SUBCOURSE EDITION

SS0607 8

THE PRINCIPLES OF TELEVISION STUDIO TIMING SYSTEMS

PRO PATRIA VIGILANS

THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

AIPD

READINESS / PROFESSIONALISM THRU GROWTH

US ARMY RADIO/TELEVISION TECHNICIAN
MOS 26T SKILL LEVELS 1, 2, AND 3 COURSE

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THE PRINCIPLES OF TELEVISION STUDIO TIMING SYSTEMS

SUBCOURSE NO. SS0607-8
(Developmental Date: 30 September 1988)

US Army Signal Center and Fort Gordon
Fort Gordon, Georgia

Four Credit Hours

GENERAL

The Principles of Television Studio Timing Systems subcourse, part of the Radio/Television Technician, MOS 26T Skill Level 1-3 course, is designed to teach the knowledge necessary for performing tasks related to timing systems used in the studio.

Lesson 1: THE BASIC VIDEO SIGNAL

TASK: Describe the basic application of the video signals in television studios and the relationship to studio timing.

CONDITIONS: Given information and illustrations relating to studio timing procedures.

STANDARDS: Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the principles of the video signal and the interconnection of studio equipment.

Lesson 2: VIDEO SIGNAL TIMING

TASK: Describe timing system designs which use delays, synchronizing generators, and multiple studio timing.

CONDITIONS: Given information on timing requirements of the video signal.

STANDARDS: Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the components of video signal timing requirements.

Lesson 3: MODERN STUDIO TIMING CONCEPTS

TASK: Define the phase relationship between subcarrier and horizontal sync (SC/H). Describe the problems and solutions of SC/H phase.

CONDITIONS: Given information and illustrations relating to SC/H.

STANDARDS: Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the phase relationship between subcarrier and horizontal sync (SC/H) and the problems and solutions of SC/H phase.

The objectives for this subcourse support these STP tasks:

113-575-3035 Troubleshoot and Repair the Power Amplifier of a Television Transmitter
113-575-0046 Troubleshoot an Audio - Tape Recorder/Reproducer

***** IMPORTANT NOTICE *****

THE PASSING SCORE FOR ALL ACCP MATERIAL IS NOW 70%.

PLEASE DISREGARD ALL REFERENCES TO THE 75% REQUIREMENT.

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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 indicated.

GRADING AND CERTIFICATION INSTRUCTIONS

INSTRUCTIONS TO THE STUDENTS

This subcourse has a posttest that is a performance-based multiple-choice test covering three lessons. You must score a minimum of 80 percent on this test to meet the objectives of this subcourse. Answer all questions on the enclosed ACCP examination response sheet. After completing the posttest, place the answer sheet in the self-addressed envelope provided and mail it to the Institution for Professional Development (IPD) for scoring. IPD will send you a copy of your score.

Four credit hours will be awarded for successful completion of the subcourse.

INTRODUCTION TO VIDEO SIGNAL TIMING

The video signal contains a large amount of information. In addition to basics such as hue, brightness, and saturation, the television video signal includes horizontal, vertical, and color timing information. Other information may be in the vertical blanking interval, vertical interval test signals (VITS), vertical interval reference signals (VIRS), time code, closed-captions, teletext, etc. Therefore, if optimum results are to be achieved, the timing relationships between the signals must be carefully maintained. A critical step in any teleproduction facility is the system timing. The final end product will reflect the quality of the system design. This subcourse will also define subcarrier and horizontal phase and explain how to maintain SC/H phase.

LESSON 1
THE BASIC VIDEO SIGNAL

TASK

Describe the basic application of the video signals in television studios and the relationship to studio timing.

CONDITIONS

Given information and illustrations relating to studio timing procedures.

STANDARDS

Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the principles of the video signal and the interconnection of studio equipment.

REFERENCES

None

Learning Event 1:
DESCRIBE THE PRINCIPLES OF THE VIDEO SIGNAL

1. Light from a scene enters the studio camera through the lens and creates a pattern of electrical charges on the pickup tube's target. An electron beam scans across the target and completes an electrical circuit with the pattern of electrical charges on the tube target. Electrons representing the scene in different degrees of lightness or darkness flow from the target and become the video signal. In this way, the pickup tube inside the camera changes the varying brightness of light that it "sees" into varying electrical voltages called video (fig 1-1).

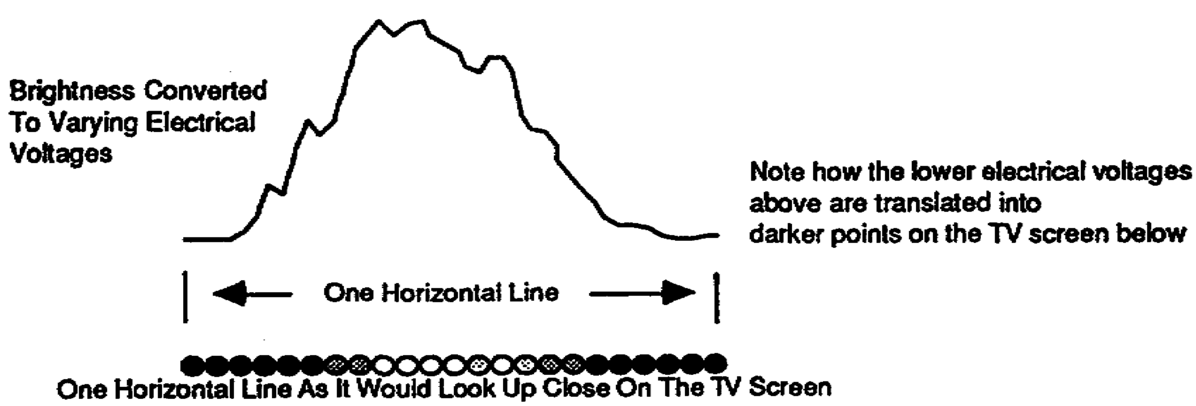

Figure 1-1. Varying video signal

a. To achieve an accurate reproduction of a scene, the scanning of the beam must be done in an organized way. In both the studio camera and the home television receiver, the scanning of the target of screen is done by the electron beam moving in horizontal lines across the target plate of a screen. At the same time, the electron beam gradually moves down the scene. When the beam reaches the bottom of the scene, the beam is sent back to the top. There are 525 horizontal lines in a complete picture.

b. The horizontal lines are alternately scanned. That is, all the odd-numbered lines are scanned first, then the beam returns to the top of the scene and scans all the even-numbered lines. This is called "interlaced" scanning (fig 1-2).

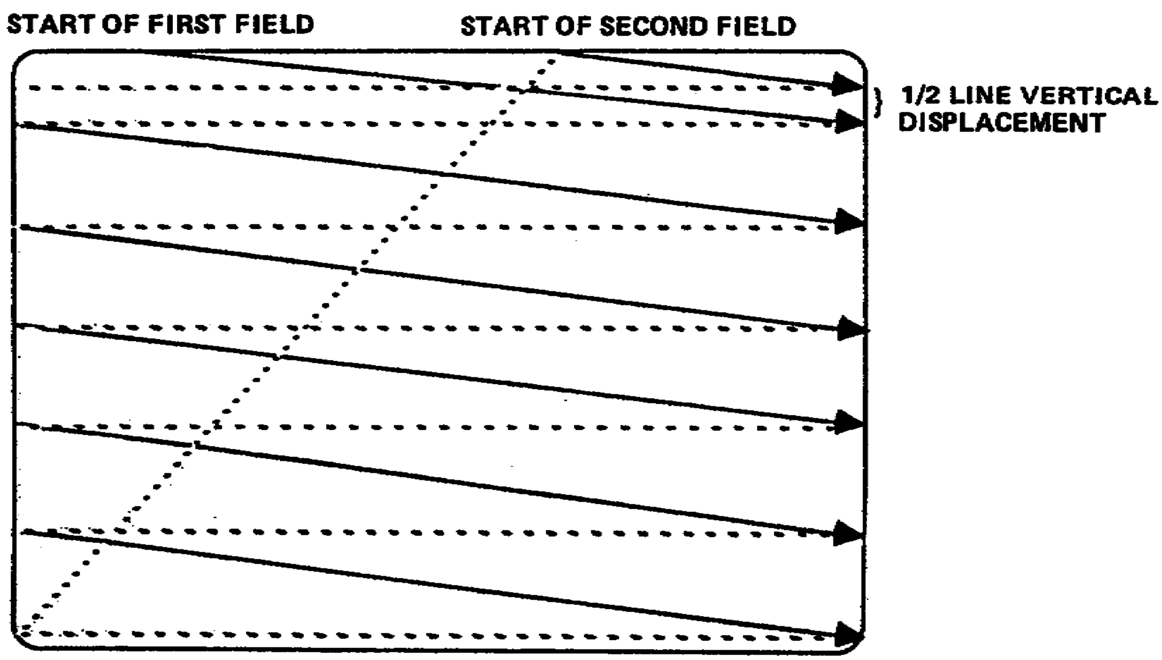

Figure 1-2. Interlaced scanning

c. Each scan of the scene is called a field and only involves half of the total 525 lines, or 262.5 lines. Two complete scans of the scene (525 lines) is called a frame. Because the fields are scanned at 60 frames per second, the viewer only perceives the completed picture.

2. The accurate reproduction of the images of both the studio camera and the television receiver must be synchronized to scan the same part of the scene at the same time. At the end of each line the beam must return to the left side of the scene. This is called "horizontal retrace". The coordination of the horizontal retrace is handled by the horizontal sync pulse (fig 1-3).

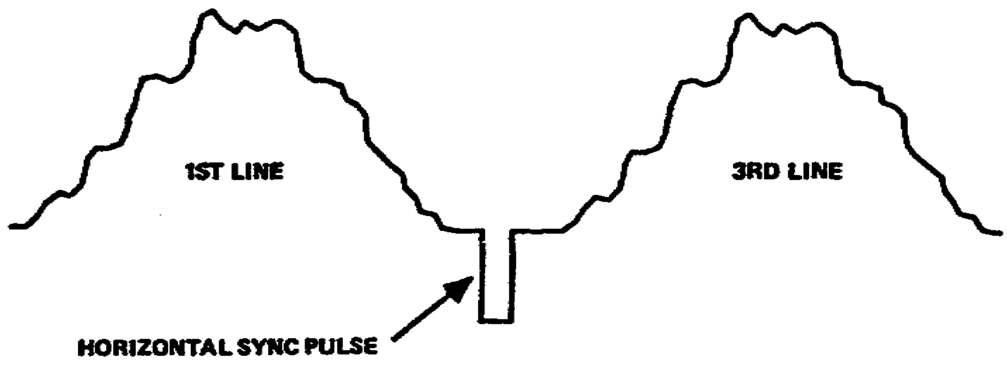

Figure 1-3. Horizontal sync pulses

a. At the bottom of the scene, when 262.5 horizontal lines have been scanned, it is time for the beam to return to the top of the scene. The start of vertical retrace is signaled by the vertical sync pulse that differs in width from horizontal sync pluses (fig 1-4). Since the vertical retrace takes much longer than the horizontal retrace, a longer vertical synchronizing interval is used.

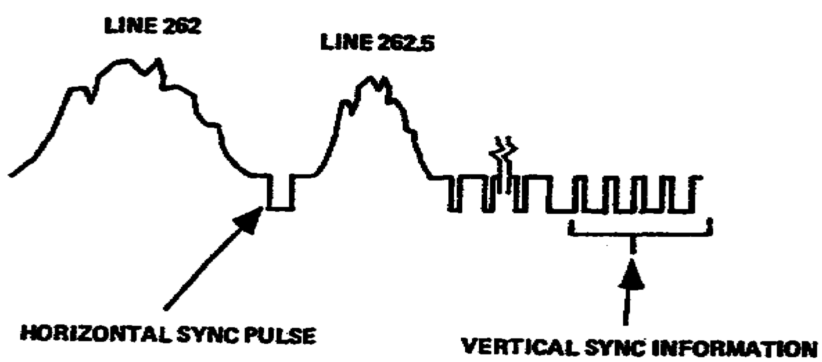

Figure 1-4. Relationship of vertical and horizontal sync pulses

b. During the time when horizontal and vertical retrace are taking place, the electron beams in the camera and home television are cut off. This time period is called blanking. Blanking means that nothing is written on the television receiver screen.

c. During horizontal blanking, "sync burst" takes place (fig 1-5). Also during the vertical blanking time, vertical sync, vertical equalizing pulses, and vertical serrations occur. The equalizing pulses are inserted to cause the video fields to begin at the proper points to achieve interlace. The vertical serrations keep the television receiver's horizontal sync circuitry from drifting off frequency during the time when no horizontal picture information is present.

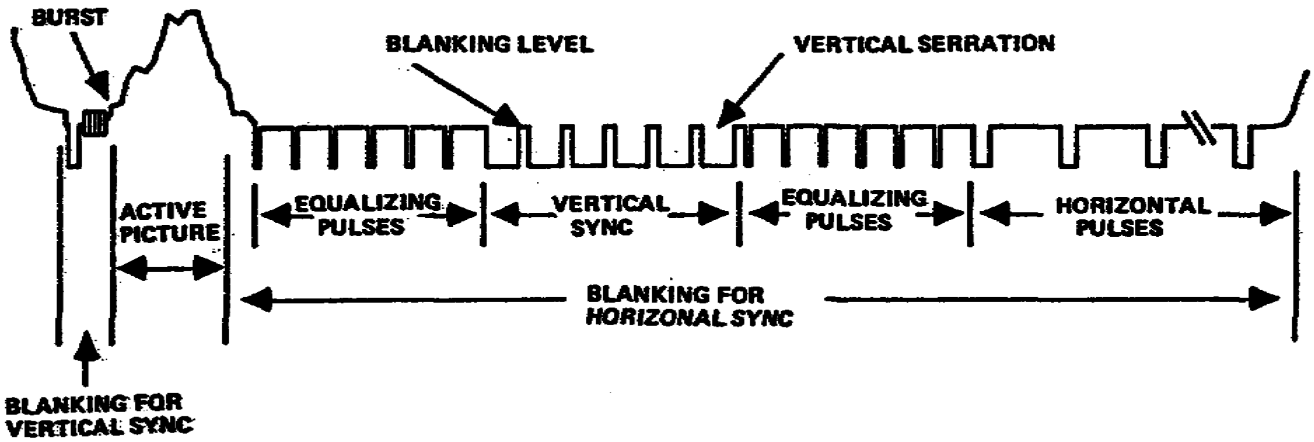

Figure 1-5. Overall video signal

3. It is very important that all video signals arrive at the switcher in synchronization. This means that the scanning sequence of each source must start and stay in time; otherwise, the picture on the receiver or monitor will roll, jump, tear, and/or have color shift problems when the source signals are combined. In all television studio facilities, a timing reference is provided by the use of a sync generator (fig 1-6).

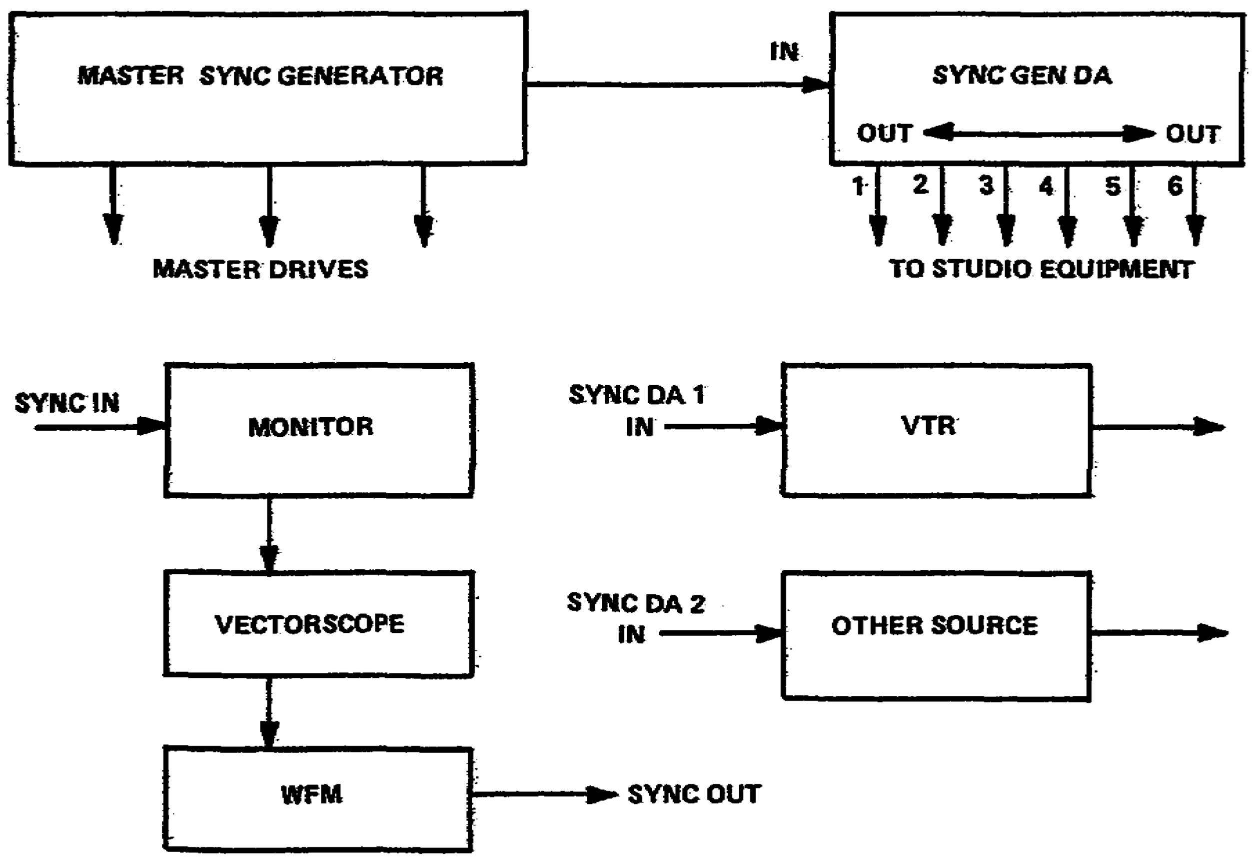

Figure 1-6. Sync generator system

a. Advance or delay between two video signals is dependent on which signal is identified as the reference. Advance on VTR 1 means its output occurs earlier in time than VTR 2's output. To look at it another way, VTR 2 is delayed when referenced to VTR 1. For example, you have video tape on VTR 1 and the same video duplicated on VTR 2. If you reference VTR 1, its output occurs earlier in time than VTR 2's output even though tapes are started simultaneously.

b. You must understand that advance is really not possible. Advance (or a time delay) does not exist. Video signals take time to move just as you or I do. A race car driver with the least delay in running time wins the race. On the other hand, the car was the most advanced at the finish line, but only because the other car racers had more delay in their running times. Frame synchronizers only make video advance appear possible, but what they really do is introduce "delay" to achieve the apparent "advance". This is proven by the fact that the audio associated with the video going through a frame synchronizer must also be delayed to avoid lip-sync errors.

Learning Event 2:
DESCRIBE HOW STUDIO EQUIPMENT IS INTERCONNECTED BY USE OF COAXIAL CABLE

1. Most state-of-the-art studio equipment is made to be interconnected with coaxial cable that has a nominal impedance value of 75 ohms. In the simplest form of connection, (point-to-point), two pieces of equipment will use a continuous length of coaxial cable that is driven from one 75-ohm source and then terminated on to a 75-ohm load (or, one output to another component's input).

a. When it is necessary to distribute a signal from one point to many other destinations (i.e. Studio A to Studio B), two possibilities exist. One way is to take one end of the cable, which is driven from a 75-ohm source, and make a "loop-through" connection (fig 1-7) instead of the load. This loop-through connection is carried to the next piece of equipment, and so on, until the last piece of equipment on line is terminated to 75 ohms. However, this approach will work only if the equipment

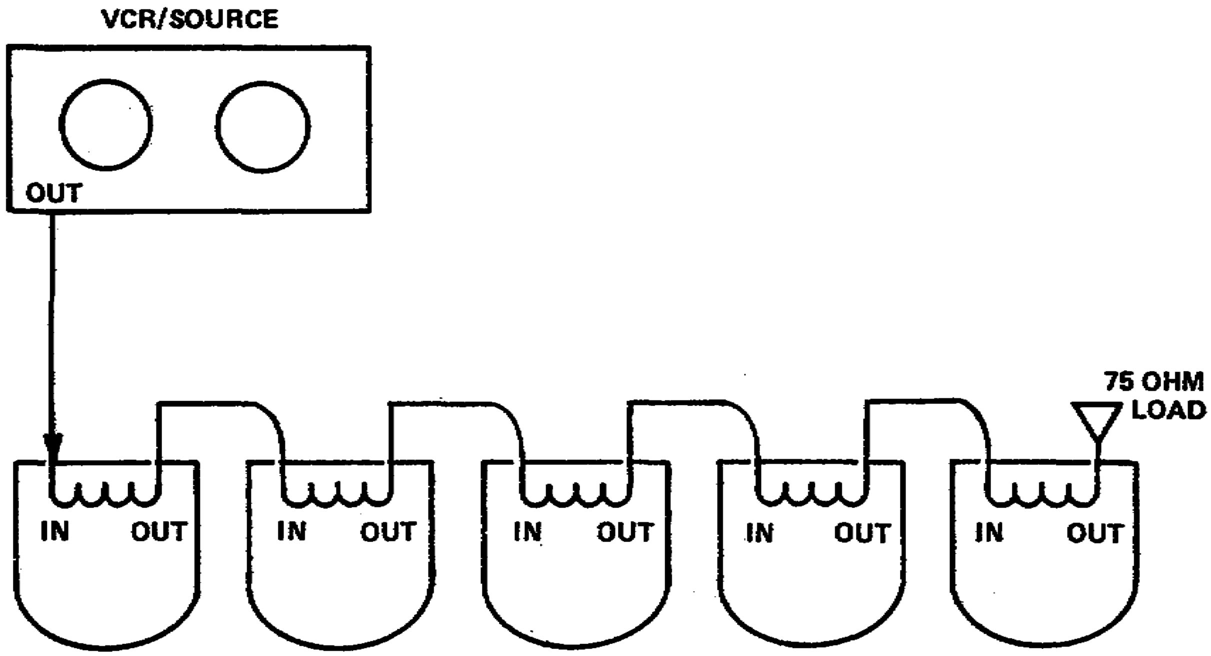

Figure 1-7. Loop-through connection

is properly designed and cable lengths are kept to a minimum (short). Otherwise, frequency response errors and signal reflections are likely to occur.

b. The second method is by the use of distribution amplifiers or routing switchers. This, in effect, will result in a point-to-point interconnection (fig 1-8).

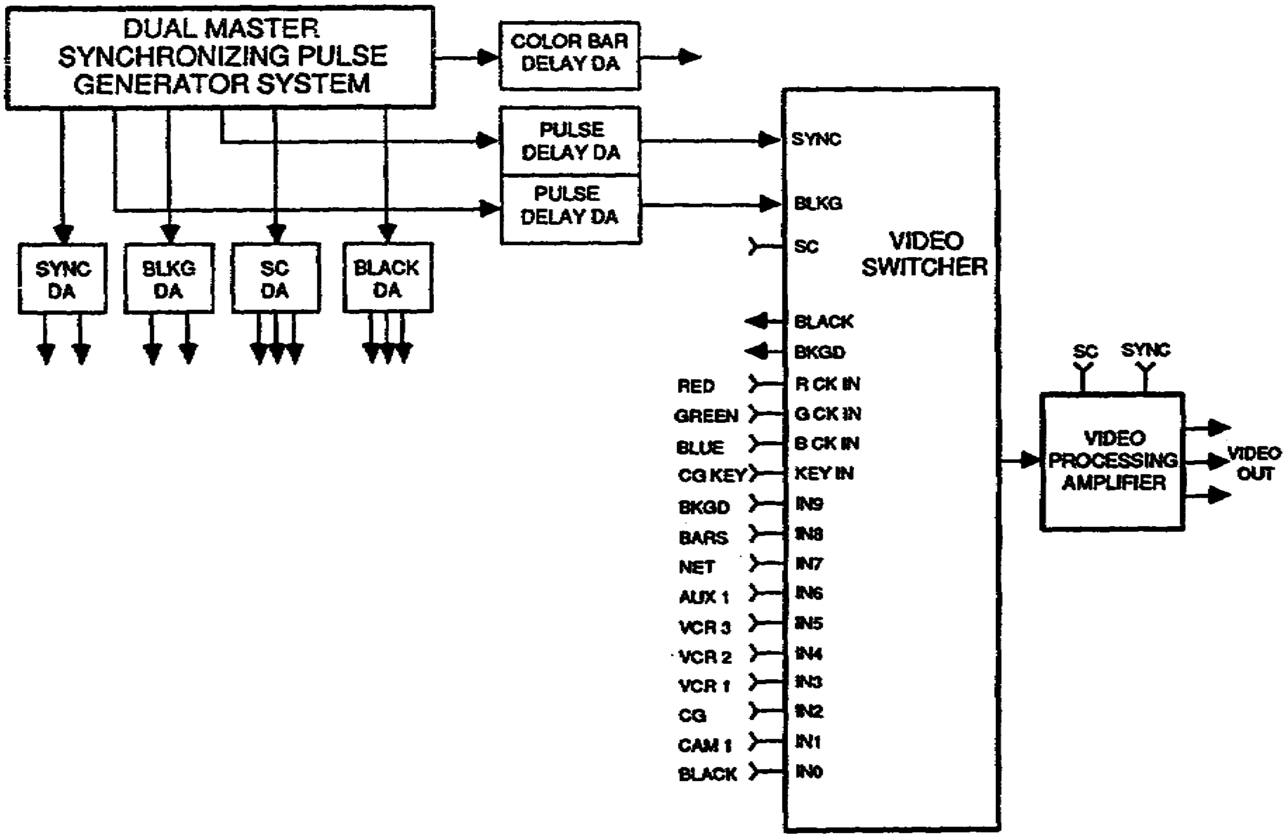

Figure 1-8. Example of rooting switcher system

2. The most popular cable for high quality video interconnection is the Belden 8281, a double-shielded 75-ohm coaxial cable designed for video use. Its double shielding prevents any likelihood of stray signal pickup. However, when space limitations or increased flexibility make the use of 8281 impractical, then Belden 8279 is the better choice. Belden 8279 is a much smaller diameter cable with the same high quality characteristics of the 8281 cable, and is good for usage on shorter cable runs.

Lesson 1
PRACTICE EXERCISE

1. What is the Belden 8281 cable used for in a television studio?

    a. Short runs
    b. Interconnecting
    c. Loop-through to other input sources
    d. Hookup to the sync generator

2. When must you terminate equipment to 75 ohms?

    a. When you use the loop-through method to interconnect equipment
    b. When you disconnect the ECU
    c. When you want to avoid a signal phase shift
    d. When you match video to audio

3. What must you do to the video when you delay the audio?

    a. Blank it
    b. Delay it
    c. Put it out of phase
    d. Lay a black control track

4. What causes the video signal to jump, roll, and tear?

    a. A defective picture tube
    b. Too much blanking
    c. A defective sync generator
    d. An open video cable

5. What has the impedance value, normally, of 75 ohms?

    a. Coaxial cable used for TV studio equipment
    b. A distribution amplifier
    c. A sync generator
    d. An oscillator

6. Which cable gives you flexibility on short run hook-up requirements?

    a. Doppler 375
    b. Belden 8281
    c. Quintex 750
    d. Belden 8279

7. How long does it take to present 30 frames?

   a. One nanosecond(ns)
   b. One microsecond
   c. One-tenth of a second
   d. One second

8. What keeps the horizontal sync circuitry on frequency?

   a. Vertical serrations
   b. Horizontal drive phasing
   c. Interlace at midpoint of the field
   d. The dot matrix repositioning every 30 ns

LESSON 2
VIDEO SIGNAL TIMING

TASK

Describe timing system designs which use delays, synchronizing generators, and multiple studio timing.

CONDITIONS

Given information on timing requirements of the video signal.

STANDARDS

Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the components of video signal timing requirements.

REFERENCES

None

General Information

Before the actual assembly of a teleproduction facility can begin, a system plan must be completed. This can only be accomplished when studio timing requirements are defined. It is necessary to know the timing requirements of the equipment to be installed. This information is usually available from the manufacturer's specifications manual. Most newer source equipment locks to color black. This implies the device has its own internal sync generator. Typically, this source equipment will have adjustments to allow the video output timing to be adjusted relative to the reference color black. You should verify that the adjustment range is sufficient for your requirements.

Learning Event 1:
DESCRIBE THE COMPONENTS USED FOR MULTIPLE SYSTEM TIMING

1. The ability to "lock-to-color-black" has not always existed. In the early years of television, cameras needed separate horizontal and vertical "drive pulses" from the sync generator to drive their scanning circuits. Sync, blanking, and subcarrier also were needed. System design required that all drive pulses be advanced by the path length of the camera. The delay from pulse input to video output may have been as long as one microsecond (a very long delay).

a. The older-style cameras would receive pulses directly from the sync generator. Drive pulses to other pieces of source equipment would then have to be delayed to time that equipment. This delay could be obtained by using several hundred feet of coaxial cable or some equivalent relay system using inductance or capacitance.

b. Cameras are in use today that require sync, blanking, and subcarrier. However, horizontal and vertical drive are now virtually obsolete. Older cameras (prior to 1978) have no internal timing adjustments, so it is necessary to adjust the advanced pulse drives to time the camera. One way to resolve this timing requirement is to drive the camera with a source-synchronizing generator. New cameras (after 1978) lock to color black and have internal timing adjustments available.

2. Until now, most character generators have required pulse drives and external adjustment to timing. This is done by dedicating a source-synchronizing generator to the character generator. Newer character generator models, like other devices, are beginning to lock to color black.

3. Digital video devices, such as digital effects generators, time base correctors, and frame synchronizers, work on the basis of storing digital video data. This allows timing to be easily adjusted and, as such, digital video devices are inherently able to time internally. Color black locking is very common.

4. Nearly all production switchers require sync, blanking, and subcarrier. Some switchers have limited adjustment of horizontal (H) delay, but still require advance pulse drives. Subcarrier phasing is normally built in and allows for color timing of the switcher. Dedication of a source-synchronizing generator to a switcher will simplify system design. Some switcher designs now incorporate color black locking.

Learning Event 2:
DESCRIBE THE EQUIPMENT AND PROCEDURES USED FOR TIMING DELAYS

1. Coaxial (coax) cable is necessary for the proper distribution of video, pulse, and subcarrier signals. Coax has an inherent delay of up to 1.5 nanoseconds (ns) per foot. This is cumulative and must be considered in-system design. Very long runs can introduce significant delay. Coaxial cable can be used for delay but it should be remembered that coax introduces frequency response loss that increases with frequency and length.

2. Distribution amplifiers (DA) introduce delay that must be planned for. This can vary from 25 to 75 ns depending on the model. Variable cable equalization adjustment will also affect electrical delay. Equalization should be adjusted prior to final system timing. Special purpose

video distribution amplifiers are available to provide delay beyond one microsecond. These DAs should be used because they have frequency response compensation that is superior to coax and passive video delay lines. Pulse DAs are available to allow for adjustment of pulse delay of up to four microseconds and regenerate the pulse to eliminate distortion.

3. Video processing amplifiers have a fixed electrical path length even though regenerated sync and color burst are adjustable. The propagation delay of a video processing amplifier can be about 225 ns.

4. Sometimes multiple studio facilities have the output of one switcher feeding a second and both share some common video sources. In this instance, the common video sources to the second switcher will need to be delayed by the path length of the first switcher. This delay may be as little as 50 ns for a small routing switcher, 700 ns for a large production switcher.

5. There are products available to aid in system design. One is the isophasing system, an automatic delay distribution amplifier, which will correct source timing errors up to plus or minus 15 ns.

a. The isophasing system can provide up to 32 channels with 5 outputs each, and keep all outputs within one degree of the subcarrier phase. This unit simplifies system design and daily system maintenance.

b. Once all the timing requirements of the equipment are known, lay out a system plan on paper. It is important that a specific piece of equipment be defined as the zero timing point. It will become the timing reference by which all calculations and measurements are made. This reference should be a source in the plant that is not easily altered, such as the test output from the master reference sync generator.

6. The illustration in Figure 2-1 shows a small system that will use cumulative delay to achieve system timing. This system consists of a camera, a character generator, two 1/2-inch and one 3/4-inch video cassette recorders.

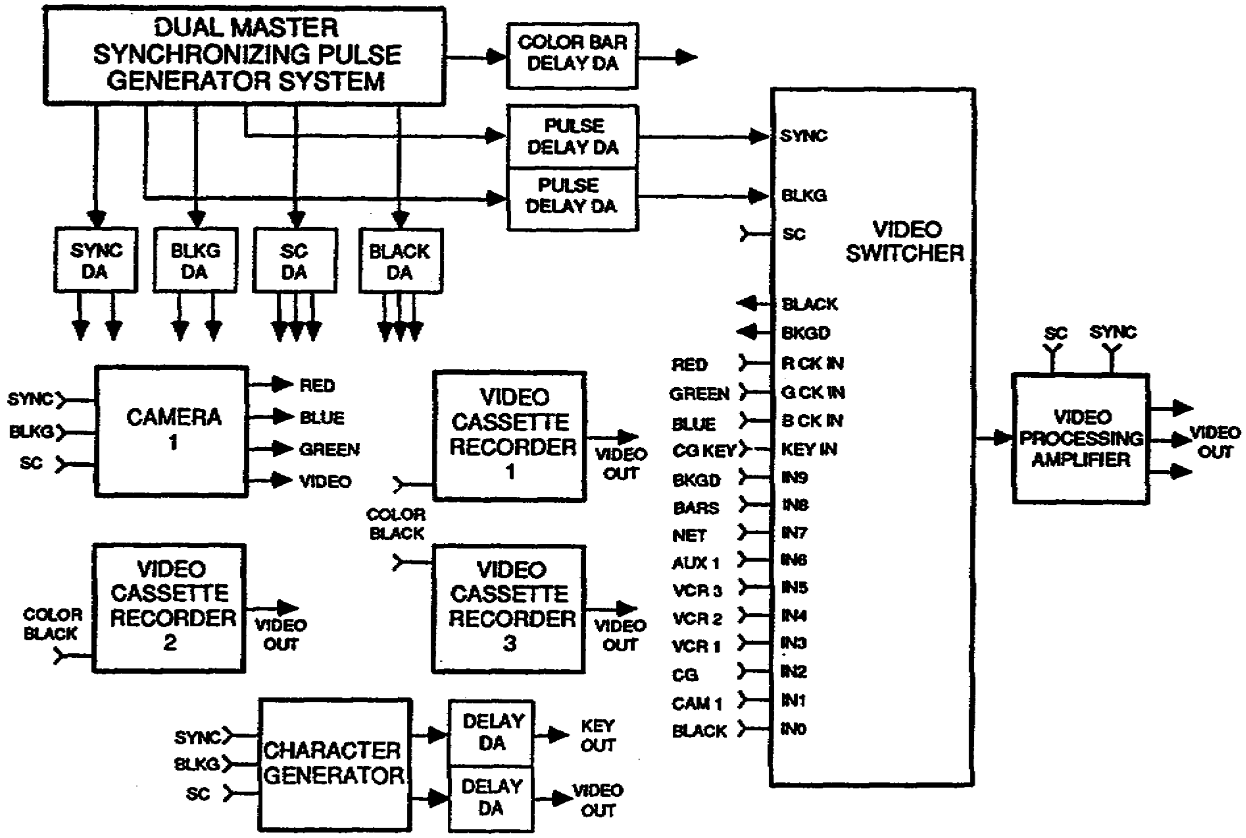

Figure 2-1. Cumulative delay timing system

7. The sources in this system that are to be mixed, keyed or wiped with the video switcher must be exactly in time at the switcher input. Hence, the obvious point of reference for this system is at the switcher input. This point is therefore designated the zero timing point, or time zero.

8. In Figure 2-2 the timing requirements of the equipment are plotted relative to time zero.

9. Camera 1 has 850 ns delay from its composite sync input to its composite video output, and represents the longest signal path of any source device in the system. The character generator, switcher, and color bars will need <u>delay added</u> to make their total delays the same as the camera. Since the camera has the longest path, the pulse drives will be provided directly from the sync generator so that the camera gets the most advanced pulses. The camera has a subcarrier phase control for color timing adjustment. The Camera 1 output becomes the reference input at the switcher.

10. To make the video switcher internal color black and the color background generator synchronize with the camera, both sync and blanking drives must be delayed to the switcher by 400 ns. This is accomplished with two adjustable pulse delay distribution amplifiers. The switcher has a subcarrier phase control for color timing adjustment.

11. Timing of the character generator can be handled in two ways. Delay can be introduced either in the pulse drives, or in the video and key outputs of the character generator. In this system, video delay distribution amplifiers are added to the character generator video and key outputs. This method provides six timed outputs. The amount of delay necessary is 250 ns as shown in the illustration in Figure 2-2.

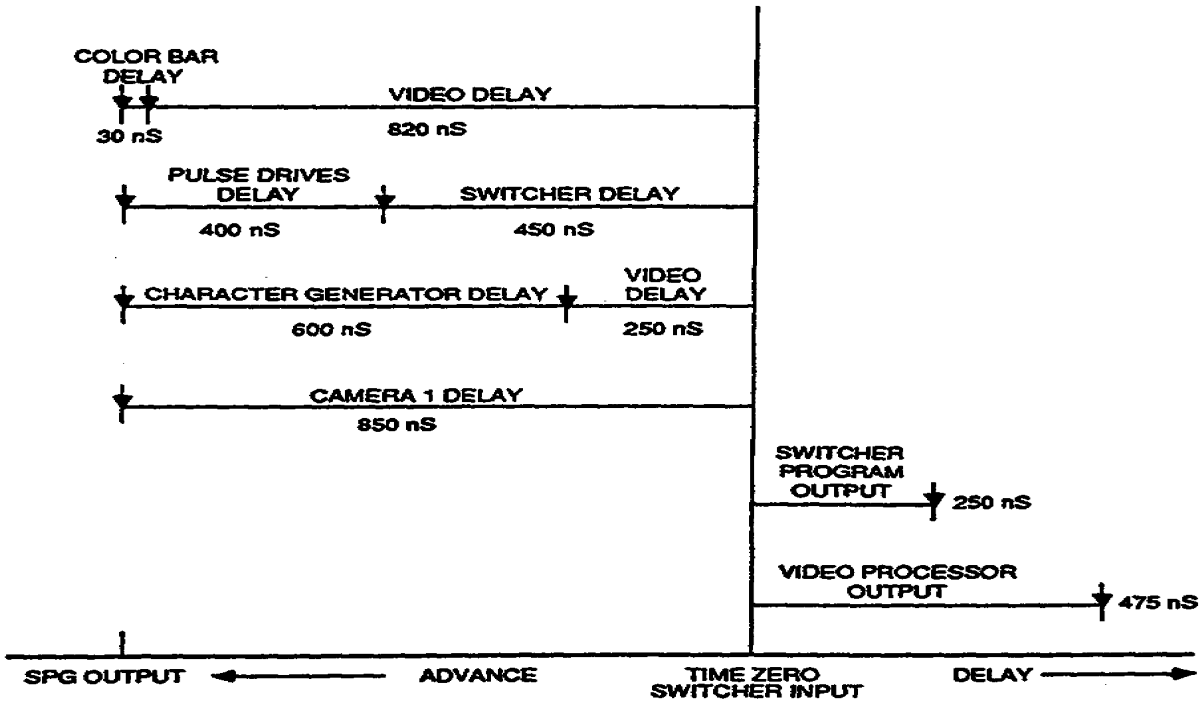

Figure 2-2. Timing requirements relative to time zero

12. The last source to be timed are the color bars from the master sync generator. The color bar output is 30 ns later than the sync output from the sync generator. With the camera as a reference, we can calculate that 820 ns delay to the color bar output is required to match the camera's delay.

13. The sync and subcarrier (required as external reference inputs for the video processing amplifier) should come from the distribution amplifiers feeding the switcher. The video processing amplifier has sufficient timing range for both sync and subcarrier.

14. The sync generator is a known SC/H phased source, and the color bar output will be SC/H phase correct. Accurate system timing can now begin by adjusting the color bars and the camera. Measurements are made at the switcher output by selecting between the reference source and the source under adjustment on the switcher. An externally locked waveform monitor and vectorscope should be connected to the switcher output.

Learning Event 3:
DESCRIBE THE PROCEDURES USED, IN SEQUENCE, TO TIME A SYSTEM IN THE SC/H PHASE

1. The following steps must be made in sequence to ensure the correct timing and SC/H phase of all sources (fig 2-3).

a. Adjust the color bar delay DA until the timing of the half amplitude (50 percent) point of the color bar horizontal sync leading edges match the timing of the camera sync. A timing match within 10 ns is desirable.

b. Camera 1 subcarrier phase needs to be adjusted to match its burst phase to the color bar burst phase.

c. The switcher, sync, and blanking pulse delay DAs must be adjusted until the switcher color background sync 50 percent point and blanking are in time with the sync and blanking of Camera 1's output.

d. Switcher color timing (internal color black and background) is matched to Camera 1 with the switcher subcarrier phase control.

e. The character generator video delay DA should be adjusted to match the character generator and Camera 1 horizontal sync leading edges.

f. Adjust the internal subcarrier phase to color time the character generator.

g. The key delay will be adjusted to center the character generator's fill video within the hole produced by the key signal.

h. Finally, adjust the VCR time base corrector H and SC phase controls to match each VCR to Camera 1 at the switcher.

2. This procedure will result in all sources being SC/H phase correct, only if the color bar video signal is SC/H phase correct. If an SC/H-phase meter is available, the SC/H phase of all sources can be verified. This approach to system design is usually the least expensive but does have serious deficiencies. We are distributing sync and subcarrier to equipment through many different paths. This will make establishing and maintaining SC/H phase very difficult. With the many variables in this system, SC/H phase may drift with time and temperature. Additional source equipment may be difficult to integrate in the future, and could require major system design changes.

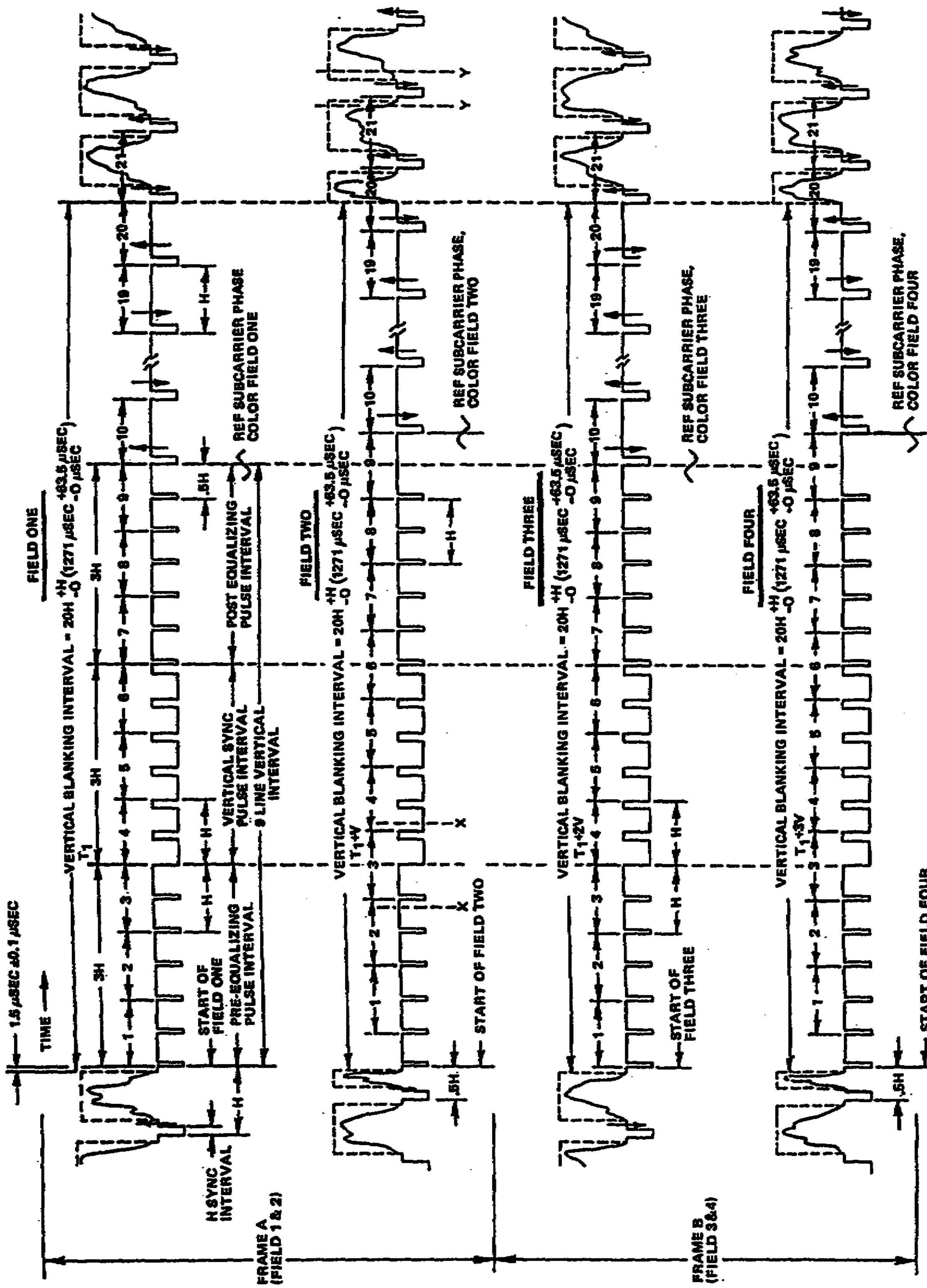

Figure 2-3. NTSC standards

NOTES:

1. SPECIFICATIONS APPLY TO STUDIO FACILITIES. NETWORK AND TRANSMITTER CHARACTERISTICS ARE NOT INCLUDED.
2. ALL TOLERANCES AND LIMITS SHOWN IN THIS DRAWING PERMISSABLE ONLY FOR LONG TIME VARIATIONS.
3. BURST FREQUENCY SHALL BE 3.579545 MHz ±10 Hz.
4. HORIZONTAL SCANNING FREQUENCY SHALL BE 2/455 TIMES THE BURST FREQUENCY.
5. VERTICAL SCANNING FREQUENCY SHALL BE 2/525 TIMES THE HORIZONTAL SCANNING FREQUENCY.
6. START OF COLOR FIELDS ONE AND THREE IS DEFINED BY A WHOLE LINE BETWEEN THE FIRST EQUALIZING PULSE AND THE PRECEDING H SYNC PULSE. START OF COLOR FIELDS TWO AND FOUR DEFINED BY A HALF LINE BETWEEN THE FIRST EQUALIZING PULSE AND THE PRECEDING H PULSE. COLOR FIELD ONE IS THAT FIELD WITH POSITIVE GOING ZERO-CROSSINGS OF REFERENCE SUBCARRIER NOMINALLY COINCIDENT WITH THE 50% AMPLITUDE POINT OF THE LEADING EDGES OF EVEN NUMBERED HORIZONTAL SYNC PULSES.
7. THE ZERO-CROSSINGS OF REFERENCE SUBCARRIER SHALL BE NOMINALLY COINCIDENT WITH THE 50% POINT OF THE LEADING EDGES OF ALL HORIZONTAL SYNC PULSES. FOR THOSE CASES WHERE THE RELATIONSHIP BETWEEN SYNC AND SUBCARRIER IS CRITICAL FOR PROGRAM INTEGRATION, THE TOLERANCE ON THIS COINCIDENCE IS ± 45° OF REFERENCE SUBCARRIER.
8. ALL RISE TIMES AND FALL TIMES UNLESS OTHERWISE SPECIFIED ARE TO BE 0.140 μSEC ±0.02 μSEC MEASURED FROM TEN TO NINETY PER CENT AMPLITUDE POINTS. ALL PULSE WIDTHS EXCEPT BLANKING ARE MEASURED AT FIFTY PER CENT AMPLITUDE POINT.
9. OVERSHOOT ON ALL PULSES DURING SYNC AND BLANKING (VERTICAL AND HORIZONTAL) SHALL NOT EXCEED TWO IRE UNITS. ANY OTHER EXTRANEOUS SIGNALS DURING BLANKING INTERVALS SHALL NOT EXCEED TWO IRE UNITS, MEASURED OVER A BANDWIDTH OF 6 MHz.
10. BURST ENVELOPE RISE TIME IS 0.30 μSEC MEASURED BETWEEN THE TEN AND NINETY PER CENT AMPLITUDE POINTS. IT SHALL HAVE THE GENERAL SHAPE SHOWN.
11. THE START OF BURST IS DEFINED BY THE ZERO-CROSSING (POSITIVE OR NEGATIVE SLOPE) THAT PRECEEDS THE FIRST HALF CYCLE OF SUBCARRIER THAT IS 50% OR GREATER OF THE BURST AMPLITUDE.
12. THE END OF BURST IS DEFINED BY THE ZERO-CROSSING (POSITIVE OR NEGATIVE SLOPE) THAT FOLLOWS THE LAST HALF CYCLE OF SUBCARRIER THAT IS 50% OR GREATER OF THE BURST AMPLITUDE.
13. MONOCHROME SIGNALS SHALL BE IN ACCORDANCE WITH THIS DRAWING EXCEPT THAT BURST IS OMITTED, AND FIELDS THREE AND FOUR ARE IDENTICAL TO FIELDS ONE AND TWO RESPECTIVELY.
14. REFERENCE SUBCARRIER IS A CONTINUOUS SIGNAL WHICH HAS THE SAME INSTANTANEOUS PHASE AS BURST.
15. PROGRAM OPERATING LEVEL WHITE IS 100 IRE, +0, -2 IRE.
16. PROGRAM OPERATING LEVEL BLACK IS 7.5 IRE, ± 2.5 IRE.
17. PROGRAM OPERATING LEVEL SYNC IS 40 IRE, ±2 IRE.
18. PROGRAM OPERATING LEVEL BURST IS 40 IRE, ±2 IRE.
19. BURST PEDESTAL NOT TO EXCEED ±2 IRE.
20. BREEZEWAY, BURST, COLOR BACK PORCH, AND SYNC TO BURST END ARE NOMINAL IN DETAIL BETWEEN YY. SEE DETAIL BETWEEN ZZ FOR TOLERANCES.
21. RATIO OF AREA OF VERTICAL EQUALIZING PULSE TO SYNC PULSE SHALL BE WITHIN 45 TO 50 PER CENT.
22. THERE WILL BE A 180 DEGREE REVERSAL OF PHASE WHEN VIEWING EVEN LINES ON A FOUR FIELD PRESENTATION. A FOUR FIELD PRESENTATION MEANS A DISPLAY DEVICE WHICH IS TRIGGERED BY FOUR FIELD (15 Hz) INFORMATION.

THIS DRAWING CORRESPONDS TO PROPOSED RS 170A VIDEO STANDARD.

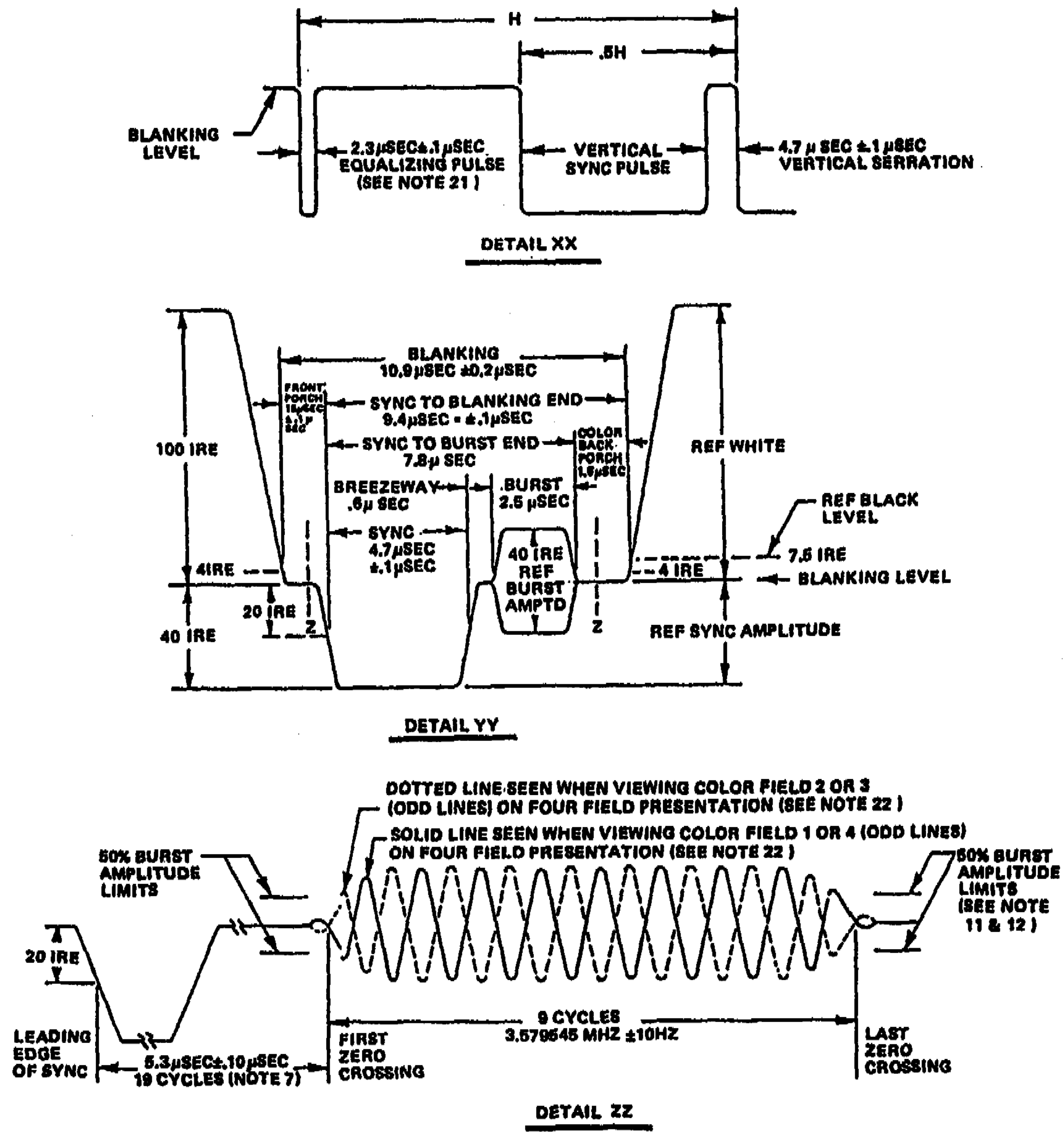

Figure 2-3. NTSC standards (continued)

Learning Event 4:
DESCRIBE THE USE OF A SOURCE-SYNCHRONIZING GENERATOR TIMING SYSTEM

1. Most of the difficulties encountered in system design can be avoided with a master/source sync generator system. This system provides maximum flexibility and the best SC/H phase stability. The approach below will be used with the same equipment employed in the previous delay system.

a. This time, rather than using the camera as the reference at the switcher input, the master synchronizing generator's color bar will be used. Because these color bars are fixed in their time relationship to the other outputs of the master sync generator, they make a rock-solid, SC/H phase-correct reference. All the sources still need to be in exact time at the switcher input. The SC/H phase pulse drives will be provided to the camera and character generator by their own dedicated source sync generators.

b. The source-synchronizing generator has the convenience of a single line locking signal, and output advance or delay, relative to the lock reference provided. This results in a much simpler system to design and maintain, and one that uses far less cabling. There is also redundancy in the system, since the source sync generators will continue to free run if the master should fail.

c. Camera 1 still requires drives which are advanced 850 ns to produce a timed, composite video output; however, this advance will now come from the source-synchronizing generator. The above is true for the character generator and video switcher, if they each have a dedicated source-synchronizing generator.

2. Final system timing is now a matter of looking at the switcher output and comparing each of the sources to the master sync generator's color bars. Each source-sync generator is adjusted to time the source it is driving. If the source device has a subcarrier phase control built in, you should adjust the horizontal phase using the source-sync generator and subcarrier with the source device's SC phase control. This adjustment will establish correct SC/H phase; however, the source sync generator may need adjustment. A SC/H phase meter will allow the source to be SC/H phased prior to adjustment of the source-synchronizing generator for final timing.

3. Sync and subcarrier for the video processing amplifier should come from the switcher source-sync generator. The source-synchronizing generator on the video switcher could be removed and the video switcher and the processor could be driven directly from the master sync generator. This would require placing about 430 ns of delay in the color bar path going to the switcher. This is the amount of delay required to generate switcher color black and background from the applied drives.

4. The single line reference signal for this master/source-synchronizing generator system can be color black or encoded subcarrier. State of the art broadcast equipment has an encoded subcarrier to improve and simplify the locking of source-synchronizing generators. The encoded subcarrier signal consists of a continuous 3.579545 MHz sine wave that contains two phase-inverted cycles (one per color frame). This brief phase inversion is precisely positioned on the front porch of blanking, preceding line 11 on field 1, of the four-field sequence (fig 2-4). The phase inversion thus communicates horizontal, vertical, and color frame information to the source-synchronizing generators. Encoded subcarrier provides a number of advantages over color black as a locking signal. Subcarrier does not have to be generated from the periodic color burst, so jitter is avoided. The use of a single frequency encoded subcarrier eliminates the normal group delay problem (usually encountered when color black travels through coaxial cable).

NOTE: Jitter is the up/down unstable movement of a video picture when it is not properly locked.

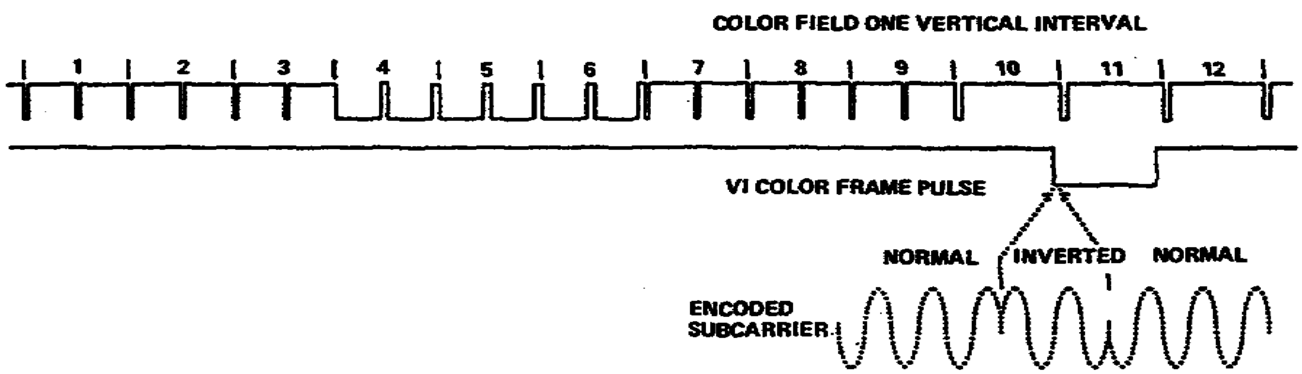

Figure 2-4. V1 color frame pulse

5. A color black reference sync generator (fig 2-5) must first regenerate subcarrier from the color burst. Jitter can result if this regeneration is not done precisely. Second, it must precisely compare the regenerated subcarrier with the exact 50-percent point on the leading edge of horizontal and vertical sync to determine color frame. If this process is not done precisely, the result may be SC/H phase instability, jitter, and independent lock to sync and subcarrier. An output SC/H phase will track reference input SC/H phase error. Sometimes SC/H error indicators are provided to help overcome these deficiencies.

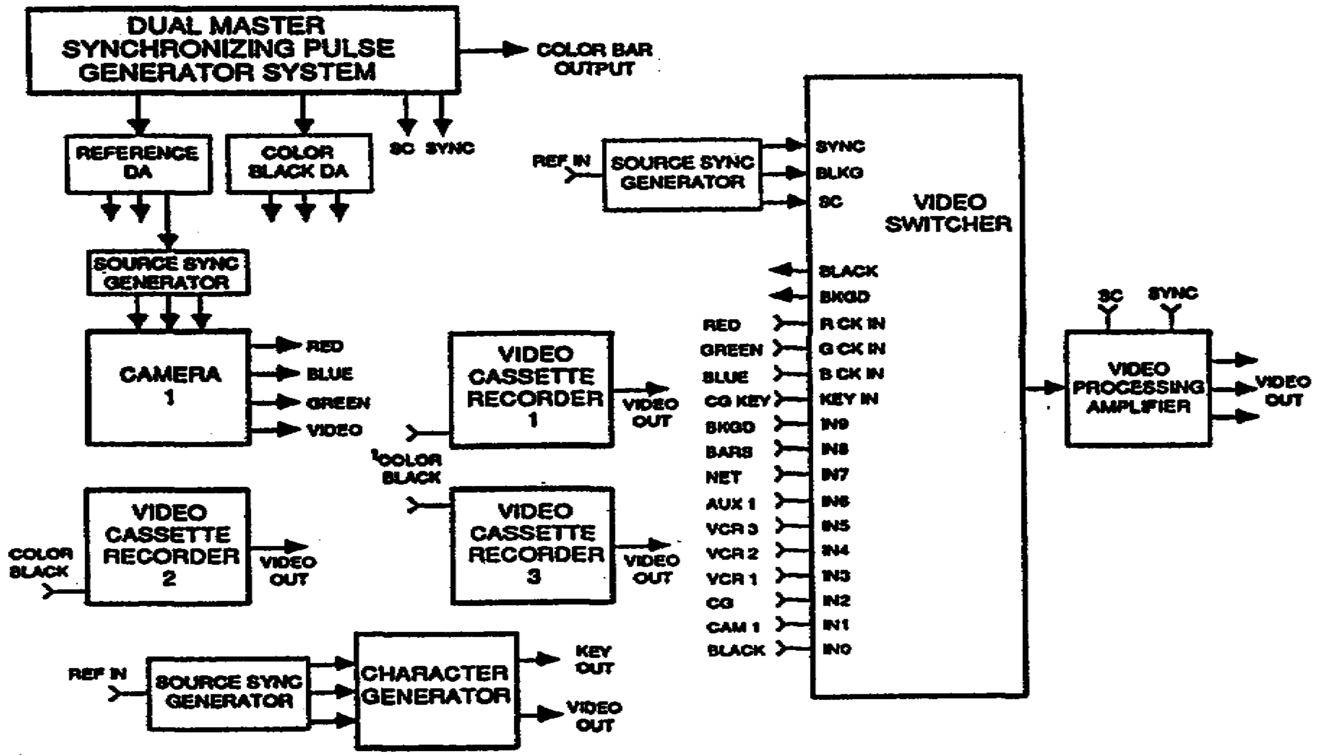

Figure 2-5. Black reference sync generator

Lesson 2
PRACTICE EXERCISE

1. What do cameras that do not have an internal timing adjustment require?

    a. A distribution amplifier and oscillator
    b. A vectorscope and waveform monitor
    c. Sync, blanking, and subcarrier
    d. Equalizers

2. Which camera locks onto the color black?

    a. New models (after 1978)
    b. Cameras in the 1/2-inch format
    c. Old cameras (prior to 1978)
    d. ENG/EFP field (portable) only, (3/4-inch format)

3. What does 1.5 ns per foot represent?

    a. The speed of light
    b. The speed of sound
    c. The inherent delay found in coaxial cable
    d. The delay always added to copper wire when used in a plastic sheath

4. A fixed electrical path length is found in which of the following?

    a. Audio control tracks
    b. Video circuit demodulators
    c. Audio attenuators
    d. Video processing amplifiers

5. What introduces a 25 ns to 75 ns delay?

    a. Standard power supply
    b. Any coaxial cable
    c. Sync generator
    d. Distribution amplifier

6. Which of the following locks on to a color black signal?

    a. Sync drive
    b. Time base corrector
    c. Vertical/horizontal control
    d. Blanking pulse

7. What does the burst phase of the color bar burst match?

   a. Input number one of the subcarrier phase
   b. Amplitude of the vertical phase
   c. Output of the sync generator
   d. Amplitude of the horizontal phase

8. What requires a 430 ns delay?

   a. Horizontal phasing generator
   b. Video processing amplifier
   c. Audio equalizer
   d. Vertical attenuator rectifier

LESSON 3
MODERN STUDIO TIMING CONCEPTS

TASK

Define the phase relationship between subcarrier and horizontal sync (SC/H), and describe the problems and solutions of SC/H phase.

CONDITIONS

Given information and illustrations relating to SC/H.

STANDARDS

Demonstrate competency of the task skills and knowledge by correctly responding to at least 80 percent of the multiple-choice test covering the phase relationship between subcarrier and horizontal sync (SC/H) and the problems and solutions of SC/H phase.

REFERENCES

None

Learning Event 1:
DESCRIBE SYSTEMS USED FOR MULTIPLE STUDIO TIMING

1. The illustration in Figure 3-1 shows a three-studio system in which the timing of entire source clusters and studios can be changed. This will allow one studio to feed any other studio in sync time.

2. This entire system is driven by a dual master reference synchronizing generator with an automatic changeover switch. This provides additional security since each master sync generator is powered from a different circuit. The master sync generators can have ovenized crystal oscillator options for higher frequency stability against temperature variations. An external frequency reference option allows a rubidium or cesium frequency standard to be used as the frequency standard, with the internal oscillator as a backup.

3. Each of the three studios is similar to the one just mentioned. The studios have dedicated source devices and additional cameras and/or video tape machines that can be assigned. A routing switcher is used to assign these sources to the studios. Every studio output is fed to a routing switcher input for assignment as a timed input to another studio. Every

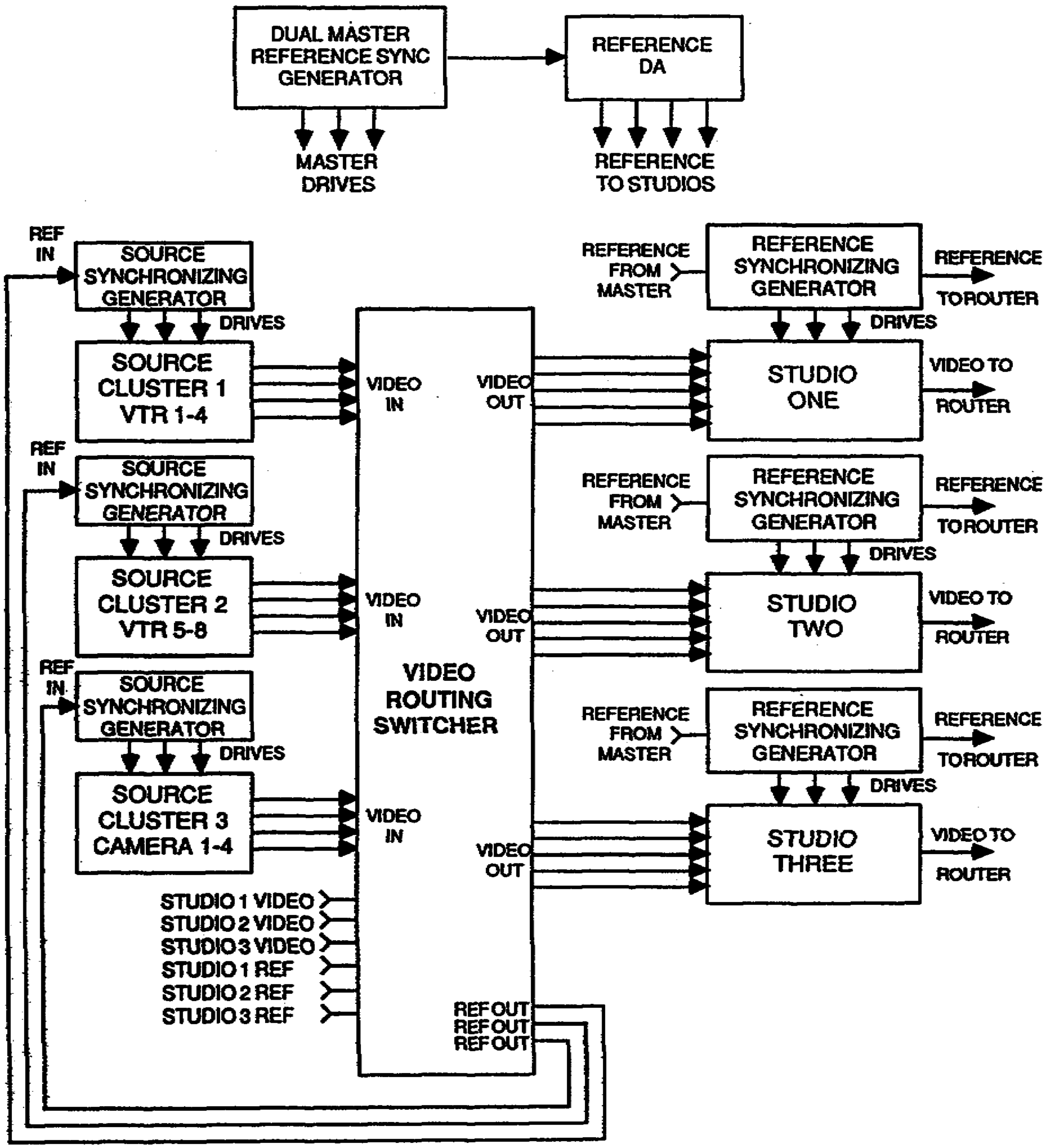

Figure 3-1. Three-studio system

studio is being driven by a reference-synchronizing generator that will adjust the timing of that entire studio. Each source cluster is driven by a source-synchronizing generator so that the source cluster timing will stay together. The reference output from each studio reference-synchronizing generator is sent to the routing switcher. The reference input to any source-cluster-synchronizing generator can be assigned to any studio. This automatically times the source cluster to the studio using it. If the reference-synchronizing generator has a phase preset installed, the phase setting for every configuration can be stored and recalled. A typical configuration could be source cluster 1 timed into studio 1, the output of studio 1 and source cluster 3 timed into studio 2, source cluster 2 timed into studio 3, which is also a timed input to studio 2. These timing assignments can easily be interchanged with the phase preset and routing switcher once the initial timing is completed and stored in each reference-synchronizing generator.

a. This system provides maximum flexibility in tailoring each studio for the production it is to be used for. The cameras would be assigned to a studio doing live production and the video tape machines could be used for post production in another studio. Many more sources can be added by using this design without causing major system design problems.

b. Distributed synchronizing generator systems also provide redundancy, which is an important advantage. Should a failure occur in the master generator, the reference and source generators will free run. The free run action will keep the equipment functioning.

Learning Event 2:
DESCRIBE THE PROBLEMS AND DEFINE SOLUTIONS OF SC/H PHASE

1. In the late 1940s the Electronic Industries Association (EIA) established monochrome television standard RS170. In recent years the proposed color standard RS170A has received increasing acceptance. RS170A fully outlines the phase relationship of the color subcarrier to horizontal sync. A graphic representation of this standard is included in Figure 2-3, p. 16. If we look at the equation that relates horizontal sync to subcarrier and consider the number of lines in each frame, several conclusions can be made.

$$\underline{H = 2 \times 3.579545}$$
$$455$$

2. First, there are 227.5 subcarrier cycles per horizontal line; so, subcarrier phase reverses every line. This is desirable to reduce the visibility of color subcarrier on monochrome receivers. Second, with 525 lines per frames, there are 119437.5 subcarrier cycles in each frame.

This causes subcarrier phase to reverse every frame. Because of the extra half cycle of the subcarrier, it takes two frames to complete one full four-field color sequence, called a color frame. It can be seen from the horizontal frequency equation above, that horizontal is frequency locked to subcarrier. However, it does not define the phase relationship between them. Proposed color standard RS170A clearly defines SC/H phase as: the zero crossing of the extrapolated subcarrier of color burst shall align with the 50-percent point of the leading edge of horizontal sync (fig 3-2). For color field one, the extrapolated subcarrier zero crossing will be positive-going on even lines (fig 3-3). This definition of sync to subcarrier phase (SC/H) is required for the clear identification of the four-field color sequence. The operational ramifications of these definitions are not obvious and require further explanation.

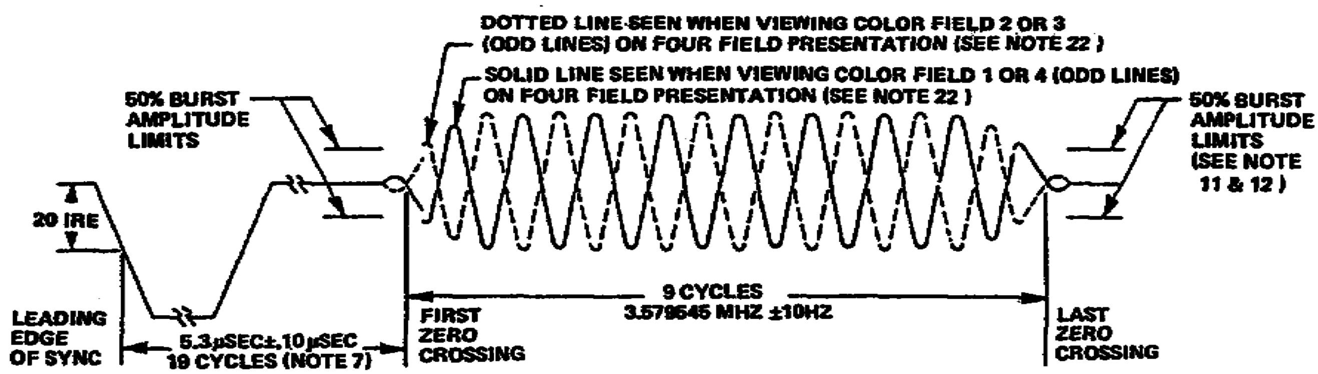

Figure 3-2. Amplitude limits

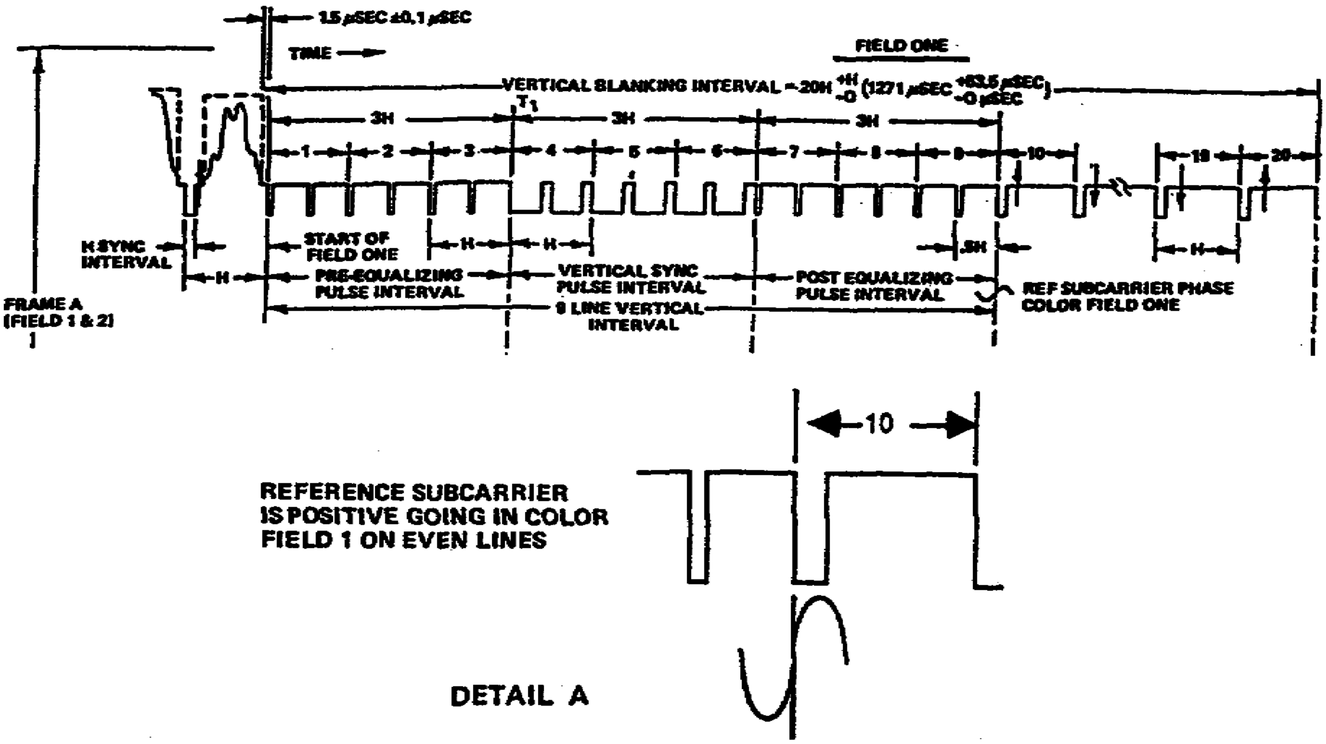

Figure 3-3. Part of color field one and detail A

3. The importance of SC/H phase is primarily useful in the video tape editing environment. If during playback the video Signal coming off the tape is not of the same color frame as the house reference, the video at the machine's time base corrector output must be shifted horizontally. The shift can be in either direction and be up to 140 ns (one half subcarrier cycle). This may result in loss of active picture and a widening of blanking, since the output processor blanking is referenced to the house. Even if the off-tape video is of the correct color frame, the machine-output video will be shifted horizontally to a smaller degree in an amount equal to any SC/H phase difference between the off-tape and house video.

a. These horizontal shifts are troublesome in a tape editing environment, especially when editing scenes together of similar content. At the edit point, the background will appear to jump horizontally. This jump is unacceptable and dictates the need for an SC/H phase facility.

b. To ensure the proper operation of the tape machine color-framing circuits, the SC/H phase relationship of the video recorded on tape and house video must match. Proper uniformity of the SC/H phase is defined by RS170A. It is important that all recorded video have a constantly correct SC/H phase relationship. Also, the reference input to the tape machine should be a stable SC/H phase source.

4. Subcarrier timing in a studio is a well-understood concept in the television broadcast industry; if timing is not correct, there will be color hue shifts between sources. If sync timing is not correct, horizontal shifts will occur at the video switcher. The concept of SC/H phasing in a studio requires a higher level of knowledge regarding each element within the studio.

a. First, and most obvious, is the house sync generator. If, the sync generator cannot generate consistent SC/H phased outputs, maintaining SC/H phase in the plant will never be possible. It is equally important that all the sync generators in a multiple sync generator facility maintain correct SC/H phase and color frame relationships.

b. Once SC/H phase has been established by the sync generator, none of the elements in the system should alter the SC/H phase. Some elements are obvious, like the video processor which regenerates sync and burst. If the phase of the regenerated sync or burst is different from the incoming video, the SC/H phase is altered. Less obvious are sources which derive timing from externally applied sync and subcarrier. If sync and subcarrier are fanned out through DAs, then their phase can be altered independently.

c. To avoid altering of phase, the output of each source device (SC/H phased) must be timed prior to, or at, the input of the switcher. There are many distortions which make the determination of color frame and SC/H phase difficult. The most prominent is sync-to-subcarrier time base error. This can be generated by many devices, such as sync generators (with noise in the horizontal sync circuits), linear and regenerative pulse DAs (which suffer from pick-off jitter or low frequency response problems), or any device that has separate sync and subcarrier regeneration circuitry.

d. Noise, low frequency smear, hum, and power glitches are distortions that may occur in signal transmissions. If these are not removed prior to sync separation, determination of the exact 50-percent point of sync will be difficult.

e. Video time base error is different than sync to subcarrier time base error. Sync to subcarrier time base is seen when triggering a scope on the leading edge of sync and viewing color burst. What should be seen are two overlapping cycles of subcarrier that are not blurred. An example of sync to subcarrier time base error is shown in Figures 3-4 and 3-5.

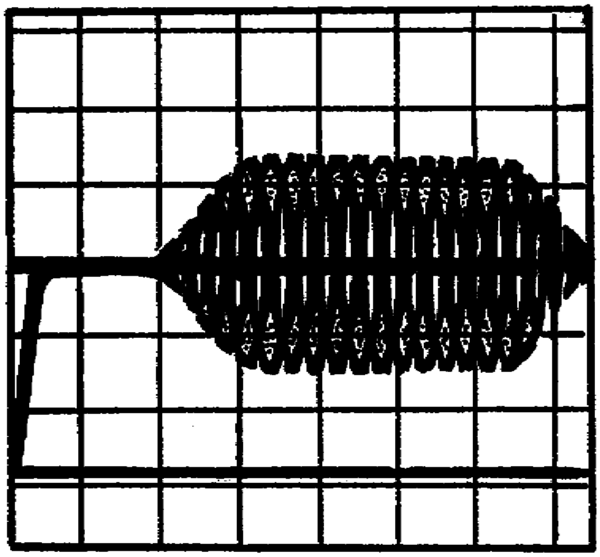

Figure 3-4. Video time base error

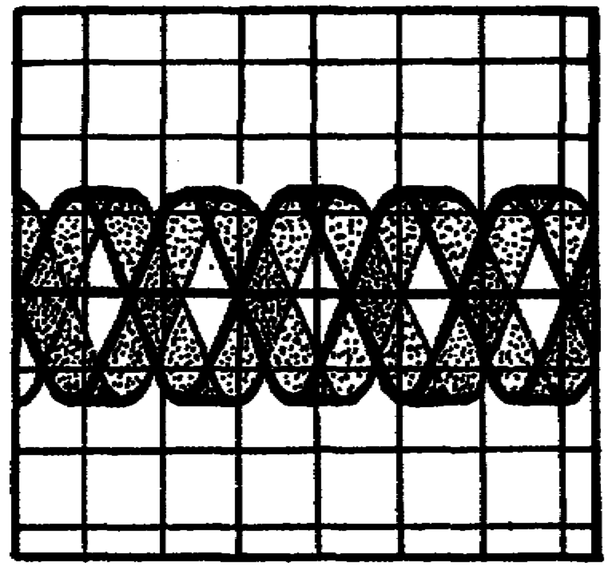

Figure 3-5. Sync to subcarrier time base error

f. If sync to subcarrier time base error occurs either on the reference pulses to a tape machine, or exists on the recorded video tape, color frame lock will be difficult. In the normal playback mode, excessive sync to subcarrier time base error will cause the tape machine to shift horizontal lines by 279 ns (subcarrier cycle) increments. This phenomenon is seen as a tearing of the picture.

Learning Event 3:
DESCRIBE COMPONENTS USED TO BUILD AND MEASURE AN SC/H-PHASED PLANT

1. The heart of every system is the synchronizing generator. The requirements for the sync generator should include the following:

a. Less than 1 ns sync to subcarrier time base error.

b. Less than 10 ns long term SC/H phase stability.

c. Consistent SC/H phase regardless of operational mode or initial conditions.

d. Compatibility with other equipment.

2. Many studios use multiple sync generators to provide advanced drive pulses and subcarriers to various source equipment. Every source-synchronizing generator must meet these requirements, and be able to color-frame lock precisely to the master reference-synchronizing generator.

To achieve an SC/H phase plant, the timing of sync becomes as important as subcarrier, and each element should be viewed in that light. To aid video tape editing, it is important to record video with proper SC/H phase and also supply SC/H-phased reference to the machine in playback. These criteria do not have to be compromised with the system approach offered in this subcourse.

3. The SC/H phase is the time relationship between the subcarrier and the leading edge of horizontal sync. A properly adjusted SC/H phase occurs when the 50-percent points of the leading edge of sync and the subcarrier zero crossing are coincident. The color frame pulse (V1) appears on line 11 of field 1. V1 identifies field 1 of the 4-field color sequence.

4. The following test equipment is required to perform the SC/H phase measurement procedure. Equivalent test equipment may be substituted but must be equal to or superior in performance.

a. Dual Trace Oscilloscope (with delayed sweep and one channel input inversion)	AN/USM 425 (V) 1
b. Switchable Delay Line or Subcarrier Delay DA (360-degree range)	Mathey 511

5. The following are test procedures used to measure the SC/H phase (figs 3-6 through 3-12).

a. Connect a video source requiring SC/H phase measurement to the inverting channel of the oscilloscope.

b. Connect subcarrier (3.58 MHz continuous) to the second channel of the oscilloscope.

c. While observing the oscilloscope (triggered at a horizontal rate), adjust subcarrier to match amplitude of burst.

d. At the oscilloscope, invert the video display and set mode to alternate sweep. Figure 3-6 shows inverted video (top) and continuous subcarrier (bottom).

e. Adjust the oscilloscope for A plus B mode.

f. Adjust subcarrier phase and fine level at the generator or delay line for a null at burst as shown in Figure 3-7.

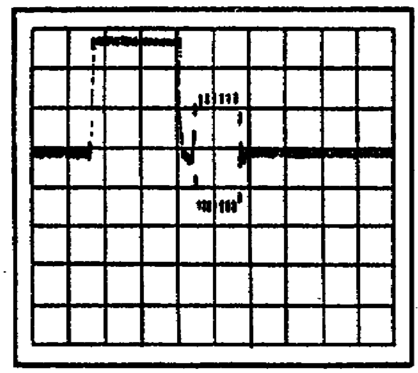

Figure 3-6. Inverted video phase and continuous subcarrier

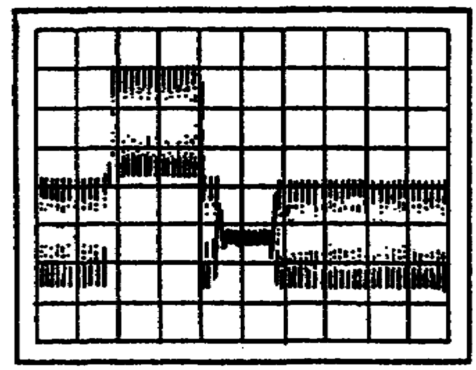

Figure 3-7. Subcarrier phase adjusted for null at burst

g. Adjust the oscilloscope for chop mode, noninverted video, and adjust vertical positions to exactly overlay subcarrier and sync.

h. Adjust the oscilloscope-delayed sweep for a display showing the leading edge of sync and the subcarrier. A proper phase relationship requires coincidence at the 50-percent points of the leading edge of sync and the subcarrier zero crossings (fig 3-8). An improper phase relationship is shown in Figure 3-9.

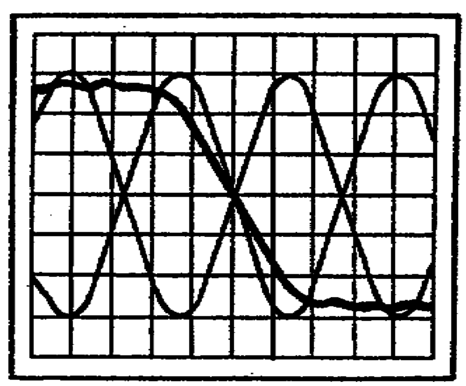

Figure 3-8. Properly-phased SC/H signal

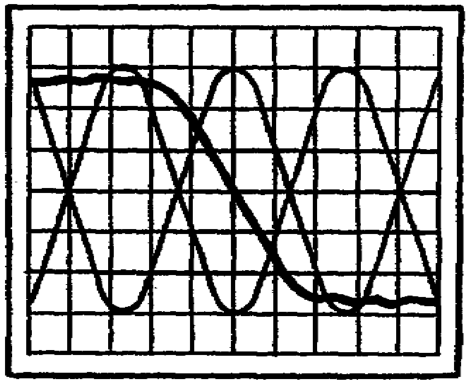

Figure 3-9. Improperly-phased SC/H signal (70-phase error)

i. Adjust the SC/H phase as described in steps 5a through 5h for proper coincidence.

j. Trigger the oscilloscope on the leading edge of the V1 pulse with video and subcarrier connected to the two input channels (fig 3-10).

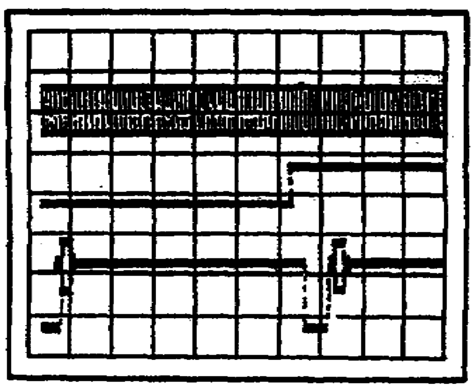

Figure 3-10. Subcarrier, V1 pulse, and video display

k. Increase the oscilloscope sweep rate and use the delayed sweep option to view a display showing the first leading edge of sync following the trigger.

l. If the negative transition of the subcarrier is coincident with the leading edge of sync, the triggering V1 pulse is a color frame identification pulse that occurs on line 11 of field 1 (fig 3-11).

NOTE: The SC/H phase is easiest to observe on a display that is horizontally triggered. Because of the low repetition rate of V1 and the fast sweep rates (50 ns/div) required, only the direction of subcarrier signal can be easily observed by triggering on V1.

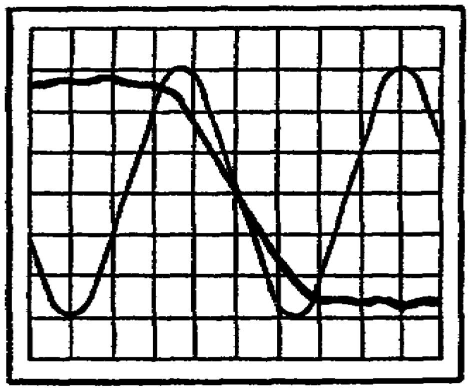

Figure 3-11. Leading edge of line 11, field 1, and SC

NTSC REFERENCE TIMING DATA

Subcarrier Frequency	3.579545MHz
Subcarrier Period	279.37nS
Horizontal Frequency	15.734264KHz
Horizontal Period	63.556µS
Vertical Frequency	59.94Hz
Vertical Period	16.683mS
Vert. Equalizing Pulse Width	2.3µS
Horizontal Sync Width	4.7µS
Horizontal Blanking Width	10.9µS
Vertical Sync Width	27.1µS
Vertical Blanking Width	21 lines
Front Porch Width	1.5µS
Breezeway	0.6µS
Burst Width	2.5µS
Color Back Porch Width	1.6µS

Color Timing Data:

1° = .776nS

1nS = 1.289°

For Cable With 66% Propagation Factor

1° = 6.035" = .503'

1nS = 7.778" = .648'

Zero SC/H phase is the coincidence of the zero crossing of a subcarrier the same phase as color burst with the 50% point of the leading edge of horizontal sync. On color frame one, the subcarrier zero crossing will be negative going on odd numbered lines.

Figure 3-12. NTSC reference timing data

Lesson 3
PRACTICE EXERCISE

1. The use of what system gives redundancy?

    a. Distributed sync generator system
    b. Horizontal drive system
    c. Vertical amplifier system
    d. The encoded subcarrier system

2. What provides maximum flexibility?

    a. A field-matching amplifier system
    b. A properly-tuned capacitor
    c. A source-synchronizing generator system
    d. The color-bar generator

3. What happens at the input of the switcher?

    a. Each input source is phased
    b. Each source is timed
    c. Each signal is matched
    d. Each signal is attenuated

4. What causes horizontal shift?

    a. Sync timing is not correct
    b. Phase balance is not correct
    c. High video levels
    d. Overdriven audio

5. What is certain when the color frame pulse arrives on line 11, field 1?

    a. The subcarrier is balanced
    b. The horizontal sweep is untimed
    c. The vertical pulse is phased
    d. The SC/H is properly adjusted

6. Dual trace oscilloscopes and a switchable delay line are used to perform what measurement?

    a. Power output
    b. SC/H phase
    c. Power input
    d. Frequency ratios

ANSWERS TO PRACTICE EXERCISES

Test Question Number	Correct Response	Reference (Learning Event	Paragraph	Page)
		Lesson 1		
1	b	2	2	7
2	a	2	1a	5
3	b	1	3b	5
4	c	1	3	4
5	a	2	1	5
6	d	2	2	7
7	d	1	1c	2
8	a	1	2c	3
		Lesson 2		
1	c	1	1b	11
2	a	1	1b	11
3	c	2	1	11
4	d	2	3	12
5	d	2	2	11
6	b	1	3	11
7	a	3	1b	15
8	b	4	3	18
		Lesson 3		
1	a	1	3b	25
2	c	1	3a	25
3	b	2	4c	28
4	a	2	4	28
5	d	3	3	27
6	b	3	4a,b	28