OPERATOR'S MANUAL

SIMPSON 454
DUAL TRACE OSCILLOSCOPE

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Figure 1-1. Dual Trace Oscilloscope

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NOTE: This Operator's Manual contains information essential to the operation of this Instrument. Therefore, it should be kept in a convenient place and used for reference as required.

SAFETY SYMBOLS

⚠ This marking adjacent to another marking or a terminal or Operating device indicates that the Operator must refer to an explanation in the Operating Instructions to avoid damage to the equipment and or to avoid personal injury.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, which if not correctly performed or adhered to, could result in personal injury.

CAUTION The CAUTION sign denotes a hazard. It calls attention to a procedure, practice or the like, which if not correctly adhered to could result in damage to or destruction of part or all of the Instrument.

WARNING

This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurements. Failure to follow directions can result in a serious or fatal accident.

SHOCK HAZARD: As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts rms (sine wave) or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurment of AC leakage current and can be used for this purpose. To measure DC Leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

SECTION I
INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson 454 Dual Trace Oscilloscope (hereafter referred to as the 454 or simply as the Instrument) is a solid-state instrument, useful for observing and measuring waveforms in electronic circuits. It is designed with a dual vertical input that allows simultaneous viewing of two waveforms. The chopping rate is 200 kHz for low repetition rate waveforms. The alternate mode is automatically selected when viewing high speed waveforms. The sum or difference of the two waveforms can be displayed as a single trace. Its design fulfills all major requirements of accurate performance and excellent dependability. Among its many applications are laboratory measurement, industrial maintenance, production line circuit alignment, checkout, troubleshooting of electronic circuits and servicing of color and black-and-white television receivers.

1.1.2 Other distinctive characteristics of the 454 include a DC to 15 MHz vertical amplifier, 5mV/div vertical and horizontal sensitivity and 100 nanosec/DIVto .5 sec/div speed range for automatic and triggered sweeps. The 454 is useful for many laboratory, manufacturing and service applications. All the operating functions are controlled through circuits designed with highly reliable integrated circuits and the latest state-of-the art solid state components. In addition, differential amplifier from the input stage, through the deflection power stages, provide common mode noise rejection for reproduction of a stable low distortion waveform.

1.1.3 The vertical and horizontal input attenuators are calibrated directly in volts to allow the Instrument to be used as a visual instantaneous waveform voltmeter. An internal .5 volt/pp square wave signal calibrated to 1 percent accuracy, provides a source for the voltage range calibration and low capacitance probe alignment.

1.1.4 To expand the application of the Instrument, two standard probes are provided with each Instrument. Each probe is switch-selectable for X1 and X10 attenuation with 10MΩ input impedence and low capacitance.

1.2 SUPPLIES AND ACCESSORIES

1.2.1 All supplies and accessories required for the operation of the 454 are furnished with each Instrument, and listed in Table 1-2. Available replacement parts are listed in Table 7-1.

1.3 SAFETY CONSIDERATIONS

1.3.1 This Operator's Manual contains cautions and warnings alerting the user to hazardous operating and service conditions. This information is flagged by CAUTION or WARNING headings throughout this publication, where applicable, and is defined at the front of the manual under SAFETY SYMBOLS. To ensure the safety of operating and servicing personnel and to retain the operating conditions of the Instrument these instructions must be adhered to.

1.4 TECHNICAL DATA

1.4.1 Table 1-1 lists the technical data for the 454.

Table 1-1. Technical Data

(1) POWER REQUIREMENTS:	
AC Voltage:	120V AC ±10% or 240V AC ±10%
Frequency:	50 to 60 Hz
Average Power Consumption:	16 VA
Fuse Ratings:	½ Ampere 250V 3AG Slow-Blow fuse for 120 volt operation. ¼ Ampere 250V 3AG Slow-Blow fuse for 240 volt operation.
(2) VERTICAL AMPLIFIER:	
(CH A and CH B) Bandwith, at −3 DB:	6 division reference signal
DC:	DC to 15 MHz
AC:	5 Hz to 15 MHz
Input Impedance:	1M Ohm shunted by 25 pF
Maximum Input Voltage:	500V (DC + AC peak) with X10 probe, 250V with X1 probe up to 1k Hz.
Deflection Sensitivity:	5mV/div to 10V/div calibrated in 1-2-5 sequence in eleven steps; accuracy within ±5% of full screen deflection; uncalibrated continuous variable control between steps.
Risetime:	24 nanoseconds
Overshoot:	5% or less
Display Modes:	Channel A only Channel B only Channel A and B, automatically chopped at 1msec/div and slower sweep speeds, and automatically alternated for all faster sweep times. Add: Algebraic sum of Channel A and B signals. Channel B Invert; Inverting of Channel B (allows algebraic difference of Channel A and B signals).
Chopping Frequency:	200 kHz

(3) HORIZONTAL AMPLIFIER:	
(Input through CH B) Bandwidth, at − 3 dB:	
DC:	DC to 1.0 MHz
AC:	5 Hz to 1.0 MHz
Input Impedance:	1M Ohm shunted by 25 pF
Maximum Input Voltage:	500V (DC + AC peak) with X10 probe, 250V with X1 probe.
Deflection Sensitivity:	5mV/div to 10V/div calibrated in 1-2-5 sequence in eleven steps; accuracy within ±5% of full screen deflection; uncalibrated continuous variable control between steps.
(4) CALIBRATION VOLTAGE:	.5V p-p ±1%, square-wave — 1kHz approx.
(5) HORIZONTAL SWEEP RANGES:	
Time/div (19 Ranges):	.5μsec/div to .5sec/div (±5%) calibrated to 1-2-5 sequence in 19 steps; uncalibrated continuous variable control between steps.
Magnifier:	X5 Expands the fastest sweep speed from .5μs/div to .1μs/div
(6) TRIGGERING:	
Source:	External, CH A or CH B
Mode:	Normal and Automatic
Coupling:	AC
Slope:	Positive and Negative
Trigger Sources and Sensitivity:	
Normal & Auto	
Internal:	1div for signal frequencies 5 Hz to 15MHz. .5div for signal frequencies from 10 Hz to 10 MHz.
External:	.5V p-p for signal frequencies from 5 Hz to 15MHz.
Auto:	1div. p-p of deflection for signal frequencies from 50 Hz to 15 MHz.
TV Sync:	.5div.
Maximum External Input	100V p-p (AC + DC)
External Trigger Input Impedance	100KΩ in parallel with 35 pF
(7) SIZE AND WEIGHT:	
Size:	4⅝" H x 9⅞" W x 13¼" D
Weight:	13 lbs. approx.
(8) CRT:	
Type:	75AWB31
Screen Size:	3" round flat face
Display Area:	4.8 x 6 cm
Screen Phosphor:	P31
(9) ENVIRONMENT:	
Operating Temperature:	0°C to 45°C
Vibration Spec.:	EIA spec RS 152B

Table 1-2. Items and Accessories Furnished With This Instrument

Quantity	Description	Number
1	Oscilloscope, Dual Trace, for 120 VAC 50/60 Hz Operation	12524
2	Probe Low Capacitance	00791
1	Operator's Manual	6-111433

SECTION II
INSTALLATION

2.1 GENERAL

2.1.1 This section contains instructions for the installation and shipping of the 454. Included are unpacking and inspection procedures, warranty, shipping, power source requirements, installation, and care.

2.2 UNPACKING AND INSPECTION

2.2.1 Examine the shipping carton for obvious signs of damage. Inspect the Instrument for possible damage incurred during shipment. If damage is noted, notify the carrier and supplier and do not use the Instrument. If Instrument appears to be in good condition, read Operator's Manual in its entirety. Become familiar with the Instrument as instructed in the manual, then proceed to check the electrical performance as soon as possible. Also, check that all items are included with the Instrument (Table 1-2).

2.2.2 Save the shipping carton and packing materials for future storing or shipping of the Instrument.

2.3 SHIPPING

2.3.1 Pack the Instrument carefully and ship it prepaid and insured to the proper destination.

2.4 WARRANTY

2.4.1 The Simpson Electric Company warranty policy is printed on the inside front cover of this manual. Read it carefully prior to requesting a warranty repair.

> **NOTE:** For assistance of any kind, including help with the Instrument under warranty, contact the nearest Authorized Service Center for instructions (listed on the last pages of this manual). If it is necessary to contact the factory directly, give full details of any difficulty and include the Instrument model number, serial number (at the back of the Instrument) and date of purchase. Service or shipping instructions will be mailed promptly. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without prior approval.

2.5 POWER SOURCE REQUIREMENTS

CAUTION

Do not connect the Instrument to a power source until instructed to do so. The power source should agree with the voltage requirements of the Instrument.

2.5.1 The input power requirement of the 454 is prewired for 120 VAC, 50/60 Hz operation. To operate the Instrument from 240VAC 50/60 Hz source, the input powerline connections to the primary windings of the power transformer must be changed. (To change input power requirements, refer to paragraph 7.2.) The required power source must be a 3-wire, grounded outlet, wired according to the latest electrical code. The line voltage should be within ±10% of the rated value for the Instrument.

CAUTION

If the unit is operated on a 2-wire system (although it is not recommended) connect a ground lead from earth GROUND to chassis GND terminal.

2.6 INSTALLATION

2.6.1 The 454 is equipped to operate in a horizontal, vertical or inclined position. Although CRT shielding is provided, the Instrument and test leads should be kept away from strong electrical fields (such as controllers, motors, blowers). This will assure accurate waveforms and stable triggering.

2.6.2 If possible, use the 454 in a clean dry area, preferably one maintained at constant normal indoor temperature and humidity levels. Avoid dust and corrosive fumes. Isolate the oscilloscope from mechanical shock, vibration, and electrical interference.

2.7 CARE

2.7.1 The 454 Oscilloscope is a reliable instrument, and requires very little maintenance. Daily care of the Instrument basically consists of the following:

a. Turn off power and disconnect any power and signal leads, etc. Immediately clean all spilled materials from the Instrument and wipe it dry. If the spillage is corrosive, remove the spillage and use a suitable chemical to neutralize the corrosive action. Then clean the Instrument and wipe it dry.

b. Whenever possible, avoid prolonged exposure or usage of the Instrument in areas which are subject to temperature and humidity extremes, vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interferences.

2.7.2 Monthly Care: Verify Instrument calibration by performing operational checks using known, accurate stable sources. If the need for re-calibration is indicated contact the nearest Authorized Service Center (refer to list on last pages of this manual).

2.7.3 Annual Care: It is recommended that the Instrument be returned annually to the nearest Authorized Service Center or the factory for complete overall check, adjustment, and calibration.

2.7.4 Storage: When the Instrument is not in use, store it in an area free from temperature extremes, dust or corrosive fumes, and mechanical vibration or shock

SECTION III
CONTROLS, CONNECTORS, AND INDICATORS

3.1 GENERAL

3.1.1 All controls, connectors, indicators and other operational items are described in Table 3-1, and shown in Figures 3-1 and 3-2. Become thoroughly familiar with the name and purpose of each item before operating the Instrument.

Table 3-1. Controls, Connectors, and Indicators

Item	Description
1. Cathode Ray Tube and Graticule	3″ flat-faced cathode ray tube with 4.8 x 6 cm graticule.
2. POSITION	Adjusts CH A vertical position of trace on CRT.
3. VOLTS/DIV, VARIABLE (CH A)	
Gray Knob	An 11 position step attenuator for 5 mV/div to 10 V/div.
Red Knob	Variable attenuator with Cal (calibration) at max CW position.
4. VERTICAL INPUT	BNC connector for vertical CH A signal input.
5. DC/AC Switch	
AC	Selects input mode for CH A vertical amplifier.
DC	Blocks DC component of input signal. Processes both DC and AC signal components.
6. GND Switch	Grounds input of vertical amplifier. Used to obtain DC reference (zero signal baseline) on CRT screen without disconnecting signal leads to CH A.
7. CH A Switch	Displays the input signal to channel A as a single trace or as a dual trace when CH B switch is also depressed.
8. CH B Switch	Display the input signal to channel B as a single trace or as a dual trace when the CH A switch is also depressed. With both CH A and CH B switches pulled the algebraic sum is displayed. If CH B invert switch is depressed the algebraic difference is displayed.
9. GND Switch	Grounds the input of vertical amplifier. Used to obtain DC reference (zero signal baseline) on CRT screen without disconnecting signal leads to CH B.
10. DC/AC Switch	Selects input mode for CH B vertical amplifier.
AC	Blocks DC component of input signal.
DC	Processes input of both DC and AC signal components.
11. VERTICAL OR HORIZONTAL INPUT	BNC connector for vertical CH B signal input as well as external horizontal signal input.
12. CH B INVERT	Invert the polarity of channel B signal displayed or applied in conjunction with CH A and CH B switches as described in item 8.
13. VOLTS/DIV, VARIABLE (CH B)	
Gray Knob	An 11 position step attenuator for 5 mV/div to 10V/div.
Red Knob	Variable attenuator with CAL (calibration) at max CW position.
14. POSITION	Adjust CH B vertical position of trace on CRT.
15. ASTIG	Adjusts line sharpness of trace.
16. INTENSITY	Adjusts brightness of trace.
17. TRACE ROTATION	Adjusts angle of trace.
18. FOCUS	Adjusts line width or sharpness of trace.
19. Red Pilot Light	LED lights when the power is turned on.
20. POWER	Power on/off switch.
21. EXT Trigger Jack	BNC connector for external trigger signal.
22. GND Jack	Common ground connection for external trigger signal input and grounding of the instrument.
23. CAL OUTPUT	Provides 1 kHz, .5 volt peak-to-peak square wave signal which is used for calibration of the vertical (or horizontal) amplifier attenuators and to check the frequency compensation adjustment of the low capacitance probes.

24. CH A/CH B	Selects source for triggering.
25. INT/EXT	With switch depressed the sweep is triggered by external signal applied to jack 21.
26. NORM/AUTO Mode	Selects mode for triggering synchronization.
NORM	– or + LEVEL adjustment control determines points and waveform slope where sweep starts.
AUTO	When switch is set to automatic triggering, a sweep is generated even without an input signal.
27. TV Sync	Provides TV triggering synchronization in conjunction with TIME/DIV switch. The Vertical Sync Pulse is provided when the TIME/DIV switch sets between .5 sec and 0.1 msec, otherwise, the composite sync pulse is provided.
28. –/+ Slope	Selects the slope of the point on the trace at which trigger starts.
29. POSITION	Adjust horizontal position of trace on CRT screen.
30. TRIG LEVEL	Adjust the triggering level point for the display of a stable waveform.
31. VARIABLE (PULL FOR X5 MAG.)	Adjust sweep time. In the extreme clockwise (CAL) position the sweep time is calibrated. The control in the out position provides X5 magnification of the sweep.
32. TIME/DIV	Switch with twenty positions selects sweep speed from .5 μsec/div to .5 sec/div (calibrated with VARIABLE control set to maximum clockwise position at CAL). Included, CH B position turns off sweep circuit and provides access to horizontal amplifier through channel B input.
33. Power Cord	Provides AC power.
34. Fuse Holder	Accepts type 3 AG fuse. (See label 38 for fuse ratings.)
35. Nameplate	Lists serial number of the instrument and rating for the fuse.
36. Handle	Handle for carrying the instrument.

Controls, Connectors and Indicators

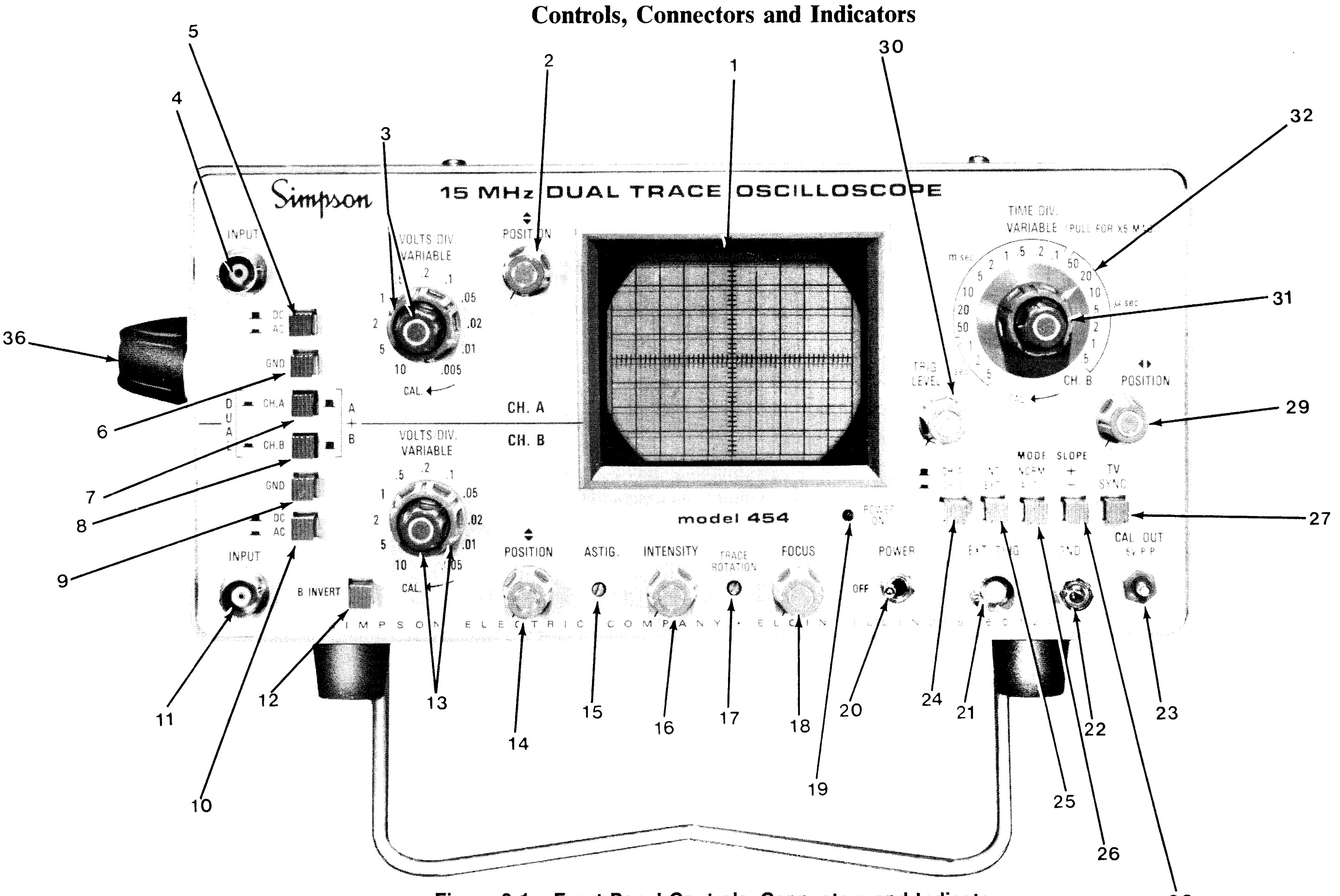


Figure 3-1. Front Panel Controls, Connectors and Indicators

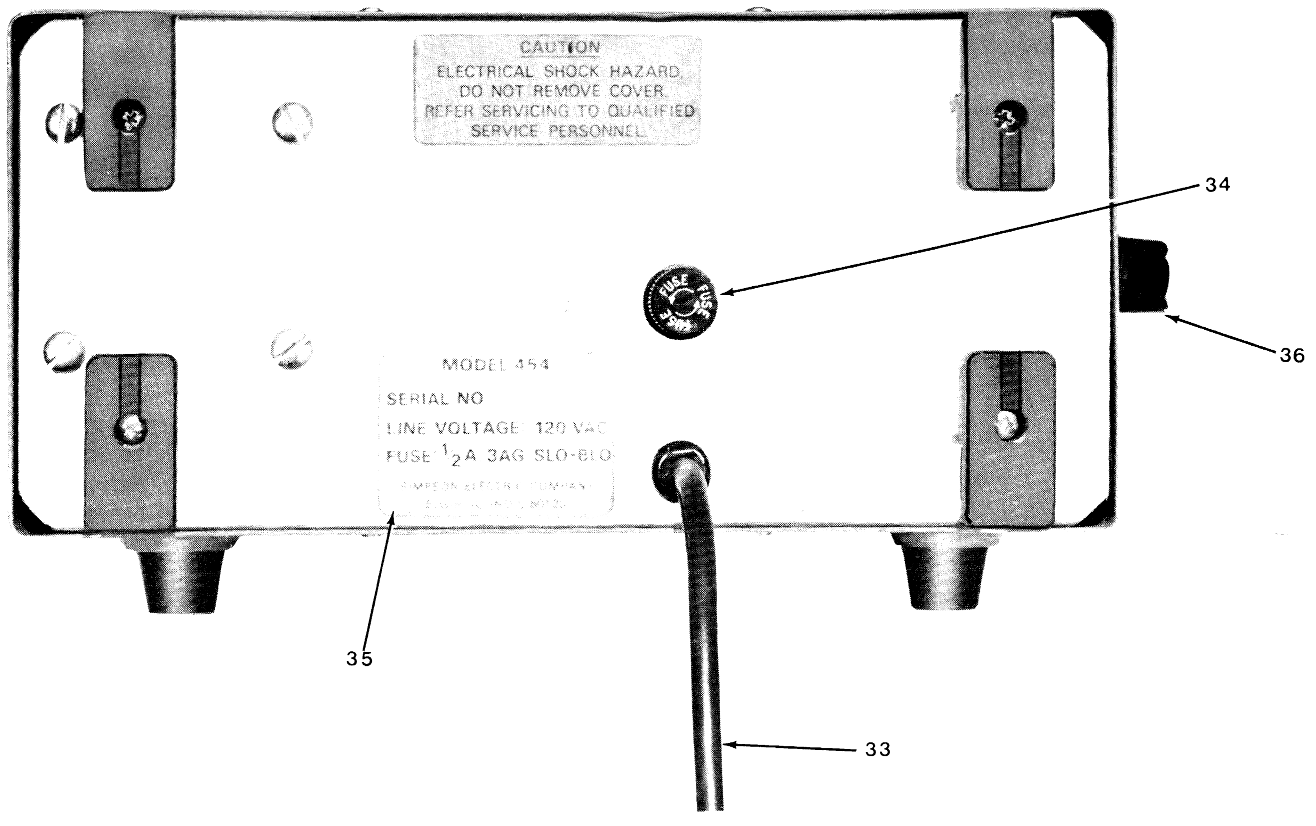


Figure 3-2. Rear and Side Panel Facilities

SECTION IV
OPERATION

WARNING

Before proceeding with the operation of this Instrument review the Shock Hazard definition at the front of this manual.

4.1 GENERAL

4.1.1 This section of the manual contains information required to use and operate the 454 in a safe and proper manner. Special notes and instructions also have been provided for added user safety and convenience.

4.2 SAFETY PRECAUTIONS

WARNING

In equipment known to be (or thought to be) "solid-state," it can be very tempting to suppose that only low voltages are present. On the contrary, lethal shock situations are often present in transistor circuitry, and definitely in equipment which employs vacuum tubes. When servicing TV sets, do not assume that the "high Voltage compartment" is the only place where you must be careful. Other circuit sections can carry high voltages as well.

4.2.1 The 454 is intended to be used only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury.

4.2.2 Do not work alone when making measurements or adjustments where a shock hazard can exist. Notify another nearby person that you are making, or intend to make such measurements.

> **REMEMBER:** Voltages may appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured before making connections or disconnecting the Instrument.

4.2.3 Locate all voltage sources and current accessibility paths prior to making any connections.

4.2.4 Before each use, inspect the test leads, probes, connectors, and power cable for cracks, breaks or crazes in the insulation. If any defects exist, destroy, and replace the defective item(s) immediately.

4.2.5 Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color emanating from sharp metal points in the circuit or a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates presence of high voltage, and probably a malfunction of some kind.

4.2.6 Hands, shoes, floor and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage of the test lead or the Instrument.

4.2.7 For maximum safety, test leads, circuit and Instrument should not be touched while power is applied to the circuit being measured.

4.2.8 Use extreme caution when making measurements in a circuit where dangerous composite voltages could be present, such as an r-f amplifier.

4.2.9 When using the 454 Oscilloscope ensure that it is connected to a three-wire powerline outlet that is correctly wired in accordance with the latest National Electrical Code. If in doubt of the integrity of the powerline outlet, or forced to use a 3-wire to a 2-wire cheater plug, then be sure to ground by means of the GND pin jack located along the lower right edge of the front panel.

4.2.10 Do not exceed the maximum input voltage ratings of the 454, which are tabulated in Table 1-1. To do so endangers personal safety and may also damage the oscilloscope.

4.2.11 Do not attempt to float the grounded terminal (the GND pin jack and the body of the BNC input connector which are all electrically connected to the case), or the case of the 454 above earth powerline ground. To do so risks personal safety and may damage the 454 as well as the equipment under test.

4.3 INITIAL CONTROL SETTINGS:

a. Prior to performing any test or adjustments, review paragraphs 4.1 and 4.2, then proceed as follows:

CAUTION

Use the 454 in an area which is free from magnetic disturbances, to prevent possible waveform distortion. Magnetic fields from motors or transformers in nearby equipment may cause such distortion. During stand-by periods, when the beam of the cathode ray tube is concentrated in a particular spot on the screen, adjust the INTENSITY control to extinguish the spot, or keep the spot in motion. This precaution will prevent burning a spot on the face of the CRT.

b. Turn power off by setting POWER control to OFF position.

c. Turn INTENSITY control to mid-position.

d. Rotate FOCUS control to mid-position.

e. Rotate all vertical and horizontal POSITION controls to mid-positions.

f. Set VOLTS/DIV switches of both channels to .1.

g. Rotate both vertical VARIABLE controls to CAL positions.

h. Push the vertical channel selector switches CH A and CH B.

i. Set sweep TIME/DIV switch to 1 mSEC.

j. Rotate horizontal VARIABLE control to CAL position.

k. Push the magnifier switch, X5 MAG, in for X1 position.

l. Set TRIGGER MODE switch to AUTO.

4.4 INITIAL OPERATIONAL TEST:

a. Plug AC line cord to AC power source.

b. Turn the power on and after approximately 20 seconds the two traces should appear on CRT screen.

c. If no trace appears, rotate INTENSITY control clockwise until the traces are easily observed.

d. Adjust FOCUS, ASTIG and INTENSITY controls for sharpest trace of medium brightness.

e. Readjust vertical and horizontal POSITION and trace rotation controls, if necessary, to center the traces, or adjust the traces for any other position within the screen periphery, as may be required.

f. Rotate VOLTS/DIV VARIABLE control of channel A and that of channel B from extreme clockwise to extreme counterclockwise positions. Observe respective trace. The trace should not move more than ½ division. Return the VARIABLE control to extreme CW position.

g. Connect X1 probe to channel A BNC input connector. Release GND switch.

h. Connect the tip of the probe to CAL OUT .5V p-p pin jack.

i. Set the TRIGGER SOURCE switches to CH A position and INT position.

j. Adjust TRIGGER LEVEL control for a stable square-wave on the screen.

k. Readjust INTENSITY and FOCUS controls to obtain a clear, well defined 5 div p-p square-wave display.

l. To remove channel B trace (straight horizontal line) for better square-wave observation, push (to release) vertical CH B switch.

m. Remove X1 probe cable from channel A connector and connect it to channel B BNC connector input.

n. Push the vertical CH B switch in and push (to release) the CH A switch for single CH B trace observation.

o. Set TRIGGER SOURCE switches to CH B position and INT position.

p. Observe square-wave signal displayed. It should be 5 div p-p. Adjust TRIGGER LEVEL as required for stable display.

q. Remove probe tip from CAL OUT .5V p-p jack.

r. The oscilloscope is now ready for applications of waveform observation.

4.5 SINGLE-TRACE WAVEFORM OBSERVATION:

a. Either channel A or B can be used for single-trace operation. The only difference between the two channels is that polarity of waveform on channel B can be reversed by actuating the CH B INVERT switch.

b. Connect the probe to either channel A or channel B input and set vertical mode switches (CH A and CH B) correspondingly.

WARNING

The ground lead is earth grounded in the oscilloscope. Make certain that the circuit point to which it is to be connected is also earth grounded or can tolerate being grounded by the lead.

c. Connect the probe tip and ground lead to the signal source desired for observation or measurement.

d. Proceed with control adjustment procedure in paragraph 4.5.1.

4.5.1 DC/AC Input and Signal Attenuation:

a. Set input DC/AC switch to AC for measuring only the AC component and blocking DC component contained in test signal.

b. Use DC switch position for measuring both the AC and DC component and any time a very low frequency waveform is to be observed.

c. The GND switch disconnects test signal from the amplifier input and provides zero-signal ground reference on the CRT.

d. Set VOLTS/DIV selector and VARIABLE control to a position that gives 2 to 6 DIV vertical deflection with the test signal to be observed.

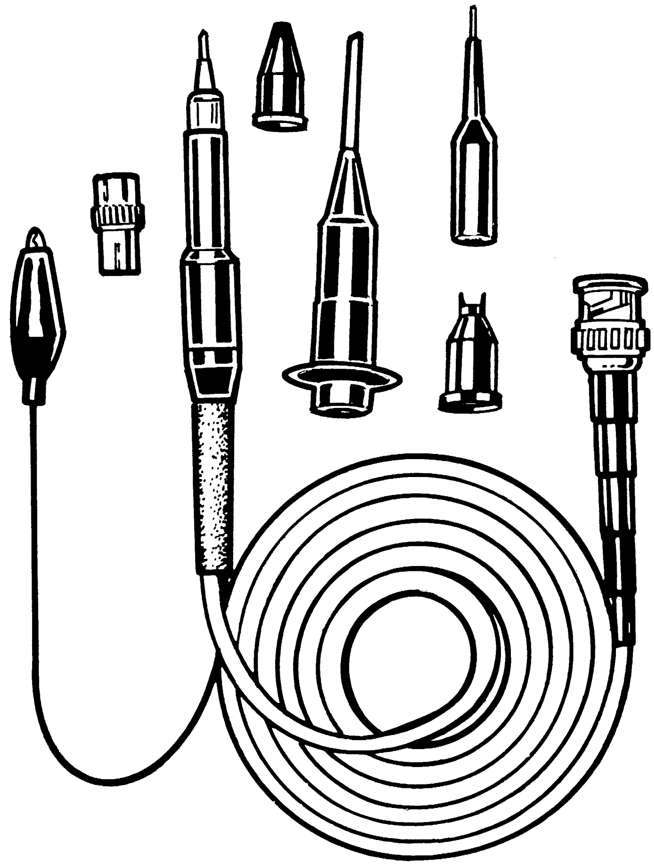


Figure 4-1. Low Capacitance Probe, Model 00791

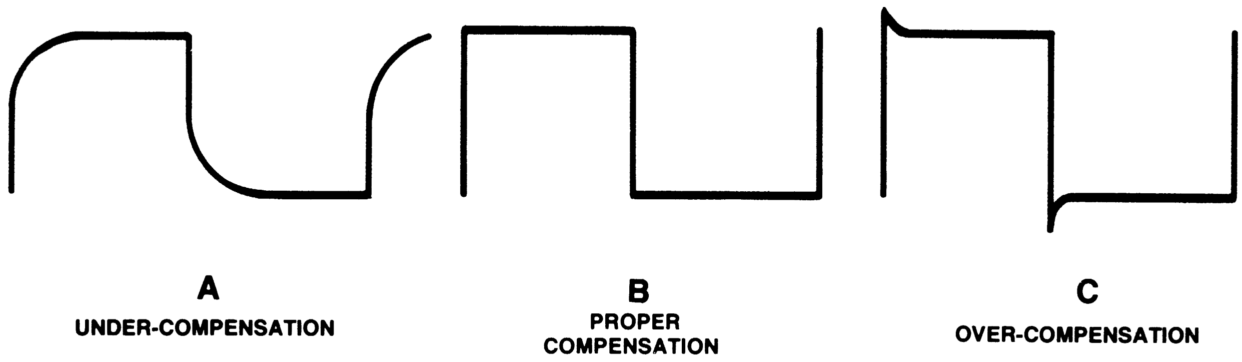


Figure 4-2. Compensation Waveforms

4.5.2 Internal Sweep:

a. TRIGGER MODE switch selects either AUTO for automatic recurrent sweep or NORM for triggered sweep operation. AUTO provides automatic recurrent sweep in the absence of trigger signal.

b. In the presence of trigger signal there is no difference between the AUTO and NORM modes of triggering. The point on the trace, at which sweep triggering occurs, is selected by adjusting TRIGGER LEVEL control. The main purpose of TRIGGER LEVEL control is to obtain a stable display.

c. Set TRIGGER SLOPE switch to (+) position if the sweep is to be triggered at a point on the positive portion of the displayed waveform or to the (−) position if the sweep is to be triggered at a point on the negative portion of the waveform.

d. Most waveforms can be observed by using internal trigger with either CH A or CH B trigger source switch out or in. When an external trigger source is required, INT/EXT TRIGGER SOURCE switch must be depressed and trigger signal applied to the EXT TRIG BNC input.

e. For normal operation the magnifying switch, X5 MAG, is pushed in to operate without magnification. If magnification of a waveform is desired, pull X5 MAG switch out, to expand the sweep and waveform to be observed horizontally by a factor of 5. Use the horizontal POSITION control to bring the desired magnified position into view on the screen.

f. Set sweep TIME/DIV switch and VARIABLE control for the desired number of wave cycles to be displayed.

4.5.3 Using the X5 magnification position, the trace becomes progressively dimmer with increased sweep speed; the trace writing speed increases and less energy per unit time is absorbed by the light emitting phosphor layer at the CRT screen.

4.5.4 External Horizontal Signal

4.5.5 For some specialized applications, the sweep can be controlled externally. External control is accomplished as follows:

a. Rotate TIME/DIV switch to CH B which enables channel B to be the horizontal amplifier. The signal input to channel B is used to obtain and control the horizontal sweep.

b. The signal input to channel A deflects the beam vertically, which, with the channel B input, causes a variety of patterns to be displayed.

4.6 CALIBRATED VOLTAGE MEASUREMENTS

4.6.1 Peak voltages, peak-to-peak voltages, DC voltages and voltages of a specific portion of a complex waveform can be measured using the 454 as a voltmeter. Voltages can be measured whenever waveforms are observed using either CH A or CH B inputs. Proceed as follows:

a. Set controls of the 454 as instructed in preliminary procedure, to display the desired waveform.

> **NOTE:** For the vertical calibration (or horizontal calibration applying external horizontal signal to CH B input) to be correct, the VARIABLE knob of the VOLTS/DIV variable control must be fully clockwise in the CAL position.

b. Set VOLTS/DIV control to obtain maximum vertical deflection within upper and lower limits of vertical scale.

c. For AC voltage, set DC/AC switch to AC, and note the amount of vertical deflection in divisions. Adjust the horizontal POSITION control to shift the reference point for easier scale reading, if desired.

d. For DC or complex signals, set the input grounding switch to GND, and adjust the vertical POSITION control to a convenient reference level. Set the DC/AC switch to DC and observe the amount of deflection. A positive voltage input will deflect the trace upwards; a negative voltage input will deflect the trace downward.

> **NOTE:** Use the LOW CAPACITANCE X10 ATTENUATOR PROBE for display of short rise-time waveforms.

e. To calculate the voltage reading, multiply the vertical deflection (in divisions) by the setting of the VOLTS/DIV switch.

> **NOTE:** When the LOW CAPACITANCE PROBE is used, the deflection displayed on the 454 is only 1/10 of the actual voltage measured (see compensation procedure for probe.)

4.7 LOW CAPACITANCE PROBE (Figure 4-1)

4.7.1 For all test procedures other than low-amplitude waveform (below .2 volt peak-to-peak) observations, the supplied X 10 low capacitance probe is required. The shunt resistance and capacitance of the probe connected to the oscilloscope is 10 megohms and 11pF. This probe offers minimum loading to the signal and circuit under test.

A 10 to 1 reduction in voltage to the CH A and CH B input will result and must be taken into account in quantitive measurements.

4.8 X10 PROBE COMPENSATION TEST:

a. Set VOLTS/DIV switch to .01 and VARIABLE control to CAL. Apply the CAL OUT square wave to the probe tip. The deflection on the screen should be 5 div p-p.

b. Adjust sweep rate for at least one complete rectangular waveform. The waveform should have square corners and flat top and bottom.

4.9 COMPENSATION PROCEDURE

4.9.1 Connect probe tip to CAL OUT jack and adjust capacitor setscrew with a tuning wand or a nonferrous screwdriver until a good sharp leading edge without any overshoot is obtained (B Figure 4-2).

4.10 DUAL-TRACE WAVEFORM OBSERVATION

4.10.1 In observing simultaneous waveforms on channels A and B, the necessary condition for having a stable display on both channels is that the frequency or repetition rate of one waveform is identical or a multiple to that of the other waveform. If this condition is met, the trigger signal could be from either channel in order to have a stable dual trace display. An example of a dual-channel signal is in measuring the waveforms at the input and output of a multiplier or a divider using dual trace display.

4.10.2 To display two waveforms simultaneously, perform the steps as follows, starting with Initial Control Settings in 4.3 and 4.4.

a. Push vertical mode switches CH A and CH B in. Two traces should appear on the screen.

b. Connect test probes to both channel A and channel B input connectors.

c. Set both channel A and B, DC/AC input switches to the AC position, which is used for most measurements. It must be used if the signals being measured include a large DC component and only the AC component to be measured.

d. Adjust channel A and B POSITION controls to obtain proper separation and reference.

e. Connect the ground clips of the probes to the chassis ground of the equipment under test. Connect the tips of the probes to points in the circuit where the waveforms are to be measured.

f. Set the VOLTS DIV switches of both channels A and B to positions that give vertical deflection of both waveforms within screen graticule area.

g. Select either one of the TRIGGER SOURCE positions. If a trigger signal other than the waveforms displayed above is required, depress INT/EXT TRIGGER SOURCE switch for external triggering and connect cable from EXT TRIG BNC Connector to the trigger source.

h. Set the TRIGGER slope switch to the (+) position if the sweep is to be triggered on positive-going portion of the displayed waveform, or to the (–) position if the sweep is to be triggered on negative-going portion of the displayed waveform.

i. Adjust TRIGGER LEVEL control to obtain waveform display.

j. The observed waveforms of channels A and B can be expanded horizontally by a factor of 5 by pulling the VARIABLE (PULL for X5 MAG.) knob outward.

k. Calibrated voltage measurements and calibrated time measurements are identical to those previously described for single-trace operation. These measurements can be done either by using the dual display operation with vertical mode selector switches CH A and CH B depressed or by reverting to a single-trace operation with only CH A or CH B switch depressed.

l. The channel A and channel B waveforms displays can be added algebraically by pulling vertical mode switches CH A, CH B out, or subtracted algebraically by setting vertical mode switches CH A, CH B out and CH B setting invert pushed in.

4.11 DIFFERENTIAL VOLTAGE MEASUREMENT

4.11.1 The dual trace feature of the 454 may be used to observe waveforms and measure voltages between points in a circuit, neither of which is circuit ground. Measurement of differential amplifier input, phase splitter outputs, push-pull amplifier outputs and many other measurement's differential voltages require dual trace technique.

a. To perform these measurements, connect ground clips of both the channel input probes to the chassis ground of equipment under test, and connect probe tips to the points in the circuit where measurements are to be made.

b. Proceed with the control setting as described in previous sections to display two waveforms simultaneously. Set DC/AC switches of both vertical channels for AC input.

c. Set channel A and channel B VARIABLE controls to CAL position and VOLTS/DIV selector switches of both channels to the same position.

d. Adjust TRIGGER LEVEL control to display a synchronized pattern.

e. If the channel A and B inputs observed in d are in phase, subtract both waveforms algebraically by pulling vertical mode switches CH A, CH B and push in the B invert switch. The displayed waveform is the peak-to-peak difference between two points of measurement. If the difference is small, the vertical sensitivity may be increased by resetting both channel A and channel B VOLTS/DIV switches to a more sensitive position.

f. If the channel A and B inputs observed in step d are 180 degrees out of phase, such as the output of a differential amplifier, pull the vertical mode switches CH A, CH B and CH B INVERT pushed in to measure the full peak-to-peak waveform. Pull the vertical mode switches CH A, CH B to measure any imbalance between the two points of measurement. Readjust the VOLTS/DIV switches as above in step e to obtain as large a waveform as possible without exceeding the limits of the vertical graticule scale.

g. To measure DC voltage or the DC component of the waveform differential signal proceed as described in preceding steps above with the following exceptions:

- Set the DC/AC input switches of both vertical channels to DC positions (push in to release).
- Push in GND switches of both vertical inputs in and adjust channel A and channel B POSITION controls to bring both traces displayed in coincidence with graticule line selected as a zero baseline for reference.
- Release GND switches of CH A and CH B one at a time, observing direction so that polarity of differential voltage can be determined.

SECTION V
THEORY OF OPERATION

5.1 POWER SUPPLIES AND BLANKING SYSTEM (See Schematic Diagram Figure 7-4 for Power Supply)

5.1.1. Low Voltage Power Supply: Individual outputs of +5V, ±12V, and −91V are independently regulated. Output of −175V is unregulated.

5.1.2 High Voltage Power Supply: A full wave doubler and a regulator consisting of Q501, Q502, IC504 produces a regulated −1350V power supply source. The error amplifier IC504 controls the collector voltage of Q501 so that the high voltage (−1350V) is always constant, regardless of the normal variation of line voltage.

5.1.3 Blanking Circuit: The grid and the cathode of the CRT are, in essence, biased at the same potential. However, a DC restorer circuit during the re-trace interval produces an additional amount of negative voltage which is applied to the grid of the CRT and reduces the beam current (brightness) to zero. The amount of grid to cathode bias voltage is produced by a 20 kHz oscillator, (Q506 and Q509) which is controlled by VR505.

5.2 HORIZONTAL SYSTEM (Figure 7-3 Horizontal Circuit)

5.2.1 Triggering Circuit: The trigger signal from the vertical amplifier is processed through comparator IC101 and is compared with a reference level set by VR201. The output of the comparator is inhibited by the sweep gate during the sweeping period. In the absence of a triggering signal, the output of IC102 (pin 5) is going to be high so that in the AUTO mode J-K flip-flop (IC104) is reset and the sweep generator becomes recurrent. In the NORMAL mode a trigger signal is required for the initiation of a trace. Unless IC102 receives a trigger signal within approximately one second, its output will be held at a low level, disabling the sweep generator from producing a trace. Therefore, in the NORMAL mode, a trigger signal is required for the initiation of a trace.

5.2.2 Sweep Generator: Integrated circuit IC201 constitutes the sweep generator which is a Miller Integrator. The slope of the sawtooth depends on the position of TIME DIV switch, which switches various time constants, depending on the sweep speed. VR101 controls the height of the sawtooth, which is the sweep length. At the termination of the sweep, the output of IC201 triggers IC103, then sets IC104 which in turn turns on Q113, producing a rapid discharge of the timing capacitor through Q103.

5.2.3 Horizontal Amplifier: The horizontal amplifier Q107 through Q111 provides sufficient amplification to deflect the beam horizontally. VR202 is the horizontal position control.

5.3 VERTICAL AMPLIFIER (Diagram For the Vertical Circuit Figure 7-2)

5.3.1 Input Attenuation: The VOLTS/DIV switches select the proper attenuator and fixed gain position of the vertical amplifier for an input signal from 5mV/div to 10V/div. The input impedance always remains constant at 1 MΩ shunted by 25 pF.

5.3.2 Input Source Followers: The dual FETS Q301, and Q313 maintain a high input impedance and low DC drift. VR301 and VR309 provide DC balance adjustment.

5.3.3 Input Amplifiers — Gain Programmable Amplifiers: IC301 and IC304 comprise two variable gain amplifiers that are part of the attenuator. Depending on the setting of VOLT/DIV switches the gain of 1/2 4 ratio can be selected. VR302 and VR310 provide DC balance adjustment.

5.3.4 Preamplifiers: Transistors Q303, Q304, Q315, Q316 serve as preamplifiers with variable gain which are controlled by the variable VOLT/DIV VR303 and VR311. VR304 and VR312 are the vertical position controls. IC302, IC303, and IC305 constitute the cascode amplifier for CH A and CH B respectively. Transistors Q305, Q306 are used for amplitude limiting.

5.4 CHANNEL SELECTION MODE AND TRANSISTOR SWITCH

5.4.1 Diodes D302 to D305 and D311 to D314 are used to provide the following modes:

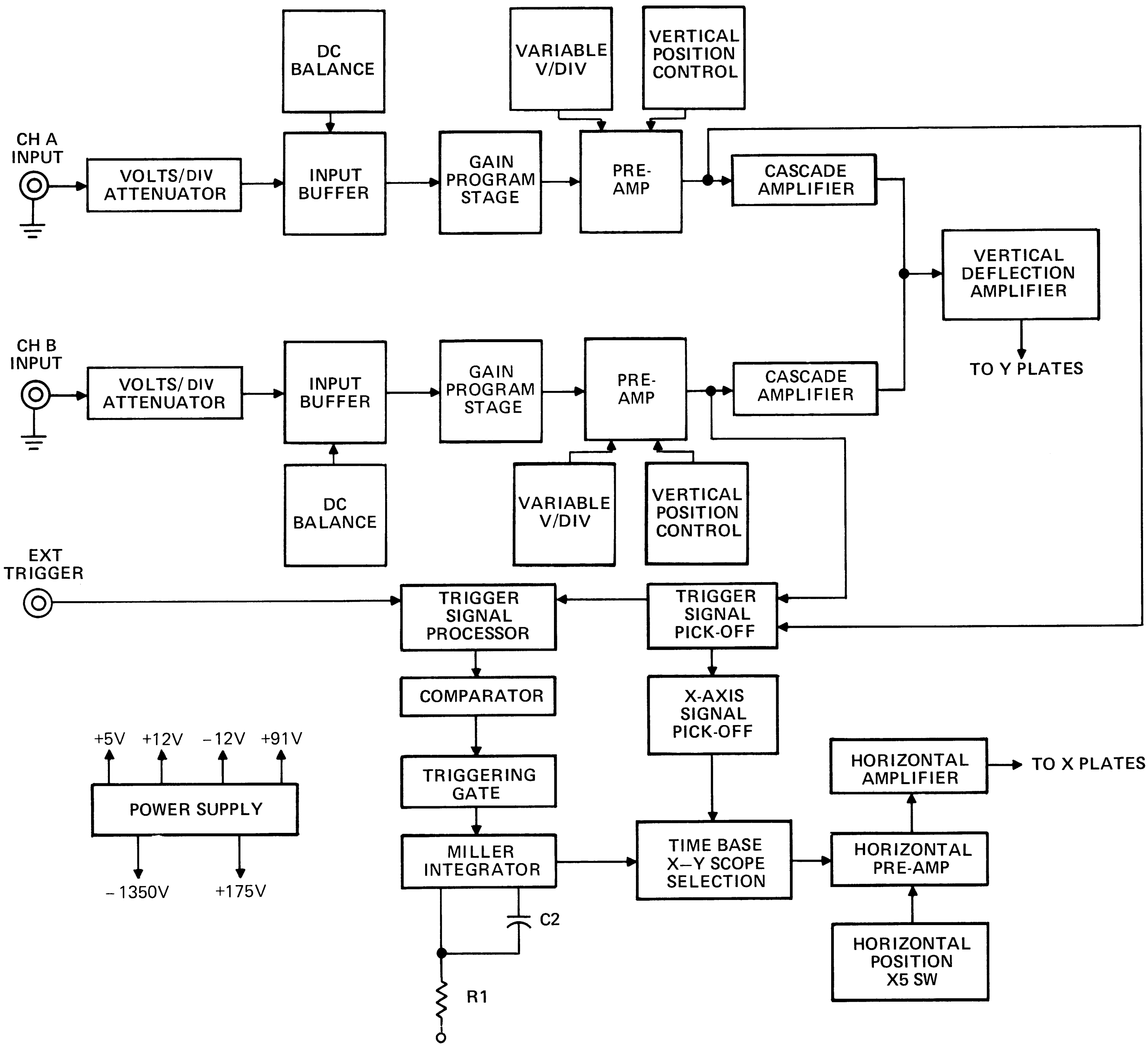


Figure 5-1. Block Diagram

a. **CH A mode:** In this mode, the CH A switch on the front panel sets the output of IC307 pin 11 to a low level and IC307 pin 8 to a high level. This allows the CH A amplifier to be enabled and CH B amplifier to be inhibited.

b. **CH B mode:** In conjunction with the CH B switch and IC304 CH B is enabled by the add switch. The subtraction mode is accomplished by reversing the phase of CH B.

c. **CH A ± CH B mode:** In this mode, both cascode amplifiers of CH A and CH B are enabled by pulling both switches. The subtraction mode is accomplished by reversing the phase of CH B.

d. **Dual channel mode**: When both CH A and CH B switches are pressed, the outputs of IC307B are out of phase and are driven by a 200 kHz oscillator. This allows the two channels to be chopped at the rate of the oscillator ÷2 for sweep speeds slower than 1 msec/div. At sweep speeds faster than 1 msec/div. the sweep is automatically changed to the alternate mode.

5.4.2 Output Amplifier: The cascode differential amplifier, consisting of Q307 through Q312, constitutes the vertical amplifier for CH A, and CH B. VR308 provides the adjustment of operating point. Capacitors C330 and C331 provide frequency compensation.

5.4.3 Trigger Circuit: Depending on the trigger switch selection, portions of the integrated circuits IC107, IC302 and IC305 constitute the trigger pick-off signal for CH A and CH B respectively.

5.4.4 Horizontal Input: For X-Y vector scope operation, channel B functions as the horizontal preamplifier. The input signal to the horizontal output amplifier is provided by the CH B trigger signal.

SECTION VI
APPLICATIONS

6.1 GENERAL

6.1.1 The 454 features speed and the capability of observing simultaneous signals that are related in terms of frequency and phase. Several applications utilizing dual trace as well as single trace applications of the 454 are reviewed briefly here.

6.2 MEASUREMENTS OF WAVEFORM TIME RELATIONSHIP IN DIGITAL CIRCUITS

6.2.1 Capabilities for viewing two waveforms simultaneously and availability of calibrated horizontal display time axis make the 454 a valuable aid for measurement of digital circuit-frequency time relationships and pulse train propagation times.

6.2.2. Figure 6-1 illustrates the waveform relationships for the Simpson 7016 frequency counter circuit with the block diagram shown in Figure 6-2.

- To view and compare any two waveforms shown in Figure 6-1, press vertical mode switch buttons CH A and CH B in and adjust all other controls as indicated for viewing dual-trace display in Section IV.
- Select a desired reference waveform and apply its signal to channel A input. Set TRIGGER SOURCE to CH A (unless CH B or EXTERNAL sync is desired). Apply the other signal to be compared to channel B input.
- Set VOLTS/DIV selectors of both channels A and B, the TIME/DIV and the TRIGGER SLOPE switches and TRIGGER LEVEL control as required to produce suitable display of vertical amplitude and horizontal spread of the sychronized waveforms.
- If the exact measurement of the pulse duration, pulse repetition rate (frequency), propagation delay time or any other specific time relationship between waveforms is desired set horizontal VARIABLE control to maximum clockwise CAL position. Set the VARIABLE controls of channel A and channel B to CAL positions also, whenever vertical amplitudes of these waveshapes have to be measured.
- Increase horizontal time axis resolution and accuracy of time interval measurement either by spreading the display pattern with faster TIME/DIV sweep setting or magnifier switch setting to X5 MAG position.

6.3 PHASE MEASUREMENTS

6.3.1 Phase measurements have a distinct advantage when using a dual-trace oscilloscope. The dual-trace method, contrary to the X-Y methods, can measure phase difference accurately between signals of different amplitudes, frequency multiples, and wave shapes. The procedure for checking amplifiers for phase shift is described below.

6.3.2 Figure 6-3 shows the procedure for measuring phase shifts between input and output signals of an amplifier consisting of several stages.

- Pre-adjust the controls for a horizontal AUTO (automatic) trace display as described under initial control settings, adjustments, and waveform observation in Section IV.
- Set the vertical mode switches for both channel A and channel B operation and set DC/AC input switches to AC on both channels.
- Push TRIGGER SOURCE CH A button out.
- Apply the signal from amplifier input to the CH A input and the signal from amplifier output to the CH B input.
- Set the VOLTS/DIV switches and adjust VARIABLE and vertical POSITION controls to display the signals of both channels centered vertically within the screen area.
- Select TIME/DIV switch position and adjust TIME/DIV VARIABLE and TRIGGER LEVEL controls until stable waveforms are displayed. Spread the pattern displayed over the screen as much as possible or as desired by adjusting the above switch and controls.
- Select either of the two signals (input or output), unless otherwise required by specifications, as reference signal. Set CH A input signal as reference waveform in this example.
- Adjust sweep VARIABLE control unit 1 cycle of the reference signal (CH A input signal in this case) extends exactly 9 divisions horizontally on the screen. This corresponds to the angle of a full cycle (360°). Divide this number by 9 divisions and the result is 40° per division, the factor for our phase shift scale.
- Measure the horizontal distance in divisions on graticule between the amplifier (Figure 6-3 A) input and output waveform's corresponding points and multiply the distance by scale factor 40°/Div. The product

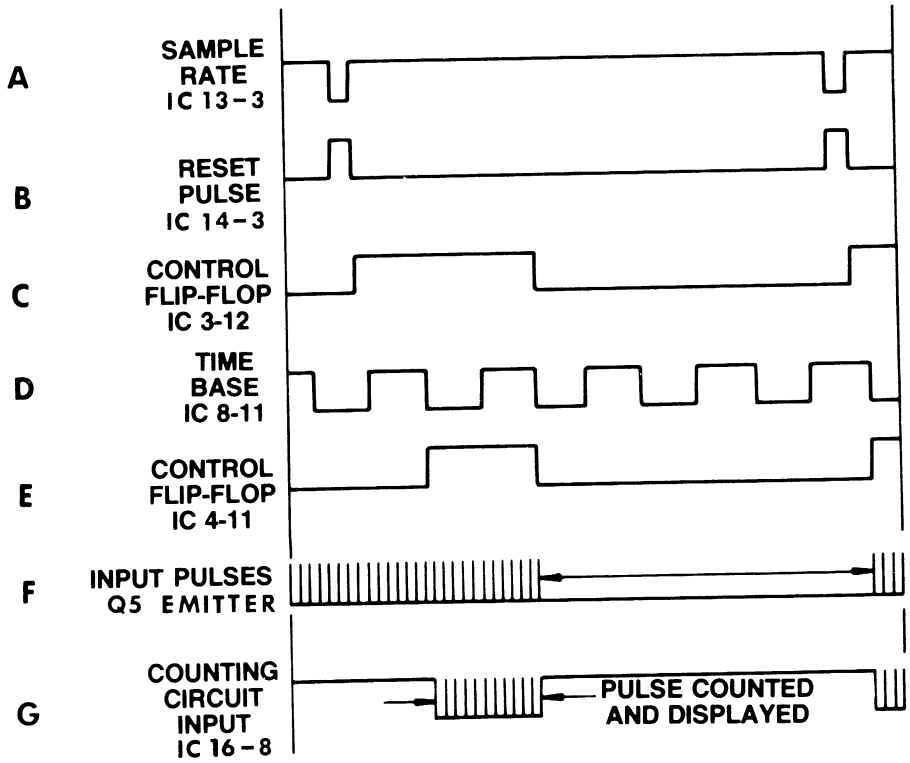


Figure 6-1. Family of Time Related Waveforms as Checked With The Simpson 7016

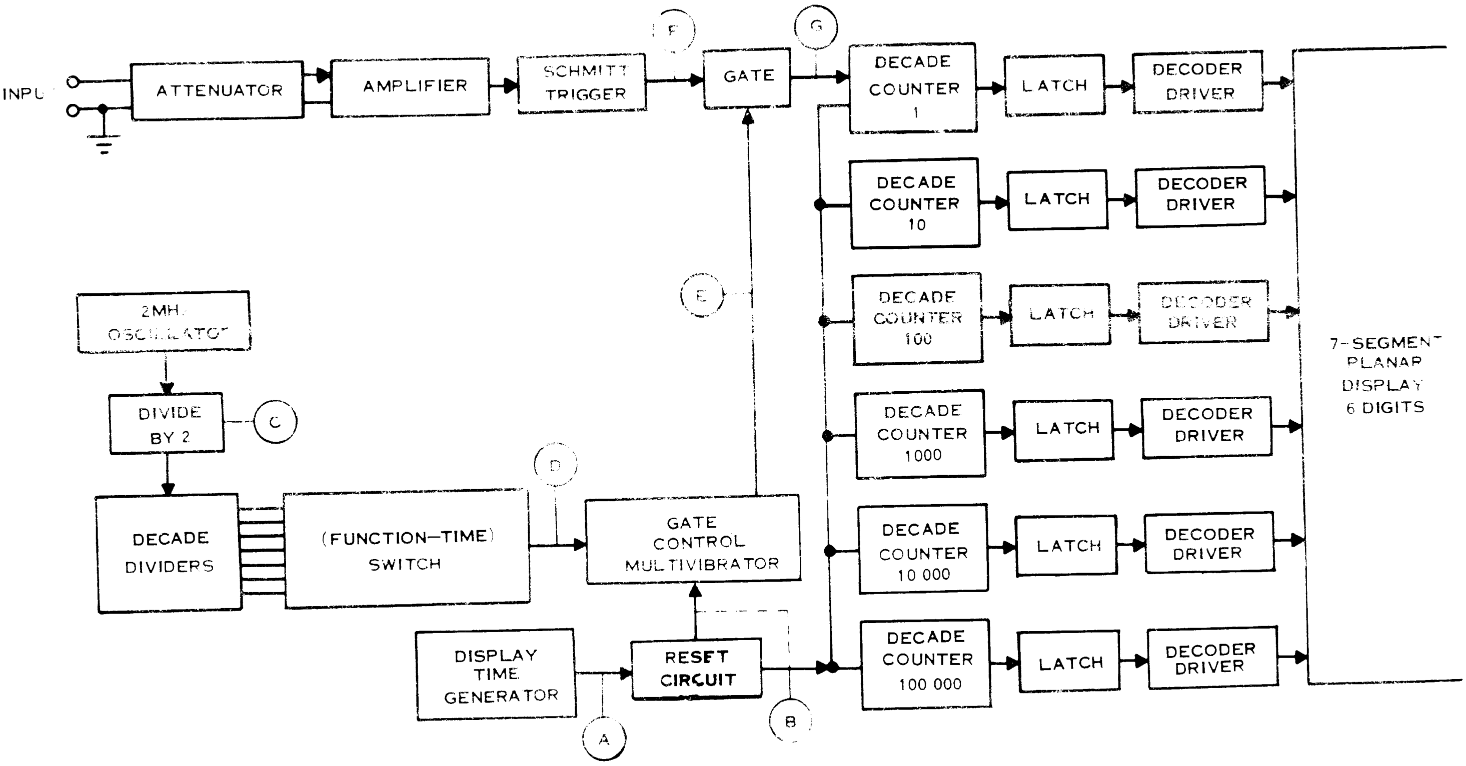


Figure 6-2. Block Diagram. Frequency Counter-Timer Simpson 7016

obtained will be the amount of phase difference in degrees between the input and output signals.

- To increase accuracy of measurement, especially in measuring minor phase differences, pull the sweep speed magnifier outward in X5 MAG position. Now only a portion (one fifth) of one cycle of the waveform obtained in the above step is displayed over nine divisions of the screen horizontally, and the scale factor is one fifth of 40°/Div, i.e. 8 Degrees/Div (Figure 6-3 B).

6.4 DUAL TRACE APPLICATIONS IN TV SERVICING

6.4.1 The dual trace feature makes the 454 ideal for analyzing TV chroma and video circuits. The phase relationships of burst and keying pulser, the matrixed waveforms of a colorcast and the incoming chroma signal, the video and sawtooth signal could be easily analyzed using dual trace display. Among other applications are the comparison of input and output waveforms of a phase shifter, simultaneous display of any two color bar signals and locating circuit intermittents, etc.

6.5 SQUARE WAVE TESTING

6.5.1 One description of circuit performace is the faithfulness with which a square wave at specified frequency is transferred. The square wave testing method provides an easily applied and duplicated basis for comparing two circuits to determine whether a particular circuit still performs as it was designed to perform.

6.5.2 A square wave is equivalent to the summation of numerous sine waves; a fundamental component of largest amplitude and odd-order harmonics of ever decreasing amplitude (higher order harmonics). For an idealized square wave, all component waveforms are exactly in phase; that is, at the instant the fundamental component is passing through zero, all of the harmonics are passing through zero in the same direction.

6.5.3 Assume the square wave is applied as an input signal to circuit under test and the output is monitored on the 454. If the harmonic components do not get through the circuit with their original relative amplitudes, or if the phase relationships among the input frequencies are upset, the appearance of the circuit output signal on the CRT will be distorted from its original squareness.

6.5.4 A drop-off of response at low frequencies has the effect of imparting a downward slope or droop to the originally horizontal portions of the waveform. Vertical waveform transitions from high to low (and back again) customarily follow an exponential curve. The "risetime" of the circuit under test is the time required for the circuit output signal to go from 10 to 90 percent of its amplitude change. When resonance prevails in the signal path, the output squarewave might "ring"; that is, the display might show a suggestion of damped oscillation along a portion of the wave that was originally horizontal. For example, the square wave response of a circuit might be specified as: 1kHz square wave, with a droop of no greater than 5 percent, rise time not to exceed 15 microseconds and 10 percent maximum overshoot. A very brief test with the 454 will disclose whether performance of the circuit is within those specified limits.

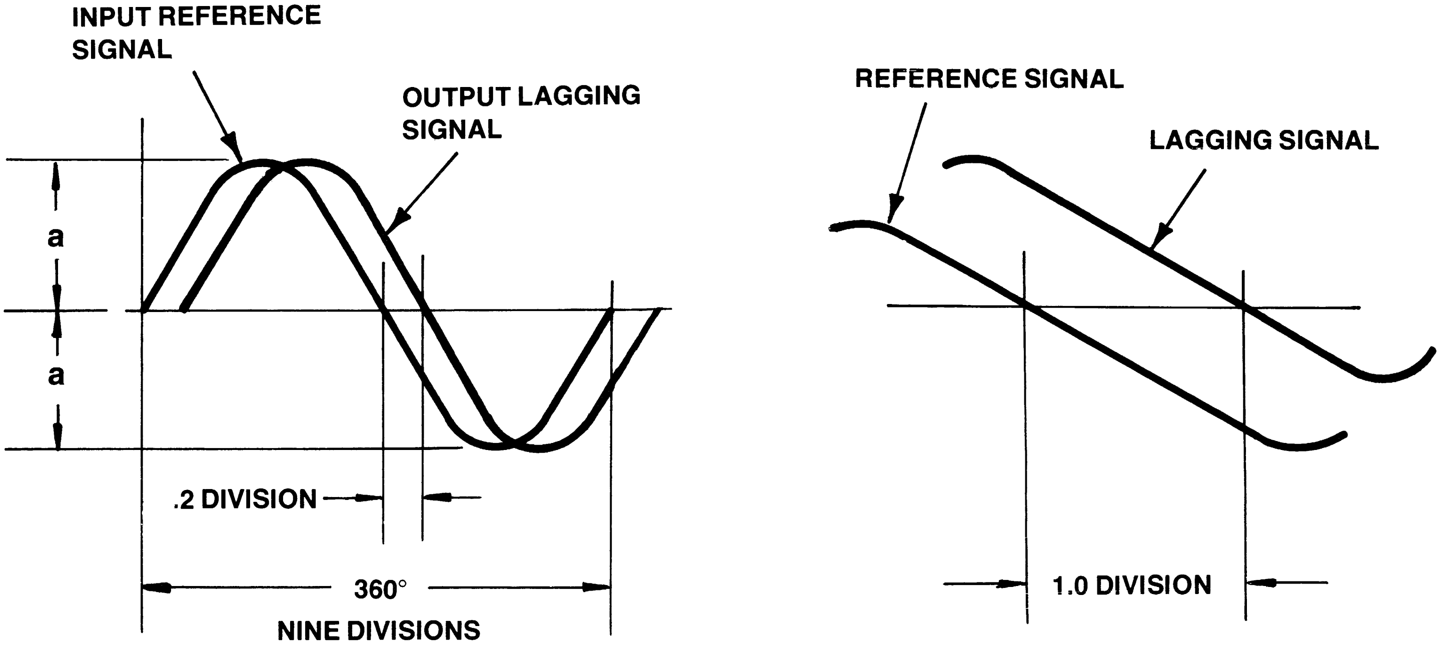
6.5.5 The rise time of the 454 is only 24 nanoseconds (.024 μ second). This rise time must be taken into consideration only in high-speed circuits. At very low frequencies (below 50 Hz), the optional coupling capacitor, at the vertical channel inputs, can introduce appreciable droop. Always make sure the vertical input switch is in the DC position.

6.6 PHASE SHIFT MEASUREMENTS BY X-Y METHOD

6.6.1 The familiar figures are stationary patterns displayed when the vertical and horizontal signal inputs are of fundamental frequencies related to each other by a whole number ratio.

6.6.2 If the same frequency is applied at the vertical and horizontal inputs, the CRT beam traces an ellipse simultaneously. This ellipse becomes a line which will slant upward to the right for 180 degrees out-of-phase. For intermediate phase relationships, ellipses are displayed. The special case of a circular display results from sine waves of equal deflection amplitudes in a 90 degrees phase relationship.

6.6.3 To measure the phase shift of sine waves at the same frequency and deflection note the ratio of minor axis to major axis length. The angle of phase shift is twice that angle, the tangent of which is the ratio of width to the length of the ellipse, that is $\emptyset = 2 \arctan (a/b)$ where $\emptyset$ is the phase difference in degrees, and a and b are the shorter and longer dimensions of the ellipse, respectively. For example, if the major axis of the ellipse slopes upward to the left and the ellipse is one-fourth as wide as it is long, the angle which has a tangent of 1:4 is about 14 degrees. The phase shift, therefore, is twice 14 or 28 degrees.



Phase Difference $= .2\text{ div.}\ \dfrac{360^\circ}{9\text{ div.}} = 8^\circ$

Without sweep magnification (MAG switch in x1 position)

Phase Difference $= 1\text{ div.} \times \dfrac{360^\circ}{9\text{ div.} \times 5} = 8^\circ$

Sweep speed magnified by factor 5 (MAG switch in x5 position

Figure 6-3. Phase Shift Measurements

COMPOSITE SIGNAL SYNCHRONIZED AT HORIZONTAL BLANKING RATE

COMPOSITE SIGNAL SYNCHRONIZED AT VERTICAL BLANKING RATE

Figure 6-4. Representative Oscillograms of Composite Signals

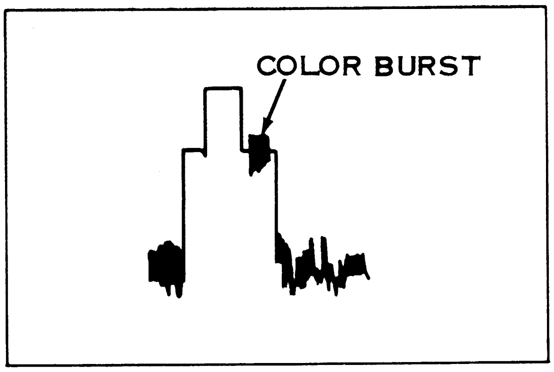


Figure 6-5. Color-Burst Shows to Right of Sync. Pulse

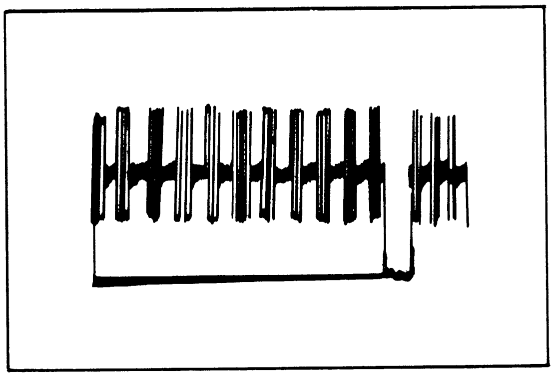


Figure 6-6. Typical Output From Color-Bar Generator

6.6.4 The 454 has been designed and built with a greater bandwidth in its vertical channels than in its horizontal channel. Somewhere in the supersonic range the scope will begin to introduce a phase difference between the two (vertical and horizontal) channels. (For more accurate measurement, use the dual trace method described in paragraph 6.3).

6.6.5 The frequency range for accurate phase shift measurements can be extended by calibrating the particular Instrument. Plot a curve of the scope's phase difference as a function of frequency. Correct circuit readings accordingly.

6.7 STABILITY OF FEEDBACK AMPLIFIERS

6.7.1 To obtain the high performance common in high-quality servo-mechanisms and audio amplifiers, heavy usage of negative (inverse, or degenerative) feedback is required. Using this technique, a portion of the output voltage of an amplifier is fed back to the input, in proper polarity, to reduce net gain. The advantage of applying feed back is that the extent of distortion that originally occurred throughout most of the passband will be reduced by approximately that factor by which the voltage amplification is reduced when the feedback is connected .

6.7.2 The presence of reactive elements (transformers, inductances, and various capacitances, both intended and stray) limit the amount of negative feedback that can be applied without regenerative trouble outside the intended passband. Often, there is some frequency (or frequencies) at which the phase shift around the overall loop will support oscillation. Oscillation will occur if the "gain" around the broken loop is at least unity at that frequency. Damped (transient) oscillations can occur, under signal conditions, if the loop gain is slightly less than one and if the phase requirement for sustained oscillation is almost satisfied.

6.7.3 The avoidance of oscillation, either sustained or damped, plus the general desirability of knowing what safety factors prevail necessitate measurement with the proper instruments. The 454 is useful in this kind of measurement, especially when using the dual trace method described in paragraph 6.3.

6.7.4 Adequate safety margins for gain and phase stabilities are about 6 dB and 30 degrees, respectively. To avoid false oscillations under signal conditions, limit the open-circuit loop to no more than one half (6 dB down) the value that would result in sustained oscillations. For any frequency at which the open circuit loop gain exceeds unity, make sure the overall phase shift (around the open loop) differs by at least 30 degrees from the in-phase condition that would produce oscillation, were the feedback disconnected, the feedback source and load impedances of the intended complete feedback loops must be simulated.

6.8 TUNING FOR MAXIMUM OR NULL

6.8.1 The 454 may be used for tuning frequency selective circuitry. When tuning a filter or selective amplifier, the oscilloscope serves as a highly sensitive detector and also informs the user of whether the correct frequency component is being maximized or minimized. In the absence of this waveform indication, one can easily be misled by the presence of electrical noise (or a strong harmonic signal) and tune the circuit improperly.

6.8.2 Equipment for measuring harmonic distortion usually involves measuring what remains when the fundamental frequency component has been nulled. By monitoring the null network with the 454, the nulling process can be simplified by observing the nature of the distorted products.

6.8.3 The oscilloscope is effective as a null indicator when balancing an impedance bridge (used for inductance of capacitance measurements). The CRT is a more flexible indicator than a simple meter. It permits the user to achieve a sharper null more quickly. The bridge nulls only the fundamental frequency of the test voltage, leaving the harmonics to cloud the issue. Usually, the harmonics originate in the bridge generator and the difficulty can be lessened by using a harmonic-free signal source. When measuring iron or ferrite core indicators, the non-linearity of the sample can contribute harmonics in the bridge output. Use external sync derived directly from the bridge signal source, to easily follow progress in nulling the fundamental component thereby bringing the bridge into proper balance.

6.9 TIME OR FREQUENCY MEASUREMENT

6.9.1 The measurement of frequency and time are closely related, since frequency is the reciprocal of time ($F=1/T$). With a stable and accurate horizontal sweep generator it is easy to measure the time duration of a given waveform. After the time for one cycle is known, the frequency can be readily obtained as follows:

- Adjust the TRIGGER LEVEL and TIME/DIV switches to display one or two complete cycles. Be sure the TIME/DIV VARIABLE control is in the CAL position.
- Count the number of DIV (left to right) from the start of the first waveform to the start of the second.
- Multiply the number of DIV by the sweep TIME/DIV switch setting. This gives you the period of this waveform (or portion of interest) and reciprocal of it is the frequency.

> **NOTE:** If the TIME/DIV VARIABLE switch is in the X5 MAG position, remember to divide the time by 5.

6.10 TV SERVICING

6.10.1 The modern oscilloscope is invaluable for proper servicing and alignment of television receivers. The 454 is excellent for measuring signal levels, analyzing various signal waveforms, signal tracing and alignment of the many tuned circuits. This section is intended as a guide for some of the more common servicing procedures. Waveforms, test points, and procedures will vary with sets from different manufacturers and at times for sets by the same manufacturer. The first and most important step in television servicing is to obtain the manufacturer's test procedure for the set. Do not guess whether a given waveform or procedure is correct.

6.10.2 The amplitude and shapes of signal waveforms throughout the TV circuits are the best indications of normal operation or where trouble is occurring. The sensitivity of the 454's vertical channels permits making virtually all needed TV measurements. When the Low-Capacitance Probe is used, take into account that the actual signal voltage is 10 times that displayed on the CRT and control settings on the Instrument. The regular shielded input cables have about 90 pF capacitance and may interfere with normal operation of some TV circuits. Often an isolation resistor can be used to minimize the effect of high capacitance.

6.10.3 While the description presented here is typical of standard television sets, minor departures prevail among various manufacturer's equipment. Signal shapes are primarily determined by the output of related test equipment or of a transmitted composite signal. (Refer to the manufacturer's service data for representative signal amplitudes.) The signal amplitude usually is quoted on a peak-to-peak basis, and usually without regard to a DC component that often is present. Ordinarily, keep the input DC/AC pushbutton switch in the AC position.

WARNING

Use extreme caution when servicing strange equipment; a small AC signal might be riding on DC voltage of lethal proportions. Also do not exceed the input voltage ratings of the 454 (see maximum input voltage rating in Table 1-1) and those of shielded cable or the 10 : 1 Low Capacitance probe used.

6.11 ANALYZING TV COMPOSITE VIDEO WAVEFORM

6.11.1 The composite video waveform is a combination of the video signal, blanking pedestals and synchronization pulses. Representative oscillogram of composite signal synchronized at horizontal blanking rate is shown in Figure 6-4. To display details depress switch TV Sync and set interval CH A trigger source and either AUTO or NORM trigger modes. Adjust TRIGGER LEVEL for stable display. Be sure that the TIME/DIV switch sets 50 μsec or higher sweep speed. Otherwise, the sync separator provides vertical sync only.

6.11.2 When servicing any electronic equipment, observe what waveforms prevail throughout a set known to be in good operating condition. Compare the waveforms with data from the manufacturer for the particular set being worked.

6.11.3 To set-up a composite waveform display, proceed as follows:

a. Tune in a strong TV signal. Finding a station broadcasting a stationary test pattern is helpful, but a satisfactory display can be set-up when using regular program material.

b. Turn the INTENSITY control clockwise to give a suitable bright trace. Adjust FOCUS control for minimum trace width. Set trigger MODE, SLOPE, and SOURCE switches to AUTO, +, and CH A or CH B channel sync depending on which vertical channel is used.

c. Connect Low-Capacitance Probe X10 to vertical CH A or CH B input connector.

d. Connect ground clip of the probe to chassis of TV set.

e. Connect the signal tip of probe to the grid terminal socket of the TV picture tube.

f. Set the 454 VOLTS/DIV switch to .5 position.

g. To read vertical amplitude correctly, vertical VARIABLE control must be in CAL position; however, to merely observe nature of waveform, adjust VARIABLE control for desired display height.

h. To synchronize at horizontal sweep rate, set sweep TIME/DIV switch to 50 μsec or faster; if desired, adjust sweep TIME/DIV VARIABLE control for expansion to less than two horizontal line periods. A better sweep synchronization may be obtained by selecting "–" instead of "+" on trigger SLOPE switch or trigger LEVEL control, depending on the signal polarity.

i. Typical composite signals for black-and-white TV are shown in Figure 6-4. Only synchronization pulses show any resemblance of standing still on the display.

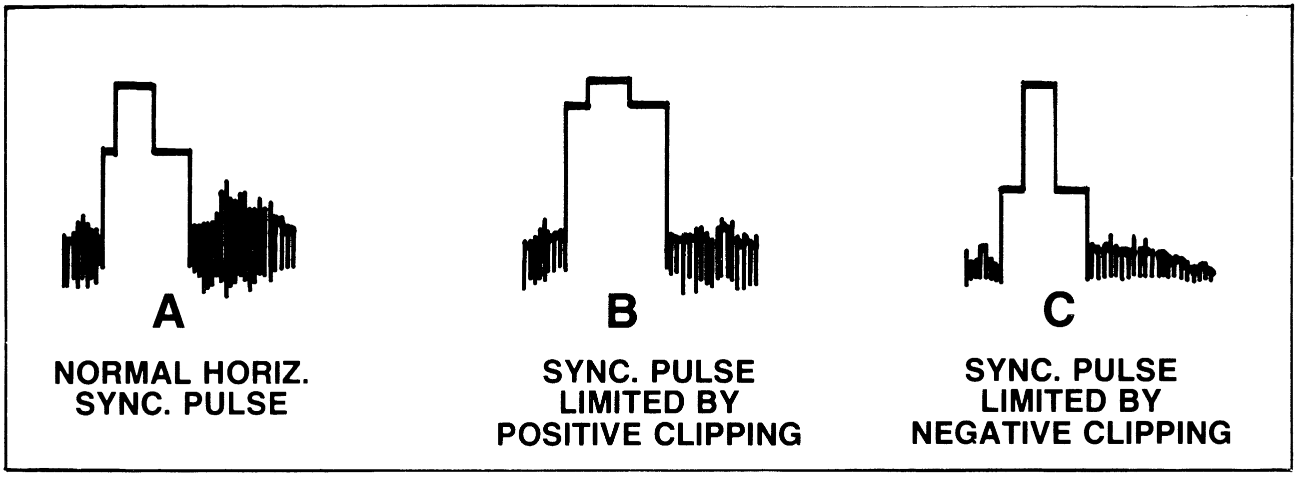


Figure 6-7. Sync. Pulse Suppression

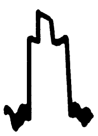
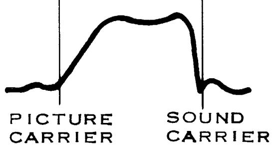
CIRCUIT ALIGNMENT SITUATION	SHAPE OF HORIZONTAL SYNC PULSE	OVERALL FREQ. RESPONSE OF RECEIVER	EFFECT ON PICTURE
NORMAL			NORMAL PICTURE
HIGH–FREQUENCY LOSS			PICTURE BLURRED LOSS OF DETAIL
HIGH–FREQUENCY BUMP OR BOOST			VERTICAL SHADOWS OR GHOSTS APPEAR TO RIGHT OF SHARP DETAILS IN PICTURE
LOW–FREQUENCY LOSS OR ROLL–OFF			NON–UNIFORM SHADING OF LARGE PICTURE AREAS

Figure 6-8. Sync. Pulse and Frequency Response Waveforms

The portion of the display which resembles electrical noise is the video signal. It varies continually and virtually never maintains a fixed appearance.

j. Figure 6-5 shows typical color TV signals. The color-burst is situated immediately to the right of the sync pulse. When a color bar generator is used, the composite display resembles that of Figure 6-6.

k. Figure 6-7 shows variations possible in the shape of the sync pulse when signal overload (or a biasing problem) prevails. Normally, the sync pulse exceeds pedestal height by about 50 percent as indicated in Figure 6-7A. If limiting occurs in the positive direction, clipping (sometimes referred to as "compression") occurs as in Figure 6-7B. If limiting (or overload) occurs, in the opposite polarity, the sync pulse proportions are changed as shown in Figure 6-7C.

l. To appraise the overall alignment of RF and IF circuits inspect the shape of the horizontal sync pulse. Figure 6-8 indicates the correlation between a sync pulse shape and frequency response of the tuned circuits. Figure 6-8 also provides a brief description of the likely effect upon picture quality.

6.12 ALIGNING TV TUNED CIRCUITS

NOTE: If the Low-Capacitance Probe (X10) is used, compensation must be checked. (See paragraph 4.8 and 4.9 for test and calibration procedures.)

6.12.1 The need for aligning a TV set can come from several common causes: drift due to aging of components, replacement of components and replacement of tubes. Sometimes the problem is merely maladjustment of accessible controls by someone who is not qualified or who does not have proper equipment.

6.12.2 The following information applies to aligning the tuner (front end), I-F and subsequent detector circuits. While the basic principles are common among TV sets, it is always necessary to have the manufacturer's service procedures available for the particular set to save time in evaluating the signals at the test points.

6.13 ALIGNING A TUNER

6.13.1 Proceed as follows:

a. Connect output of sweep generator to the antenna terminals on the TV set.

b. Connect ground clip of the probe to metal frame or shield of TV tuner.

c. Generally hum interference can be reduced by making the probe ground as close as possible to the test signal pickup point. Usually service instructions include a signal in the mixer grid circuit, where a demodulated signal is present. The signal level at this point is only a small fraction of a volt peak-to-peak, so the scope must be operated at a high gain position with the probe set to theX1 position. Therefore, the input capacitance of the overall scope and probe substituted cable might be much higher. To avoid upsetting the tuner by the scope cable connection, use a series ½-watt carbon resistor of 10k ohms to isolate the cable capacitance. If the resistor connections are not kept short, there might be too much hum pick-up, making it impossible to obtain a clear trace.

WARNING

Note that even though tuner r-f signal levels are low, there could be dangerous DC voltages present. Take whatever precautions are necessary to avoid this eventuality.

d. One advantage of the high vertical sensitivity of the 454 is that the sweep generator can be operated at a low enough level to not overload the tuner circuits. Such overload could prevent a true picture of the circuit alignment. With too little signal input, hum and noise can become very troublesome.

e. When using a sweep generator, apply an r-f test signal to the tuner input. The signal frequencies sweep periodically across the channel being aligned. The marker generator places a marker ("pip") on the trace at the instant the sweep generator frequency passes through a calibrated value. The oscilloscope monitors the instantaneous amplitude of the signal that comes through the input tuned circuits.

f. Figure 6-9 shows a typical front end frequency response obtained during sweep frequency measurement. The saddle-backed shape is typical of slightly over-coupled tuned circuits, and also of properly adjusted stagger tuned channels. Become familiar with the set-up of such a display on a TV set known to be good. Only with this technique perfected can one be fairly sure that an improper display is the set's fault. A minor departure usually can be remedied by tuning adjustments. A major departure might also indicate a loose connection in a tuner, or possibly the need to find and replace a faulty component.

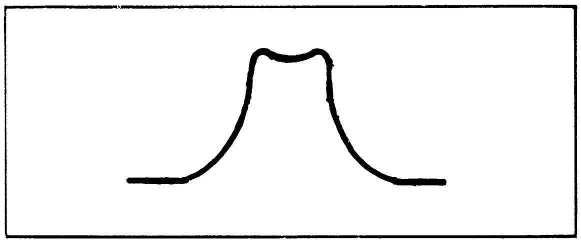


Figure 6-9. Typical Appearance of Detected Output With Sweep Generation Output

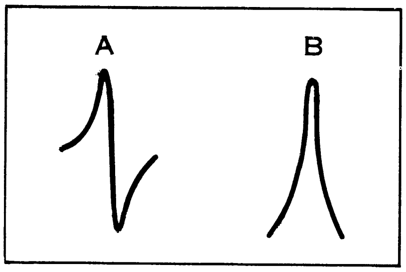


Figure 6-10. Ratio Detector and Sound I-F Response Curves

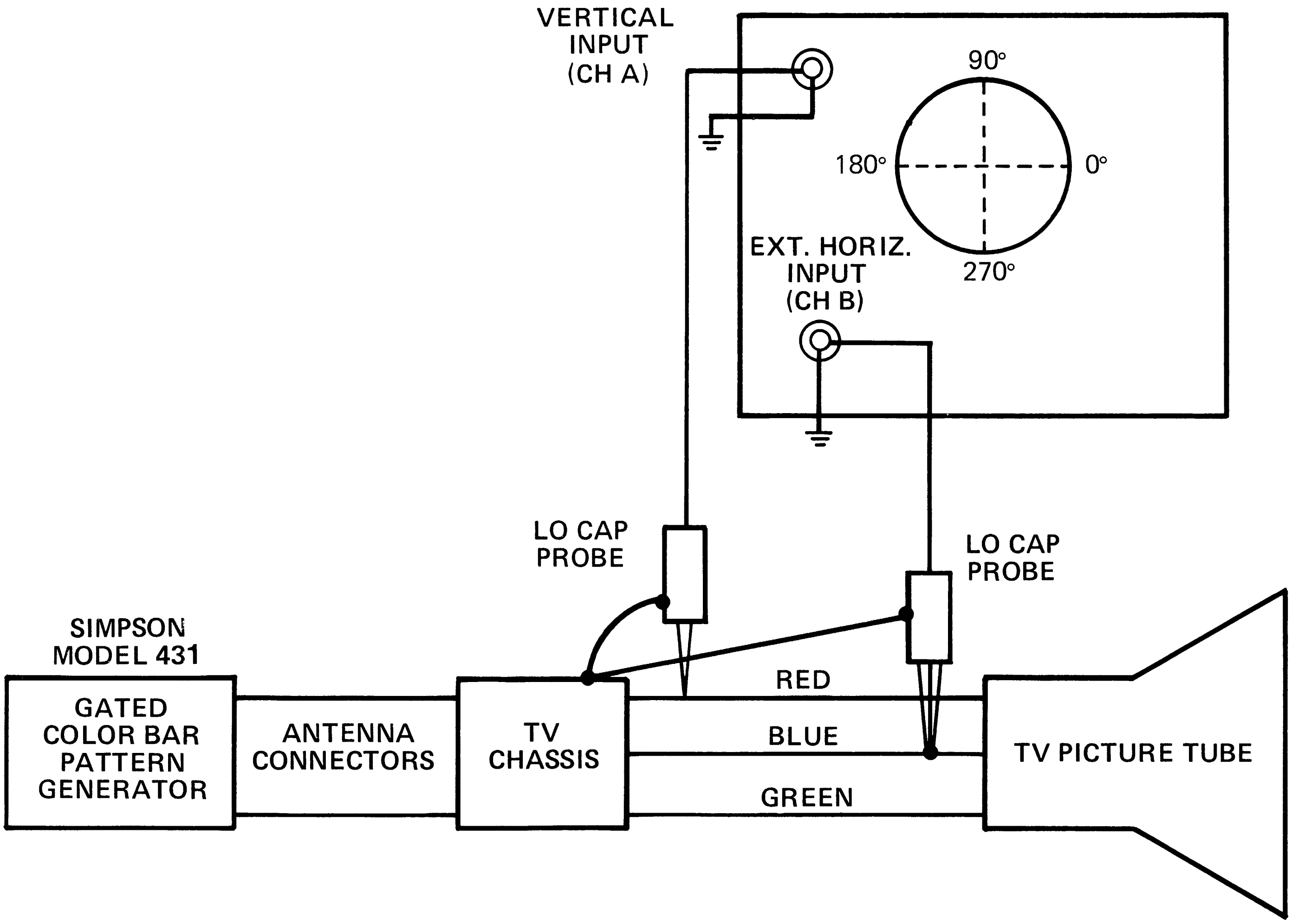


Figure 6-11. Vector Pattern Display

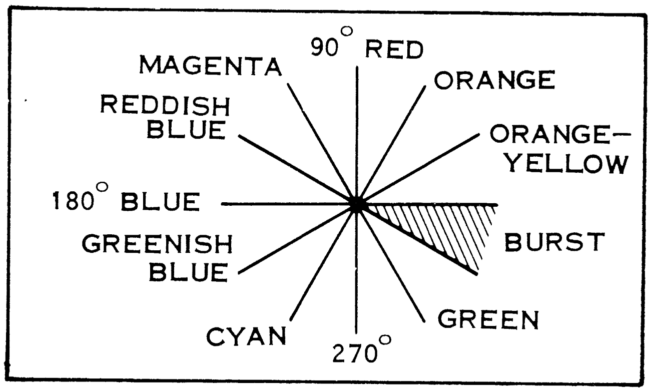


Figure 6-12. Vector Pattern Analysis

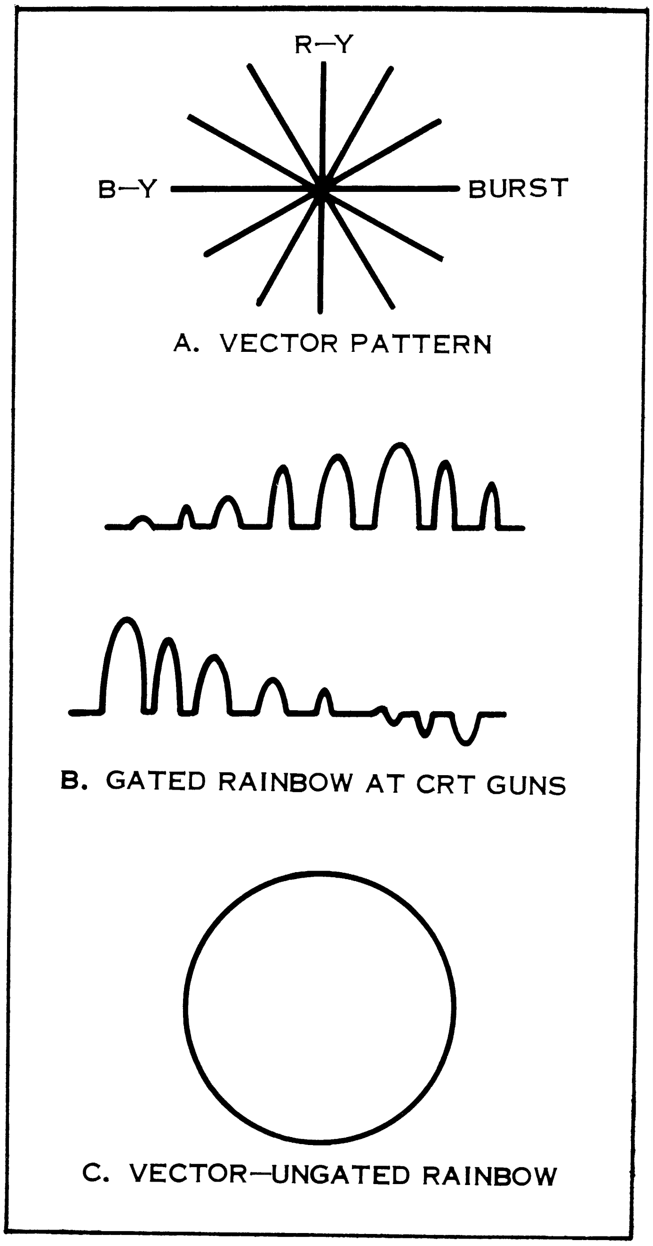


Figure 6-13. Vector and Gun Displays

NOTE: Sweep generators and marker generators are set up in various ways, according to their particular characteristics. Sometimes the functions are combined into one package. Follow the manufacturer's recommendations.

6.14 ALIGNING PICTURE I-F CIRCUITS

6.14.1 Proceed as follows:

a. When a good signal is present at the mixer, examine the frequency response of the I-F (Intermediate Frequency) portion of the set. Pick up the signal with the low-capacitance probe.

b. Use the load resistor of the video detector as a test point. Sometimes the test point is located at the input of the first video stage.

c. To minimize the influence of hum pick-up, connect the ground clip of the scope probe to a ground point near the signal test point on the set. Since the signal will be larger here than at the tuner, a 10:1 low-capacitance probe can be used to reduce circuit loading and still achieve sufficient heights of the displayed wave amplitude.

NOTE: With all R-F and I-F measurements, proper impedance matching (per manufacturer's recommendation) is preferable. If possible, use a connector similar to that used for interconnection in the set.

d. Follow manufacturer's instructions for adjusting the bias level of the I-F amplifier. The signal from the sweep generator is unlike the signal that the set's AGC (Automatic Gain Control) is designed to accommodate. AGC must be disabled during sweep frequency alignment. The service instructions might include applying a fixed bias from an external battery. Sometimes the set manufacturer will recommend temporary wiring changes with the TV set.

e. Except for less vertical gain and bandwidth being required, display of I-F frequency response is similar to that obtained at the mixer. The indicating bandwidth will usually be substantially less.

NOTE: Be sure the output of the sweep generator is kept low to avoid overloading the video detector.

6.15 ALIGNING THE SOUND I-F CIRCUITS

6.15.1 TV Sound is transmitted via frequency modulation, for which the detector is either (usually) a discriminator or a ratio detector. Proceed as follows:

a. Connect a probe using a 10k ohm isolation resistor to output of sound detector.

b. Connect sweep and marker generators to receiver as directed in set manufacturer's instructions. Figure 6-10 A shows the nature of the response curve which will be displayed. Faithful sound reproduction requires that the central slope of the curve be a straight line.

c. A curve, similar to that shown in Figure 6-10 B, will be obtained if the probe is connected to the grid return of the limiter stage.

6.16 ALIGNING COLOR TV AFPC CIRCUITS

6.16.1 With proper adjustment of the AFPC (Automatic Frequency and Phase Control) circuits, the hue (tint) control of a color TV can accommodate all the hue variations present in the transmitted picture. When all controls are adjusted properly, the hue control will not affect intensity. Color sync will hold even on weak signals, and color balance will not be upset as luminance is varied.

6.17 VECTOR DISPLAY OPERATION

6.17.1 The vector display operation of the 454 can be used to check and adjust the chroma section in color television receivers. A color bar/pattern generator is required to simulate the composite video signal. Because of the sensitivity of the 454, the vector pattern can be traced from the demodulators, through the amplifiers, and the guns of the color tube. Normally the vector pattern is obtained at the guns of the color tube as follows (Figure 6-11):

a. Connect color bar/pattern generator to antenna terminals and adjust the pattern on television set, following the instruction manual to the particular color bar generator.

b. Set the 454 TIME/DIV switch to CH B position.

c. Connect low-capacitance probe from vertical input CH A of scope to red gun of color tube, and vertical input CH B of scope to blue gun of color tube.

d. Turn on television set and adjust 454 horizontal and vertical (CH B and CH A) VARIABLE gain controls for a round pattern perimeter. (Refer to Figure 6-12).

e. Adjust VOLTS/DIV or VARIABLE if necessary.

6.18 VECTOR PATTERN ANALYSIS

6.18.1 At the present time, very few manufacturers provide vector pattern information. They show the waveshape and voltage at each gun of the color tube. A typical representation of this information is shown in Figure 6-13B (vector pattern 6-13A). The R-Y and B-Y waveforms differ in phase by about 90 degrees and if the envelope (assume a continuous pair of waveforms rather than gated waveforms) alone was supplied to the 454, a circular vector pattern would be formed as in Figure 6-13C. (This is the pattern seen with a pure rainbow color generator.) With a gated rainbow pattern generator each pulse will bring the trace to the edge of the circle and then drop back to the center during the blanked portion, giving a flower petal effect.

6.18.2 The ideal pattern rarely occurs on an actual television set. The reason is that intentional phase angle distortion is introduced in the demodulator to improve the flesh tones and to simplify tuning. This distortion moves the sixth color bar from its ideal 180 degrees position to somewhere near 210 degrees. The effect is to make the vector pattern slightly elliptical. When using the oscilloscope for most TV servicing, the best "teacher" is looking at the critical patterns in a set which is known to be properly adjusted.

6.19 ALIGNING AM RECEIVERS

6.19.1 As with all superheterodyne receivers, whether TV, FM or AM, the overall shape and width of the passband is determined by the tuning of the I-F (Intermediate Frequency) portion of the system. The principles applied in aligning AM sets are similar to those for TV and FM. The differences are mainly the much lower frequencies and narrower bandwidths involved in a broadcast AM receiver.

6.19.2 The sweep-generator/marker-generator meth... conjunction with a good oscilloscope like the 454, is ... fastest and most effective method to use. The only si... alternative is alignment using a tunable signal gene... and output indicator, combined with either mental c... lations or a point-by-plotting of frequency response. W... sweep-generator/marker-generator method, the pres... situation is immediately apparent, and the effects of w... ever adjustments are made can be seen instantly.

6.19.3 As with TV alignment, the set manufacturer's ... is highly valuable in supplying critical frequencies ... showing where the most useful test points are locate... the chassis. Do not merely "peak up" the I-F amp... response. Undue emphasis on gain alone, or on band... alone cannot give optimum performance for either sp... or music reception. Also, the center frequency of the ... passband must be properly adjusted; otherwise it m... be impossible to get the r-f (front end) circuits to fun... over the full dial-calibrated frequency range of the se...

6.20 ALIGNING FM RECEIVERS

6.20.1 The sweep-generator / marker-generator me... vital to rapid TV servicing, is useful in FM servicing ... The major practical distinction from TV alignment is ... both tuner and I-F selectivity are notably less fo... Otherwise, follow the guidelines of paragraphs ... through 6.11. To the critical ear, the potential of FM ... high-fidelity transmission is severely undermined b... proper set alignment.

NOTE: Refer to the set manufacturer's data fo... recommended frequency setting and test points. With common acceptance of FM multiplex stereo and 4-channel systems, the importance of proper FM alignment is very important.