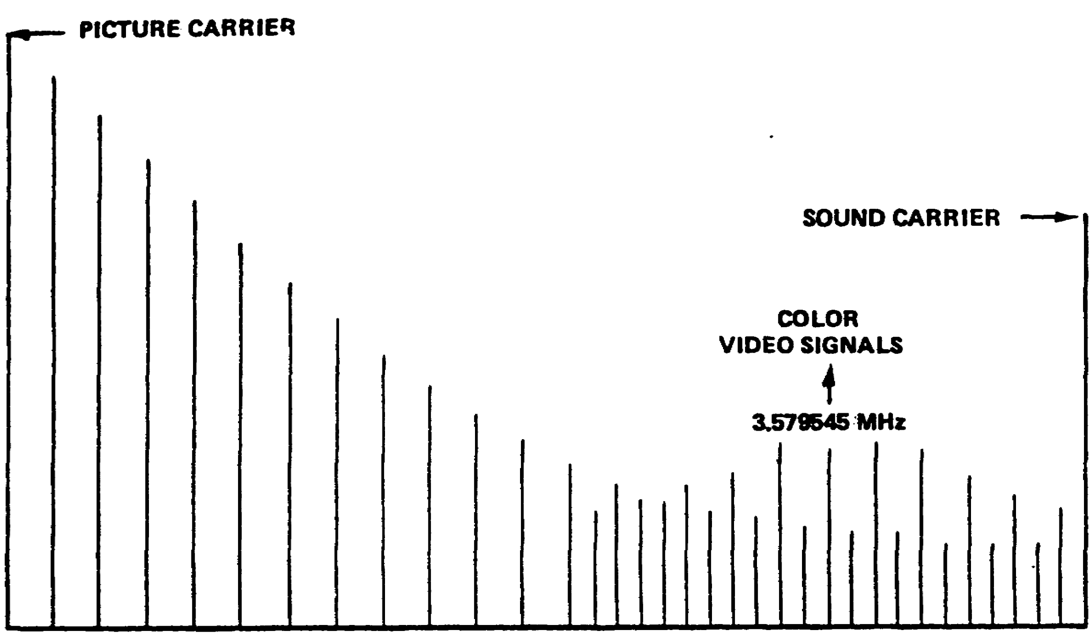


Figure 1-16. Placement of the color subcarrier

(5) There is a very objectionable 0.92 MHz (920 kHz) signal generated from the beat between the sound carrier and the color subcarrier (4.5 MHz - 3.58 MHz = 0.92 MHz). The beat is much less objectionable if the sound-carrier frequency is a multiple of the horizontal scan frequency away from the video carrier frequency. In standard black and white TV, the 286th harmonic of the horizontal line rate, 15750 Hz is 4.5045 MHz. The line frequency whose 286th harmonic is 4.5 MHz is 15734.26 Hz. F (line) = 4.5 MHz / 286 = 15734.26 (new line frequency for color).

(a) This frequency is within the deviation limit set by the NTSC monochrome standards. With the horizontal scan frequency changed, the color subcarrier must be chosen to interleave. It must be an odd multiple of one-half the horizontal scan rate. With 3.6 MHz as an upper limit, it was found that the 455th harmonic of half the horizontal scan rate becomes:

F (color subcarrier) = 455 x 15734.26 Hz / 2 = 3.58 MHz.

Since there are 525 lines, and using a 2:1 interlace, the new vertical scan frequency becomes:

F (vertical) = 2 / 525 x 15734.26 Hz / 1 = 59.94 Hz.

(b) Notice that the new scanning frequencies used for color transmission are slightly below the nominal values used in monochrome receivers. However, the changes amount to less than the 1 percent tolerance allowed, and the new frequencies fulfill the requirements for compatibility in monochrome reception.

6. Tolerance of subcarrier frequency. To maintain close synchronization of the color receivers, the tolerance for the subcarrier frequency is set at +/- 0.0003 percent, or around +/10 Hz; and the rate of change cannot be more than 1/10th Hz per second. The same tolerance applies to the field and line frequencies. In actual practice, all of these frequencies are developed from the same source to minimize variations from established figures.

7. Chrominance sideband transmission. Since picture detail is a function of the transmitted signal bandwidth, and since there is a limited amount of bandwidth allowed for chrominance information, this is an important point to consider. The highest usable video brightness signal frequency is 4.1 MHz, with the chrominance subcarrier at 3.58 MHz (fig 1-17). Transmitting symmetrical or double sidebands of chrominance would mean that color definition would be limited to 0.5 MHz and color would be absent in all fine detail in the picture. It is possible however, to transmit the chrominance sideband vestigially: that is, with one side band suppressed, the same as the black and white signal.

Although this would extend the color definition to possibly 1.5 MHz, it is practical to transmit only one of the chrominance signals vestigially. One of the color difference signals would then extend from 0 to 1.5 MHz, while the other color difference would be limited from 0 to 0.5 MHz.

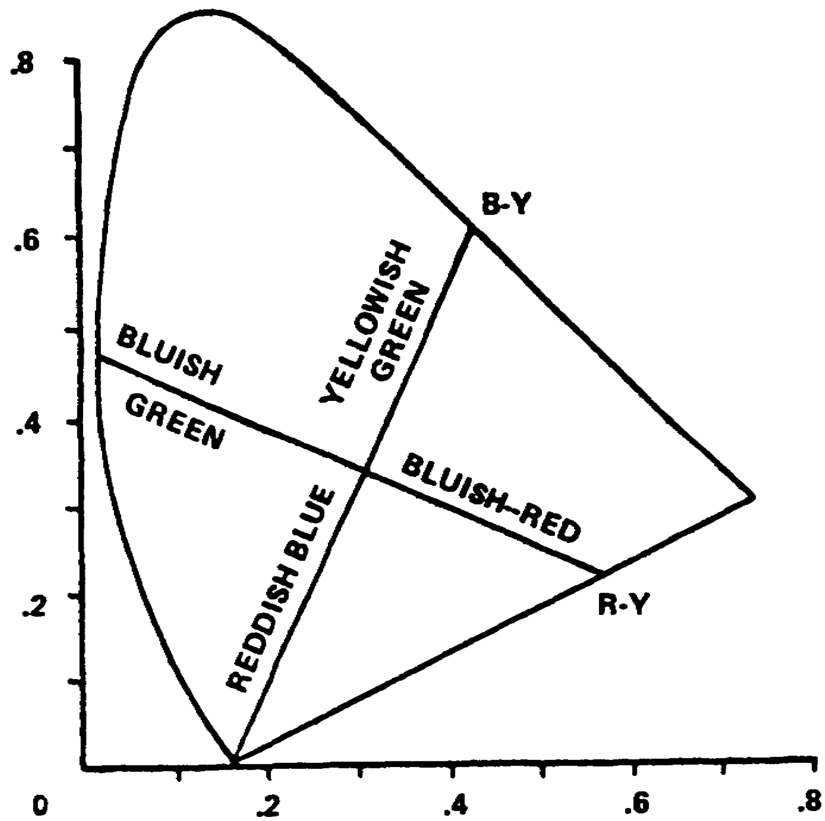


Figure 1-17. R-Y and B-Y chromaticity coordinates

8. Color difference signals. The color difference signals are the signals which can be produced by subtracting the Y signal from each color camera signal. For example, the Y signal is inverted so that all values are negative (-30R, -59G, -11B). This is algebraically added to each camera tube output in turn, producing three chrominance signals, R-Y, G-Y, and B-Y. Only two color difference signals plus the Y signal need to be transmitted to reproduce the color elements of any televised scene. One of the color difference signals may be developed in the receiver, since any two color difference signals contain all the necessary color information. Thus, only the R-Y and the B-Y signals need to be transmitted.

a. It should be noted that if R-Y were the extended sideband, fine detail would appear as either a bluish-red (magenta) or a bluish-green (cyan). On the other hand, if B-Y were the extended sideband, only reddish-green or yellow-green colors would be produced (fig 1-17).

b. Fine color detail is represented accurately to the eye by orange or cyan for any color. If this principle were to be used by R-Y and B-Y transmission standards, it would still be necessary to transmit extended sidebands of both color difference signals, since both are necessary to reproduce either cyan or orange.

(1) It appears then, that color definitions using the color difference signals must be limited to 0.5 MHz of sidebands extension (upper), and therefore cannot, by their inherent colors, represent full fidelity of the televised scene. The eye cannot detect all colors accurately for all sizes of picture detail. Color areas beyond a certain fineness of detail can be accurately represented to the eye by either orange or cyan, since the eye cannot distinguish any color other than one of these. For extreme fineness of detail the eye cannot detect any color sensation. Only a brightness variable is necessary to represent the object as having color.

(2) If the axis of the color subcarrier signals were shifted in phase from the reference subcarrier so that one axis would represent orange and cyan, with the other axis at right angles to it, then many transmission problems would be solved. The orange-cyan axis could be extended to 1.5 MHz, and since the fine detail conveyed by this extended bandwidth need only be either orange or cyan to represent accurate color reproduction to the eye, full color fidelity would be possible in picture detail up to 1.5 MHz of picture definition.

(3) By readjusting the phase of the chrominance signals and transmitting one signal vestigially with extended bandwidth, all colors are reproduced in picture detail from 0 to 0.5 MHz. Beyond this point, one of the chrominance signals drops out. With the orange-cyan signal still present to 1.5 MHz, effectively the eye still sees all color though only orange and cyan are transmitted. The eye cannot distinguish color in picture detail represented by video frequencies beyond 1.5 MHz. With no chrominance signals transmitted beyond this point, the brightness signal will accurately convey the illusion of color in video detail from 1.5 to 4.1 MHz.

9. High definition color transmission. The readjustment of chrominance signal phases is called high definition color transmission and is the system of color transmission used today. Since the chrominance axes in this system are not the same as R-Y and B-Y, they have been given new titles. One is called the "I" signal since it is nearest in phase to the burst or the reference subcarrier, and the other is called the "Q" signal as it is in quadrature with the I signal.

a. Figure 1-18 is a vector diagram of the I and Q color coordinates and their relationship to the old R-Y/B-Y system. The I and Q signals are produced with their phase coordinates 90 degrees from each other. The +I signal is 57 degrees from the reference subcarrier, with -I at 237 degrees (180 degrees from +I). The +Q signal is displaced 57 degrees + 90 degrees, or 147 degrees from reference subcarrier, with the -Q signal 180 degrees from it, or 327 degrees from the reference subcarrier.

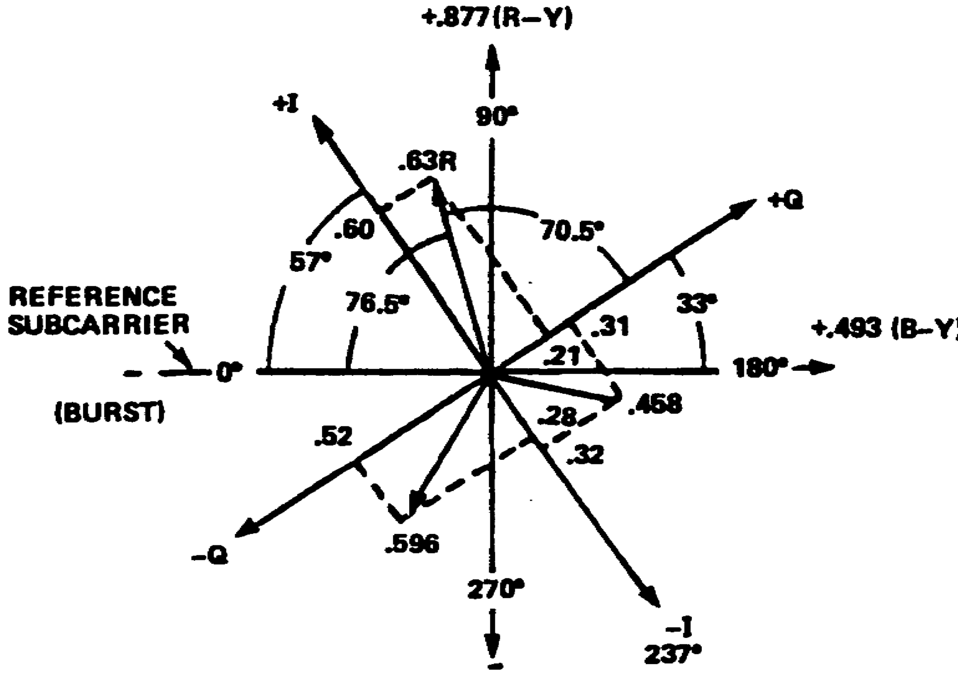


Figure 1-18. Vector diagram

b. Color transmission begins at the camera where the light of the original scene is separated into three primary colors; red, blue, and green.

(1) Three individual signals or electrical elements are provided by means of three pickup tubes to represent the information of the three primary colors. The three electrical signals representing red, green, and blue hues of the televised scene are then routed to a device known as a colorplexer (also known as an encoder). Colorplexers are sometimes referred to as the heart of the television system. This unit combines the various individual signals originating at the camera into a composite color television signal. Figure 1-19 illustrates a typical colorplexer. One can see that the red, blue, and green signals from the camera enter the colorplexer and are fed to the matrix selection.

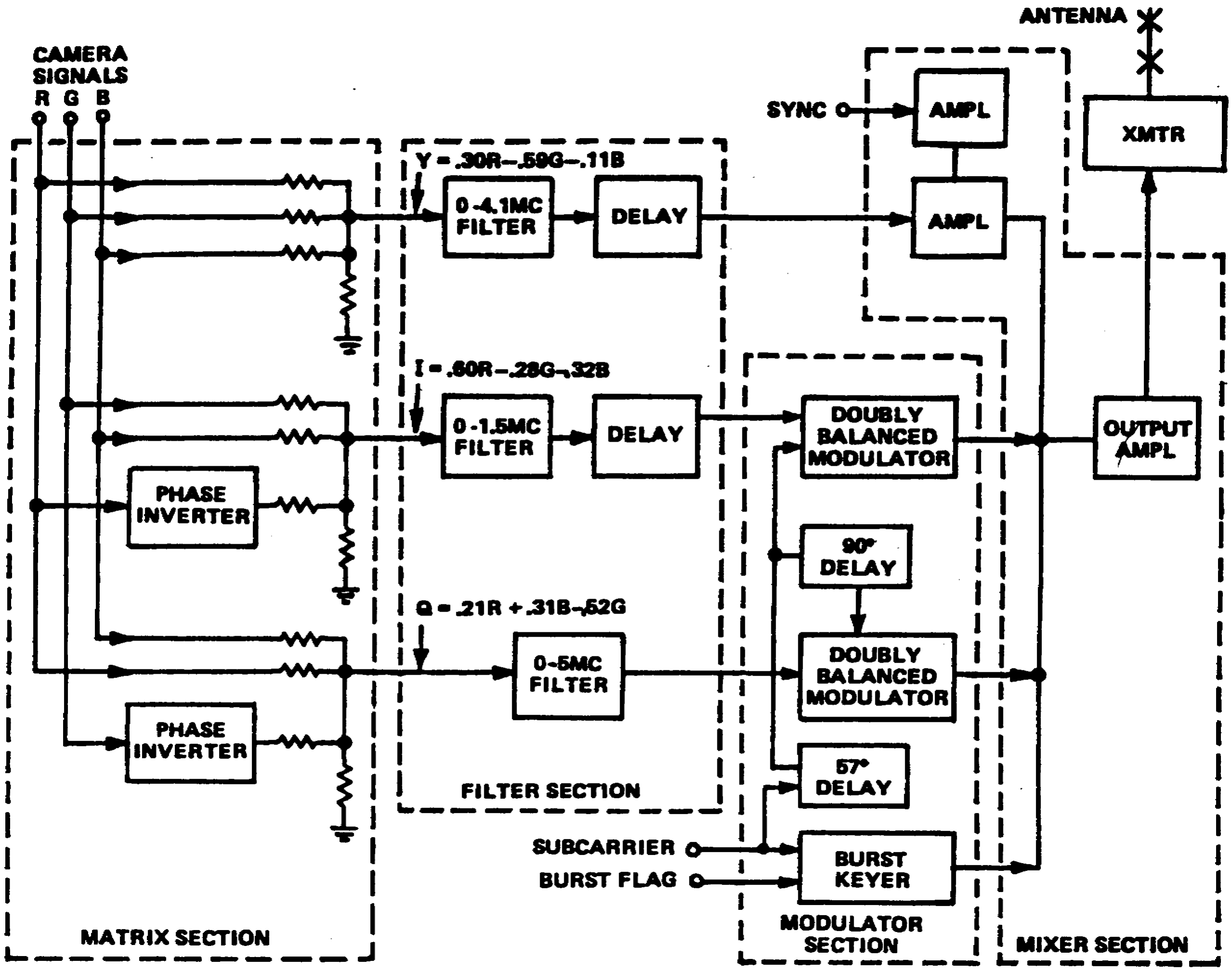


Figure 1-19. Basic colorplexer simplified block diagram

(2) Matrixing is the process of repackaging the information contained in the red, blue, and green output signals from the color camera. The outputs of the matrix are the Y, the I, and Q signals. The I and Q signals were previously known as the R-Y and B-Y signals. The Y signal is formed by applying the red, blue, and green pickup tube outputs to the base of an amplifier. Then the three signals are in phase with one another at the amplifier's input and output.

(a) A resistor network (crossconnected voltage divider) determines that the amplitude of the Y amplifier output will consist of 30 percent red, 59 percent green, and 11 percent blue. This Y signal corresponds to the variations of brightness in the scene being televised. This is the signal received by a black and white TV receiver, and is the brightness component in a color receiver.

(b) The I signal is formed by applying the red signal to the base, and the blue and green signal to the emitter of the I amplifier (fig 1-20). This circuitry determines that the output of the red signal will be 180 degrees out of phase with the other two color signals. Thus the designation is +60 percent red, +28 percent green, and +32 percent blue. The polarity signs only indicate phase relationships. The resistor network determines the amplitude of the signals.

(c) The Q signal is formed by applying the green signal to the base and the red and blue to the emitter of the Q amplifier. Here, the green is 180 degrees out of phase with the red and blue. The resistor network sets the percentages at -52 percent green, +21 percent red, and 31 percent blue (fig 1-21).

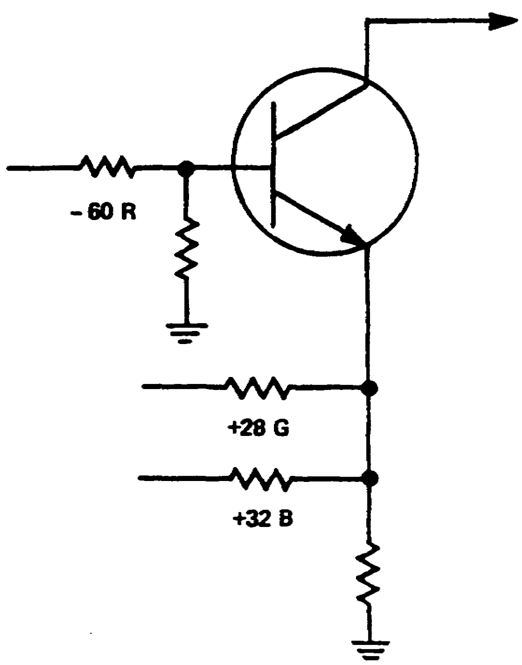


Figure 1-20. I matrix

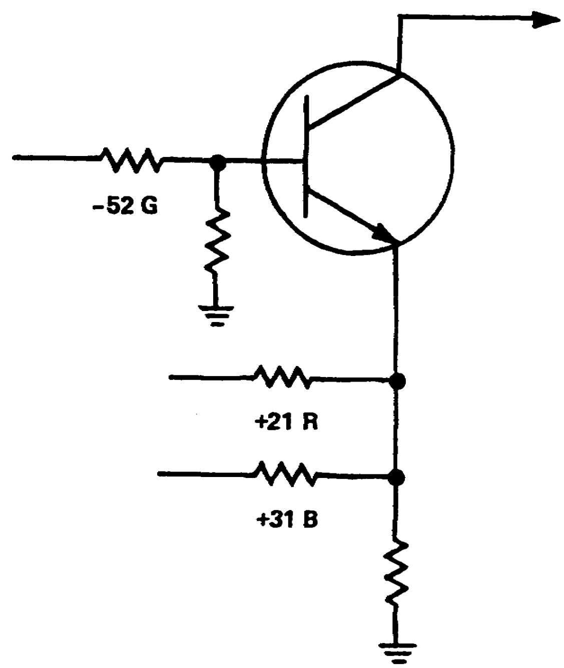


Figure 1-21. Q matrix

c. Band limiting and delay. The outputs of the individual matrix sections feed the filter section (fig 1-19). The filter section establishes a bandpass for each of the video signals, 4.1 MHz for Y, 1.5 MHz for I, and 0.5 MHz for Q. The channel is broad-banded but has vestigal-sideband characteristics because of the upper-frequency cutoff of the transmitter (fig 1-24). This channel is single-sideband for frequencies higher than 0.5 MHz. Transmission of frequencies up to 0.5 MHz is double-sideband on both the I and Q channels.

(1) This operation allows two types of receiver action: One, the receiver may use the extra color information in the wideband I channel, or, two, receivers may ignore this extra information and reproduce only chrominance detail supplied up to 0.5 MHz.

(2) Because the Y, I, and Q are different bandwidths, and since their envelopes must have a specific placement in time with regard to each other, the I and Y signals are sent through delay networks so that all three signals have the proper time placement when applied to the mixer (adder) section.

d. Two-phase modulation (generation of the color signal). The I and Q output of the filter section feeds two doubly-balanced modulators, where two-phase modulation takes place (fig 1-19).

(1) Two-phase modulation is a technique by which the I and Q signal scans are combined into a two variable signal for transmission over a single channel.

(a) This is accomplished by adding sidebands obtained through modulation of two 3.58 MHz carriers separated in phase by 90 degrees. The resultant waveform is the vector sum of the components. The two carriers, which are derived from the same oscillator, are suppressed by doubly balanced modulators. Thus, only the two amplitude modulated sidebands, 90 degrees out of phase, are transmitted.

(2) At the receiving end of the system, the I and Q signals are recovered by heterodyning the two-phase wave against two locally generated carriers of the same frequency (but with a 90-degree separation), and applying the resultant signals through low pass filters to other matrix circuits in the receiver.

(3) Figure 1-22 illustrates a simplified diagram of a doubly-balanced modulator. The input stage is a pair of differential amplifiers which supplies signal output of equal amplitude, 180 degrees out of phase with the input.

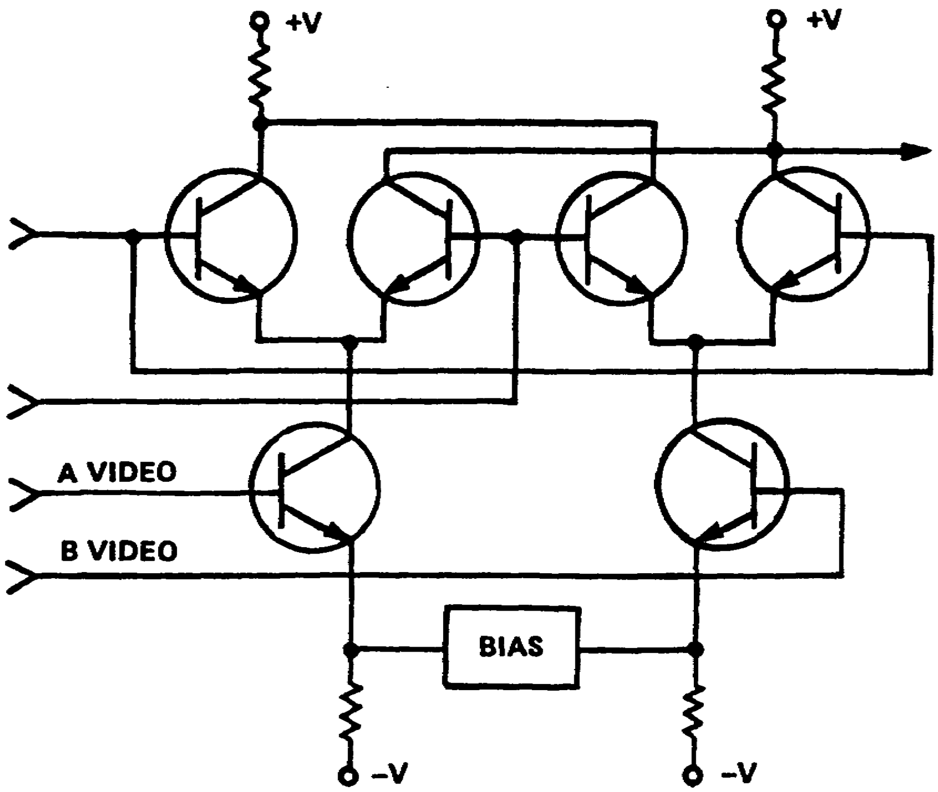


Figure 1-22. Doubly balanced modulator

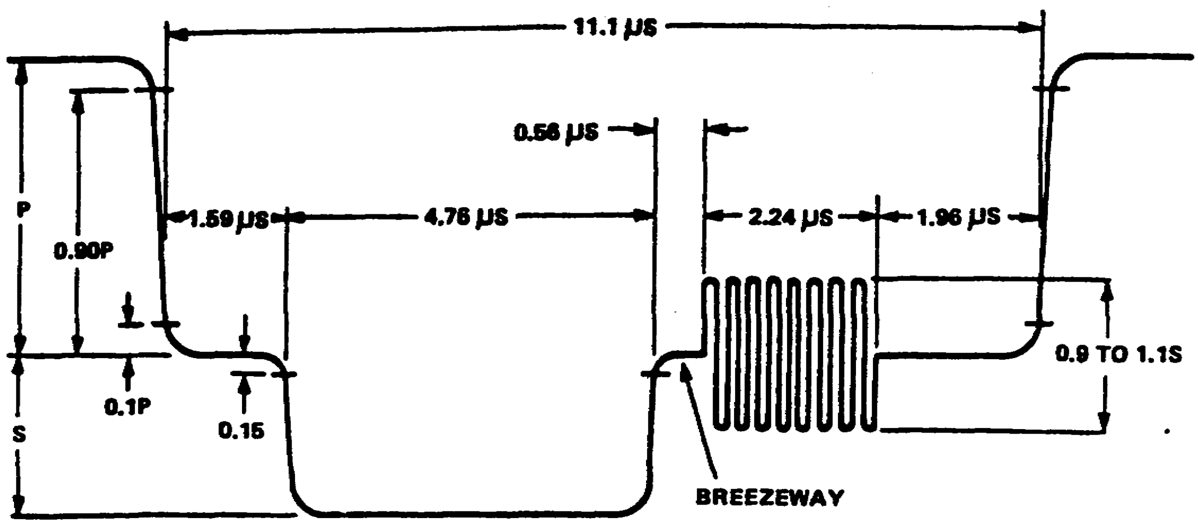
(4) Looking again at Figure 1-19, one can see that the 3.58 MHz CW subcarrier is applied to the I and Q modulators through delays. The I signal is delayed 57 degrees from subcarrier and the Q signal is delayed 57 + 90 or 147 degrees away from subcarrier. This corresponds to the I and Q vectors shown in figure 1-18. Also, the subcarrier is applied to a burst keyer where a portion of the subcarrier is inserted onto blanking for use as a color sync.

e. Color synchronization signal. Since the subcarrier is suppressed at the colorplexer, the local 3.58 MHz oscillator at the receiver must be accurately synchronized in frequency and in phase with the master oscillator at the transmitter. In order to maintain these two oscillators in phase, a short burst of the transmitter 3.58 MHz oscillator voltage is transmitted at the beginning of each horizontal scanning line.

(1) The burst is generated at the color frequency standard generator by a gating circuit which is turned on by burst keying pulses derived from a device known as a burst flag generator. This device is also locked in with the station sync generator.

(2) The burst consists of approximately 8 to 11 cycles of the 3.579545 MHz signal and is placed on the back porch of the horizontal blanking pedestal next to the horizontal sync pulse, and all are placed in the horizontal blanking interval (fig 1-23). FCC standard phase relationships between I and Q signals and the color synchronizing burst are shown in the vector diagram (fig 1-18). The I and Q signals are transmitted in phase-quadrature, and the color burst (referred to as reference subcarrier) is transmitted with an arbitrary 57-degrees phase lead over the I signal.

f. In the mixer section of the colorplexer, the outputs of the Y, I, Q, and burst keyer sections are added together to form the composite color signal (also, sync is added in the luminance channel for a single color camera chain). The bandpass is now formed with the addition of the I and Q signal,



	NOMINAL MICROSECONDS	TOLERANCE MICROSECONDS
BLANKING	11.1	+0.3 −0.6
SYNC	4.76	±0.32
FRONT PORCH	1.59	+0.13 −0.32
BACK PORCH	4.76	+0.96 −0.61
SYNC TO BURST	0.56	+0.08 −0.17
BURST	2.24	+0.27 0
BLANKING TO BURST[1]	6.91	+0.08 −0.17
SYNC & BURST	7.56	+0.38 −0.49
SYNC & BACK PORCH	9.54	±0.32

1. BLANKING TO BURST TOLERANCES APPLY ONLY TO SIGNAL BEFORE ADDITION OF SYNC.

Figure 1-23. Horizontal blanking interval

Lesson 1
PRACTICE EXERCISE

1. Brightness is synonymous with which of the following terms?

   a. Frequency
   b. Contrast
   c. Light
   d. Amplitude

2. What is the horizontal scanning rate for color transmission?

   a. 60 Hz
   b. 15750 Hz
   c. 59.94 Hz
   d. 15734.26 Hz

3. How many primary colors are required to produce any hue for a small object?

   a. Two
   b. Three
   c. Four
   d. Five

4. What is the color produced when 59 percent green is combined with 30 percent red?

   a. Cyan
   b. Yellow
   c. Magenta
   d. White

5. What is the science of determining and specifying colors?

   a. Additive mixing
   b. Subtractive mixing
   c. Luminosity
   d. Colorimetry

6. What does hue define in a color?

   a. Wavelength
   b. Luminance
   c. Saturation
   d. Purity

Lesson 2
DESCRIBE THE COLOR BAR TEST SIGNALS

TASK

Describe and identify the four basic color bar test signals.

CONDITIONS

Given information and illustrations relating to the four basic color bar test signals.

STANDARDS

Demonstrate competency of task skills and knowledge required for identification of the color bars signals discussed in this lesson by correctly responding to 80 percent of the multiple-choice test questions covering the four basic color bar test signals.

REFERENCES

None

Learning Event 1:
DESCRIBE THE ENCODED COLOR BARS TEST SIGNAL

1. The encoded color bars signal. The Electronics Industries Association (EIA) standard for the encoded color bars signal is established in their recommended standard RS-189. RS-189 provides the specification of the encoded color bars signal and its various applications. Some of the most common uses of this signal involve rapid checks of television transmitters, performing timing checks of production switchers, leader reference signals on video tapes, and to serve as a calibration signal for the adjustment of color monitors and encoders.

2. The encoded color bars signal consists of two major parts. The first three-fourths of the active scanning lines in each field are divided into seven equal intervals. These intervals represent one luminance interval and six chrominance intervals. The intervals are arranged in descending order of luminance from left to right as you observe a picture monitor or waveform monitor (fig 2-1).

a. The first interval, Gray (TV White), not to be confused with peak or reference white, has a luminance level of +77 IRE. This luminance level is normally associated with nonmodulated font. The six remaining luminance intervals are chrominance modulated in the following order: Yellow, Cyan, Green, Magenta, Red, and Blue. The luminance level for yellow is +69 IRE and the chrominance modulation level is +/31 IRE. Luminance for Cyan is +56 IRE and chrominance modulation is +/- 44 IRE. Luminance for Green is +48 IRE and chrominance modulation is +/- 41 IRE. Luminance for magenta is +36 IRE and chrominance modulation is +/41 IRE. Luminance for Red is +28 IRE and chrominance modulation is +/- 44 IRE. Luminance for Blue is +15 and chrominance modulation is +/31 IRE. These colors correspond to saturated colors transmitted at 75% of full amplitude.

b. The remaining one-forth of the active scanning lines in each field are used for the transmission of special test information. This information consist of a subcarrier signal envelope with a phase corresponding to -I, a reference white pulse with peak amplitude of 100 IRE, a subcarrier signal envelope with a phase corresponding to +Q, and a reference black interval (fig 2-2).

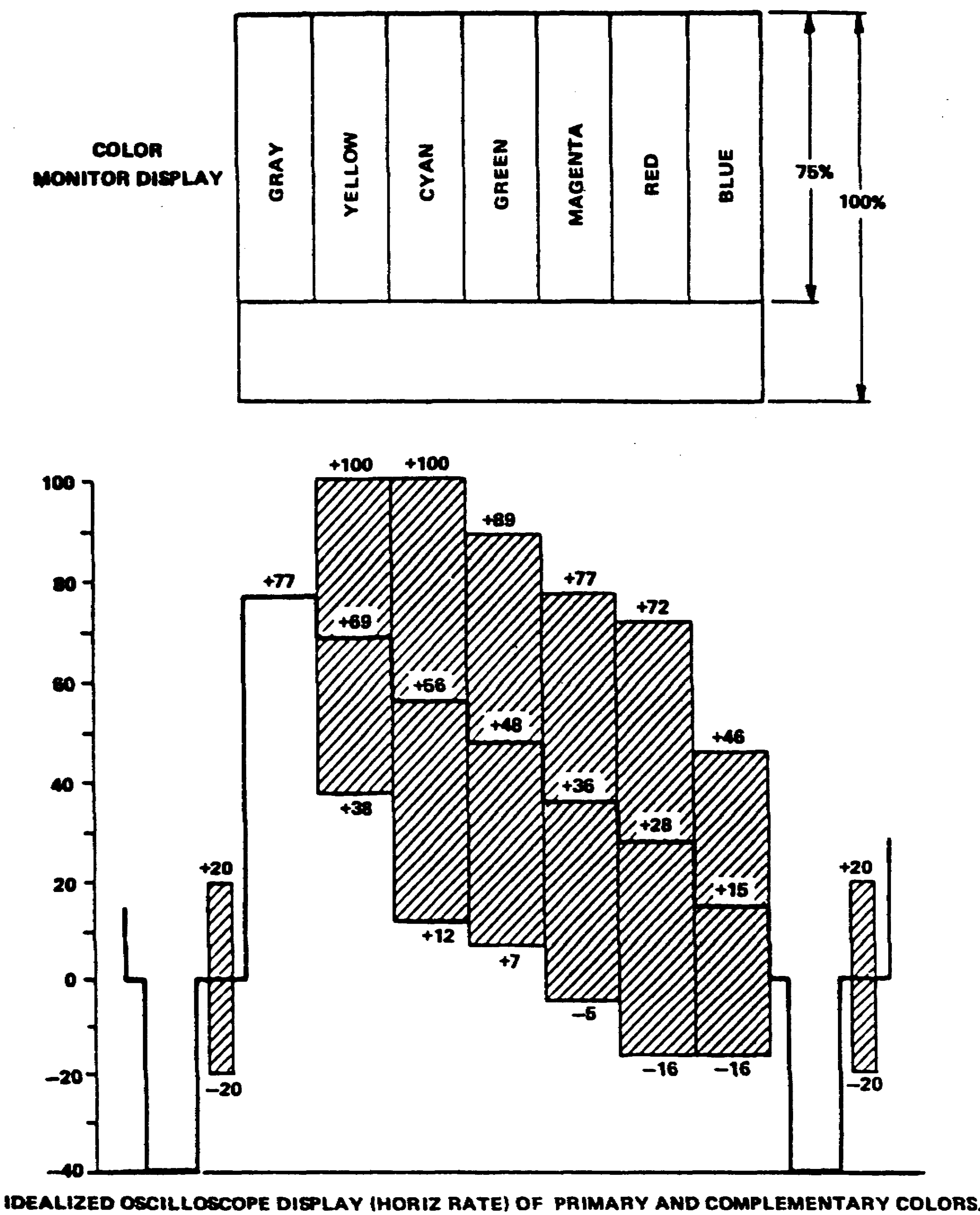


Figure 2-1. The first three-fourths of the active scanning lines in the encoded color bars signal

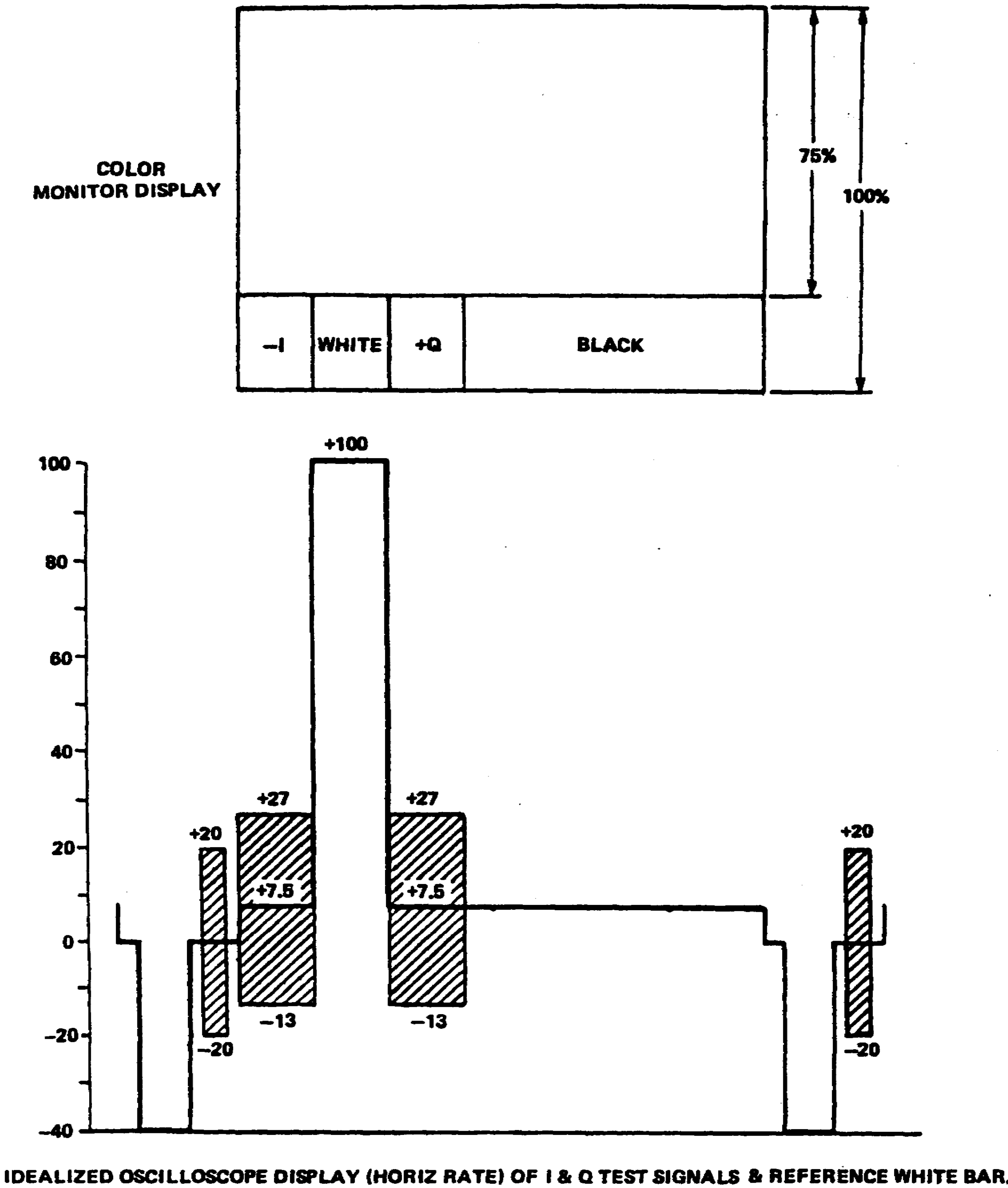


Figure 2-2. The remaining one-fourth of the active scanning line of the encoded color bars signal

Learning Event 2:
DESCRIBE THE ALIGNMENT COLOR BARS TEST SIGNAL

1. Alignment color bar test signal. The Society of Motion Picture and Television Engineers (SMPTE) published a journal containing an engineering committee report, ECR 11978. The recommendation specifies the purpose, format, and usage of a television picture monitor alignment color bar test signal with chroma set and black set signals.

2. The alignment color bar test signal is intended to standardize the adjustment of chroma gain, chroma phase, and black level monitor controls.

a. Chroma gain and chroma phase for picture monitors are conventionally adjusted by observing the standard encoded color bars signal with the red and green monitor guns switched off. The four visible blue bars are adjusted for equal brightness. This procedure is prone to error because of the subjective judgement necessary and especially because the blue bars are widely separated on the screen.

b. The use of the chroma set signal portion of the alignment color bar test signal greatly increases the accuracy of this adjustment since it provides a signal with the blue bars to be matched vertically adjacent to each other. Because the bars are adjacent, the eyes can easily perceive any difference in brightness. It also eliminates effects due to shading or purity from one part of the monitor to another.

c. Black level for picture monitors is conventionally adjusted by observing a known black portion of the signal and matching it to a blanked area of the signal. This procedure is also prone to error due to the subjective judgment necessary to make the match. The use of the black set signal portion of the alignment color bar test signal greatly increases the accuracy of this adjustment since it provides a positive go-no-go criterion for the proper setting. It also minimizes errors due to variations of ambient light.

3. Figure 2-3 shows the appearance of the EIA standard RS-189-A encoded color bar signal as it would appear on a picture monitor. Figure 2-4 shows the appearance of the alignment color bar test signal as it would be displayed on a picture monitor.

4. The SMPTE color bar signal consists of 67% of the field with the standard seven color bars, 8% of the field with the new chroma set signal, and the remaining 25% with the combination of the -I, white, Q, black, and the black set signal. The seven color bars signal is identical to the one used for the EIA signal, except for the percentage of the field it occupies.

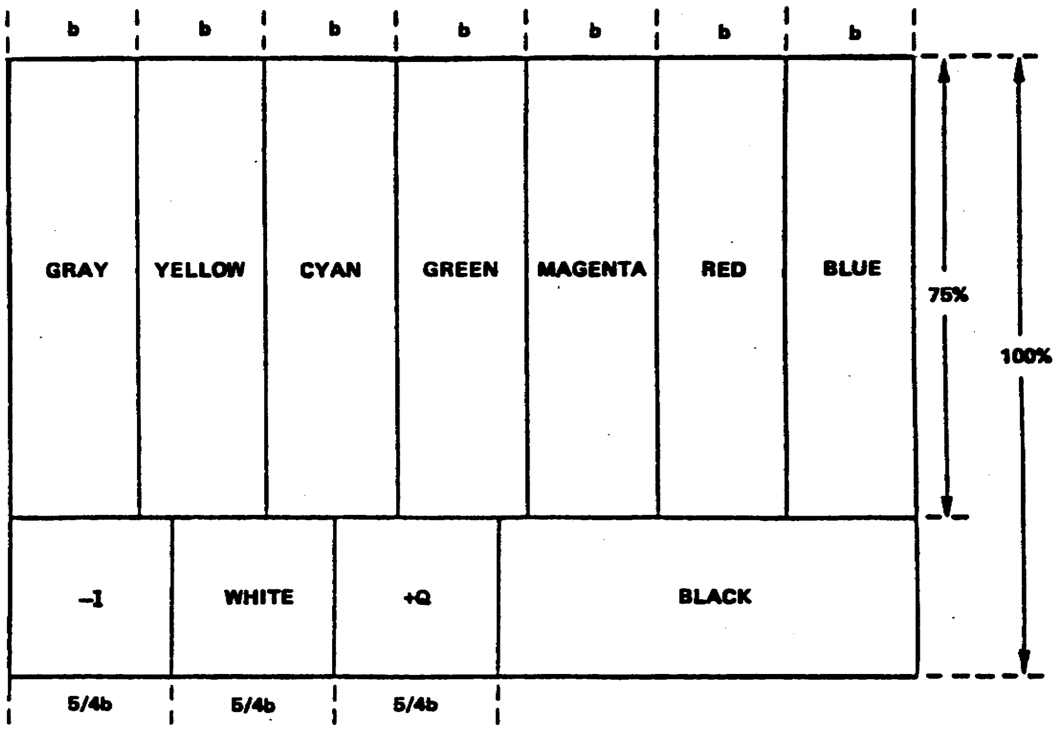


Figure 2-3. EIA standard RS-189 encoded color bars signal

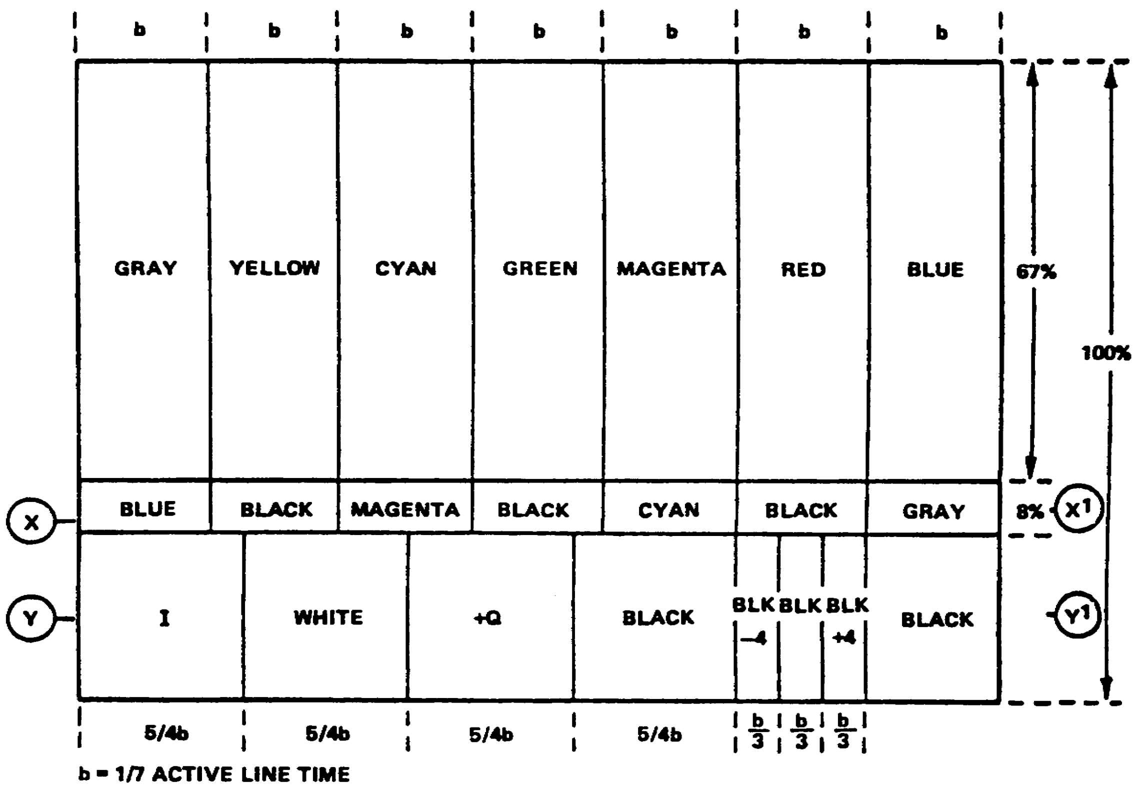


Figure 2-4. SMPTE alignment color bar test signal

a. The chroma set signal is made up of the color bars, containing blue, in reverse order. The color bars signal contains blue in every other bar (blue, magenta, cyan, and white). The color set signal consists of four color bars, separated by black bars (fig 2-5a). The color bars which contain blue are placed beneath the EIA color bars that also contain blue, but in reverse order; blue beneath white, magenta beneath cyan, and vice versa. To maintain timing, the color set signal bars are separated by black bars of equal duration.

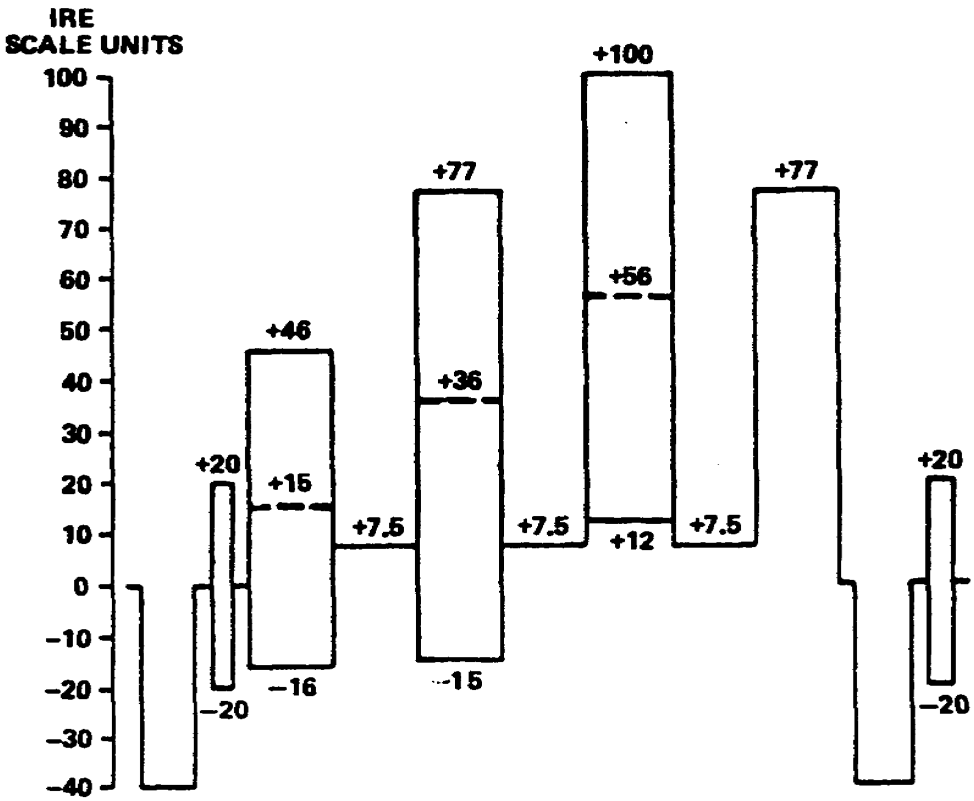


Figure 2-5a. One line of chroma set signal, X-X1

b. The -I, W, Q, and B signals, used in the SMPTE color bar signal, contain a black set signal (fig 2-5b). Its location and duration are identical to those of the red color bar. The signal itself is made up of three black amplitudes, 3.5 IRE, 7.5 IRE, and 11.5 IRE. This provides levels that are 4 IRE above and below the setup level, making it possible to compare small differences in the black level.

5. As stated earlier in this lesson, the SMPTE color bars signal is used for making phase and gain adjustments in color monitors and for verifying overall accuracy of the decoding functions. An experienced operator can learn to judge the accuracy of monitor adjustments by direct observation of the color bar pattern. For more objective measurements, the waveforms resulting from the decoding of the color bars signal can be used. For example, the phase and gain adjustments may be checked by observing the waveforms at appropriate points. The luminance component of the color bars signal provides a convenient grey scale display for setting color balance and tracking on color monitors.

a. The accuracy of matrix and phase adjustments in encoders may be readily checked by comparison of the color bars signal with the output of such a device when the signal is applied to the encoder inputs.

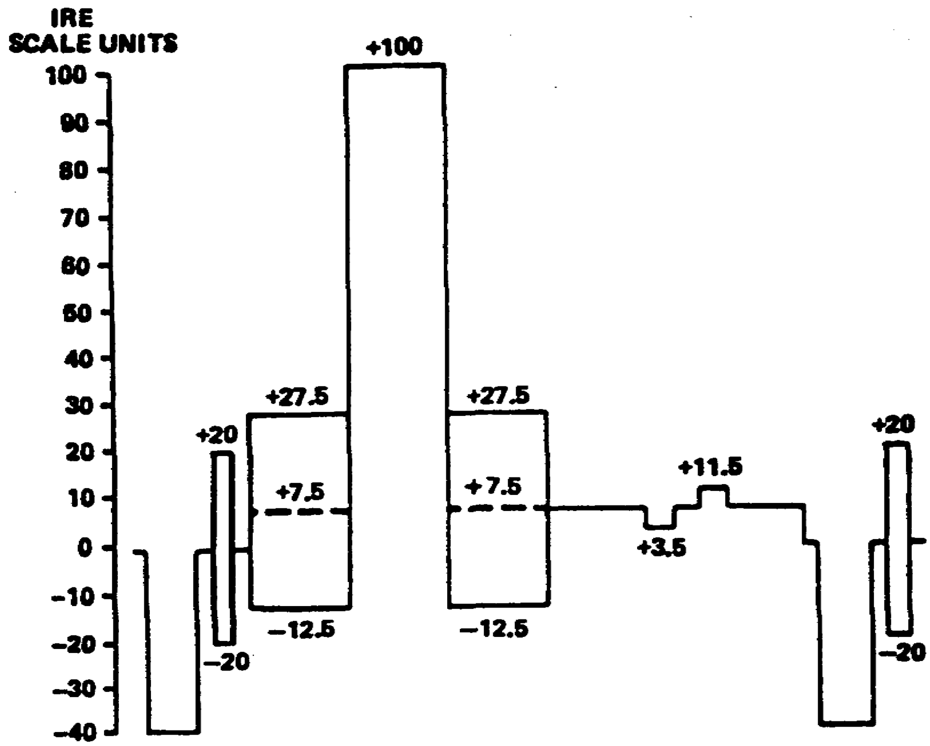


Figure 2-5b. One line of black set signal

b. The color bars signal embodies several convenient reference relationships that facilitate its use. The relative amplitudes of all signal components can be checked by direct observation of the complete waveform on a television waveform monitor. A waveform monitor should display the relationships a, b, and c, illustrated in figures 2-6 and 2-7.

(1) The positive peak levels of the yellow and cyan bars are nominally equal to reference white level.

(2) The negative peak level of the green bar is nominally equal to reference black level, when 7.5% setup is used

(3) The negative peak levels of the red and blue bars are nominally equal (-16 IRE).

c. The relative phases and amplitudes of the chrominance portion of the signal are generally checked by observation on a vectorscope. The quadrature phase relationship between I and Q components of the encoded signal can be conveniently checked by observation of the -I and Q signal axes (fig 2-8).

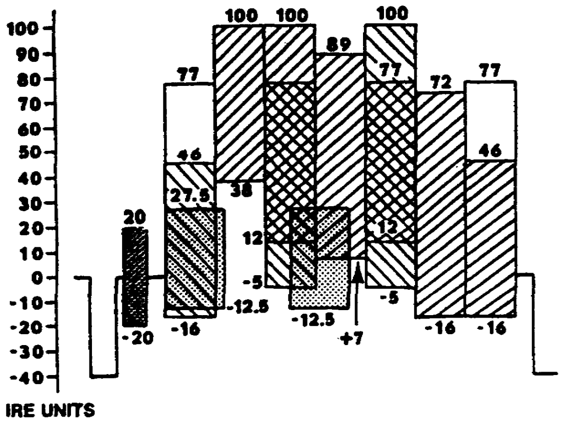


Figure 2-6. Chroma amplitudes

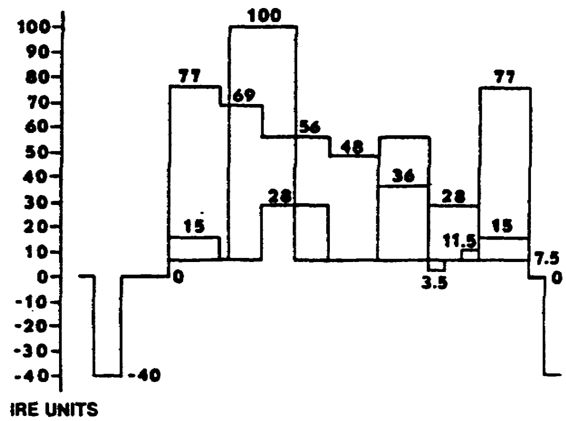


Figure 2-7. Luminance levels

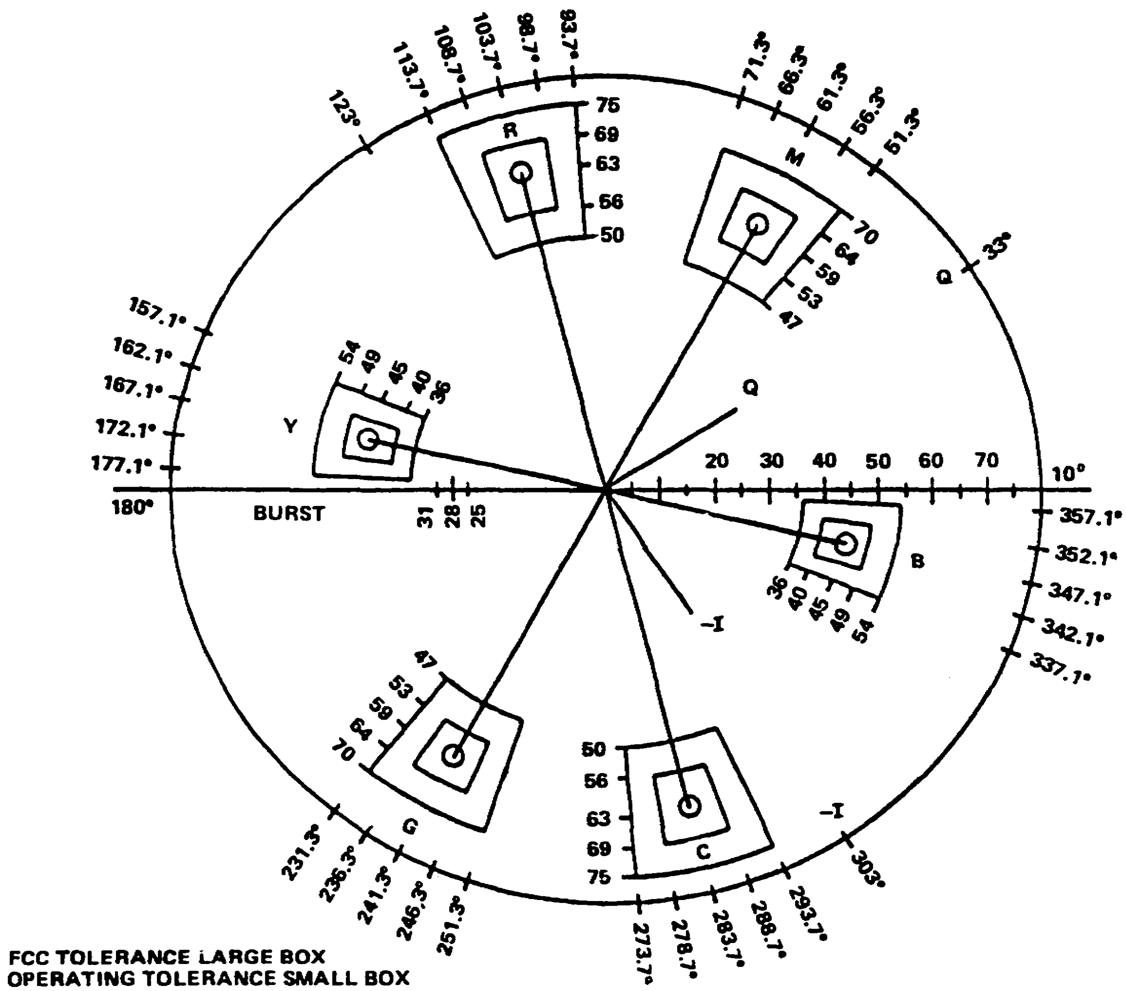


Figure 2-8. Vectorscope graticule

6. The chroma and black set signals are used to set the chroma, hue, and brightness of a picture monitor. The chroma and hue controls are set by comparing the blue chrominance from the color bars to the blue chrominance of the reverse color bars. The only required setup to making these adjustments is that the monitor must be in a blue-only mode. This is done by turning off the red and green screens.

7. The procedure for adjusting a monitor is as follows:

a. Turn off the picture monitor's red and green screens.

b. Compare the extreme left or right blue bar with the reverse color bar segment directly below it. Adjust the monitor chroma control until there is no color difference (fig 2-9).

c. Next, compare either of the center blue bars to the reverse color bars segment directly below it. Adjust the monitor hue control until there is no color difference (fig 2-9).

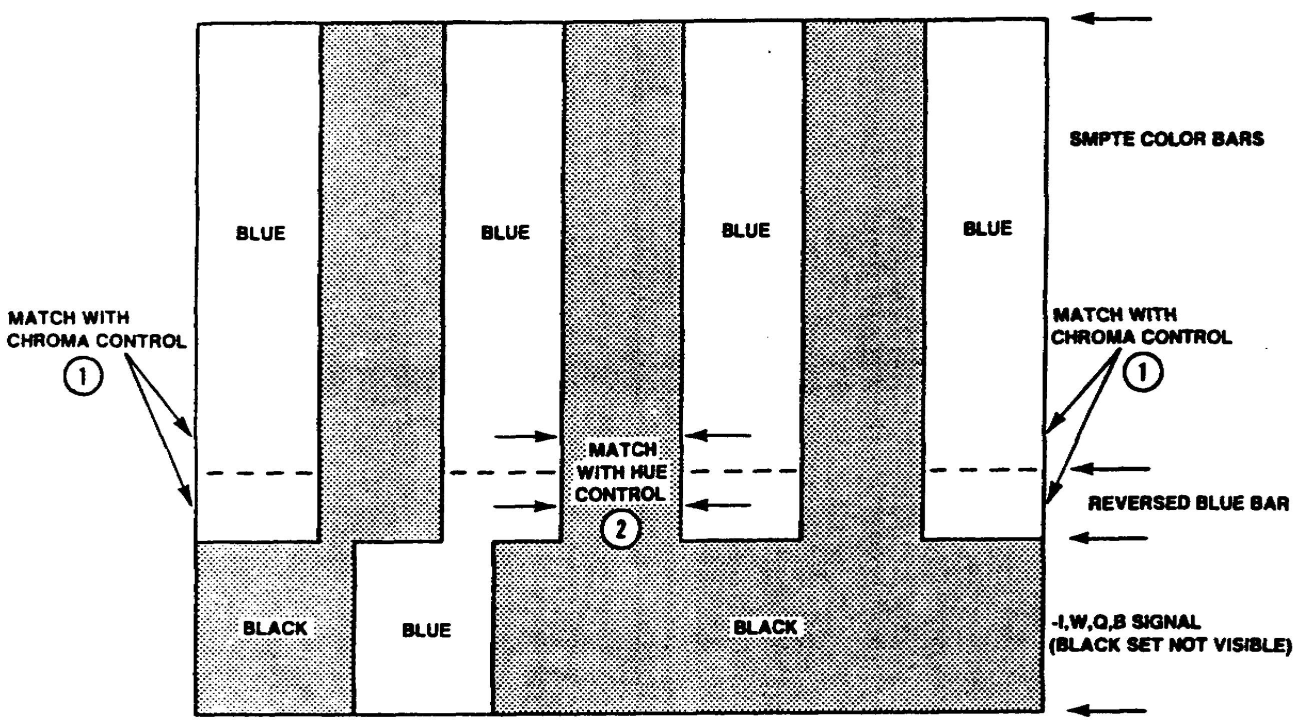


Figure 2-9. SMPTE chroma and hue set matching diagram

d. With all three of the monitor's screens turned on at ambient viewing conditions, adjust the brightness control until the gray 11.5 part of the black set signal is just visible, but the difference between the blacker than black (3.5 IRE) and the black (7.5 IRE) segments is not discernable (fig 2-10).

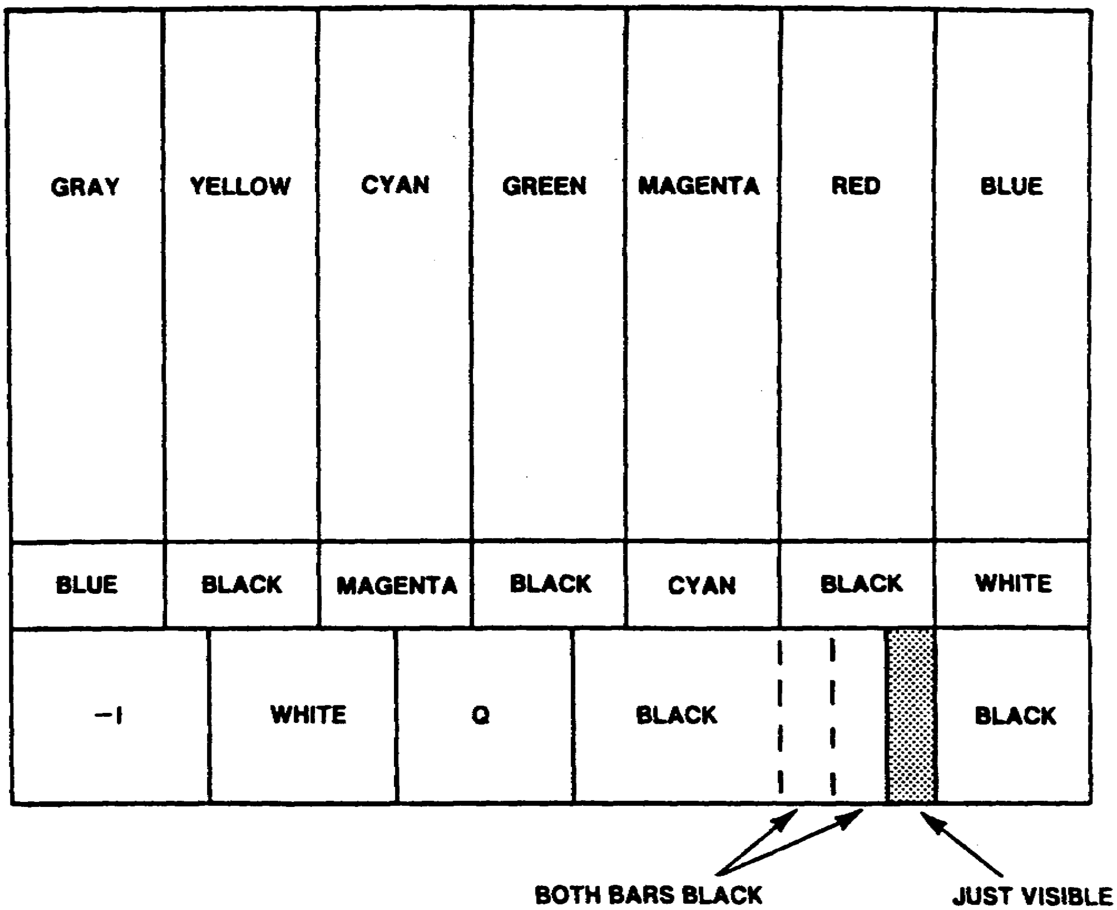


Figure 2-10. SMPTE black set matching diagram for brightness

Learning Event 3:
DESCRIBE FULL FIELD AND GATED-RAINBOW PATTERN COLOR BARS

1. The full field color bars signal consists of eight equal intervals arranged in descending order of luminance amplitudes as follows: Gray, Yellow, Cyan, Green, Magenta, Red, Blue, and Black (fig 2-11). This signal is normally used for checking luminance, hue, and saturation parameters of the television system.

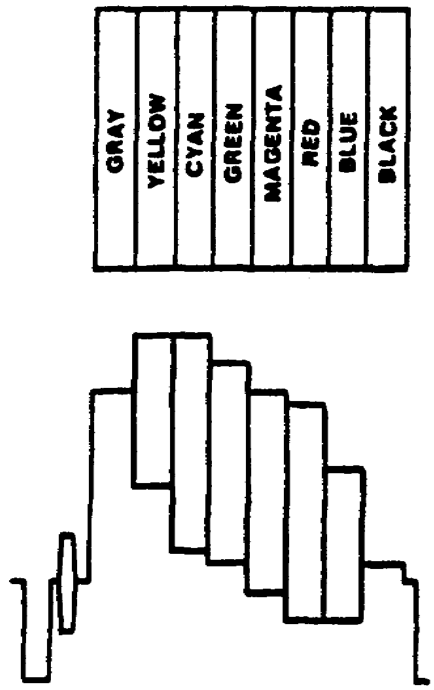


Figure 2-11. Full field color bars signal

2. The paragraphs describing the EIA and SMPTE color bars apply to the full field color bars, with exception of use of the -I, W, Q, B, chroma set, and black set signals. The full field color bars does not utilize the latter signals.

3. Certain color bar generators like the Tektronix TSG1 and TSG7 can alter the sequence of the full field color bar pattern for various test applications. The following is a sample of some of the different applications:

a. Split-field Y reference signal. This signal provides color bars in the first half of the field and luminance only gray scale in the second part of the field (fig 2-12). The split-field Y reference signal is especially useful for checking color balance and tracking of color picture monitors, chrominance-luminance delay, and chrominance-luminance intermodulation.

b. Split-field red signal. This signal includes the color bars in the first half of the field, while the second half of the field contains the red color bar signal only (fig 2-13). Video system noise, VTR head-banding, and red phase are readily seen using the solid red split field signal.

c. Split-field reverse signal. This signal consists of standard color bars in the first half of the field, followed by color bars in reverse order in the second half of the field (fig 2-14). This signal is useful in checking velocity modulation in video tape recorders.

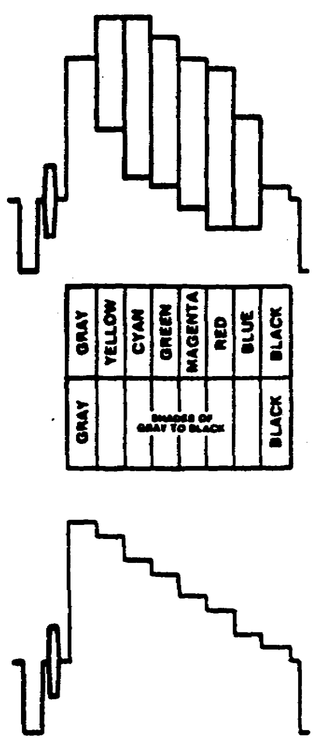


Figure 2-12. Split-field Y ref

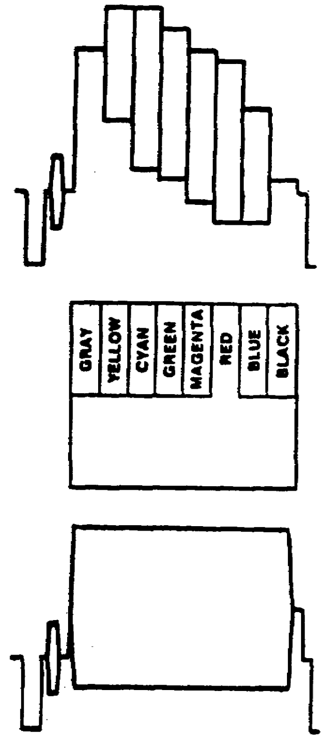


Figure 2-13. Split-field red

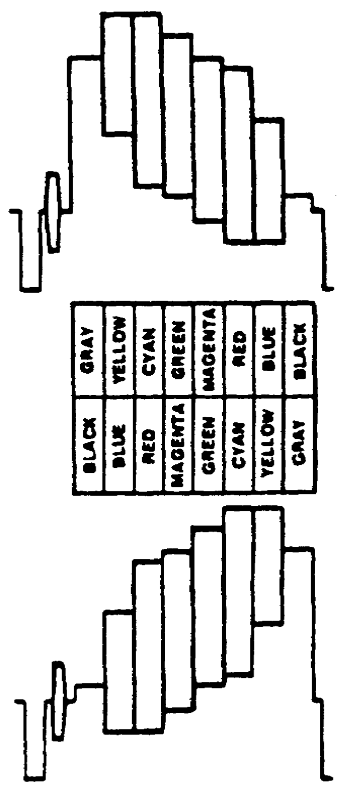


Figure 2-14. Split-field reverse

4. The gated rainbow pattern, is a ten-color bar pattern and is shown in Figure 2-15a as it appears on a TV receiver. In Figure 2-15a the sequence of each color is separated by a black vertical line. The black line is caused by gating off the signal between colors. The color bars are each separated in phase by 30 degrees, beginning with burst phase at 0 degrees. There is no bar corresponding to 330 degrees.

a. The appearance of the gated rainbow signal on an oscilloscope is shown in Figure 2-15b. Note the color burst signal, the ten color-bar signals, blanking between the color signals, and horizontal sync pulses. The color burst signal is on the back porch of horizontal sync the same as a TV station signal. However, there is no Y signal component associated with the gated-rainbow color bars. The gated-rainbow color bar pattern displays the bars with equal saturation and brightness levels on the color picture tube.

b. Another point about the gated-rainbow pattern is that the subcarrier frequency is exactly 3.563811 MHz. This differs by precisely 15 734 Hz from the 3.579545 color subcarrier frequency generated in the color TV receiver. As a result of this precise frequency difference, the phase of the color pattern signals shift through exactly 360 degrees for each horizontal line. Thus, the pattern repeats identically on every line, forming the vertical color bars.

(1) The comparison between the two subcarrier signals is performed by two color demodulators in the TV receiver. The output signals from the color demodulators and color matrix (now at video rate) are fed to the red, green, and blue guns of the color picture tube to produce the actual color bars.

(2) The gated-rainbow pattern color bar signal is generally used for the servicing of TV receivers. Some of the basic applications of this signal are confined to adjusting color automatic frequency circuits, phase control circuits, color amplitude circuits, and color synchronizing circuits.

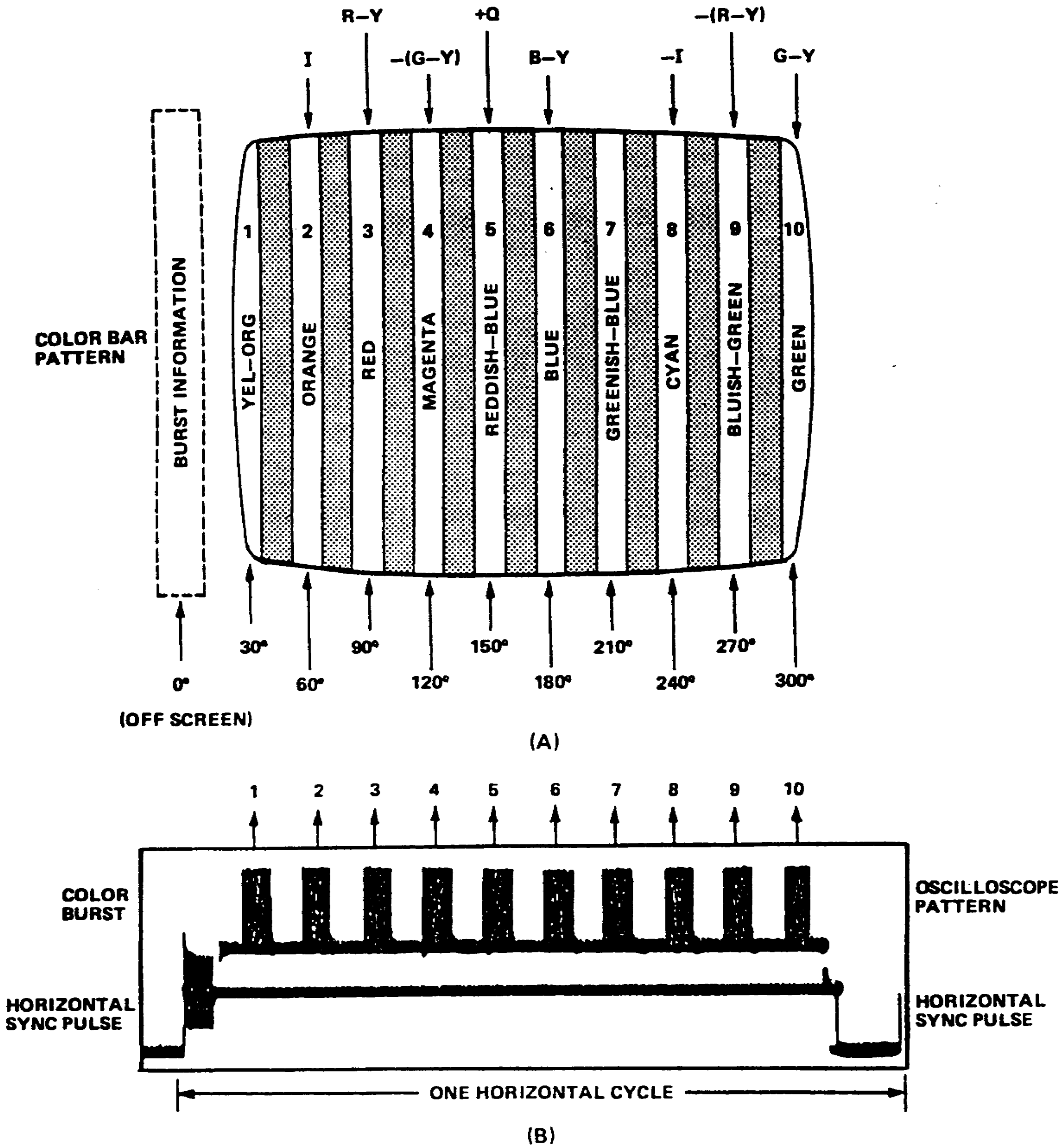


Figure 2-15A and 2-15B

(A) Picture monitor presentation
(B) oscilloscope display

Lesson 2
PRACTICE EXERCISE

1. What is a common use of the encoded color bars signal?

    a. Rapid check of servo systems
    b. Performing timing checks
    c. Linearity checks
    d. Resolution checks

2. What is the chrominance modulation percentage for the green luminance level?

    a. +/- 31%
    b. +/- 41%
    c. +/44%
    d. +/- 51%

3. What percentage of the field contains color bars in the SMPTE signal?

    a. 8%
    b. 50%
    c. 67%
    d. 75%

4. What two chrominance values have peak levels equal to the white reference level?

    a. Green and gray
    b. Gray and yellow
    c. Yellow and cyan
    d. Cyan and green

5. How many intervals are contained in full field color bars?

    a. 6
    b. 7
    c. 8
    d. 9

6. How many degrees in phase is each color separated in the gated-rainbow pattern?

    a. 10
    b. 20
    c. 30
    d. 40

Lesson 3
DESCRIBE THE BASIC ELECTRONIC TELEVISION TEST SIGNALS

TASK

Describe and identify five basic electronic television test signals.

CONDITIONS

Given information and illustrations pertaining to the basic television test signals.

STANDARDS

Demonstrate competency of task skills and knowledge required for identification of the test signals discussed in this lesson, by correctly responding to 80% of the multiple-choice test questions covering five basic electronic television test signals.

REFERENCES

None

LEARNING EVENT 1:
DESCRIBE THE MULTIBURST SIGNAL AND GRAY-SCALE LINEARITY TEST SIGNAL

1. The multiburst signal consists of a white-flag reference pulse, followed by six bursts of individually keyed sine waves in ascending frequency order. This signal is useful as a quick systems check for rapid visual presentation of amplitude-frequency response, usually to 4.2 MHz.

a. The basic block diagram of a multiburst generator is shown in Figure 3-1. The unit normally receives composite sync and composite blanking from the local sync generator. For field use, self-contained (internal) is usually available.

b. Horizontal drive is derived from incoming sync and used to trigger and synchronize six individual sine wave oscillators. It is also used to generate a white-flag pulse at the beginning of active horizontal sweep.

(1) Normally, the white-flag pulse width is adjusted for 8 microseconds. The trailing edge of this pulse triggers

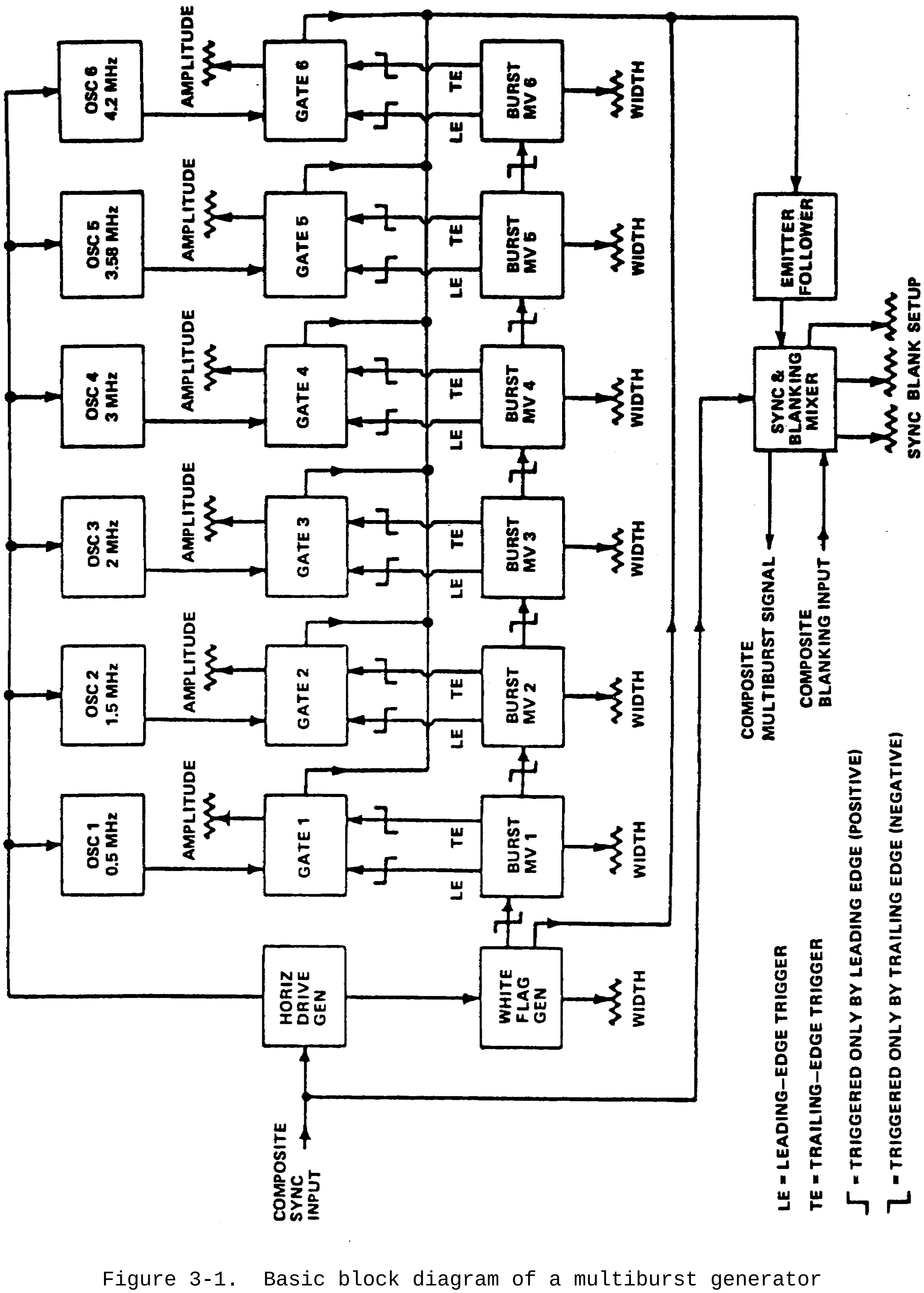


Figure 3-1. Basic block diagram of a multiburst generator

burst multivibrator MV1 on; this multivibrator is set to produce a pulse width of about 7 microseconds, as are all following multivibrators.

(2) The leading edge of the pulse from MV1 gates the signal from oscillator 1 on, and the trailing edge gates the same signal off. The trailing edge also gates MV2 on, and so forth. Thus, the output signal consists of the white-flag and six sine wave bursts on a time-shared basis during each line interval.

c. The signal and frequencies from left to right consist of white-flag, 0.5, 1.5, 2, 3, 3.58, 4.2 megahertz signals as illustrated in Figure 3-2. The multiburst test signal is inserted on the odd field of line 17 of the vertical blanking interval. The frequencies shown are those normally used for a standard multiburst signal. However, some multiburst signal generators facilitate multiburst test signals with frequencies as high as 12 MHz.

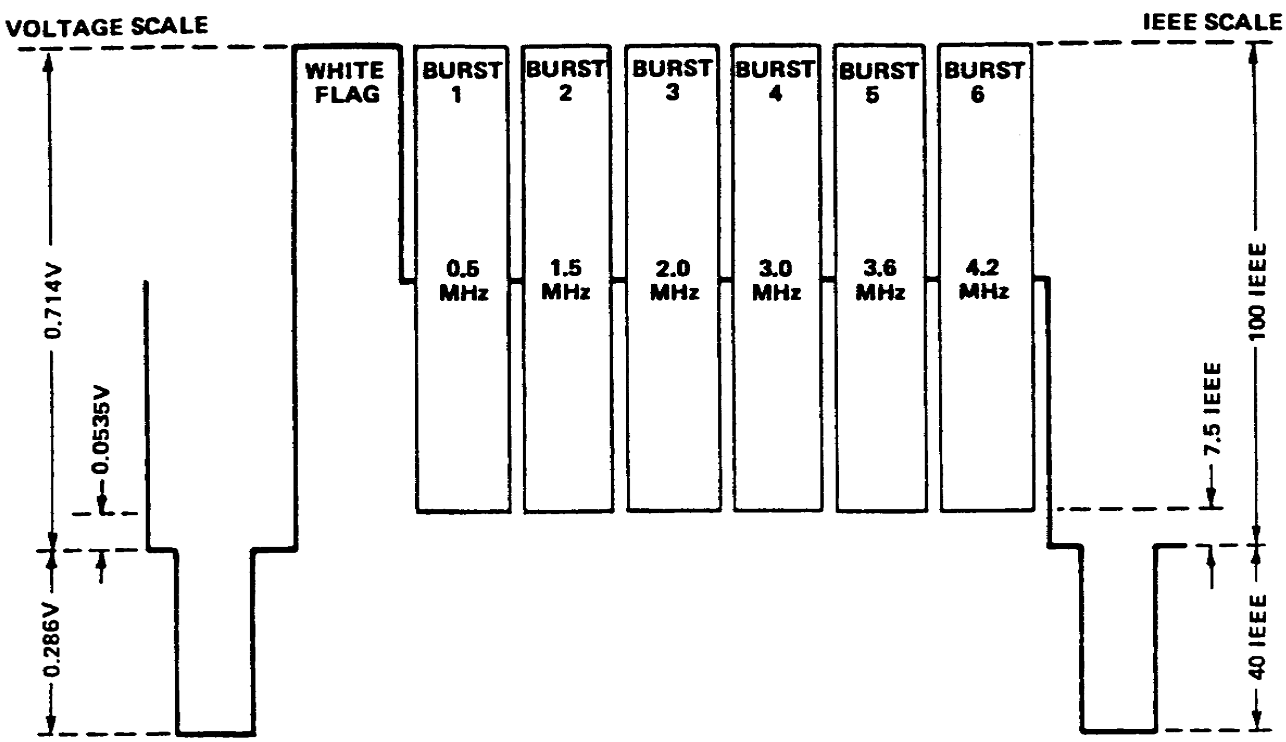


Figure 3-2. Standard multiburst signal

2. The transmission of video information over long lengths of cable degenerates the signal through frequency-dependent losses of the cable. One application of the multiburst signal is to set equalization controls on distribution amplifiers with provision for compensating cable losses.

3. Another frequently used application of the multiburst signal is in the evaluation of common carrier transmission. The multiburst signal is VITS keyed in the vertical interval for insertion into a televised program. This allows for in-service testing of the transmission path.

4. The gray-scale linearity (stairstep or sawtooth) signal is used to explore the entire picture region from black to white by means of linear variation of amplitude with time. It is useful in measuring nonlinear distortion in the system transfer characteristic.

a. Either a stairstep with well-controlled rise-time steps, or a line-duration sawtooth is suitable for nonlinear measurements. A stairstep signal consisting of 10 steps repeated every line and the sawtooth ramp is shown with subcarrier in Figures 3-3a and 3-3b. Small non-linearities throughout the grayscale are more easily observed on this type of signal than is possible with the plain sawtooth signal, since each of the 10 steps falls exactly on a graticule line when an IRE scale is used.

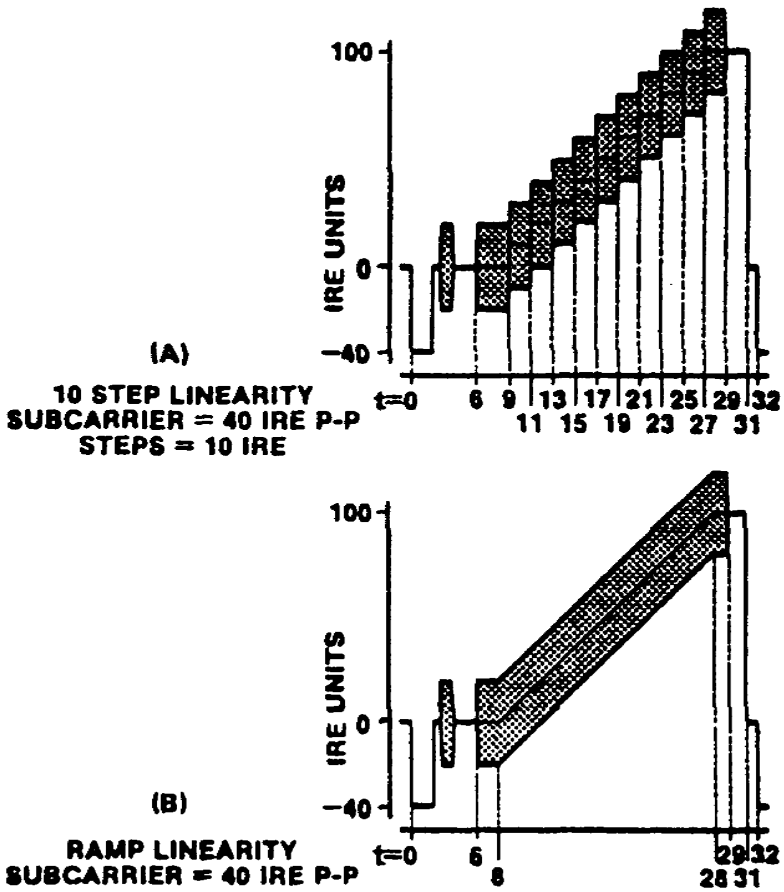


Figure 3-3a and 3-3b
(A) 10 Step linearity with subcarrier
(B) Sawtooth ramp with subcarrier

b. Sensitivity of measurement for either the stairstep or sawtooth is increased by superimposing 20 IRE units of 3.58 MHz subcarrier. Any non-linearity then results in amplitude variations of the pulses when observed through a high pass filter. This technique also allows measurement of non-linearity at the color subcarrier frequency relative to low-frequency steps. Such distortion is termed "differential gain".

5. Grayscale test signals must be able to convey information at low and high frequencies over every possible picture value likely to be encountered. This picture value is interpreted not only by amplitude, frequency, and phase response of the system but also on a widely varying duty cycle. Duty cycle in pulse work simply correlates the pulse duration with the pulse-repetition frequency (PRF):

Duty cycle = pulse duration x PRF

For television, this effect is most appropriately termed "average picture level" (APL). The amplitude, frequency, and phase response of the system must be held within tolerable limits over the gamut of APLs encountered in practice.

6. Even experienced TV engineers sometimes forget that a 1-volt peak-to-peak video signal must be transferred through an amplifier capable of handling twice this range with little degradation (figure 3-4). Although the DC component is restored at such points as blanking insertion, sync insertion, gamma-correction stages, and transmitter modulators, practically all stages in between, as well as distribution and stabilizing amplifiers, are AC coupled.

a. Waveform monitors such as those in master monitor positions use clamping circuits to hold blanking level at the reference graticule line. Some scopes designed for waveform monitoring allow switchable operation, either clamped or unclamped. Even though the monitoring CRO is clamped, "bounces" of a momentary duration will occur upon drastic scenic changes in APL, and this is normal. Most scopes for routine testing and servicing do not use DC restorers or clamping circuits.

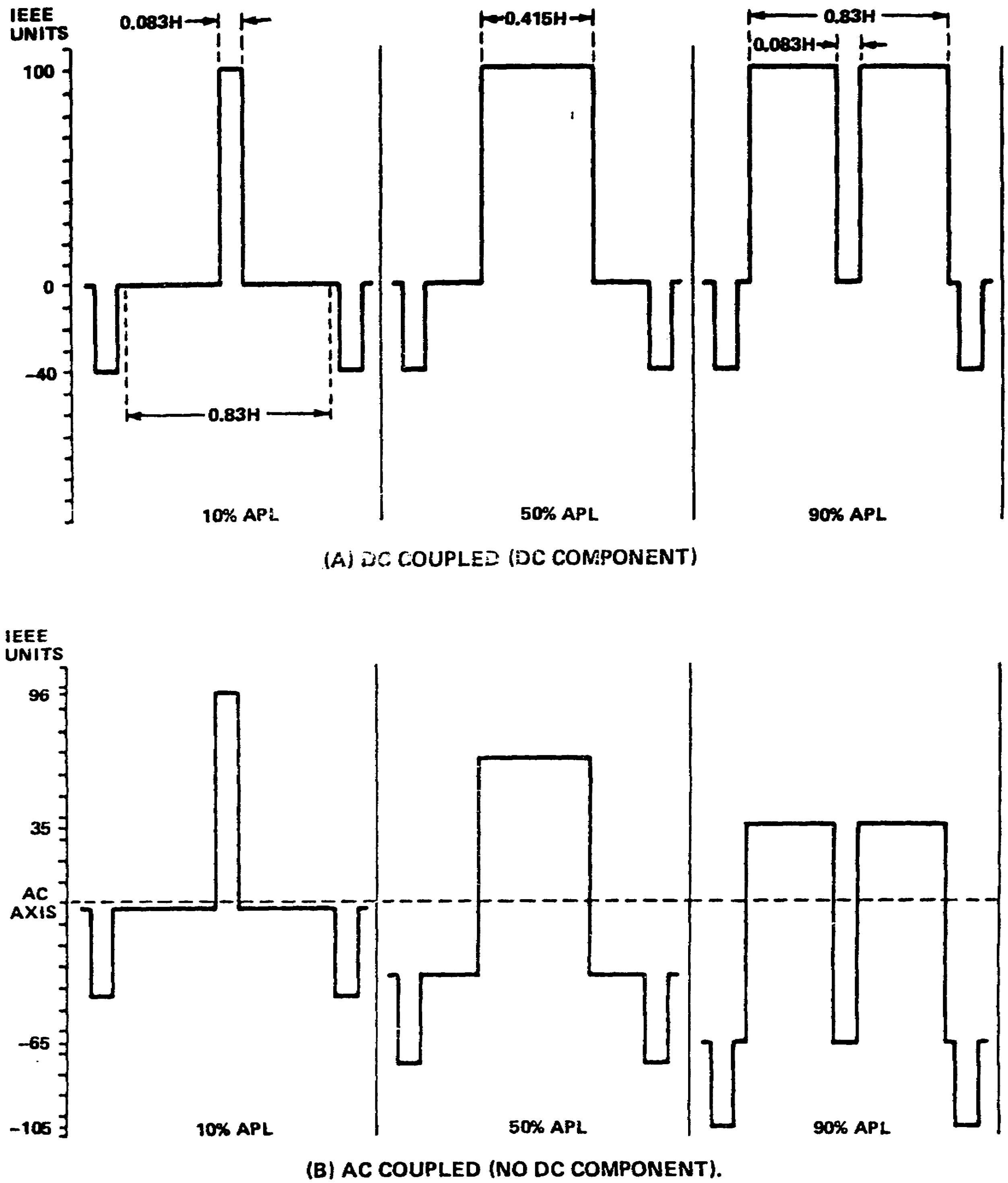


Figure 3-4. Variation of signal excursions with APL

b. Figure 3-5 presents the specifications for the stairstep generator test signal when provided with variable APL. The linearity test signal generator sometimes includes provisions for inserting horizontal sync only. In this case, the blanking width should be set for 25 percent of a line period (15.8 microseconds). If fed through equipment where composite station blanking is inserted, the normal station blanking pulse should cover the test generator blanking output (maximum of 11.4 microseconds horizontal with 7 percent vertical blanking).

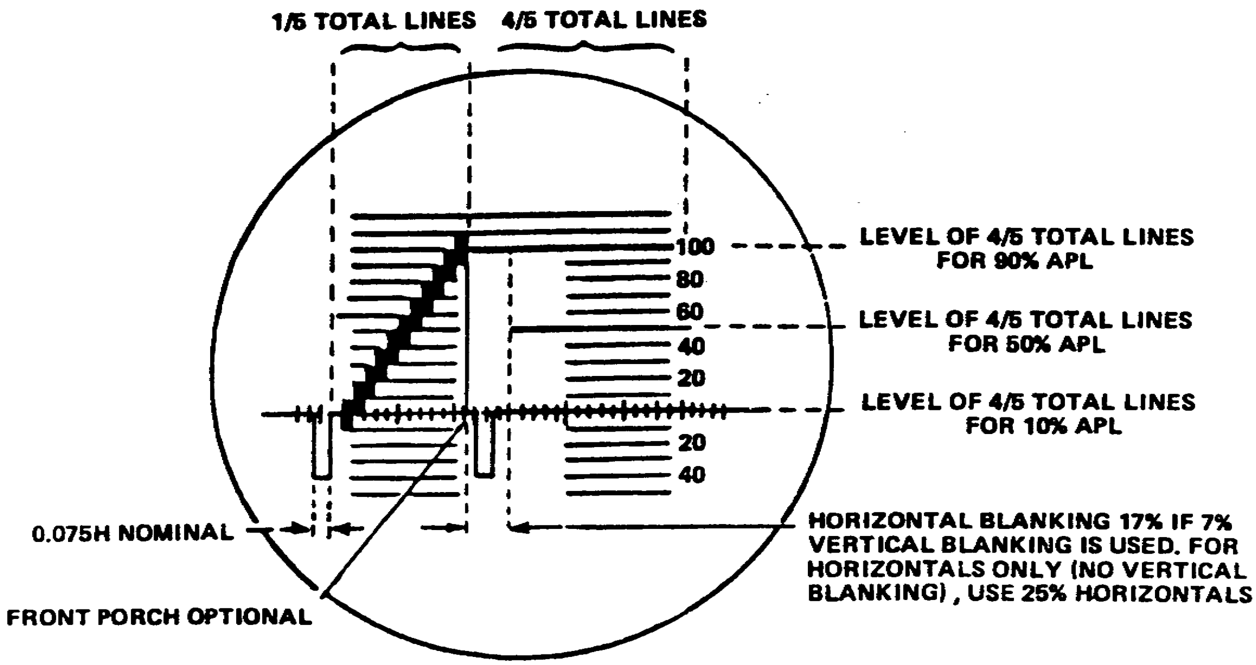


Figure 3-5. Specification for the stairstep signal

Learning Event 2:
DESCRIBE THE VERTICAL INTERVAL TEST SIGNAL (VITS) AND THE VERTICAL INTERVAL REFERENCE SIGNAL (VIRS)

1. Vertical Interval Test Signal (VITS). In the standard television signal there is, immediately following each vertical-synchronizing interval, a series of 20 or 21 horizontal lines which carry no video information. In a receiver or monitor, these lines provide an interval which ensures that the vertical retrace is complete before any video information is received and are intended to perform no other function.

a. The lines normally appear on a monitor as a gray band across the top of the picture; usually this band is adjusted so that it is behind the mask. While these are actually horizontal lines, they are conveniently considered as a part of the vertical-synchronizing interval.

b. By using suitable keying equipment, it is possible to introduce information onto one or more of these blank lines to be transmitted to a specific destination. If desired, this information can be blanked out at the receiving point before the signal is put on air, or since it is not normally visible on the receiver, it may be broadcast.

c. The NTSC established VITS on lines 17 and 18, and line 19 for transmission of the VIR test signals. The Major networks and Bell Systems, working through the Network Transmission Committee, are working to development methods to place other test and coded signals into the other lines of the vertical blanking interval.

d. The advantage, of course, of introducing these signals in the vertical interval is that a system can be checked in service, and digital information can be passed along the transmission links while a program is actually being transmitted. To this end, it is also desirable that all these signals be available for nearly simultaneous observation, and this is the ultimate objective.

2. The specification and standards for the VITS are illustrated in Figures 3-6, 3-7 and 3-8.

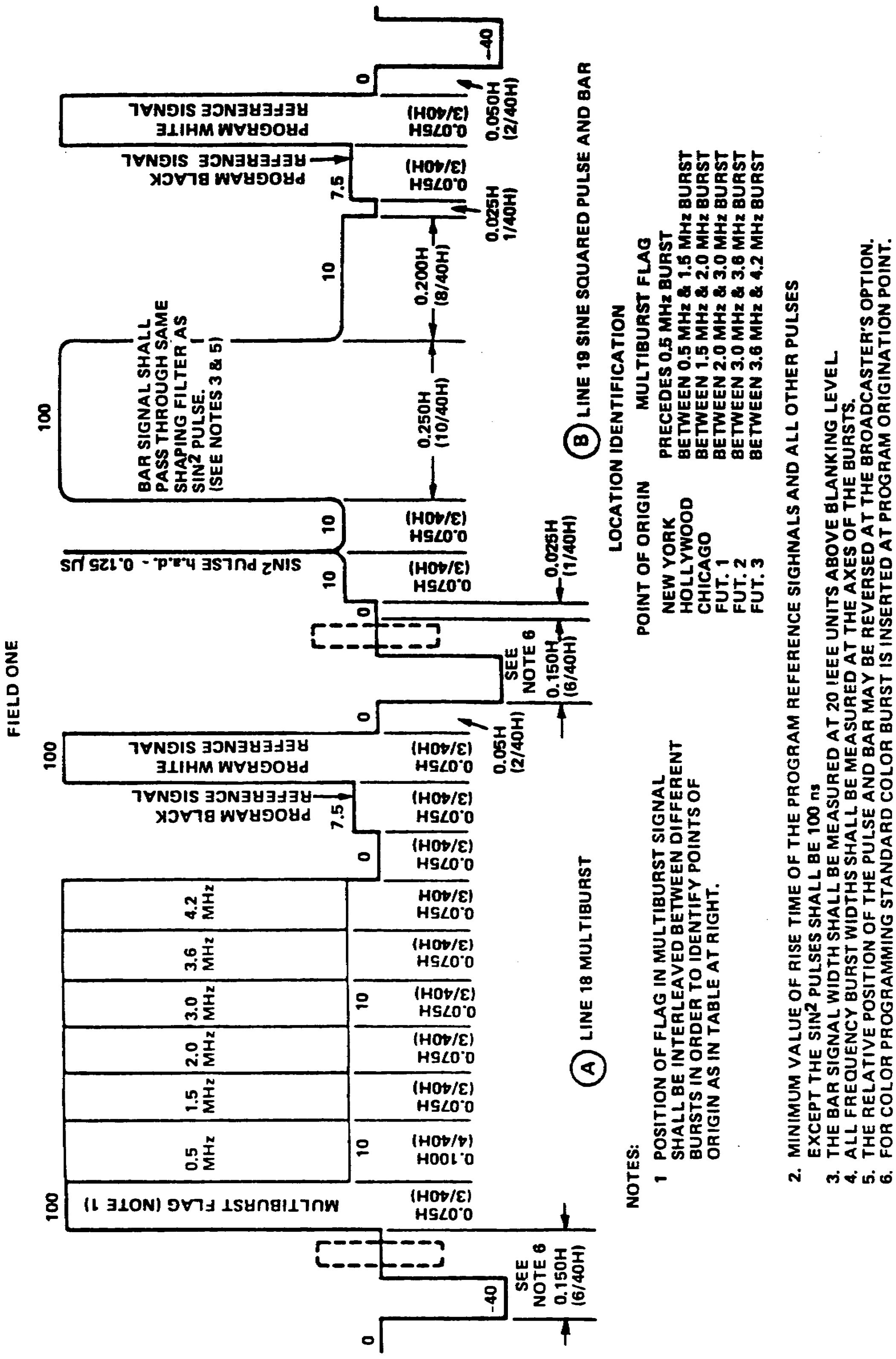


Figure 3-6. Specifications for field one (VITS)

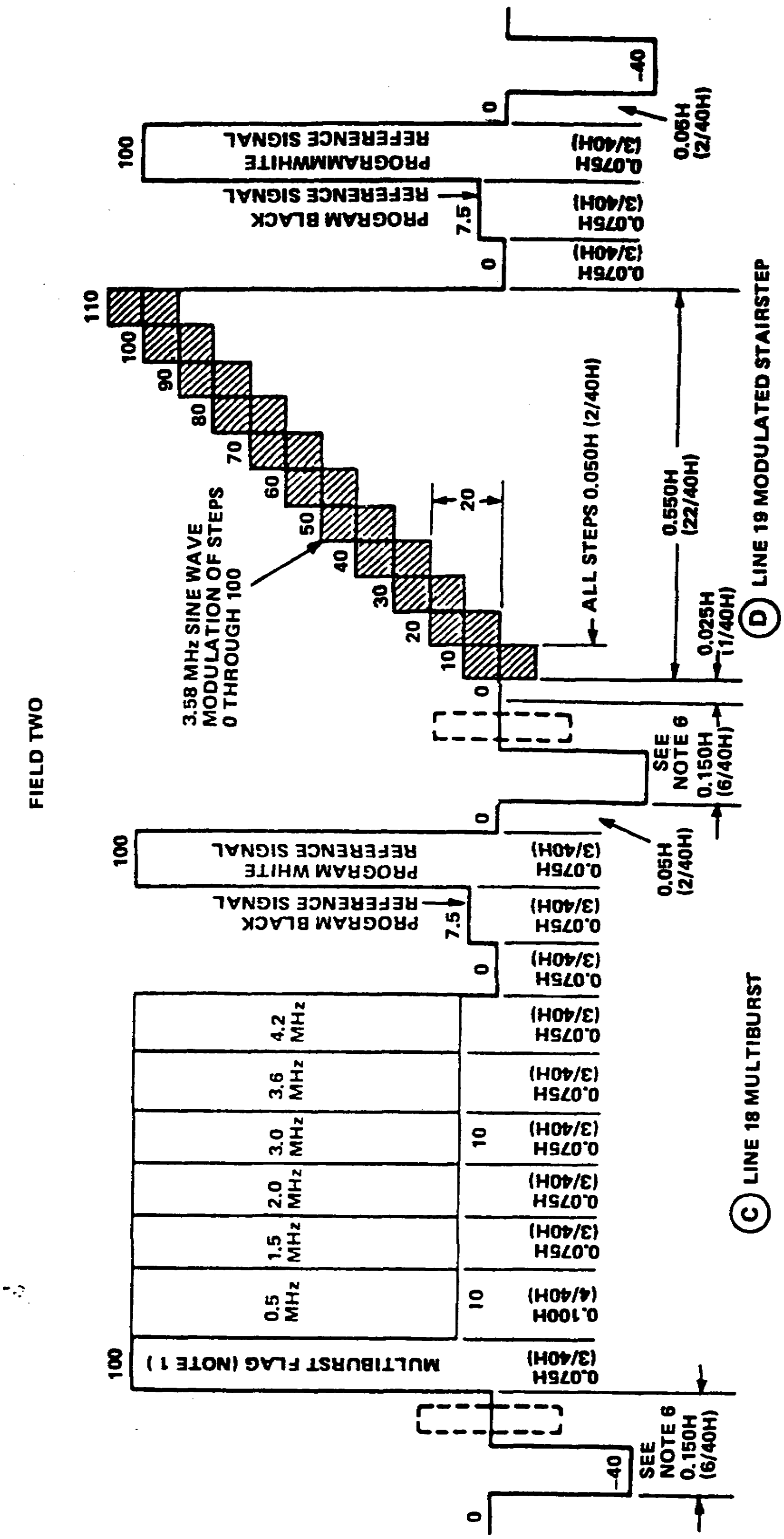
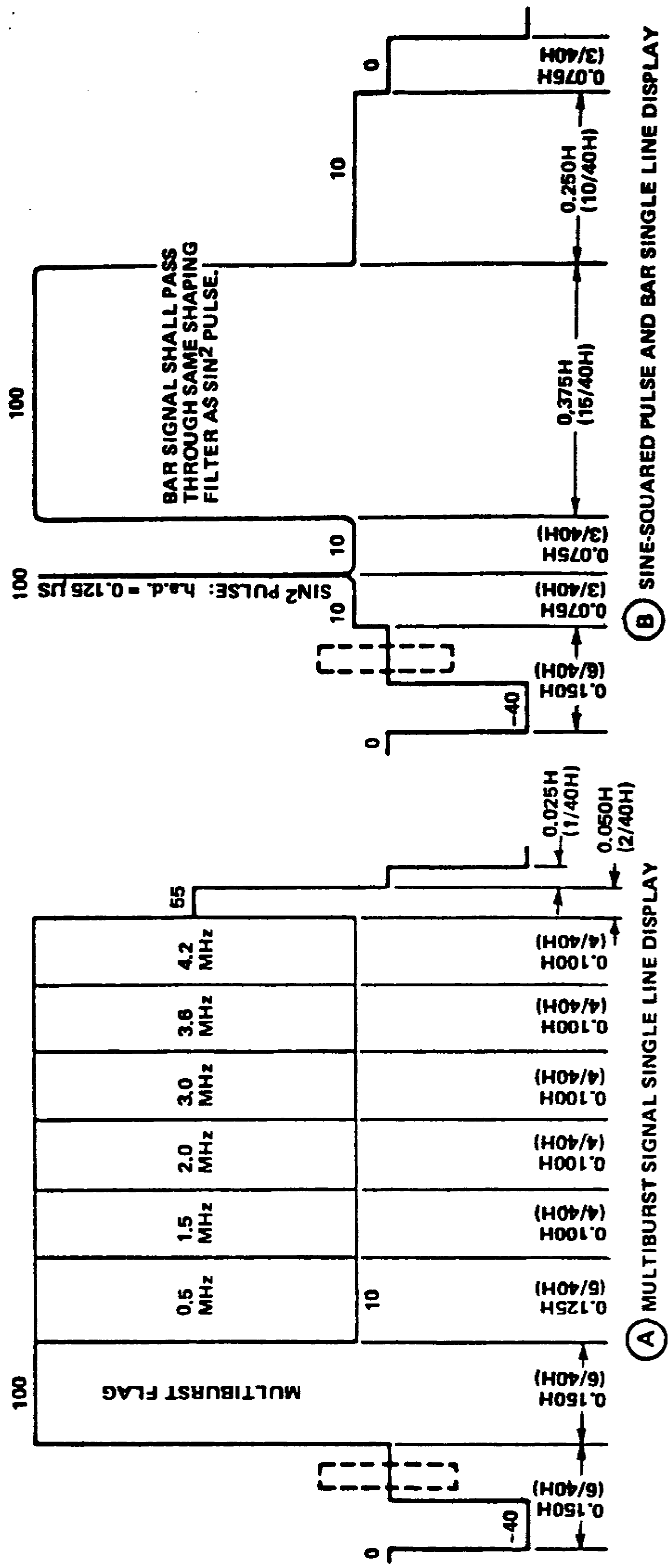


Figure 3-7. Specifications for field two (VITS)



NOTES:

1. THERE WILL BE VARIATIONS IN THE TIMING AND POSITIONS OF SOME OF THESE TEST SIGNALS DEPENDING UPON THETYPE OF TEST SIGNAL AND SYNCHRONIZING SIGNAL GENERATORS USED. WHILE MOST OF THESE VARIATIONS ARE NOT SIGNIFICANT, THE FOLLOWING DIMENSIONS SHOULD BE CAREFULLY MAINTAINED.
   A. THE WIDTH OF THE FLAG ON THE MULTIBURST SIGNAL SHALL NOT BE LESS THAN 4.8 µS (0.075H) NOR MORE THAN 9.5 µS (0.150H).
   B. THE WIDTH OF THE SINE-SQUARED BAR SHALL BE 23.8 µS (0.375H), MEASURED AT 20 IEEE UNITS ABOVE BLANKING.
   C. THE SINE-SQUARED PULSE AND BAR SHALL BE TRANSMITTED ON THE MIDDLE 50% OF THE LINES OF EACH FIELD.
2. THE SOURCE OF A FULL FRAME MULTIBURST SIGNAL MAY BE IDENTIFIED BY THE NUMBER OF CYCLES IN THE 0.5 MHz BURST.
   A. TELEPHONE COMPANY: 5
   B. EAST COAST CUSTOMER: 4
   C. WEST COAST CUSTOMER: 3
3. THE MINIMUM RISE TIME OF ALL PULSES EXCEPT THE SINE-SQUARED SIGNALS SHALL BE 100ns

Figure 3-8. Specifications for full-frame test signal

3. Vertical interval reference (VIR) signal. The VIR signal is a program-related reference signal inserted during the vertical blanking interval of a color television program. It is intended to reduce undesirable variations in color throughout the television system by assisting television producers, technicians, and operators in adjusting various signal parameters so that different programs and program segments have similar amplitude and phase characteristics whether viewed sequentially on the same channel or on different channels.

a. The VIR signal is also intended to be associated with televised programs as an operational tool for checking the parameters of the programs and is a reference for the programs being transmitted. The VIR signal, however, is not intended to provide quantitative data on transmission distortions.

b. Because the VIR signal is intended to be associated with a particular program, it should only be inserted into the program signal at a point in the video system where both the correct amplitudes and phase of the composite color signal are established and the artistic judgement is made that color reproduction is as desired. Thus, it is the responsibility of each production organization to make that artistic judgement.

(1) Once the VIR signal is inserted in this manner, it represents a certification of and a reference for the program signal. After the VIR signal has been inserted into the program signal, it must be treated exactly like the program signal in all equipment through which it passes so that the VIR signal will always correspond to the program.

(2) Then, when adjustments are made to restore a VIR signal to its proper characteristics at any point in the video system, the program will have been re-established to essentially the same characteristics as when it was initially certified.

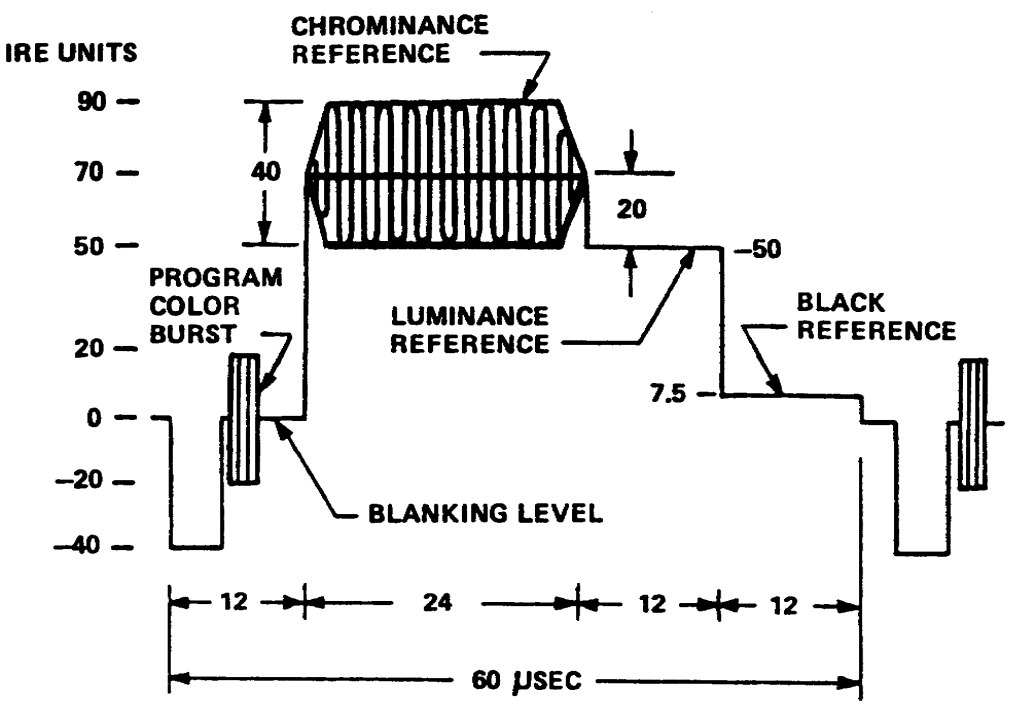
(3) The VIR signal inserted at the point of certification should remain with the program to its final destination. Exceptions to this practice should be made only at a point of recertification, such as an assembly point of various program segments.

c. One important application of the VIR signal is in the adjustment of a reproduced video tape recording. This usage applies to all video tape formats used for broadcasting and is important both for the playback of a single tape and the sequential playback of several short commercial program segments. The VIR signal will be added to each video tape at a point prior to the duplication of the final release copies. This will be done after the correct signal parameters are established and any necessary artistic judgements have been made as to proper color reproduction. The program then will have been certified.

d. When a VIR signal is present on a signal to be recorded on a video tape recorder, the VIR signal as passed by the video tape recorder shall be considered as reference for either manual or automatic adjustment of the reproduced signal characteristics listed below:

Luminance amplitude --------------------	50 Peak IRE
Black level amplitude -----------------	7.5 IRE
Sync amplitude ------------------------	-40 Peak IRE
Chrominance ---------------------------	90 Peak IRE
Color burst amplitude -----------------	+/- 20 IRE

e. The VIR signal will be recorded by only one head of a multihead video tape recorder. Since it is essential to balance head output levels, this characteristic does not reduce the usefulness of the VIR signal. The waveform of the VIR signal is shown in Figure 3-9.



NOMINAL VERTICAL INTERVAL REFERENCE (VIR) SIGNAL

Figure 3-9. Standard vertical reference signal

Learning Event 3:
DESCRIBE THE SIN2 WINDOW SIGNAL

1. The sin2 window signal is normally accompanied by a half-line and half-field window pulse, which is sometimes termed a "bar". Figure 3-10 shows a basic block diagram of a generator which also includes the modulated 20T pulse.

a. The timing circuit driver (monostable multivibrator) is triggered from the leading edge of sync and generates a rectangular pulse of about 16 microseconds duration. The trailing edge of this pulse initiates the operation of the pulse and window timing circuit, which positions the pulse and window leading and trailing edges relative to sync. Blanking pulses are used to inhibit the timing circuit action during field blanking. The output of the impulse generator is an 18-nanosecond spike which becomes the Tpulse after shaping in the T-pulse shaping network. A switch is normally provided so that either 2T, T, or T/2 pulses are available. Note also that the leading and trailing edges of the window signal, since they pass through the same shaping filter, have the same rise and fall times as the associated T pulse.

b. The 20T pulse is shaped by appropriate sin2 filters and applied to a double-balanced 3.58-MHz modulator in a manner similar to that in which chroma information modulates the color subcarrier in an encoder. Thus, both the 3.58-MHz carrier and the original 20T pulse are cancelled, and the output is the modulated sidebands of the carrier. This produces the modulated T pulse envelope (fig 3-10). Finally the original 20T pulse is linearly (resistively) added to the modulated pulse, producing the symmetrical pulse with a base line.

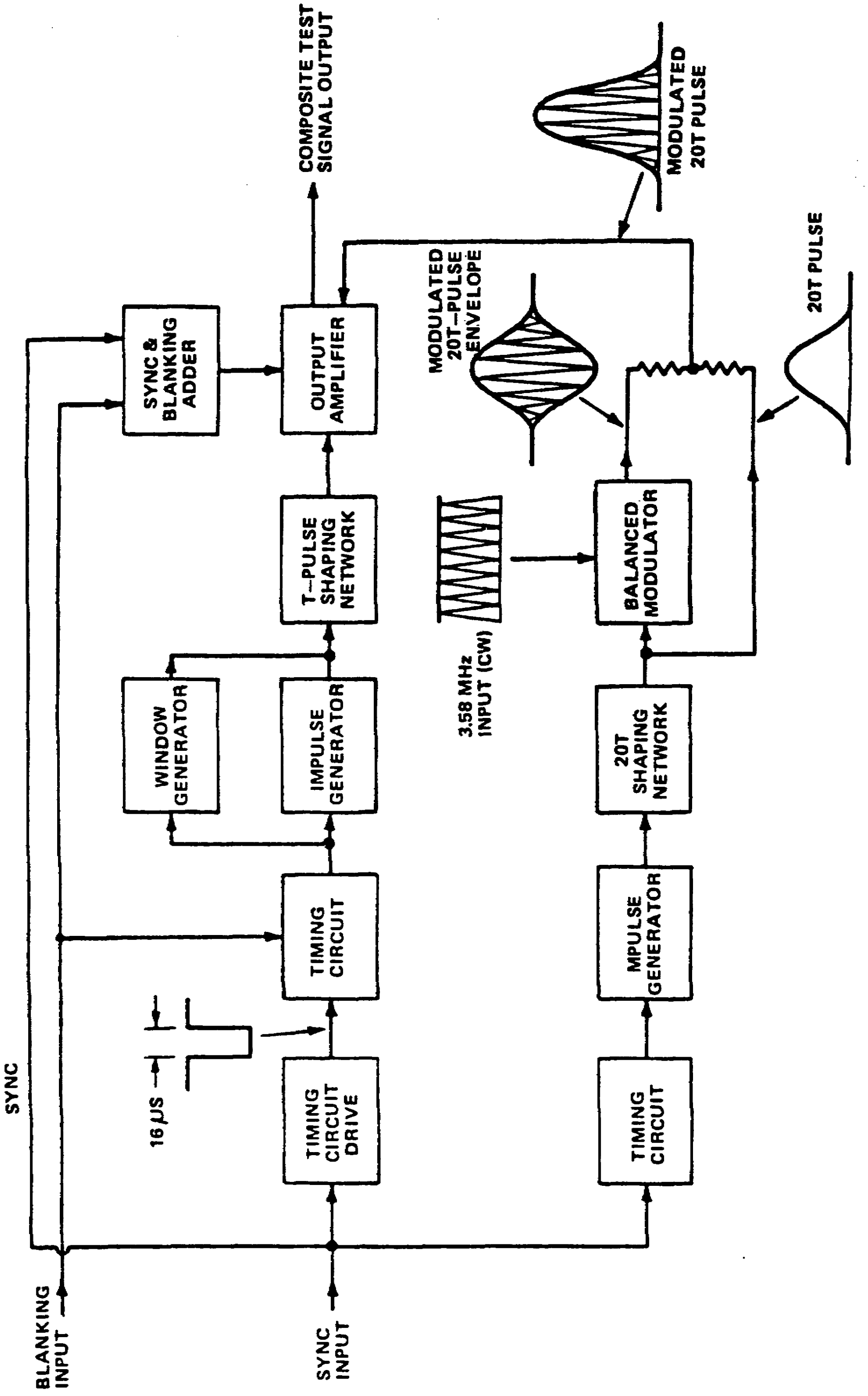


Figure 3-10. Basic block diagram of sin2-pulse and window generator

(1) Figure 3-1a, gives the line-rate specifications of the standard pulse-bar signal, with relative timing from the leading edge of horizontal sync. Figure 3-11b, gives the field rate specifications of the same signal.

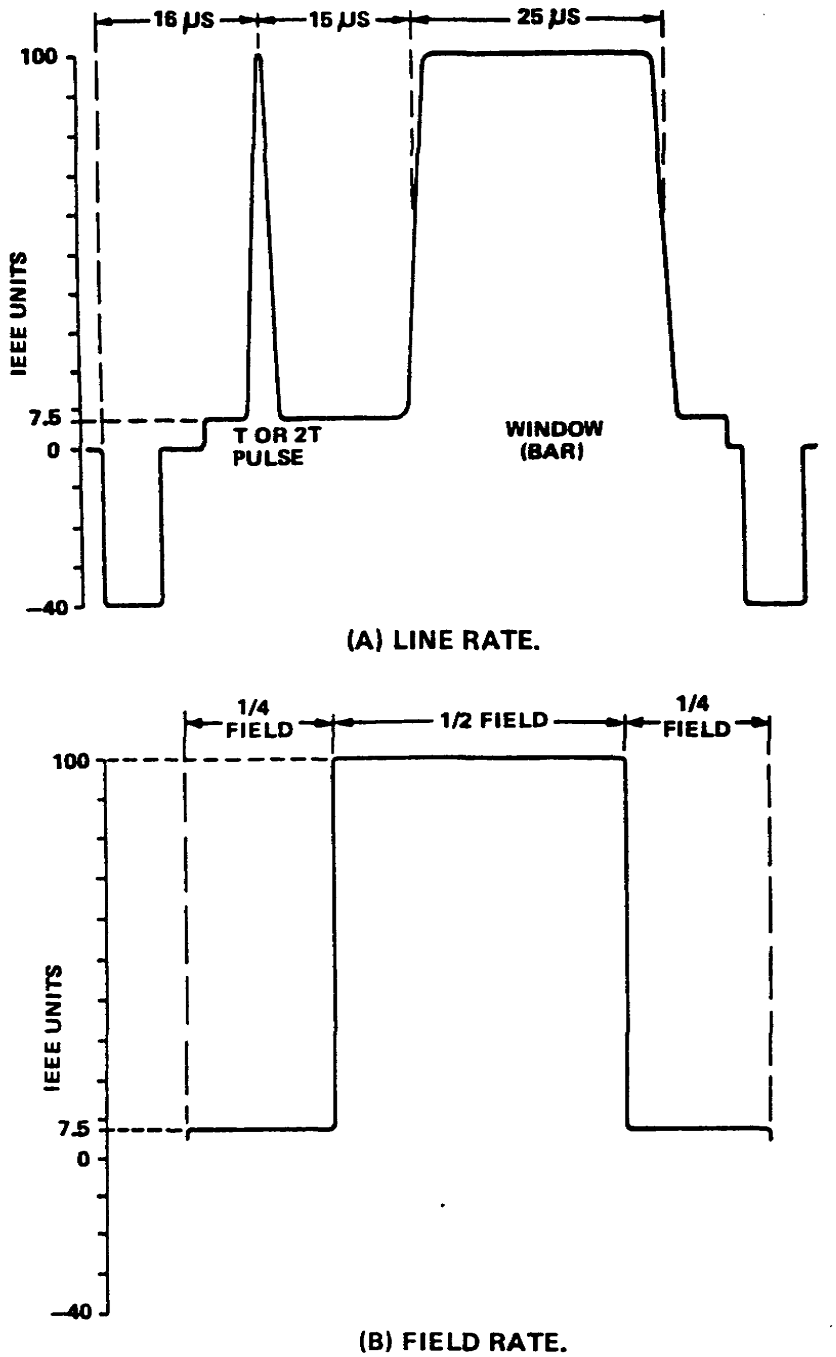


Figure 3-11. Pulse-window signal specifications

(2) Figure 3-12, illustrates the addition of the modulated 20T pulse to the composite test signal. Figure 3-12 displays two consecutive lines in which the window occupies one line and the pulses are contained in the following line. In Figure 3-13, the pulse and window are generated in each single line. In some generators, the positions of the pulses are interchanged; i.e., the T or 2T pulse precedes the modulated 20T pulse.

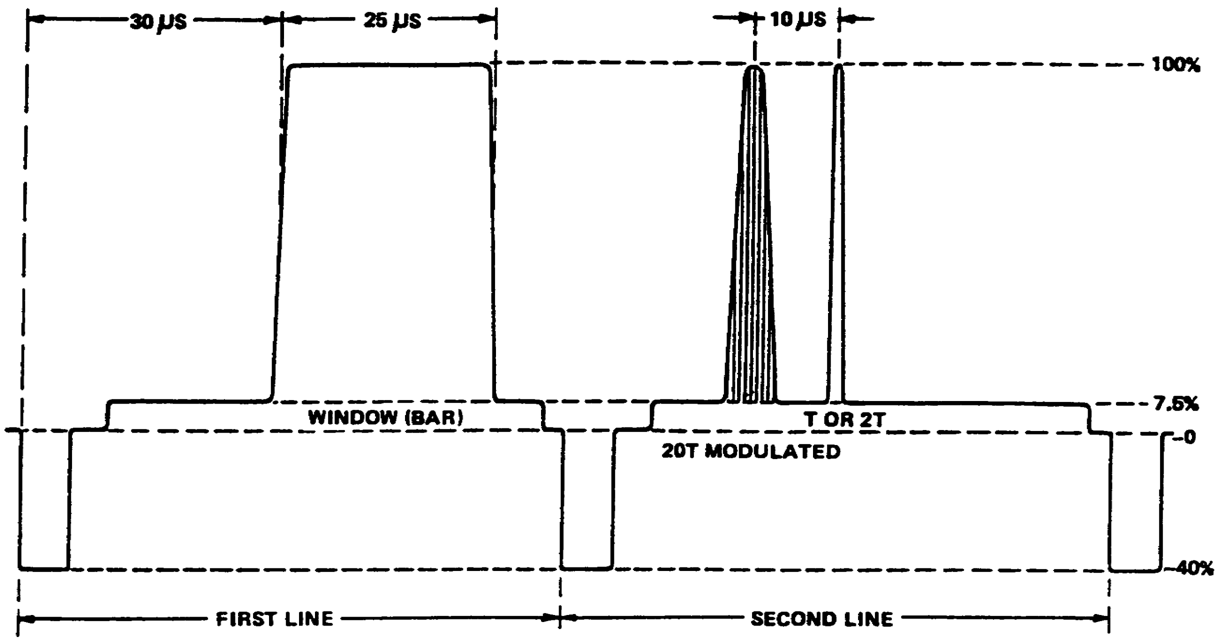


Figure 3-12. Display of 20T, T pulse and window

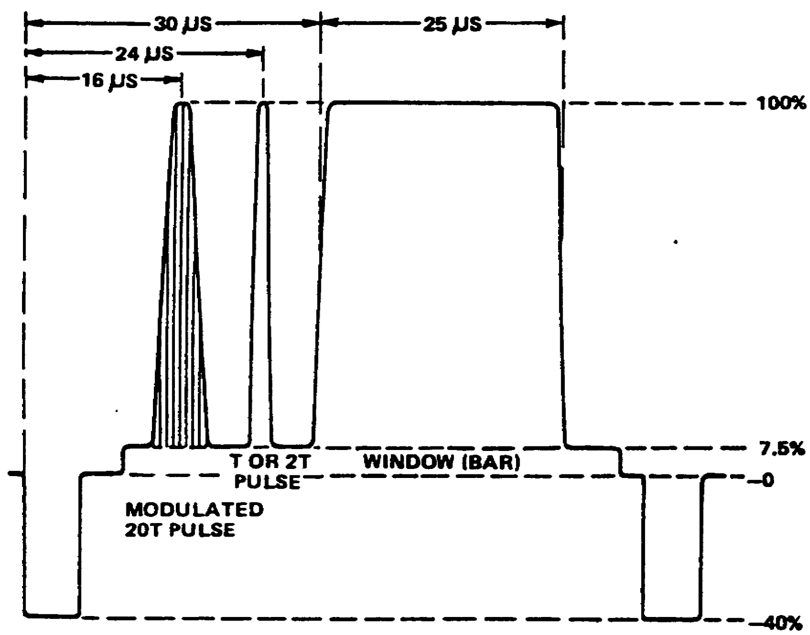


Figure 3-13. One-line display of 20T, T pulse and window

(3) The type of display convenient for one of the tests associated with this signal occurs when all the pulses and the window are in a single line. The scope must be double triggered; that is, it must be triggered from successive sync pulses. The two consecutive-line signal (fig 3-12) eliminates the need for double triggering, since a repetitive sweep automatically provides the double-triggered display. However, the two-consecutive-line signal has the disadvantage of being subject to error from frequency distortion because of the large difference in APL between the two separate lines (window on one line and pulses on the other).

2. Use of the pulse-window signal in practice involves, a special graticule to indicate certain K-factors, particularly for routine testing to provide a quick observation to go no/go quality.

3. In an attempt to correlate test-signal measurement with an actual degree of picture impairment, the K-factor is used. The K-factor is basically defined in terms of a standard picture distortion which is a single echo spaced in time 8T or more from the main transition. For example, if the peak amplitude of this single echo is 4 percent of the original transition amplitude, the K-factor is 4 percent.

a. In Figure 3-14, "A" signal transition with a sine squared shape occurs at t = 0. At a point spaced at +8T, a certain amplitude of "ring", or echo, exists. Let us arbitrarily assume that this amplitude is 4 percent of the original amplitude, so B = 4 percent. Waveform distortion A (fig 3-14) much closer to the transition is larger, but its effect, as judged by an average observer, is only equal to the picture impairment caused by echo B. Thus, although echo A may be 16 percent of the original amplitude, echo B, of only 4 percent amplitude, results in the same degree of picture impairment. We may construct a graticule mask which defines limits within which a waveform must fit if it is to have a K-factor equal to or less than the limits specified.

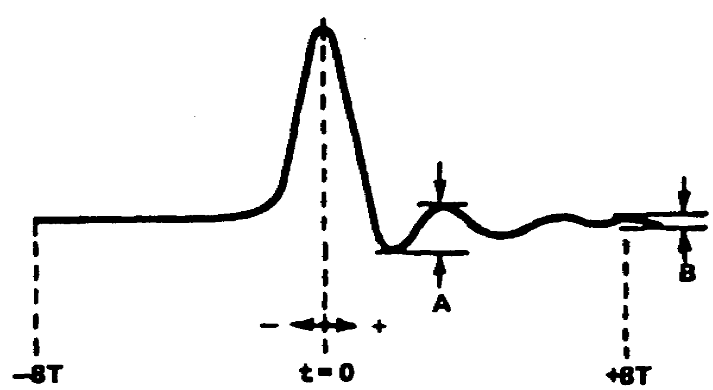


Figure 3-14. Basic qualities involved in explaining K-factor

b. For the purpose of assigning a numerical value to a subjective assessment, we can say that for a K-factor of 5 percent, picture impairment is noticeable to an experienced and critical observer, whereas a K factor equal to or less than the limits specified is not noticeable.

(1) In Figure 3-15, along the positive base of the transition, for h.a.d. = 0.250 microseconds the time from t = 0 to t = T is 0.125 microseconds (A in Figure 3-15). Then the time to 8T is 8 x 0.125 = microseconds. When h.a.d. = 0.125 microseconds T = 0.0625 microseconds (B in Figure 3-15). Therefore, 8T = 8 x 0.0625 = 0.5 microseconds. Obviously, the transition along the negative time base is the same, but progresses in the opposite direction from t = 0.

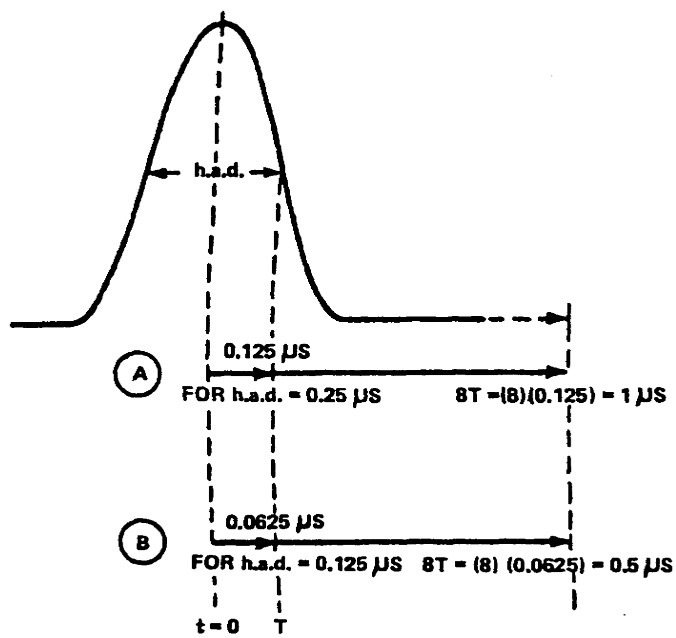


Figure 3-15. Pulse transition along positive time base

(2) Look at Figure 3-16, at plus and minus 8T, lines representing the limits of the K-factor are spaced in reference to the amplitude at t = 0. If the K-factor limit is to be 4 percent, then at the 8T points the lines are spaced plus and minus 4 percent of the amplitude at t = 0. Echos of larger amplitudes may occur closer to the main transition with no increase in subjective picture impairment. Note, for example, that at 2T the limit increases to 4 times that at 8T. Thus, if the 8T point has a K-factor of 4 percent, the 2T point is allowed an amplitude of 4 x 4 = 16 percent to fit within the 4 percent K-factor mask. Note also that the same mask can be used for pulses of either 0.025 microseconds or 0.125 microseconds h.a.d. by proper adjustment of the waveform monitor time base. The time base of 0.250H/cm x 25 is the proper time base for the pulse with h.a.d. of 0.250 microseconds. For the pulse with h.a.d. of 0.125 microseconds, 0.125H/cm x 25 is the proper time base.

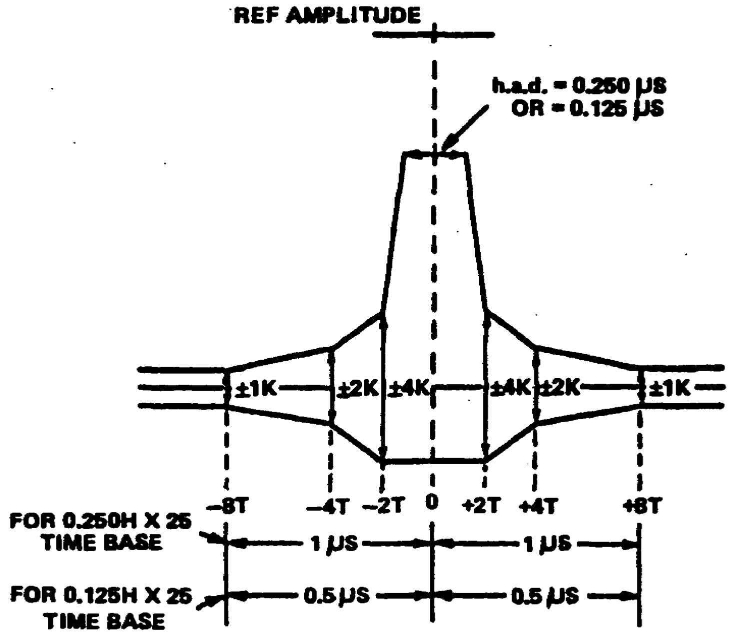


Figure 3-16. Basic K-factor

c. The K-factor graticule includes the limits of flatness for the window signal and the limits for the pulse-to-bar amplitude measurements for the K-factor used. Figure 3-17, which indicates how these limit lines are established. Observe, also, in this drawing that an indicator is used to show the correct waveform centering to place the leading edge of the window signal.

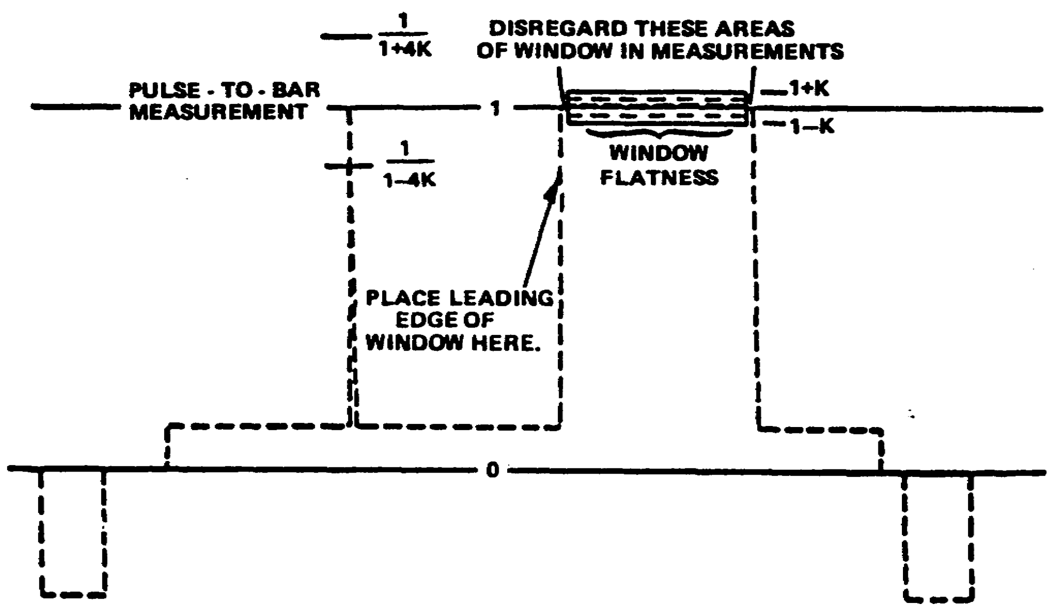


Figure 3-17. Pulse and window K-factor limits

d. Note that an area of either side of the window is disregarded in this measurement, and that only the enclosed area along the top of the bar is used. This is true for either horizontal or the vertical rate waveform displays.

4. Figure 3-18 illustrates the basic T-pulse responses encountered.

a. In Figure 3-18a, an amplitude-response error is apparent without phase-response error. Waveform errors this close to the transition do not impair the signal as much as errors farther away. In fact, this type of error should be recognized as that obtained from "phaseless aperture correction" in camera chains. Thus, there is a "crispening" effect of a single overshoot as compared with the actual picture impairments such as would result from the remaining waveforms of Figure 3-18.

b. Figure 3-18b, shows the "skew symmetrical" distortion caused when the delay increases with increasing frequency. Figure 3-18c, shows the opposite type of phase distortion, where the delay decreases with increasing frequency. In a system with a fairly rapid rolloff that uses phase equalizers to correct the resulting phase distortion, proper equalizer adjustment is indicated when ringing amplitudes are equally distributed preceding and following the pulse as shown in Figure 3-18d.

c. The amplitude-frequency and amplitude-phase response at frequencies higher than about 100 kHz is most evident in the measurement of the sin2 pulse. Amplitude-phase response at frequencies below 100 kHz is most evident in measurement of the window signal.

5. Distortions. Distortions at low frequencies produce waveform distortion with a long time constant, as for example, streaking. This is most evident in window measurement. Distortions at higher frequencies produce waveform distortions with shorter time constants as, example, smearing, loss of resolution, or edge effects from bad transient response. This is most evident in sin2 pulse measurement or in window-signal transitions.

a. High-frequency rolloff results in loss of amplitude. Loss of amplitude results in a widening of the pulse, since the area of the pulse represents a constant DC component. A slow rolloff within the video band produces a large reduction in amplitude (and pulse-width increase) with little or no ringing. A rapid rolloff close to the top of the band but still within the desired video bandwidth produces both a reduction in amplitude, and ringing. A rapid rolloff just above the video bandwidth concerned results in practically no effect on amplitude, but does not produce ringing. The shape of the rolloff and whether the resulting phase shift is leading or lagging is revealed by the distribution of ringing before and after the pulse.

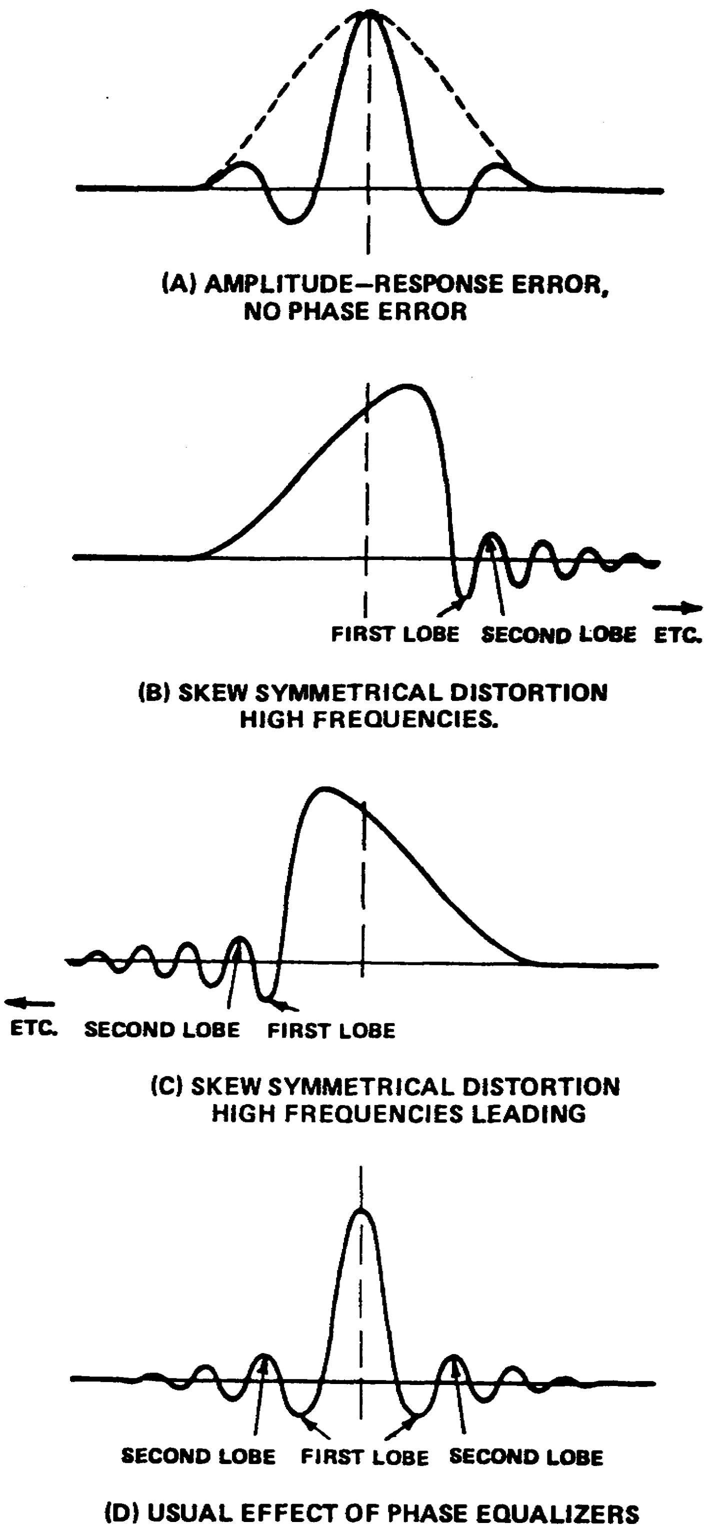


Figure 3-18. Basic T-pulse

b. The window permits detecting low-frequency distortion, which has practically no effect on the sin2 pulse. The window shows undershoot, overshoot, and horizontal tilt, depending on the time constant of the impairment. When used with the sin2 pulse, the window has the same rise time as the pulse so that no frequencies higher than the system test reference are introduced.

6. Ringing.

a. Ringing occurs at the frequency at which the gain dip occurs in the system being measured. The ringing amplitude depends on the sharpness of this gain-dip characteristic.

b. The ringing period (fig 3-19) is defined by the following relationship:

Rp = 1/fc

where fc is the cutoff frequency.

For example, if we have a 4-MHz cutoff, the ringing period (Rp) is:

Rp = 1/4(10 to the 6th power) = 0.250 microseconds

To find the cutoff frequency for a given measured ringing period:

fc = 1/Rp

where fc is the cutoff frequency in megahertz, Rp is the ringing period in microseconds.

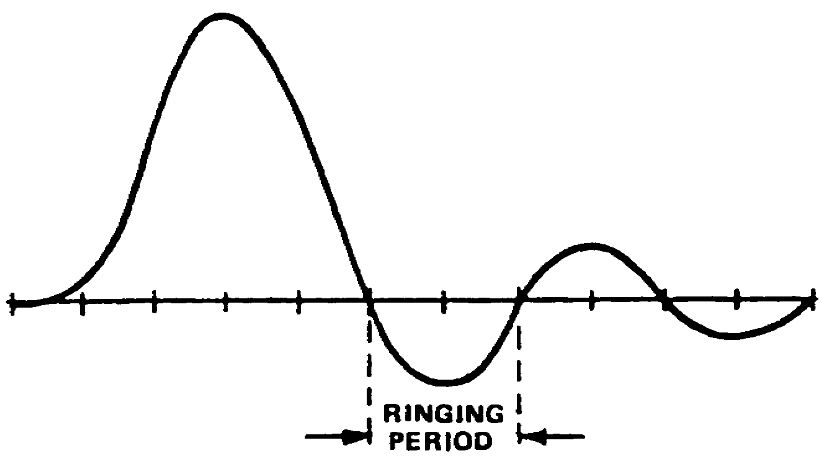


Figure 3-19. Ringing period

7. Waveform Distortion. Certain terminology is becoming standard, when defining waveform distortion, and following is a brief review of this terminology.

a. Short-time Waveform Distortion (SD) involves impairment of small picture detail in the horizontal direction. It is seen as blurring or smearing of a sharp brightness transition. It may or may not be accompanied by an overshoot or ringing to the right or left of the transition. Measurement of the SD may be accomplished by observing the leading and trailing edge of the window signal displayed at the horizontal rate; the display may be expanded on the scope time base.

b. Line-time Waveform Distortion (LD) concerns a longer time constant than does SD, and it results in impairment of brightness reproduction between the sides of a picture detail. When detail is smaller than full picture height, the streaking is most noticeable to the right of the detail. Details extending all the way up and down the picture may result in streaking across the full raster horizontally. Measurement of LD is done across the top of the window signal viewed at a horizontal rate, and by the relationship of the leading and trailing edges to reference black.

(1) In one type of LD, (fig 3-20) positive streaking is indicated preceding the window (black-after-black) and following the window (white-afterwhite) on the raster. Note the blacker-than-black tilt prior to the window, and the time duration required to fall to black at the trailing edge of the window. In actual measurement, the 1 microsecond intervals at the leading and trailing edges are not used, and the same durations for a and b relative to A are used. The window is approximately 1/2H in duration, and the time from the trailing edge of the window to the leading edge of sync is about 1/4H. So one-half of the window tilt is included in the (a) measurement, as indicated on the drawing.

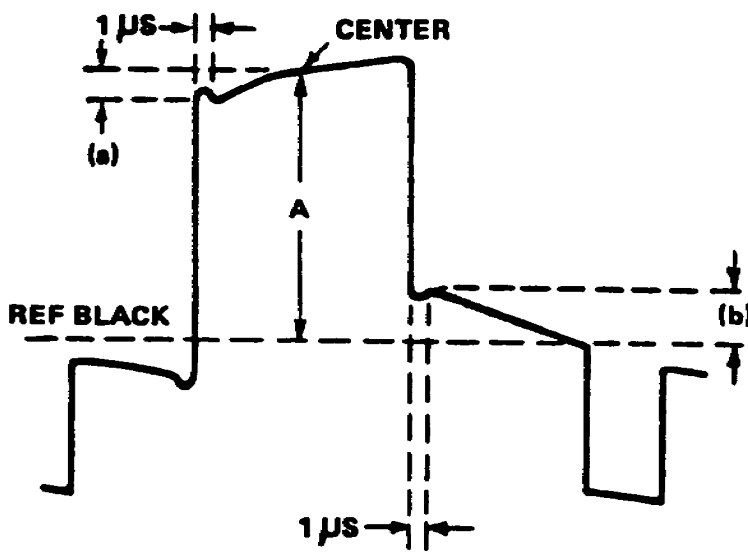


Figure 3-20. LD with leading and trailing positive streaking

(2) If the type of distortion is strictly linear, dimensions a and b are equal. If nonlinear distortion is present, these dimensions may differ. If reducing the level of the test signal into the system changes the relative dimensions of a and b, nonlinear distortion is present, and a lower level of test signal input should be used to check the actual linear distortion.

(3) Using the vertical-rate CRO display of the same signal, the white-going setup between the bottom of the white signal and blanking serves as an accurate indicator of the percentage of distortion. This defect is the result of excessive gain at low frequencies and causes an increase in setup level, in addition to the streaking effect from the attendant low-frequency phase shift. Such distortion is usually the result of a defective equalizer on long lines, or overcompensation with low-frequency compensation controls or tilt controls.

(4) LD resulting in negative streaking (black-after-white) impairs the display of lettering. The vertical-rate display indicates clearly the loss of setup, which occurs because this type of phase distortion is the result of insufficient gain at low frequencies, up to about the tenth harmonic of the nominal linescanning frequency of 15,750 Hz. In practice, the loss of gain occurs below the first few harmonics, or approximately 50 kHz.

8. Field-time Waveform Distortion (FD) results in impairment of brightness reproduction from top to bottom of the picture. Measurement of FD is done across the top of the window signal viewed at the vertical rate, and by the relationship of the leading and trailing edge of reference black.

9. Relative Chroma Level (RCL) is a measure of the faithfulness of reproduction of the saturation of all colors in a color picture. High RCL causes more vivid colors than intended; low RCL causes colors more pale than intended. Measurement of RCL is done most readily with the modulated 20T pulse.

10. Relative Chroma Time (RCT) is a measure of relative chroma and luminance delay. The results of RCT errors is misregistration of all colors with their respective luminance components. Delayed RCT places chroma to the right of its luminance component; advanced RCT places chroma to the left. Measurement of RCT is done with the modulated 20T pulse.

11. Modulated 20T Pulse. The modulated 20T pulse is the most convenient method of displaying RCL and RCT. Figure 3-21 typifies the display when pure amplitude distortion exists (no phase distortion). A change in amplitude of the 3.58-MHz subcarrier results in a cosine-shaped distortion of the base line, and a departure from reference peak level (top of window signal). When the distortion is linear, dimensions dl and d2 are equal. If these dimension are unequal, nonlinear distortion (differential gain) is present. In this case, linear distortion normally can

be measured by reducing the test signal input to one-half the normal input level, or about 0.5 volts peak to peak.

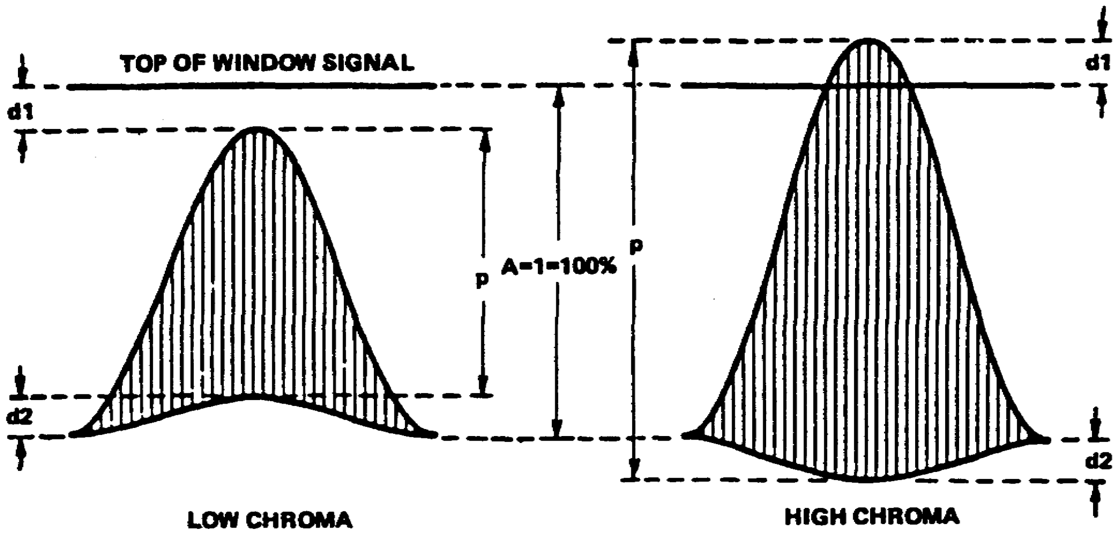


Figure 3-21. RCL only, no phase distortion

a. Dimension p (fig 3-21) represents the peak-to-peak level of the 3.58-MHz signal. Therefore (assuming dl and d2 are equal), RCL = p. Thus, assuming p is 80 percent, RCL is 80 percent, or simply 0.8.

b. Figure 3-22 typifies RCT (without amplitude distortion). The envelope of the line 3.58MHz subcarrier has a sinusoidal baseline distortion indicating a delay (fig 3-22A). The sinusoidal base-line distortion indicates an advance (fig 3-22B). Although dimension d can be expressed as a percentage of A, the scope display does not provide a very convenient method of specifying the actual group delay in nanoseconds. The maintenance technician normally is interested only in the fact that he has a delayed-chroma or advanced-chroma problem, not in the measurement of actual delay. When this measurement must be determined, a calibrated variable chroma delay or advance is used at the generator output and is adjusted for a flat base line. The degree of RCT (delay or advance) can then be read directly from the calibrated dial in nanoseconds. Otherwise, RCT may be specified in terms of whether chroma is delayed or advanced, and the percentage of d to A.

c. It is often the case that RCL and RCT distortion occur simultaneously. Figure 3-23 represents typical displays. The figure is self-explanatory if the preceding two figures are understood.

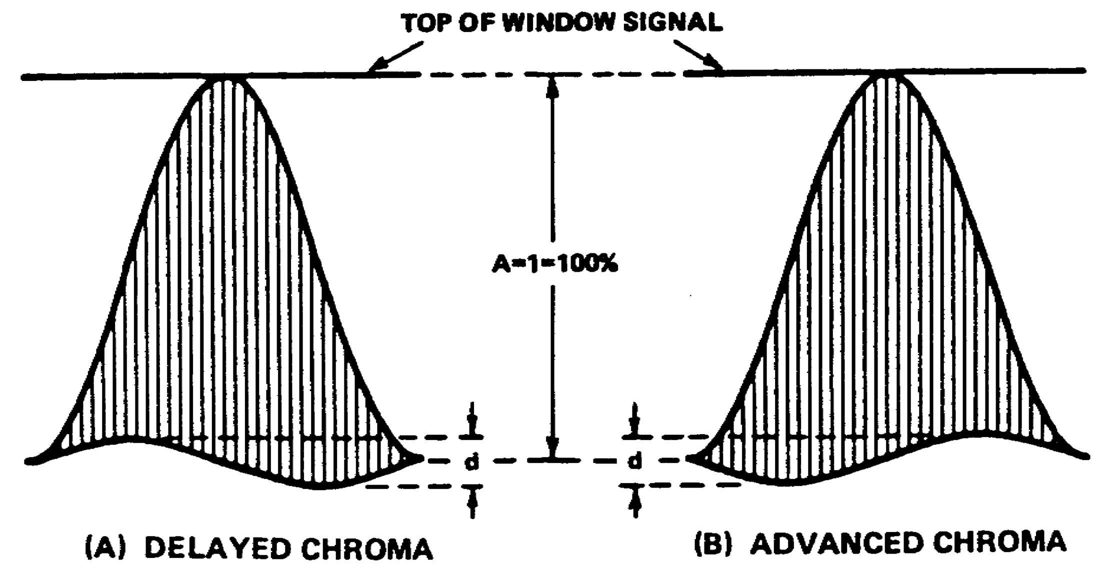


Figure 3-22. RCT only, no amplitude distortion

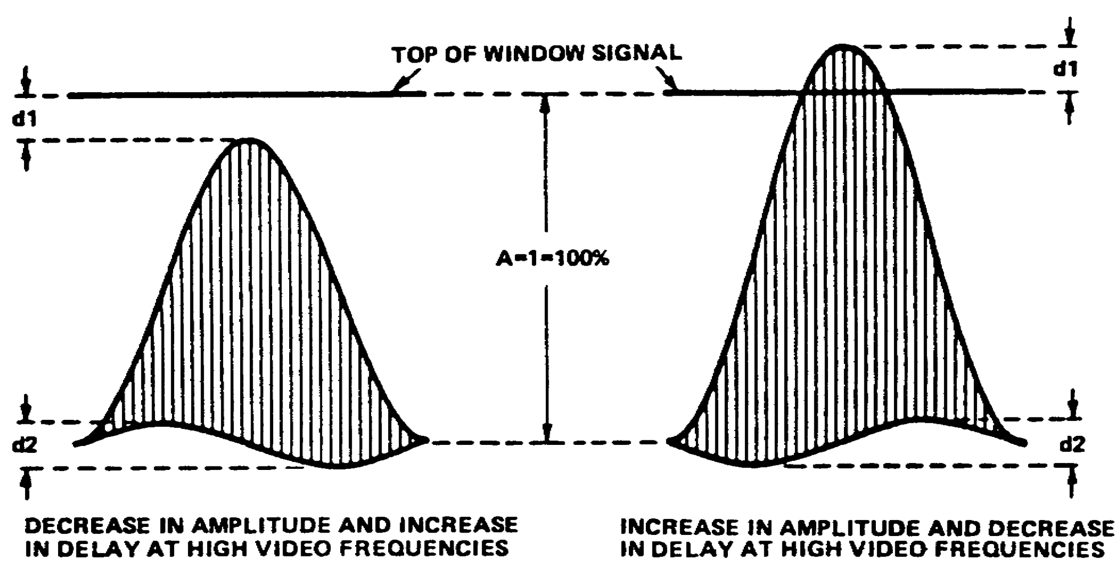


Figure 3-23. RCL and RCT simultaneously

Lesson 3
PRACTICE EXERCISE

1. What are the burst frequencies of the multiburst signal?

    a. 0.15, 0.5, 1, 2, 3, & 3.58 MHz
    b. 0.5, 1.5, 2.5, 3, 3.58, & 4 MHz
    c. 0.15, 0.5, 1.5, 3, 3.58, & 4.2 MHz
    d. 0.5, 1.5, 2, 3, 3.58, & 4.2 MHz

2. How many steps are used in gray-scale linearity signal?

    a. Four
    b. Six
    c. Eight
    d. Ten

3. How many horizontal lines are contained in the vertical synchronization interval?

    a. 17-18 lines
    b. 18-19 lines
    c. 19-20 lines
    d. 20-21 lines

4. What is the peak chrominance amplitude for the VIRS?

    a. 40 IRE
    b. 60 IRE
    c. 75 IRE
    d. 90 IRE

5. What type of test signal measurement is used to correlate the actual degree of picture impairment?

    a. B-factor
    b. E-factor
    c. K-factor
    d. Q-factor

6. What involves impairment of small picture detail in the horizontal direction?

    a. Line-time waveform distortion
    b. Field-time waveform distortion
    c. Short-time waveform distortion

ANSWERS TO PRACTICE EXERCISES

Test Question Number	Correct Response	(Learning Event	Reference Paragraph	Page)
		Lesson 1		
1	d	2	2c	6
2	d	3	6b(5)	
3	a	2	3	6
4	b	2	4a	6
5	d	1	2	1
6	a	2	2a	6
		Lesson 2		
1	b	1	1	29
2	b	1	2a	29
3	c	2	4	33
4	c	2	5b(1)	37
5	c	3	1	41
6	c	3	4	44
		Lesson 3		
1	d	1	1c	49
2	d	1	4a	51
3	d	2	1	54
4	d	2	3d	59
5	c	3	3	65
6	c	3	7a	71