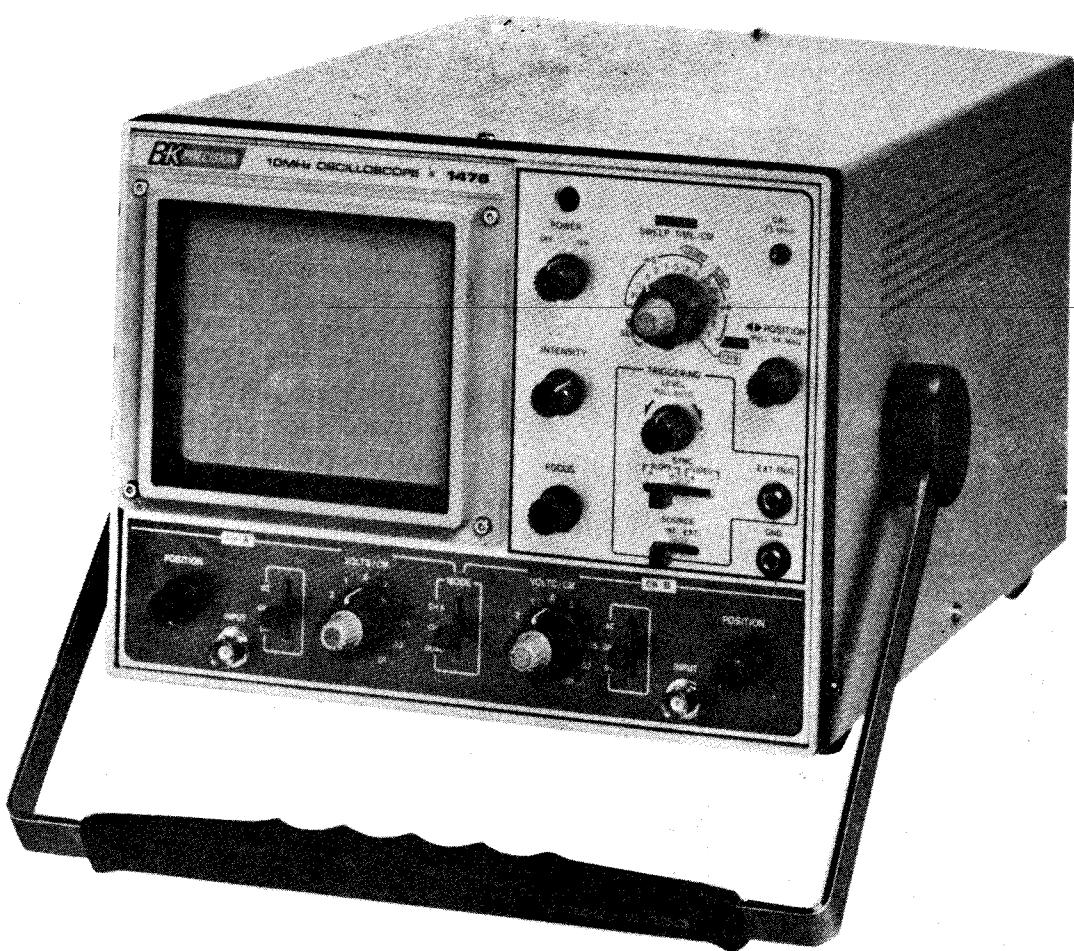


**INSTRUCTION
MANUAL**

BK PRECISION 1476

**10 MHz, TRIGGERED SWEEP
Dual-Trace Oscilloscope**



BK PRECISION DYNASCAN
CORPORATION

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed voltage is present. An electrical shock causing 10 millamps of current to pass through the heart will stop most human heartbeats. Higher voltages pose an even greater threat because such voltages can more easily produce a lethal current. However, voltage as low as 35 volts DC or AC RMS should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly. Remove housings and covers only when necessary. Turn off equipment while making test connections in high voltage circuits.
2. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; and make certain such surfaces are not damp or wet. Where insulated floor surface is not available, wear heavy gloves.
3. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.
4. Always use an isolation transformer to power transformerless "hot chassis" equipment, where one side of the AC power line is connected directly to the chassis. This includes most recent television sets and audio equipment. Without an isolation transformer, the chassis of such equipment may be floating at line voltage (120 VAC, 60 Hz in USA), depending upon which way the 2-wire AC power plug is inserted. Not only does this present a dangerous shock hazard if the chassis is touched, but damage to test instruments or the equipment under test may result from connecting the ground lead of some test instruments to a "hot" chassis. The ground lead of most oscilloscopes and most other test instruments with 3-wire power plugs is an earth ground.
5. On test instruments or any equipment with a 3-wire AC power plug, use only a 3-wire outlet. This is a safety feature to keep the housing or other exposed elements at earth ground.
6. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
7. Also remember that AC line voltage is present on some power input circuit points such as on-off switches, fuses, power transformers, etc., even when the equipment is turned off.
8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

INSTRUCTION MANUAL
FOR
B & K-PRECISION
MODEL 1476
10 MHz, TRIGGERED SWEEP
DUAL-TRACE OSCILLOSCOPE

BK PRECISION DYNASCAN
CORPORATION

6460 West Cortland Street
Chicago, Illinois 60635

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INTRODUCTION

The B & K-Precision Model 1476 Dual-Trace Oscilloscope is a laboratory-quality, professional instrument for observing and measuring waveforms in electronic circuits. Dual vertical inputs are provided for simultaneous viewing of two waveforms. Low-frequency, low repetition rate waveforms are chopped at a 200 kHz rate to provide for simultaneous viewing. Alternate sweep of the two inputs permits simultaneous viewing of high-speed, high repetition-rate waveforms.

The dual-trace feature, together with the 10 MHz bandwidth, wide range of sweep speeds, and high sensitivity provided, make this the ideal oscilloscope for a broad range of applications, including troubleshooting and repairing electronic equipment, research and development, and laboratory instruction.

FEATURES

DUAL TRACE	Two input waveforms can be viewed either singly or simultaneously, as desired.	EXPANDED SCALE	A five time magnification (5X) of the horizontal sweep allows close-up examination of a portion of the waveform. In addition, the 5X magnification provides a maximum sweep speed of 0.2 μ SEC/cm.
FULLY SOLID STATE	Only the cathode ray tube uses a filament. All other stages use transistors, diodes, FET's (field effect transistors) and IC's.	HIGH SENSITIVITY	Permits the low-capacitance, high-impedance, 10:1 attenuation probes to be used for virtually all measurements, thus assuring less circuit loading.
TRIGGERED SWEEP	The 1476's stability of waveform presentations is beyond comparison with non-triggered sweep oscilloscopes. The sweeps remain at rest until triggered by the signal being observed, to assure that they are always synchronized. Fully adjustable trigger threshold allows the desired portion of the waveforms to be used for triggering. Waveforms can also be synchronized to an external sync trigger.	VIDEO SYNC	A built-in sync separator circuit is included specifically for viewing television signals. When using VIDEO SYNC, vertical sync pulses are automatically selected at sweep times of 0.5 SEC/cm to 0.1 mSEC/cm for viewing television frames. Horizontal sync pulses are automatically selected at sweep times of 50 μ SEC/cm to 1 μ SEC/cm for viewing television lines.
LARGE SCREEN	The 130 mm (approx. 5.1 inches) diameter cathode ray tube gives easy-to-read presentation on an 8 x 10 cm rectangular viewing area.	VECTORSCOPE	The unit may be used as a vectorscope to provide a color display exactly as specified by color television manufacturers.
CALIBRATED VOLTAGE SCALES	Accurate measurement of the instantaneous voltages on 11 different attenuator ranges for both Channel A and Channel B.	CALIBRATION SOURCE	A built-in calibrated 1 volt peak-to-peak square wave permits checking and recalibration of the vertical amplifiers without additional equipment.
CALIBRATED SWEEP SPEED	Accurate time measurements on 18 different ranges.	Z-AXIS INPUT	Intensity modulation capability included for time or frequency markers. Compatible with TTL logic; brightness increases in logic high state, decreases in logic low state.
WIDE BANDWIDTH	DC to 10 MHz bandwidth and 35 nSEC rise time assure distortion-free, high resolution presentation at high frequencies.	MECHANICAL FEATURES	Carrying handle with comfortable molded fingergrip also doubles as tilt stand. Locking detent each 22-1/2° allows adjustment of viewing angle. Rear feet support oscilloscope in face-up position and double as cord wrap for storing power cord. Slotted bezel over face of CRT mounts standard oscilloscope camera for making waveform photographs.
WIDE RANGE OF SWEEP SPEEDS	Sweep speed range of 1 μ SEC/cm to 0.5 SEC/cm provides every speed necessary for viewing waveforms from DC to 10 MHz.		

SPECIFICATIONS

VERTICAL AMPLIFIERS (CH A and CH B)

Deflection Factor	0.01 V/cm to 20 V/cm in 11 calibrated ranges in 1-2-5 sequence. Variable between ranges.
Calibration Accuracy	$\pm 5\%$ on all ranges.
Frequency Response	DC: DC to 10 MHz (-3 dB) AC: 2 Hz to 10 MHz (-3 dB).
Risetime	35 nanoseconds.
Overshoot	3% or less at 100 kHz squarewave display.
Ringing	3% or less at 100 kHz squarewave display.
Input Resistance	1 megohm, $\pm 5\%$.
Input Capacity	22 pF (± 3 pF).
Max. Input Voltage	300 V (DC + AC peak) or 600 V p-p.
Operating Modes	Channel A only. Channel B only. Dual-trace automatically chopped at all sweep times of 1 mS/cm and slower; alternate trace automatically selected for all faster sweep times.
Chop Frequency	200 kHz ($\pm 20\%$).
Channel Separation	Better than 60 dB @ 1 kHz.

SWEEP CIRCUITS (Common to CH A and CH B)

Sweep System	Triggered and automatic. In automatic mode, sweep is obtained without input signal.
Sweep Time	1 μ SEC/cm to 0.5 SEC/cm in 18 calibrated ranges, in 1-2-5 sequence. Variable between ranges.
Sweep Time Accuracy	$\pm 5\%$.
Sweep Magnification	Obtained by enlarging the above sweep 5 times from center. Maximum sweep speed becomes 0.2 μ SEC/cm.
Horizontal Linearity	3% or less distortion.

TRIGGERING

Source	INT and EXT (1 V p-p sensitivity). MODE switch selects source of internal trigger; the CH A signal is the triggering source in the CH A and DUAL modes, and the CH B signal is the triggering source in the CH B mode.
Slope	Positive and negative, continuously variable level control; pull for AUTO.
Triggering Range	INT: 20 Hz to 10 MHz (min. 1 cm deflection as measured on cathode ray tube). EXT: DC to 10 MHz.

Video Sync

Vertical and horizontal sync separator circuit provided so that any portion of composite video waveform can be synchronized and expanded for viewing. LINE (horiz.) and FRAME (vert.) sync switched automatically by SWEEP TIME/CM switch.
FRAME = 0.5 SEC/cm to 0.1 mSEC/cm (vertical sync pulses).
LINE = 50 μ SEC/cm to 1 μ SEC/cm (horizontal sync pulses).

HORIZONTAL AMPLIFIER (Horizontal Input through CH B Input)

Deflection Factor	.01 V/cm to 20 V/cm.
Frequency Response	DC to 1 MHz (-3 dB).
Input Resistance	1 megohm (nominal).
Input Capacity	22 pF (± 3 pF).
Maximum Input Voltage	300 V (DC + AC peak) or 600 V p-p.
X-Y Operation	With SWEEP TIME/CM switch in CH B position, the CH A input becomes the Y input (vertical) and the CH B input becomes the X input (horizontal). The CH B position control becomes the horizontal position control.

CALIBRATION VOLTAGE

1 V p-p square wave ($\pm 5\%$) at line frequency.

INTENSITY MODULATION

Voltage	TTL logic-compatible, high logic — increases brightness; low logic — decreases brightness.
Input Resistance	10 k Ω (nominal).

POWER REQUIREMENTS

Input	120 or 240 V AC, $\pm 10\%$, 50/60 Hz, 20 watts. (3-wire line cord, CSA-approved for oscilloscopes.) See Fig. 51.
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PROBES

Model No.	PR-31, PR-35, PR-36, PR-37.
Attenuation	Combination 10:1 and direct.
Input Impedances	10:1 = 10 megohms, 18 pF. Direct = 1 megohm, 120 pF.
Connector	BNC
Tip	Spring-loaded, hook-on tip.

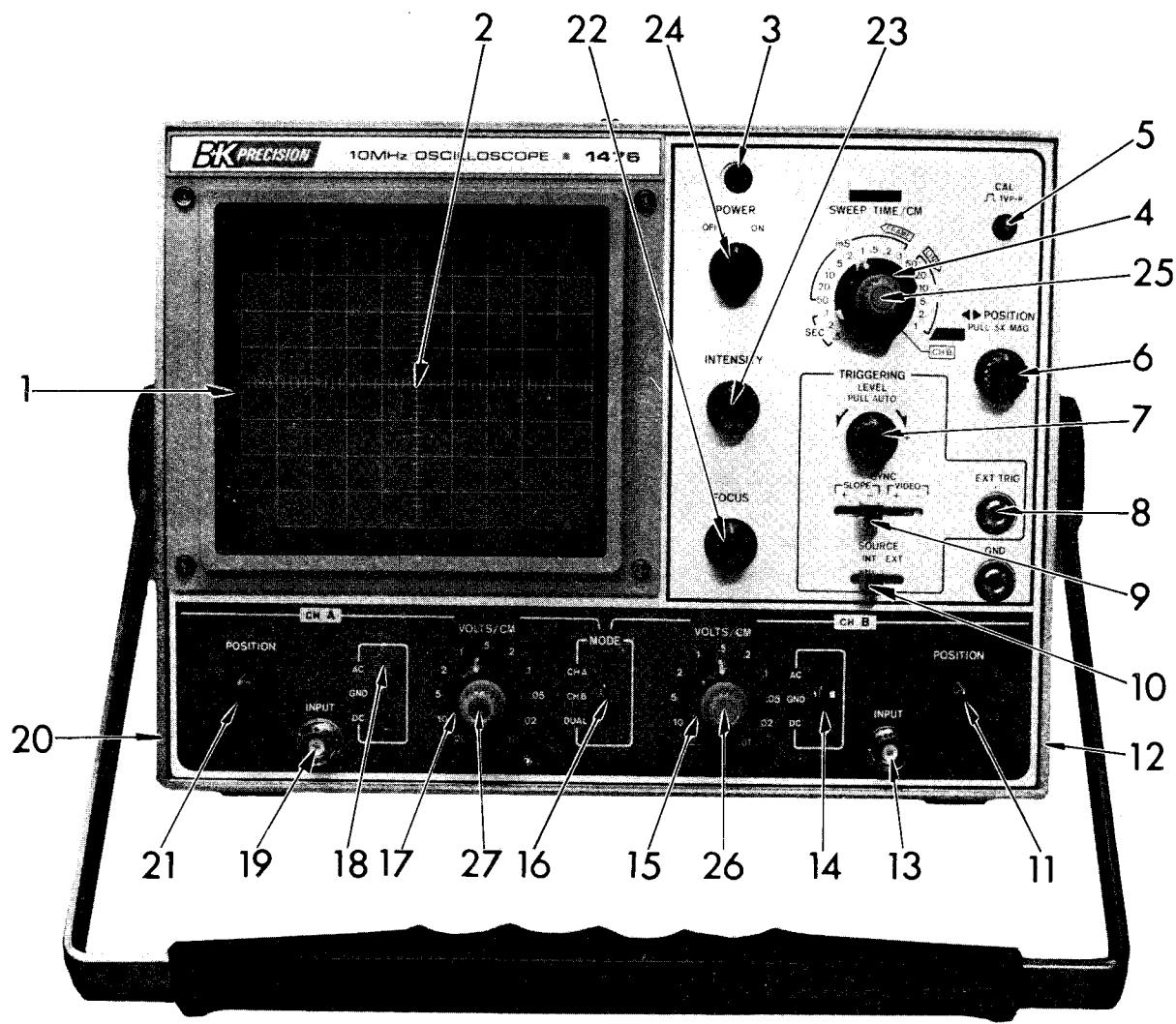


Fig. 1. Front panel controls and indicators.

OPERATOR'S CONTROLS, INDICATORS AND FACILITIES

1. **Cathode Ray Tube (CRT).** This is the screen on which the waveforms are viewed.
2. **Scale.** The 8 x 10 cm graticule provides calibration marks for voltage (vertical) and time (horizontal) measurements.
3. **Pilot Lamp.** Lights when oscilloscope is turned on.
4. **SWEEP TIME/CM Switch.** Horizontal sweep time selector. Selects calibrated sweep times of 1 $\mu\text{SEC}/\text{cm}$ (microsecond per centimeter) to 0.5 SEC/cm in 18 steps. In the CH B position, this switch disables the internal sweep generator and permits the CH B input to provide horizontal sweep.
5. **CAL 1 V P-P Terminal.** Provides calibrated 1 volt peak-to-peak square wave input signal at the line frequency. This is used for calibration of the vertical amplifier attenuators.
6. **↔ POSITION Control.** Rotation adjusts horizontal position of traces (both traces when operated in the dual trace mode). Push-pull switch selects 5X magnification when pulled out (PULL 5X MAG); normal when pushed in.
7. **TRIGGERING LEVEL Control.** Sync level adjustment determines points on waveform slope where sweep starts; (-) equals most negative point of triggering and (+) equals most positive point of triggering. Push-pull switch selects automatic triggering when pulled out (PULL AUTO). When automatic triggering, a sweep is generated even without an input signal.
8. **EXT TRIG Jack.** Input terminals for external trigger signal.
9. **SYNC Switch.** Four-position lever switch with the following positions.
 - SLOPE. The SLOPE positions are used for viewing all waveforms except television composite video signals.
 - (+) Sweep is triggered on positive-going slope of waveform.
 - (-) Sweep is triggered on negative-going slope of waveform.
- VIDEO. In the VIDEO positions, the sync pulses of a television composite video signal are used to trigger the sweep; the vertical sync pulses (frame) are automatically selected for sweep times of 0.5 SEC/cm to 0.1 mSEC/cm, and horizontal sync pulses (line) are automatically selected for sweep times of 50 $\mu\text{SEC}/\text{cm}$ to 1 $\mu\text{SEC}/\text{cm}$.
 - (+) Sweep is triggered on positive-going sync pulse.
 - (-) Sweep is triggered on negative-going sync pulse.
10. **SOURCE Switch.** Selects triggering source for the sweep.
 - INT Sweep is triggered by CH A signal when MODE switch is in CH A or DUAL position.
 - Sweep is triggered by Channel B signal when MODE switch is in CH B position.
 - EXT Sweep is triggered by an external signal applied at the EXT TRIG jack 8.
11. **Channel B POSITION Control.** Vertical position adjustment for Channel B trace. Becomes horizontal position adjustment when SWEEP TIME/CM switch 4 is in the CH B position.
12. **Channel B DC BAL Adjustment.** Vertical DC Balance adjustment for Channel B trace.
13. **Channel B INPUT Jack.** Vertical input jack of Channel B. Jack becomes external horizontal input when SWEEP TIME/CM switch 4 is in the CH B position.
14. **Channel B DC-GND-AC Switch.**
 - DC Direct input of AC and DC component of input signal.
 - GND Opens signal path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing DC measurements.
 - AC Blocks DC component of input signal.
15. **Channel B. VOLTS/CM Switch.** Vertical attenuator for Channel B. Vertical sensitivity is calibrated in 11 steps from .01 to 20 volts per cm. This control adjusts horizontal sensitivity when the SWEEP TIME/CM switch 4 is in the CH B position.
16. **MODE Switch.** Three-position lever switch; selects the basic operating modes of the oscilloscope.
 - CH A Only the input signal to Channel A is displayed as a single trace.
 - DUAL Dual-trace operation; both the Channel A and Channel B input signals are displayed on two separate traces.
 - CH B Only the input signal to Channel B is displayed as a single trace.
17. **Channel A VOLTS/CM Switch.** Vertical attenuator for Channel A. Vertical sensitivity is calibrated in 11 steps, from .01 to 20 volts per cm.
18. **Channel A DC-GND-AC Switch.**
 - DC Direct input of AC and DC component of input signal.
 - GND Opens signal path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing DC measurements.
 - AC Blocks DC component of input signal.
19. **Channel A INPUT Jack.** Vertical input jack of Channel A.
20. **Channel A DC BAL Adjustment.** Vertical DC balance adjustment for Channel A trace.
21. **Channel A POSITION Control.** Vertical position adjustment for Channel A trace.
22. **FOCUS Control.**
23. **INTENSITY Control.** Clockwise rotation increases the brightness of trace.
24. **POWER Switch.** Turns unit on and off.

25. **VARIABLE Control.** Fine sweep time adjustment. In the extreme clockwise position (CAL), the sweep time is calibrated.
26. **CH B VARIABLE Control.** CH B vertical attenuator adjustment. Fine control of CH B vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.
27. **CH A VARIABLE Control.** CH A vertical attenuator adjustment. Fine control of CH A vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.
28. **INT MOD Jack.** Intensity modulation (Z-axis) input.

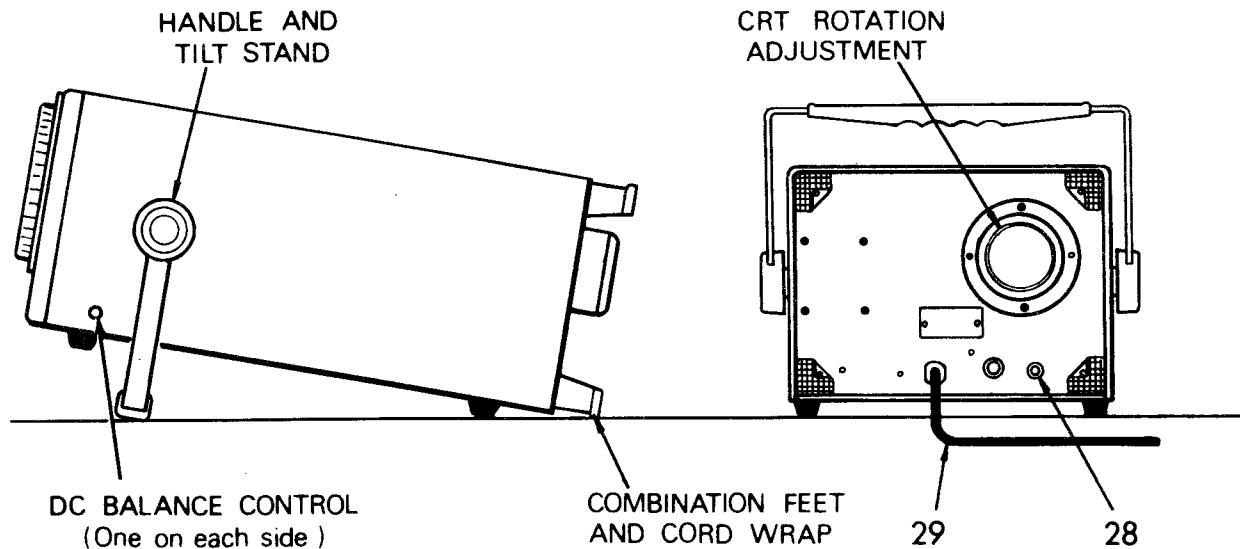


Fig. 2. Rear and side panel facilities.

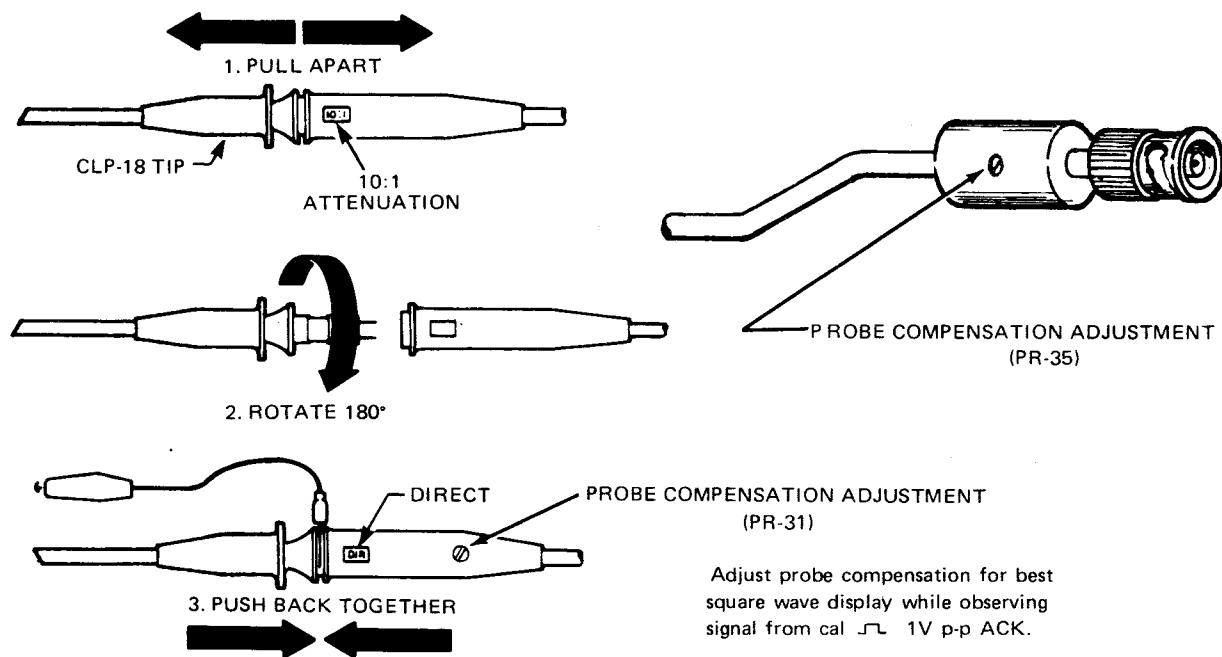


Fig. 3. Probe details.

OPERATING INSTRUCTIONS

INITIAL STARTING PROCEDURE

1. Set POWER switch 24 to OFF position.
2. Connect power cord 29 to a 117-volt, 50/60 Hz outlet.
3. Set CH A POSITION control 21, CH B POSITION control 11 and $\blacktriangle\blacktriangleright$ POSITION control 6 to the centers of their ranges.
4. Pull TRIGGERING LEVEL control 7 to the AUTO position.
5. Set CH A DC-GND-AC switch 18 and CH B DC-GND-AC switch 14 to the GND positions.
6. Set MODE switch 16 to the CH A position for single-trace operation or the DUAL position for dual-trace operation.
7. Turn on oscilloscope by turning POWER switch 24 to ON position. Pilot lamp 3 will light.
8. Wait a few seconds for the cathode ray tube (CRT) to warm up. A trace (two traces if operating in the DUAL mode) should appear on the face of the CRT.
9. If no trace appears, increase (clockwise) the setting of INTENSITY control 23 until the trace is easily observed.
10. Adjust FOCUS control 22 and INTENSITY control 23 for the thinnest, sharpest trace.
11. Readjust position controls 6, 21 and 11 if necessary, to center the traces.
12. Check for proper adjustment of DC BAL controls 12 and 20 as described in the MAINTENANCE AND CALIBRATION portion of this manual. These adjustments require checking only periodically.

The oscilloscope is now ready for making waveform measurements.

CAUTION

Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. Reduce intensity or keep the spot in motion by causing it to sweep.

SINGLE-TRACE WAVEFORM OBSERVATION

Either Channel A or Channel B can be used for single-trace operation. For simplicity, Channel A is used in the following instructions.

1. Perform the steps of the "Initial Starting Procedure" with the MODE switch 16 in the CH A position. Then connect the probe cable to the CH A INPUT jack 19. The following instructions assume the use of the B & K-Precision Model PR-31 combination probes.
2. For all except low-amplitude waveforms, the probes are set for 10:1 attenuation. For low-amplitude waveforms (below 0.5 volt peak-to-peak), set the probe for DIRect. See Fig. 3 for changing the probes from 10:1 to DIRect, or vice versa. The probe has a 10 megohm input impedance with only 18 pF shunt capacitance in

the 10:1 position and 1 megohm with 120 pF shunt capacitance in the DIRect position. The higher input impedance (low-capacity position) should be used when possible, to decrease circuit loading.

3. Set CH A DC-GND-AC switch 18 to AC for measuring only the AC component (this is the normal position for most measurements and must be used if the point being measured includes a large DC component). Use the DC position for measuring both the AC component and the DC reference, and any time a very low frequency waveform (below 5 Hz) is to be observed. The GND position is required only when a zero-signal ground reference is required, such as for DC voltage readings.
4. Connect ground clip of probe to chassis ground of the equipment under test. Connect the tip of the probe to the point in the circuit where the waveform is to be measured.

WARNING

- a. If the equipment under test is a transformerless AC powered item, use an isolation transformer to prevent dangerous electrical shock.
- b. The peak-to-peak voltage at the point of measurement should not exceed 600 volts when using the DIRect position of the probe.
5. Set CH A VOLTS/CM switch 17 to a position that gives 2 to 6 cm (two to six large squares on the scale) vertical deflection. The display on the screen will probably be unsynchronized. The remaining steps are concerned with adjusting synchronization and sweep speed, which presents a stable display showing the desired number of waveforms. *Any signal that produces at least 1 cm vertical deflection develops sufficient trigger signal to synchronize the sweep.*
6. Set SOURCE switch 10 to the INT position. This provides internal sync so that the waveform being observed is also used to trigger the sweep. Most waveforms should be viewed using internal sync. When an external sync source is required, the SOURCE switch should be placed in the EXT position and a cable should be connected from the EXT TRIG jack 8 to the external sync source.
7. Set SYNC switch 9 to the VIDEO(+) or (-) positions for observing television composite video waveforms or to the SLOPE (+) or SLOPE (-) positions for observing all other types of waveforms. Use the (+) position if the sweep is to be triggered by a positive-going wave, or the (-) position if the sweep is to be triggered by a negative-going wave. If the type of waveform is unknown, the SLOPE (+) position may be used.
8. Readjust TRIGGERING LEVEL control 7 to obtain a synchronized display without jitter. As a starting point, the control may be pushed in and rotated to any point that will produce a sweep, which is usually somewhere in the center portion of its range. The trace will disappear if there is inadequate signal to trigger the sweep, such as when measuring DC or extremely low amplitude waveforms. If no sweep can be obtained,

pull the control out (PULL AUTO) for automatic triggering.

- Set SWEEP TIME/CM switch 4 for the desired number of waveforms. This control may be set for viewing only a portion of a waveform, but the trace becomes progressively *dimmer* as a smaller portion is displayed. This is because the sweep speed increases but the sweep repetition rate does not change.

NOTE

When using very fast sweep speed at low repetition rates, the operator may wish to operate with the intensity control toward maximum. Under these conditions, a retrace "pip" may appear at the extreme left of the trace. This does not in any way affect the oscilloscope operation and may be disregarded.

- After obtaining the desired number of waveforms, as in step 9, it is sometimes desirable to make a final adjustment of the TRIGGERING LEVEL control 7. The (-) direction selects the most negative point on the waveform at which sweep triggering will occur and the (+) direction selects the most positive point on the

waveform at which sweep triggering will occur. The control may be adjusted to start the sweep on any desired portion of the waveform.

- For a close-up view of a portion of the waveform, pull outward on the $\blacktriangle\blacktriangleright$ POSITION control 6. This expands the sweep by a factor of five (5X magnification) and displays only the *center* portion of the sweep. To view a portion to the left of center, turn the $\blacktriangle\blacktriangleright$ POSITION control clockwise, and to view portion to the right of center, turn the control counterclockwise. Push inward on the control to return the sweep to the normal, non-magnified condition.

CALIBRATED VOLTAGE MEASUREMENT (See Fig. 4)

Peak voltages, peak-to-peak voltages, DC voltages and voltages of a specific portion of the complex waveform are easily and accurately measured on the Model 1476 Dual-Trace Triggered Sweep Oscilloscope.

- Adjust controls as previously instructed to display the waveform to be measured.
- Set CH A VOLTS/CM switch 17 for the maximum vertical deflection possible without exceeding the limits of the vertical scale.

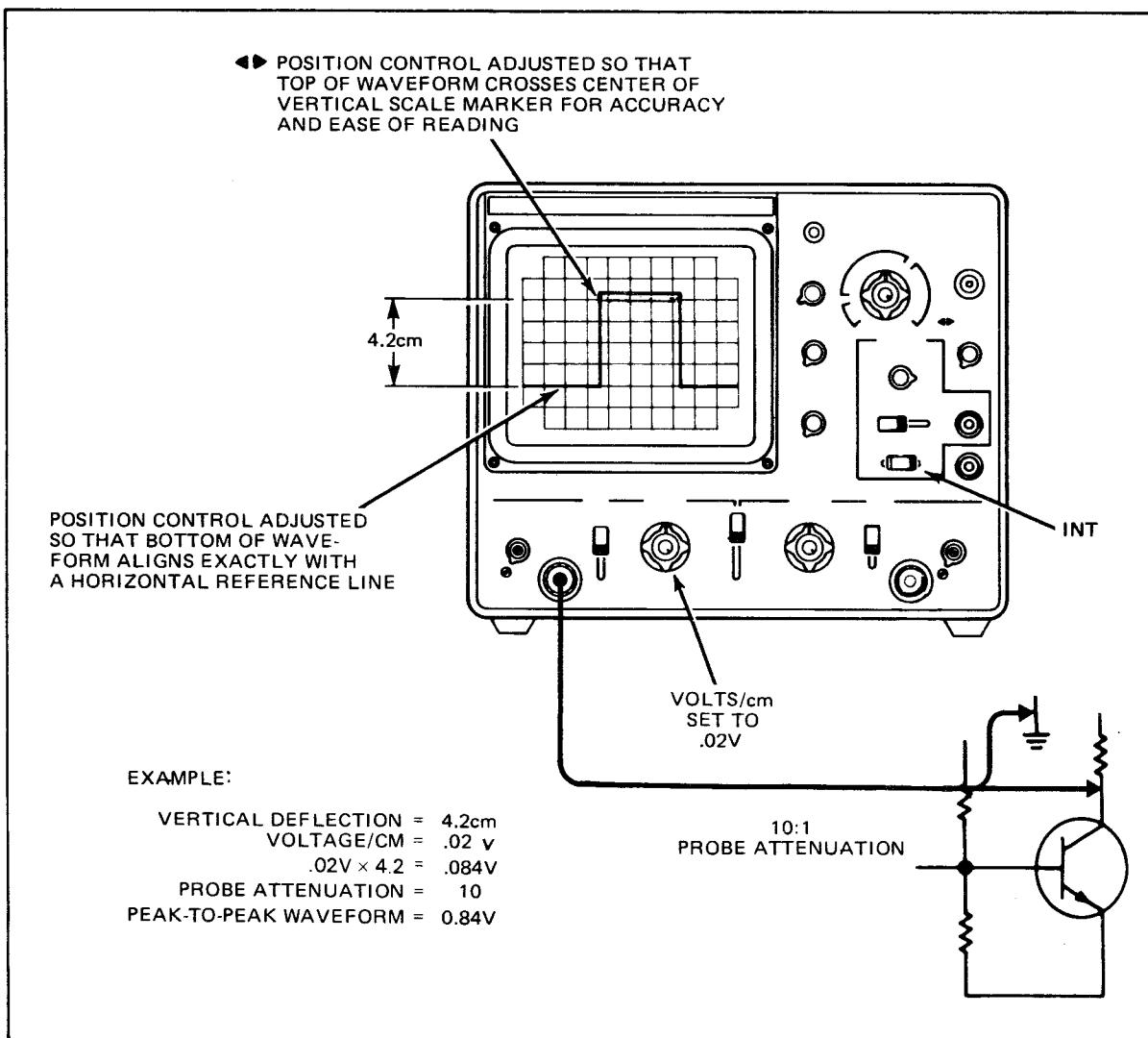


Fig. 4. Typical voltage measurement.

3. Read the amount of vertical deflection (in cm) from the scale. The CH A POSITION control 21 may be readjusted to shift the reference point for easier scale reading if desired. When measuring a DC voltage, adjust the CH A POSITION control 21 to a convenient reference with the CH A DC-GND-AC switch 18 in the GND position, then note the amount the trace is deflected when the switch is placed in the DC position. The trace deflects upward for a positive voltage input and downward for a negative voltage input.
4. Calculate the voltage reading as follows: Multiply the vertical deflection (in cm) by the VOLTS/CM control 17 setting (see example in Fig. 4) Don't forget that the voltage reading displayed on the oscilloscope is only 1/10th the actual voltage being measured when the probe is set for 10:1 attenuation. The actual voltage is displayed when the probe is set for DIRect measurement.
5. Calibration accuracy of this oscilloscope may be occasionally checked by observing the 1 volt peak-to-peak square wave signal available at the CAL 1V P-P jack 5. This calibrated source should read exactly 1 volt peak-to-peak. If a need for recalibration is indicated, see the "MAINTENANCE AND CALIBRATION" section of the manual for complete procedures.

CALIBRATED TIME MEASUREMENT (See Fig. 5)

Pulse width, waveform periods, circuit delays and all other waveform time durations are easily and accurately measured on this oscilloscope. Calibrated time measurements from .5 second down to 0.1 microsecond are possible. At low sweep speeds, the entire waveform is not visible at one time. However, the bright spot can be seen moving from left to right across the screen, which makes the beginning and ending points of the measurement easy to spot.

1. Adjust controls as previously described for a stable display of the desired waveform.
2. Set the SWEEP TIME/CM control 4 for the largest possible display of the waveform segment to be measured, usually one cycle.
3. If necessary, readjust the TRIGGERING LEVEL control 7 for the most stable display.
4. Read the amount of horizontal deflection (in cm) between the points of measurement. The \blacktriangleleft POSITION control 6 may be readjusted to align one of the measurement points with a vertical scale marker for easier reading.
5. Calculate the time duration as follows: Multiply the

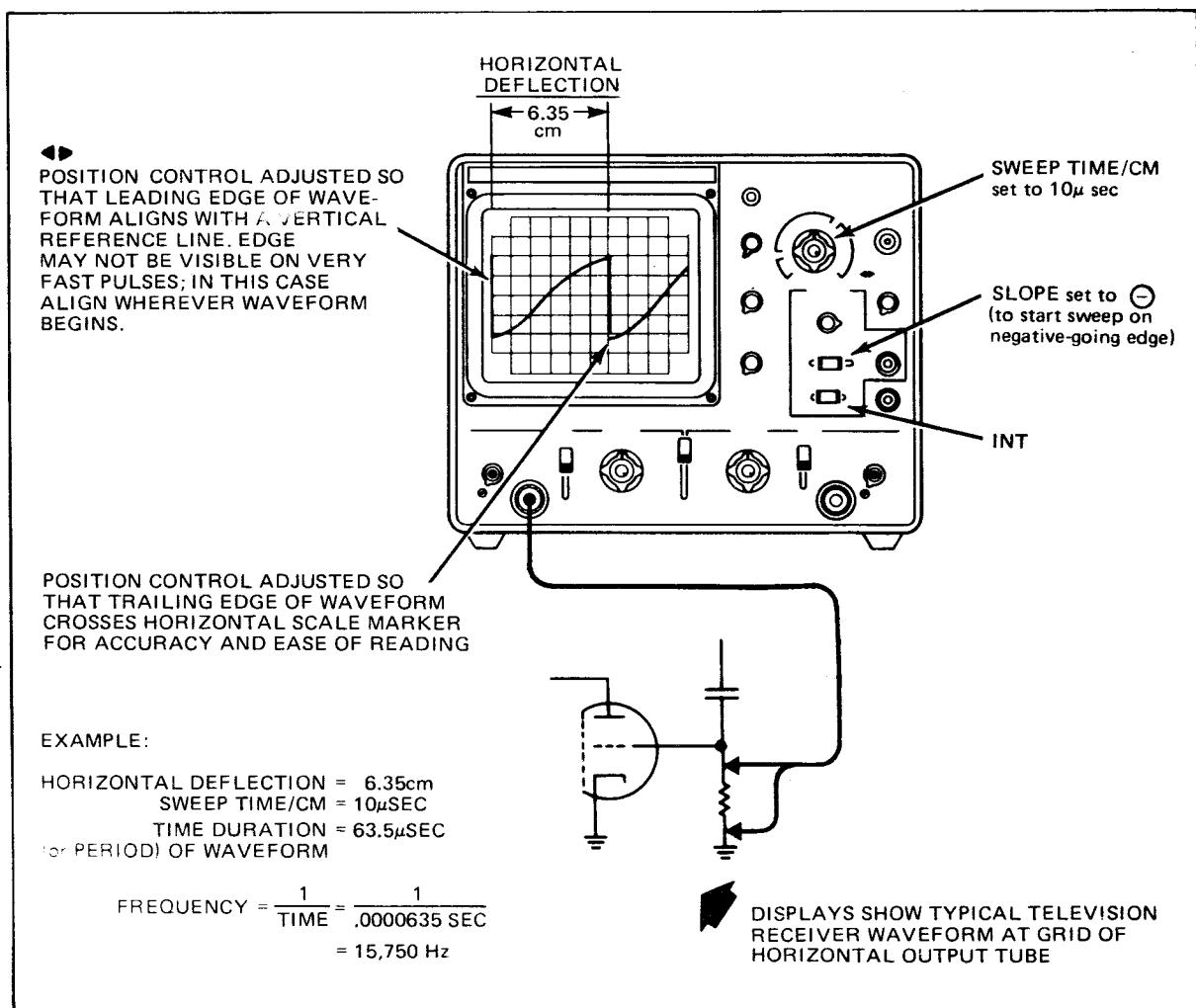


Fig. 5. Typical time measurement.

horizontal deflection (in cm) by the SWEEP TIME/CM switch 4 setting (see example in Fig. 5). Remember, when the 5X magnification is used, the result must be divided by 5 to obtain the actual time duration.

6. Time measurements often require external sync. This is especially true when measuring delays. The sweep is started by a sync signal from one circuit and the waveform measured in a subsequent circuit. This allows measurement of the display between the sync pulse and the subsequent waveform. To perform such measurements using external sync, use the following steps:
 - a. Set the SOURCE switch 10 to the EXT position.
 - b. Connect a cable from the EXT TRIG jack 8 to the source of sync signal. Use a short shielded cable.
 - c. Set the SYNC switch 9 to the SLOPE (+) or (-) position for the proper polarity for the sync signal.
 - d. Readjust the TRIGGERING LEVEL control 7 if necessary for a stable waveform.
 - e. If measuring a delay, measure the time from the start of the sweep to the start of the waveform.
7. Another excellent method for measuring time delays is with dual-trace operation. The procedures are given in the "DUAL-TRACE APPLICATIONS" section of the manual.

EXTERNAL HORIZONTAL INPUT (X-Y OPERATION)

For some measurements, an *external* horizontal deflection signal is required. This is also referred to as an X-Y measurement, where the Y input provides vertical deflection and the X input provides horizontal deflection. The horizontal input may be a sinusoidal wave, such as for phase measurement, or an external sweep voltage. This input must be 10 mV per cm of deflection or greater; thus any voltage of 100 mV or greater is sufficient for satisfactory operation. To use an external horizontal input, use the following procedure:

1. Set the SWEEP TIME/CM switch 4 fully clockwise to the CH B position.
2. Use the Channel A probe for the vertical input and the Channel B probe for the horizontal input.
3. Adjust the amount of horizontal deflection with the CH B VOLTS/CM control 15.
4. The CH B POSITION control 11 now serves as the horizontal position control, and the \leftrightarrow POSITION control is disabled.

NOTE

Do NOT use the PULL 5X MAG control during X-Y operation. Use the CH B VOLTS/CM control to adjust horizontal gain.

5. All sync controls are disconnected and have no effect.

Z-AXIS INPUT

The trace displayed on the screen may be intensity modulated (Z-axis input) where frequency or time-scale marks are required. A TTL compatible signal applied at the INT MOD (intensity modulation) jack 24 on the rear of the oscilloscope will provide alternate brightness and blanking of the trace. See Fig. 6.

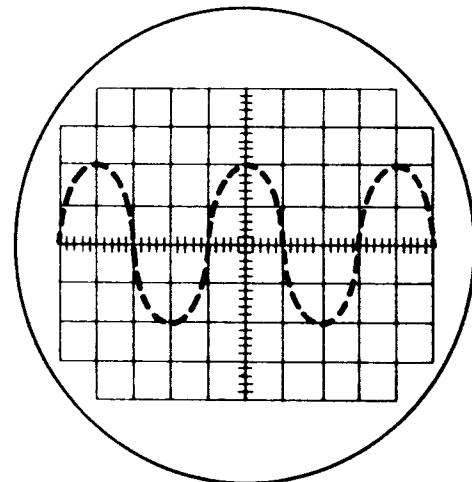


Fig. 6. Oscilloscope trace with Z-axis input.

DUAL-TRACE WAVEFORM OBSERVATION (Refer to Fig. 7)

In observing simultaneous waveforms on channels A and B, it is necessary that the waveforms be related in frequency or that one of the waveforms be synchronized to the other although the basic frequencies may be different. An example of this is in checking a frequency divider or multiplier. The reference, or "clock" frequency can be used on Channel A, for example, and the multiple or submultiple of this reference frequency will be displayed on Channel B. In this way, when the waveform display of Channel A is synchronized, the display on Channel B will also be in sync with the Channel A display. If two waveforms having no phase or frequency relationship to each other are displayed simultaneously, it will be difficult if not impossible to lock both waveforms in sync for any useful observation.

To display two waveforms simultaneously for observation, use the following procedure:

1. Perform the steps of the "Initial Starting Procedure."
2. Connect oscilloscope probe cables to both the CH A and CH B INPUT jacks 19 and 13.
3. If the recommended B & K-Precision Model PR-31 oscilloscope probes are used, 10 : 1 attenuation should be used except for waveforms of 0.5 volt peak-to-peak or less. For the lower amplitude waveforms the DIRect position should be used. See Fig. 3 for changing the probe from 10:1 to DIR or vice versa. Whenever possible, use the high impedance, low capacity 10:1 position to minimize circuit loading.
4. Set MODE switch 16 to the DUAL position. Two traces should appear on the screen.
5. Adjust CH A and CH B POSITION controls 21 and 11 to place the Channel A trace above the Channel B trace, and adjust both traces to a convenient reference mark on the scale.
6. Set both the CH A and CH B DC-GND-AC switches 18 and 14 to the AC position. This is the position used for most measurements and must be used if the points being measured include a large DC component.

7. 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. The signal to which the waveform will be synchronized must be applied to the Channel A input for internal sync operation.

WARNING

- a. If the equipment under test is a transformerless AC unit, use an isolation transformer to prevent dangerous electrical shock.
 - b. The peak-to-peak voltage at the point of measurement should not exceed 600 volts, if the probe is used in the DIR position.
8. Set the VOLTS/CM controls 15 and 17 for Channels A and B to a position that gives 2 to 3 cm vertical deflection. The displays on the screen will probably be unsynchronized. The remaining steps, although similar to those outlined for single-trace operation, describe the procedure for obtaining stable, synchronized displays.
9. Set the SOURCE switch 10 to the INT position. This provides internal sync so that the Channel A waveform being observed is also used to trigger the sweep. Often in dual-trace operation, a sync source other than the measurement point for Channel A is required. In this case set the SOURCE switch to the EXT (external) position and connect a cable from the EXT TRIG jack 8 to the sync source.
10. Set the SYNC switch 9 to the VIDEO(+) or (-) positions for observing television composite video waveforms, or to the SLOPE (+) or SLOPE (-) positions for observing all other types of waveforms.

- Use the (+) positions if the sweep is to be triggered by a positive-going wave, or to the (-) position if the sweep is to be triggered by a negative-going wave.
11. Adjust TRIGGERING LEVEL control 7 to obtain a stable, synchronized sweep. As a starting point, the control may be pushed in and rotated to any point that will produce a sweep, which is usually somewhere in the center portion of its range. The trace will disappear if there is inadequate signal to trigger the sweep, such as when measuring extremely low amplitude signals. If no sweep can be obtained, pull out the control (PULL AUTO) for automatic triggering.
12. Set SWEEP TIME/CM switch 4 for the desired number of waveforms. This control may be set for viewing only a portion of a waveform, but the trace becomes progressively dimmer as a smaller portion is displayed.
13. After obtaining the desired number of waveforms as in step 12, it is sometimes desirable to make a final adjustment of the TRIGGERING LEVEL control 7. The (-) direction of rotation selects the most negative point on the sync waveform at which sweep triggering will occur and the (+) direction selects the most positive point on the sync waveform at which sweep triggering will occur. The control may be adjusted to start the sweep on any desired portion of the sync waveform.
14. The observed waveforms of Channels A and B can be expanded by a factor of 5 by pulling outward on the ▶ POSITION control 6. This control can then be rotated clockwise or counterclockwise to view the left and right extremes of the waveform displays as desired. Push inward on the control to return the sweep to the normal, non-magnified condition.
15. Calibrated voltage measurements, calibrated time measurements and operation with Z-axis input are identical

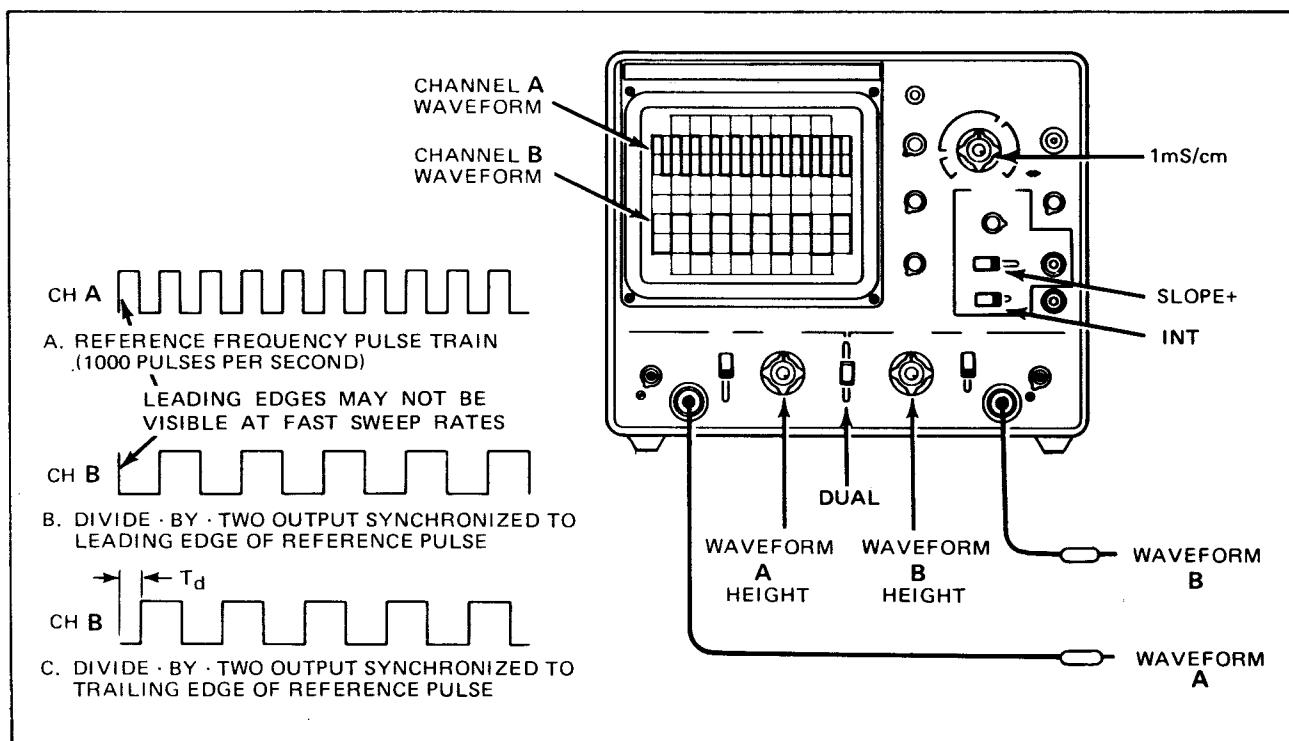


Fig. 7. Waveforms in divide-by-two circuit.

to those previously described for single-trace operation. Either the Channel A or Channel B vertical adjustment controls can be used as required in conjunction with the horizontal sweep controls to obtain the required amplitude or time interval measurements. This can be done either by using the dual display facilities such as the DUAL position of the MODE switch or by reverting to single-trace operation, using the CH A or CH B positions of the MODE switch.

DUAL-TRACE APPLICATIONS

INTRODUCTION

The most obvious and yet the most useful feature of the dual-trace oscilloscope is that it has the capability for viewing simultaneously two waveforms that are frequency- or phase-related, or that have a common synchronizing voltage, such as in digital circuitry. Simultaneous viewing of "Cause and Effect" waveforms is an invaluable aid to the circuit designer or the repairman. Several possible applications of the dual-trace oscilloscope will be reviewed in detail to familiarize the user further in the basic operation of this oscilloscope.

FREQUENCY DIVIDER WAVEFORMS

Fig. 7 illustrates the waveforms involved in a basic divide-by-two circuit. Fig. A indicates the reference or "clock" pulse train. Fig. B and Fig. C indicate the possible outputs of the divide-by-two circuitry. Fig. 7 also indicates the settings of specific oscilloscope controls for viewing these waveforms. In addition to these basic control settings, the TRIGGERING LEVEL control, as well as the Channel A and Channel B vertical position controls should be set as required to produce suitable displays. In the drawing of Fig. 7, the waveform levels of 2 cm are indicated. The Channel B waveform may be either that indicated in Fig. 7B or 7C. In Fig. 7C the divide-by-two output waveform is shown for the case where the output circuitry responds to a negative-going waveform. In this case, the output waveform is shifted with respect to the leading edge of the reference frequency pulse by a time interval corresponding to the pulse width.

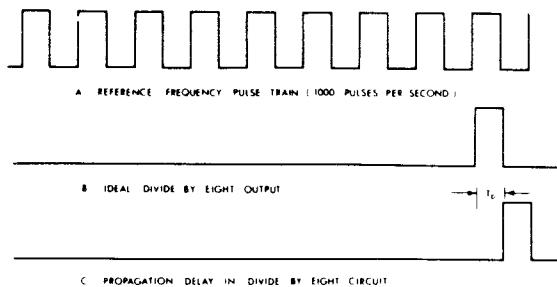


Fig. 8. Waveforms in divide-by-eight circuit.

DIVIDE-BY-EIGHT CIRCUIT WAVEFORMS

Fig. 8 indicates waveform relationships for a basic divide-by-eight circuit. The basic oscilloscope settings are identical to those used in Fig. 7. The reference frequency of Fig. 8A is supplied to the Channel A input, and the divide-by-eight output is applied to the Channel B input. Fig. B indicates the ideal time relationship between the input pulses and the output pulse.

In an application where the logic circuitry is operating at or near its maximum design frequency, the accumulated rise time effects of the consecutive stages produce a built-in time propagation delay which can be significant in a critical circuit and must be compensated for. Fig. 8C indicates the possible time delay which may be introduced into a frequency divider circuit. By use of the dual-trace oscilloscope the input and output waveforms can be superimposed to determine the exact amount of propagation delay that occurs. Significant propagation delay may occur in any circuit with several consecutive stages. Using the procedures given for calibrated time measurement, T_p can be calculated. A more precise measurement can be obtained if the T_p portion of the waveform is expanded horizontally. This may be done by pulling the PULL 5X MAG control. It also may be possible to view the desired portion of the waveform at a faster sweep speed.

DIGITAL CIRCUIT TIME RELATIONSHIPS

A dual-trace oscilloscope is a necessity in designing, manufacturing and servicing digital equipment. A dual-trace oscilloscope permits easy comparison of time relationships between two waveforms.

In digital equipment it is common for a large number of circuits to be synchronized, or to have a specific time relationship to each other. Many of the circuits are frequency dividers as previously described, but waveforms are often time-related in many other combinations. In the dynamic state, some of the waveforms change, depending upon the input or mode of operation. Fig. 9 shows a typical digital circuit and identifies several of the points at which waveform measurements are appropriate. The accompanying Fig. 10 shows the normal waveforms to be expected at each of these points and their timing relationships. The individual waveforms have limited value unless their timing relationship to one or more of the other waveforms is known to be correct. The dual-trace oscilloscope allows this comparison to be made. In typical fashion, waveform No. 3 would be displayed on Channel A and waveform No. 4 thru No. 8 and No. 10, would be successively displayed on Channel B, although other timing comparisons may be desired. Waveforms No. 11 through No. 13 would probably be displayed on Channel B in relationship to waveform No. 8 or No. 4 on Channel A.

In the family of time-related waveforms shown in Fig. 10, waveform No. 8 or No. 10 is an excellent sync source for viewing all of the waveforms; there is but one triggering pulse per frame. For convenience, external sync using waveform No. 8 or No. 10 as the sync source may be desirable. With external sync, any of the waveforms may be displayed without readjustment of the sync controls. Waveforms No. 4 thru No. 7 should not be used as the sync source because they do not contain a triggering pulse at the start of the frame. It would not be necessary to view the entire waveforms as shown in Fig. 10 in all cases. In fact, there are many times when a closer examination of a portion of the waveforms would be appropriate. In such cases, it is recommended that the sync remain unchanged while the sweep speed or 5X magnification be used to expand the waveform display.

GATED RINGING CIRCUIT

The circuit and waveforms of Fig. 11 are shown to demonstrate the type of circuit in which the dual-trace oscilloscope is effective both in design and troubleshooting

applications. The basic oscilloscope control settings are identical to those of Fig. 7. Waveform A is the reference waveform and is applied to Channel A input. All other waveforms are sampled at Channel B and compared to the reference waveform of Channel A. The frequency burst signal can be examined more closely either by increasing

the sweep time per centimeter to .5 mSEC per centimeter or by pulling out on the $\blacktriangle\blacktriangleright$ POSITION control to obtain 5 times magnification. This control can then be rotated as desired to center the desired waveform information on the oscilloscope screen.

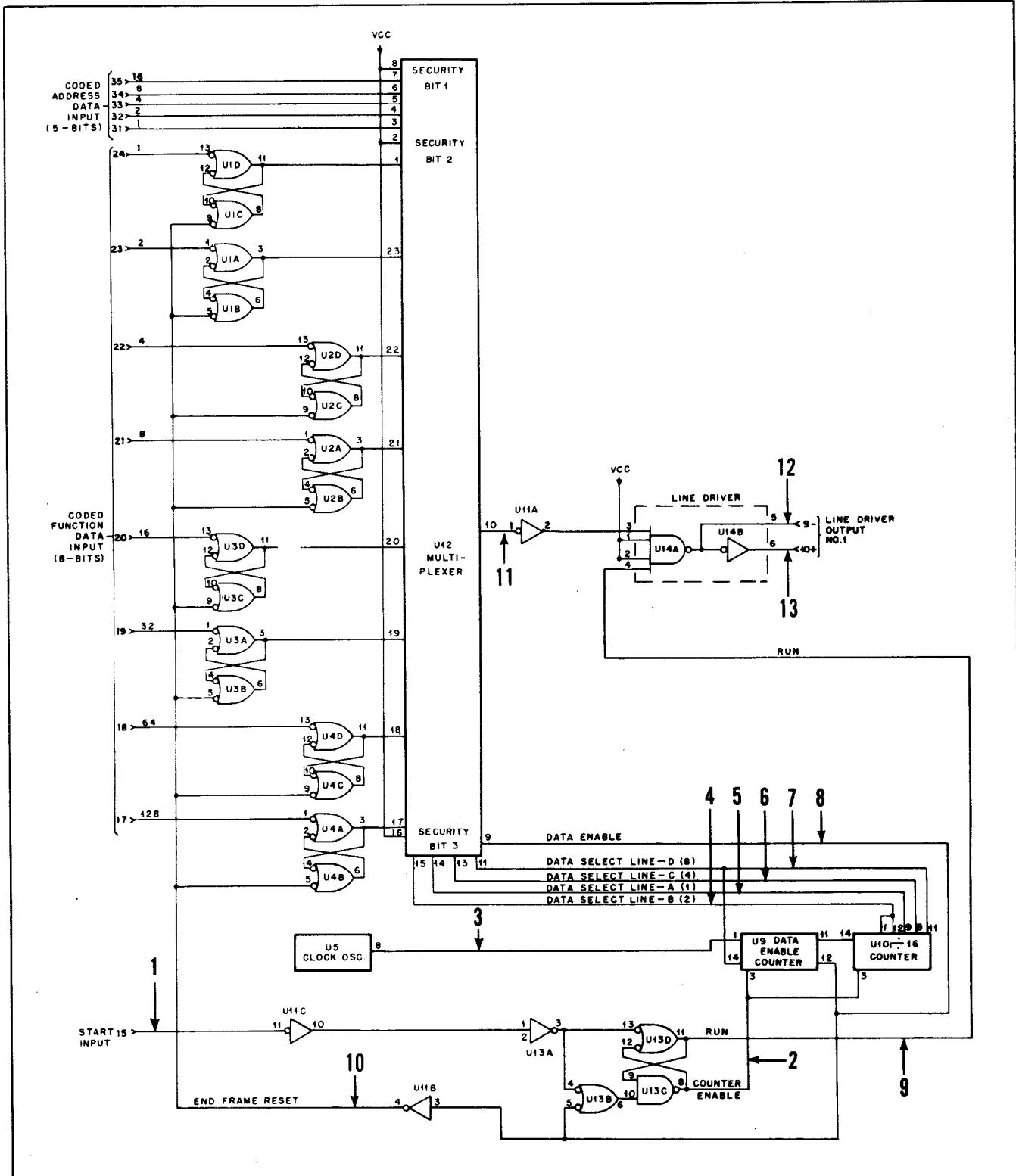


Fig. 9. Typical digital circuit using several time-related waveforms.

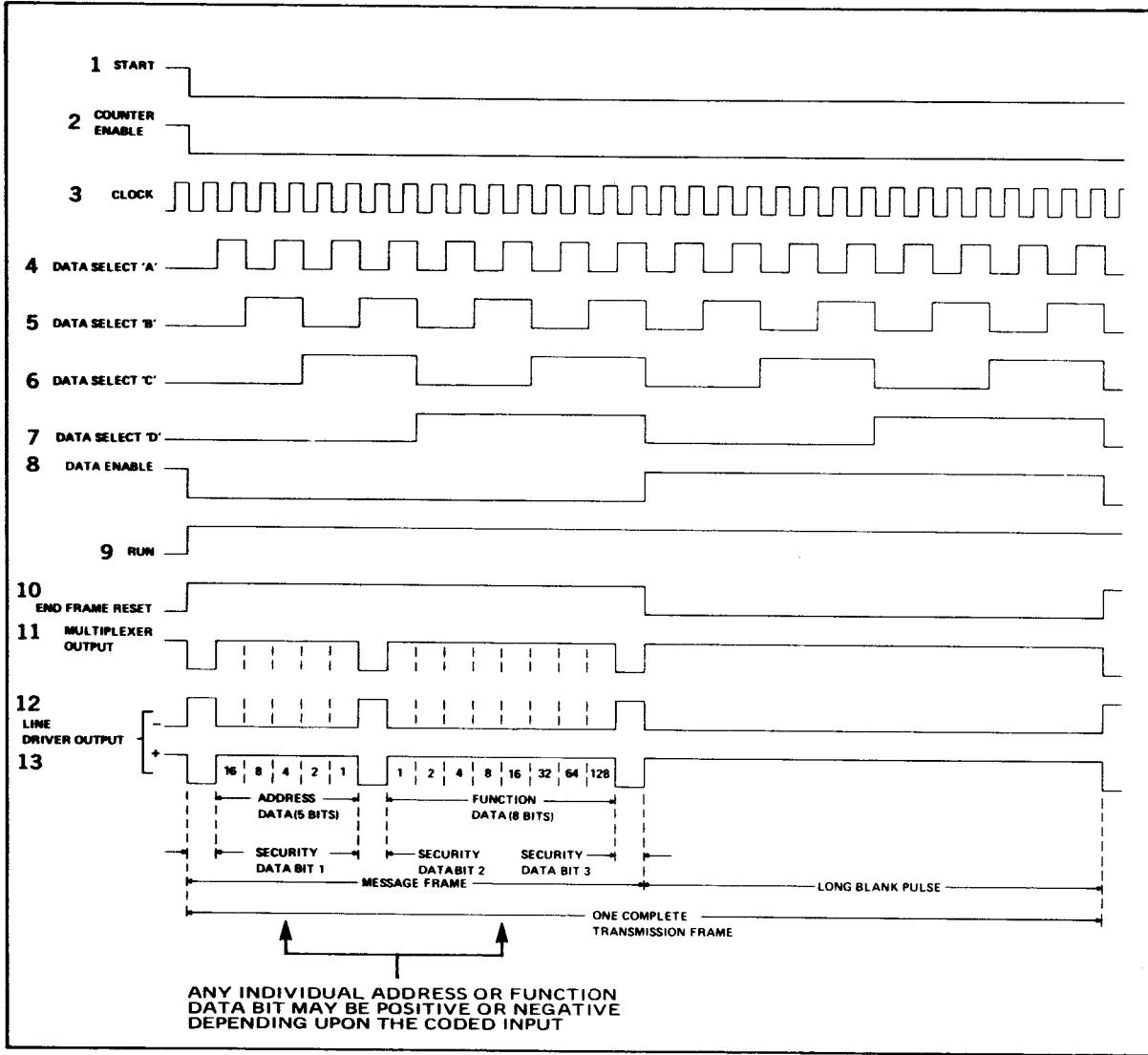


Fig. 10. Family of time-related waveforms from typical digital circuit in Fig. 9.

DELAY LINE TESTS

The dual-trace feature of the oscilloscope can also be used to determine the delay times of transmission type delay lines as well as ultrasonic type delay lines. The input pulse can be used to trigger or synchronize the Channel A display and the delay line output can be observed on Channel B. A repetitive type pulse will make it possible to synchronize the displays. The interval between repetitive pulses should be large compared to the delay time to be investigated. In addition to determining delay time, the pulse distortion inherent in the delay line can be determined by examination of the delayed pulse observed on the Channel B waveform display. Fig. 12 demonstrates the typical oscilloscope settings as well as the basic test circuit. Typical input and output waveforms are shown on the oscilloscope display. Any pulse stretching and ripple can be observed and evaluated. The results of modifying the input and output terminations can be observed directly.

A common application of the delay line checks is found in color television receivers. Fig. 13 shows the oscilloscope settings and typical circuit connections to

check the "Y" delay line employed in the video amplifier section. The input waveform and the output waveform are compared for delay time, using the horizontal sync pulse of the composite video signal for reference. The indicated delay is approximately one microsecond. In addition to determining the delay characteristics of the line, the output waveform reveals any distortion that may be introduced from an impedance mismatch or a greatly attenuated output resulting from an open line.

STEREO AMPLIFIER SERVICING

Another convenient use for dual-channel oscilloscopes is in troubleshooting stereo amplifiers. If identical channel amplifiers are used and the output of one is weak, distorted or otherwise abnormal, the dual-trace oscilloscope can be efficiently used to localize the defective state. With an identical signal applied to the inputs of both amplifiers, a side-by-side comparison of both units can be made by progressively sampling identical signal points in both amplifiers. When the defective or malfunctioning stage has been located, the effects of whatever troubleshooting and repair methods are employed can be observed and analyzed immediately.

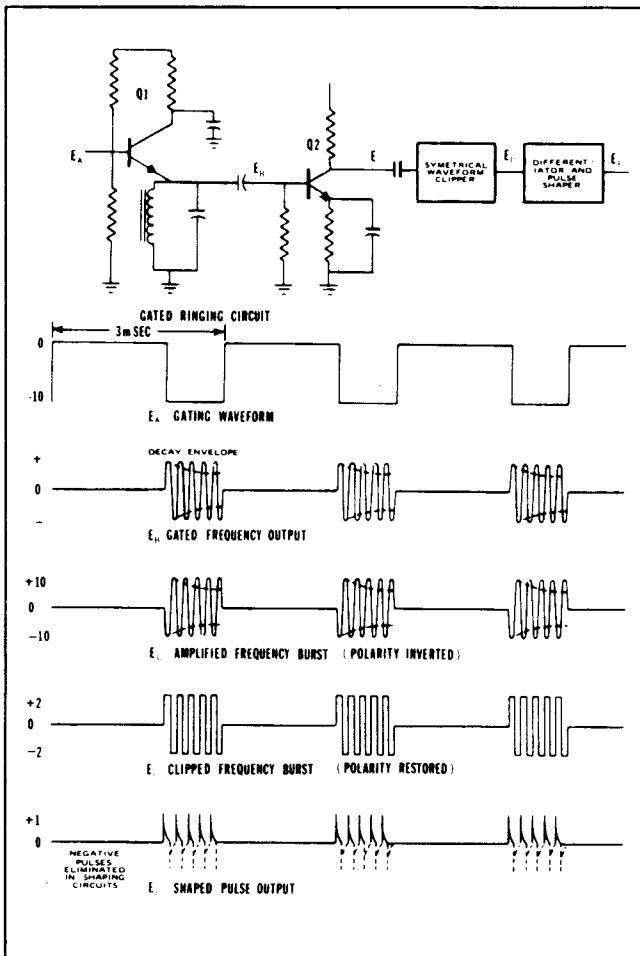


Fig. 11. Gated ringing circuit and waveform.

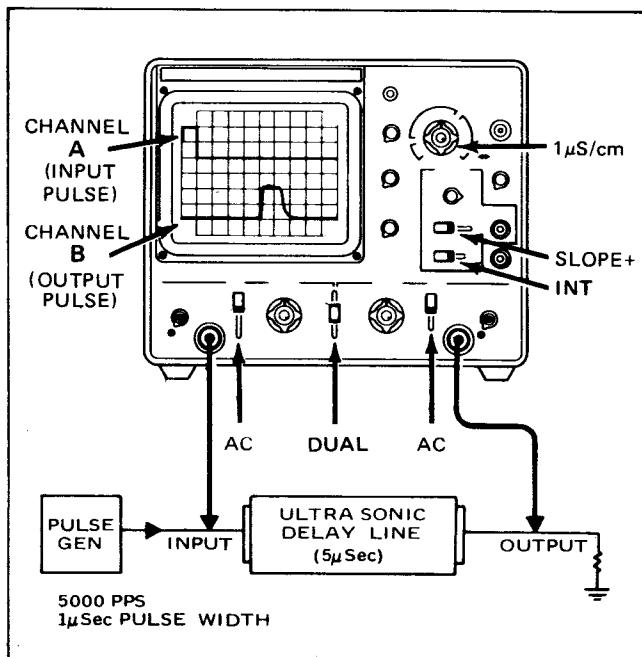


Fig. 12. Delay line measurement .

VIDEO EQUIPMENT SERVICING

Many of the video servicing procedures can be performed using single-trace operation. These are outlined later in the applications section covering single-trace operations. One of these procedures, viewing the VITS (vertical interval test signal), can be accomplished much more effectively using a dual-trace oscilloscope. As outlined in the single-trace applications section and as shown in Fig. 20 and 21, the information on the Field #1 and Field #2 vertical blanking interval pulse is different. This is shown in detail in Fig. 20. Also, because the oscilloscope sweep is synchronized to the vertical blanking interval waveform, the Field #1 and Field #2 waveforms are superimposed onto each other as shown in Fig. 22. With dual-trace operation, the signal information on each blanking pulse can be viewed separately without overlapping. Fig. 14 indicates the oscilloscope control setting for viewing the alternate VITS.

1. The video equipment from which the VITS information is to be viewed must be set to a station transmitting a color broadcast.
2. The control settings of Fig. 14 are those required to obtain a 2-field vertical display on Channel A.
3. With the oscilloscope and television receiver operating, connect the Channel A probe (set at 10:1) to the video detector test point.
4. Set the SYNC switch as follows:
 - a. If the sync and blanking pulses of the observed video signal are positive, use the VIDEO(+) switch position.
 - b. If the sync and blanking pulses are negative, use the VIDEO(-) switch position.
5. Adjust the SWEEP TIME/CM control so that 2 vertical fields are displayed on the oscilloscope screen.
6. Connect the Channel B probe (set to 10:1) to the video detector test point.
7. Set the MODE switch to the DUAL position. Identical waveform displays should now be obtained on Channels A and B.
8. Set the SWEEP TIME/CM control to the .1mS/CM position. This expands the display by increasing the sweep speed, the VITS information will appear toward the right hand portion of the expanded waveform displays. The waveform information on each trace may appear as shown in the drawing of Fig. 21. Because there is no provision for synchronizing the oscilloscope display to either of the two fields which comprise a complete vertical frame, it cannot be predicted which field display will appear on the Channel A or Channel B display.
9. Pull the \blacktriangleleft POS control outward to obtain an additional 5X magnification. Rotate the control in a counterclockwise direction moving the traces to the left until the expanded VITS information appears as shown in Fig. 15.

NOTE

Because of the low repetition rate and the high sweep speed combination, the brightness level of the signal displays will be reduced.

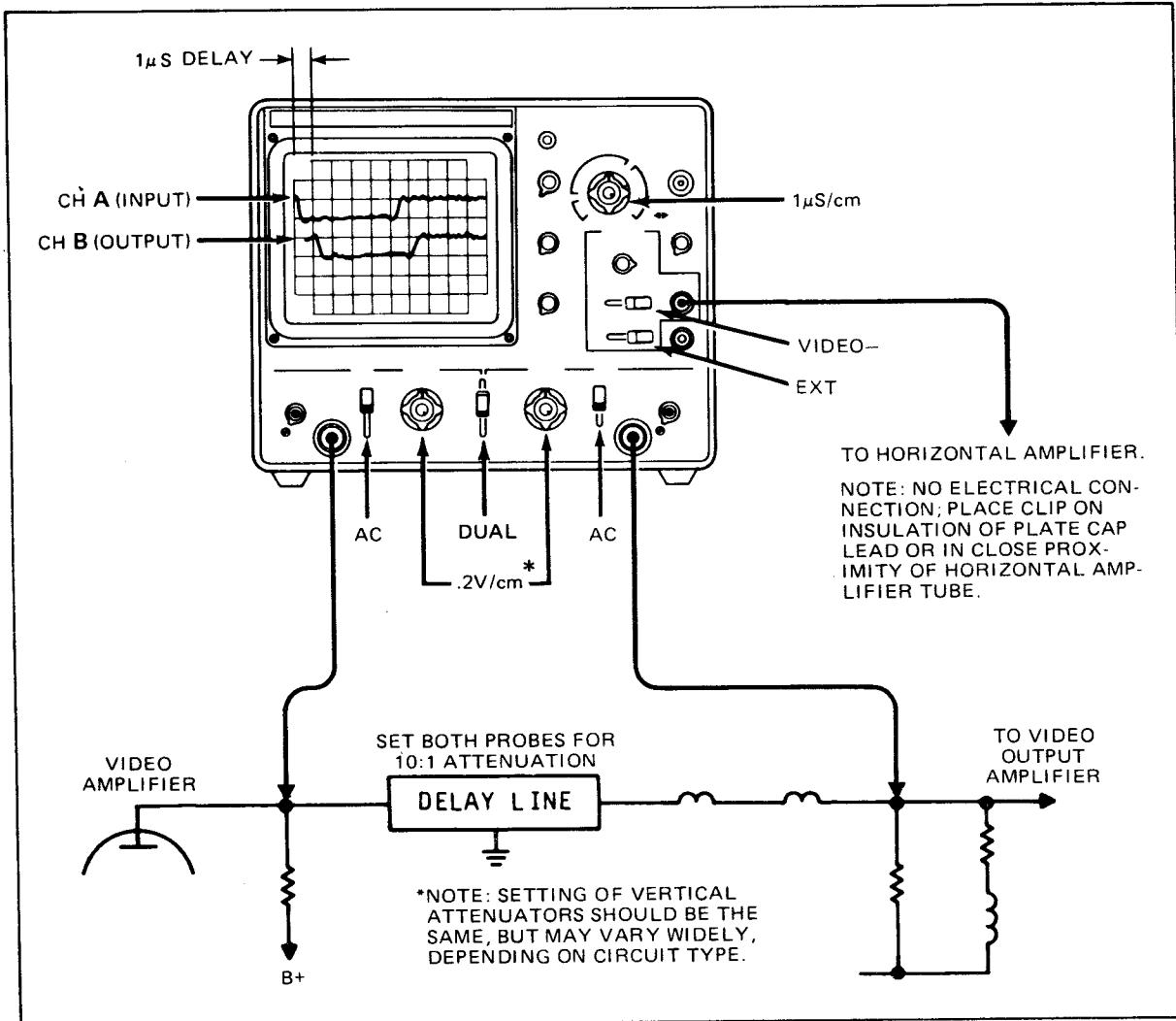


Fig. 13. Checking "Y" delay line in color television receivers.

10. Once the Channel A and Channel B displays have been identified as being either Field #1 or Field #2 VITS information, the Channel B probe may be used for signal-tracing and troubleshooting, and the Channel A probe should be left at the video detector test point to insure that the sync signal is not interrupted. If the sync signal is interrupted, the waveform displays may reverse because, as previously explained, there is no provision in the oscilloscope to identify either of the two vertical fields which comprise a complete frame.

Fig. 15 shows the dual-trace presentation of the Field #1 and Field #2 VITS information. The Field #1 information is displayed on the bottom trace.

SINGLE-TRACE APPLICATIONS

INTRODUCTION

In addition to the dual-trace applications previously outlined, there are, of course, many service and laboratory applications where only single-trace operation of the oscilloscope is required. After gaining experience with the oscilloscope, the user will be able to make the judgment as

to whether a job can be performed more efficiently by using the single-trace or the dual-trace method of operation. The following are applications in which single-trace operation is adequate. In several cases, it will be found that an alternate method using the dual-trace application has been described for the same application.

VIDEO EQUIPMENT SERVICING

A triggered sweep oscilloscope is advantageous in servicing and aligning video equipment. This oscilloscope also includes several features that were incorporated to make video servicing easier and more comprehensive. These features include:

- SWEEP TIME/CM control automatically selects vertical sync at sweep speeds appropriate for viewing frames and horizontal sync at sweep speeds appropriate for viewing lines.
- Vector overlay for color demodulator checks.
- Wide bandwidth for high resolution video and pulse presentation.

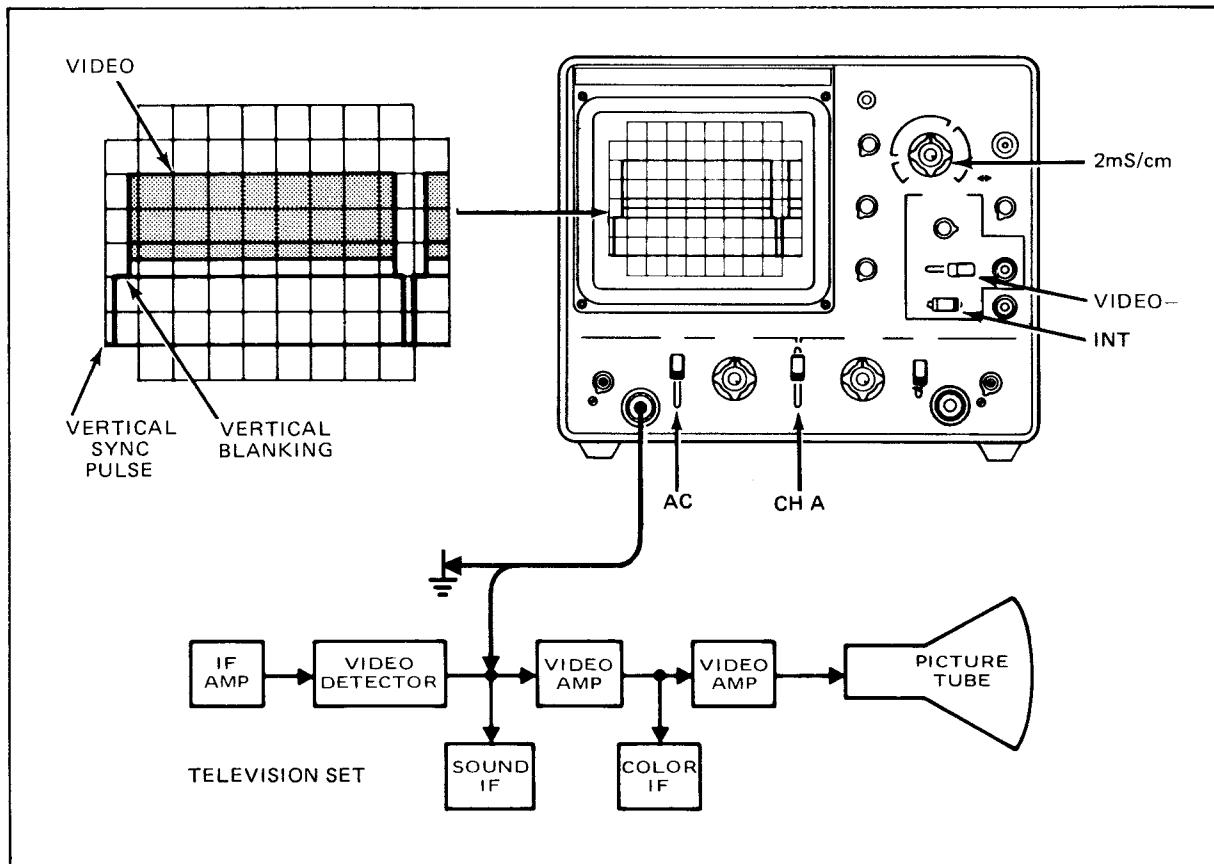


Fig. 14. Set-up for viewing fields 1 and 2 of VITS information.

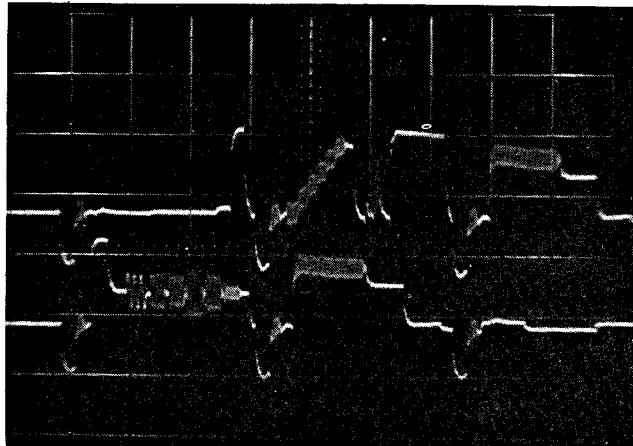


Fig. 15. Oscilloscope presentation of fields 1 and 2 of VITS information.

SIGNAL-TRACING AND PEAK-TO-PEAK VOLTAGE READINGS

For general troubleshooting and isolation of troubles in television receivers (or almost any other electronic equipment for that matter), the oscilloscope is an indispensable instrument. It provides a visual display of absence or presence of normal signals. This method (signal-tracing) may be used to trace a signal by measuring several points in the signal path. As measurements proceed along the signal path, a point may be found where the signal disappears. When this happens, the source of trouble has been located.

However, the oscilloscope shows much more than the mere presence or absence of signal. It provides a peak-to-peak voltage measurement of the signal. The cause of poor performance can often be located by making such peak-to-peak voltage measurements. The schematic diagram or accompanying service data on the equipment being serviced usually includes waveform pictures. These waveform pictures include the required sweep time and the normal peak-to-peak voltage. Compare the peak-to-peak voltage readings on the oscilloscope with those shown on the waveform pictures. Any abnormal readings should be followed by additional readings in the suspected circuits until the trouble is isolated to as small an area as possible. The procedures for making peak-to-peak voltage measurements are given earlier in the CALIBRATED VOLTAGE MEASUREMENT paragraph.

COMPOSITE VIDEO WAVEFORM ANALYSIS

Probably the most important waveform in video servicing is the composite waveform consisting of the video signal, the blanking pedestals and the sync pulses. Fig. 16 and 17 show typical oscilloscope traces when observing composite video signals synchronized with horizontal sync pulses and vertical blanking pulses. Composite video signals can be observed at various stages of the television receiver to determine whether circuits are performing normally. Knowledge of waveform makeup, the appearance of a normal waveform, and the causes of various abnormal waveforms help the technician locate and correct many problems. The technician should study such waveforms in a television receiver known to be in good operating con-

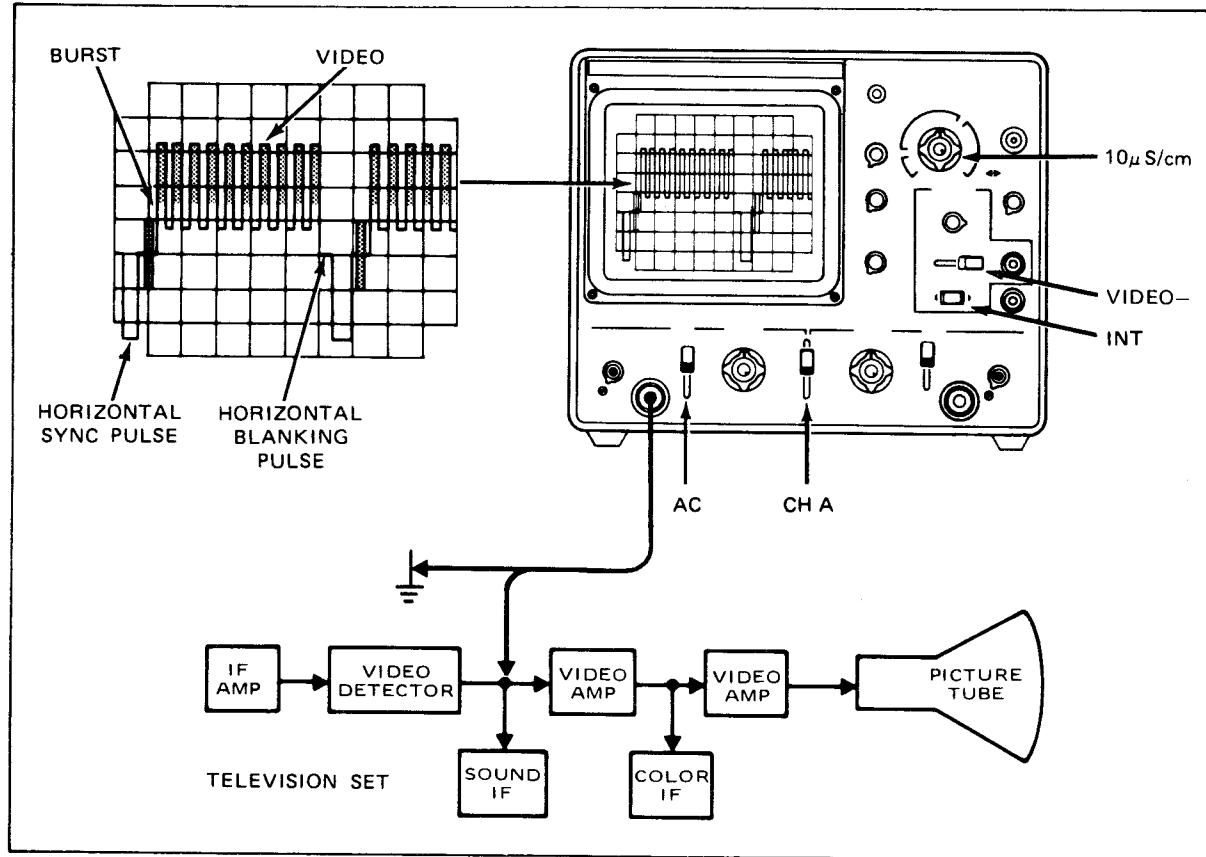


Fig. 16. Set-up for viewing *horizontal* lines of composite video signal.

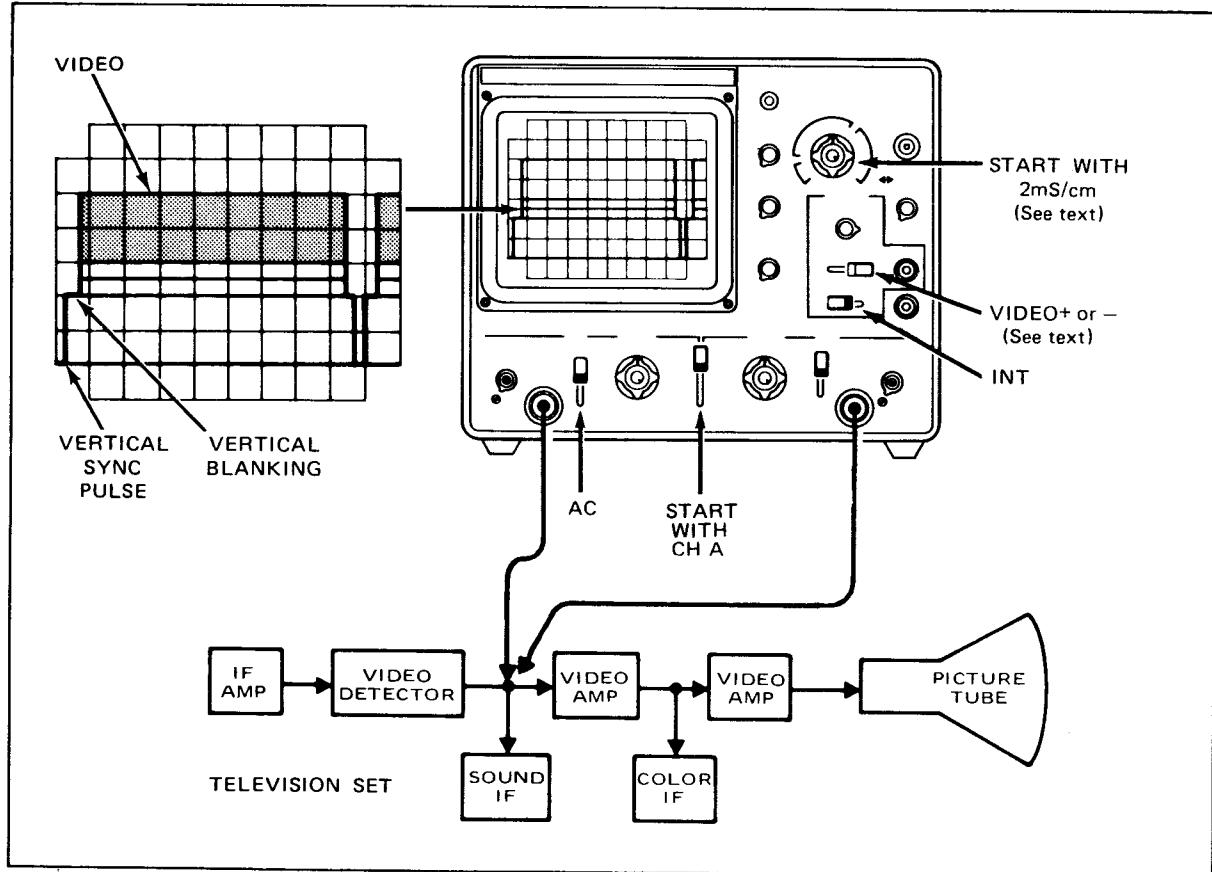


Fig. 17. Set-up for viewing *vertical* fields of composite video signal.

dition, noting the waveform at various points in the video amplifier.

To set up the oscilloscope for viewing composite video waveforms, use the following procedure:

1. Tune the television set to a local channel.
2. Set the MODE switch to the CH A position.
3. Set the SWEEP TIME/CM switch to the $10 \mu\text{s}/\text{cm}$ position for observing horizontal lines or to the $2 \text{mS}/\text{cm}$ position for observing vertical frames.
4. Set the SYNC switch to the VIDEO+ position.
5. Set the SOURCE switch to the INT position.
6. Pull the TRIGGERING LEVEL control for automatic sync.
7. Set the CH A DC-GND-AC switch to the AC position.
8. Connect a probe cable to the CH A INPUT jack. Connect the ground clip of the probe to the television set chassis. With the probe set for 10:1 attenuation, connect the tip of the probe to the video detector output of the television set.
9. Set the CH A VOLTS/CM switch for the largest vertical deflection possible without going off-scale.
10. If necessary, rotate the TRIGGERING LEVEL control to a position that provides a synchronized display.
11. If the sync and blanking pulses of the displayed video signals are positive, set the SYNC switch to the VIDEO+ position; if the sync and blanking pulses are negative, use the VIDEO- position.
12. Push in the TRIGGERING LEVEL control and rotate to a position that provides a well-synchronized display.
13. Adjust the INTENSITY and FOCUS controls for the desired brightness and best focus.
14. To view a specific portion of the waveform, such as the color burst, pull outward on the $\blacktriangleleft\blacktriangleright$ POSITION control for 5X magnification. Rotate the same control left or right to select the desired portion of the waveform to be viewed.
15. Composite video waveforms may be checked at other points on the video circuits by moving the probe tip to those points and changing the VOLTS/CM control setting as required to keep the display within the limits of the scale, and by readjusting the TRIGGERING LEVEL control to maintain stabilization. The polarity of the observed waveform may be reversed when moving from one monitoring point to another; therefore, it may be necessary to reverse the polarity of the SYNC.

SYNC PULSE ANALYSIS

The IF amplifier response of a television receiver can be evaluated to some extent by careful observation of the horizontal sync pulse waveform. The appearance of the sync pulse waveform is affected by the IF amplifier bandpass characteristics. Some typical waveform symptoms and their relation to IF amplifier response are indicated in Fig. 18. Sync pulse waveform distortions produced by positive or negative limiting in IF overload conditions are shown in Fig. 19.

CIRCUIT DEFECT	HORIZONTAL PULSE DISTORTION	OVERALL RECEIVER FREQUENCY RESPONSE	EFFECT ON PICTURE
NORMAL CIRCUIT			PICTURE NORMAL
LOSS OF HIGH FREQUENCY RESPONSE			LOSS OF PICTURE DETAIL
EXCESSIVE HIGH FREQUENCY RESPONSE, NON-LINEAR PHASE SHIFT			FINE VERTICAL BLACK & WHITE STRIATIONS FOLLOWING A SHARP CHANGE IN PICTURE SHADING
LOSS OF LOW FREQUENCY RESPONSE			CHANGE IN SHADING OF LARGE PICTURE AREAS; SMEARED PICTURE

Fig. 18. Analysis of sync pulse distortion.

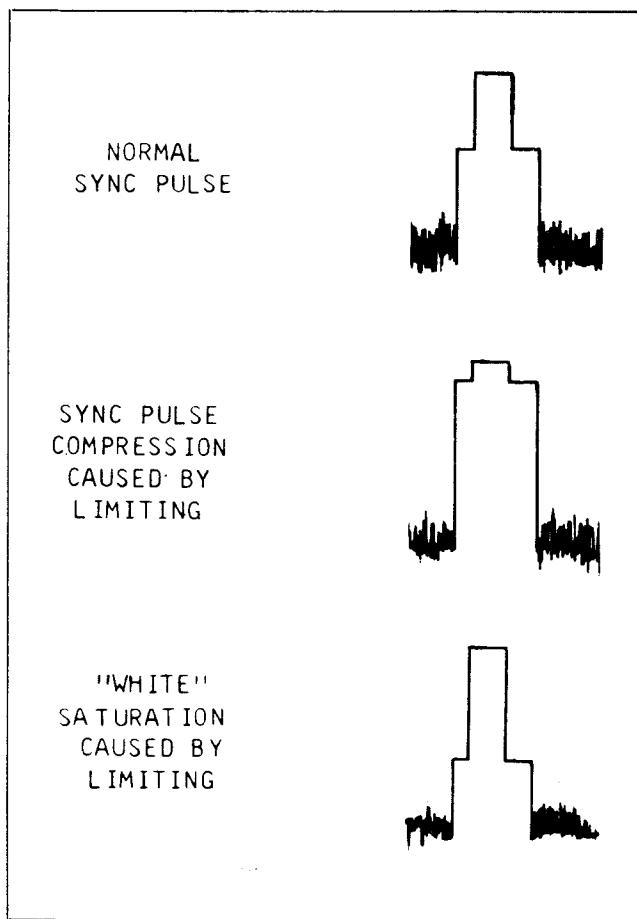


Fig. 19. Sync pulse waveforms.

VITS (VERTICAL INTERVAL TEST SIGNAL)

Most network television signals contain a built-in test signal (the VITS) that can be a very valuable tool in troubleshooting and servicing television sets. This VITS can localize trouble to the antenna, tuner, IF or video sections and shows when realignment may be required. The following procedures show how to analyze and interpret oscilloscope displays of the VITS.

The VITS is transmitted during the vertical blanking interval. On the television set, it can be seen as a bright white line above the top of the picture, when the vertical

linearity or height is adjusted to view the vertical blanking interval (on TV sets with internal retrace blanking circuits, the blanking circuit must be disabled to see the VITS).

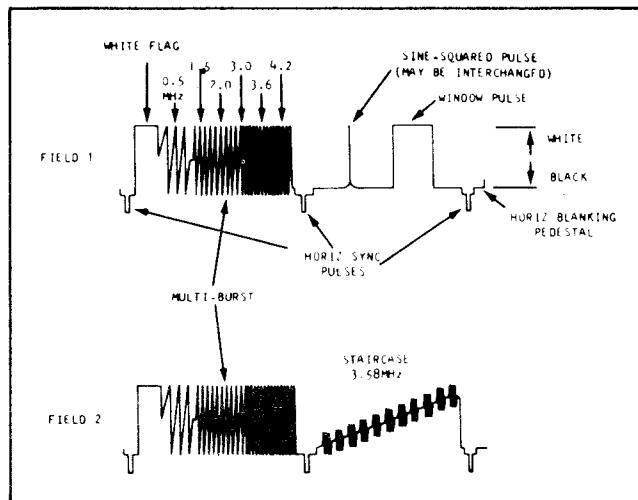


Fig. 20. Typical VITS signal, fields 1 and 2.

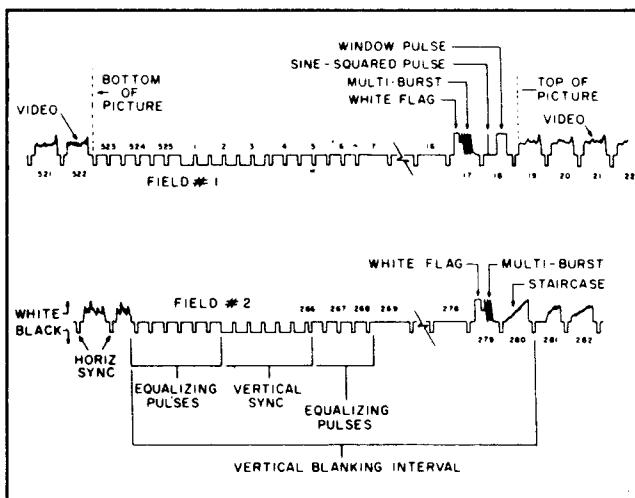


Fig. 21. Vertical blanking interval, showing typical VITS information.

The transmitted VITS may vary from one channel to another, but is a precision sequence of specific frequency, amplitude, and waveshape similar to Fig. 20 and 21. The television networks use the precision signals for adjustment and checking of network transmission equipment, but the technician can use them to evaluate television set performance. The first line of Field #1 (line 17) may begin with a "flag" of white video, followed by sine wave frequencies of 0.5 MHz, 1.5 MHz, 2 MHz, 3 MHz, 3.6 MHz, (3.58 MHz) and 4.2 MHz. This sequence of frequencies is called the "multi-burst." The first line of Field #2 (line 279) may contain an identical multi-burst. This multi-burst portion of the VITS is the portion that can be most valuable to the technician. The second line of Field #1 and Field #2 (lines 18 and 280), which may contain the sine-squared pulse, window pulse and the staircase of 3.58 MHz bursts at progressively lighter shading, are valuable to the network, but have less value to the technician. As seen on the television screen, Field #1 is interlaced with Field #2 so that line 17 is followed by line 279 and line 18 is followed by 280. The en-

tire VITS appears at the bottom of the vertical blanking pulse and just before the first line of video.

Each of the multi-burst frequencies is transmitted at equal amplitude. By observing the comparative amplitudes of these frequencies *after* the signal is processed through the television receiver, the frequency response of the set is checked.

Set up the oscilloscope as follows to view the VITS:

1. Connect the CH A probe (set at 10:1) to the output of the video detector or other desired test point in the video section of the television set.
2. If the television set has a vertical retrace blanking circuit, bypass this circuit during the measurement.
3. Set the MODE switch to CH A.
4. Set up the oscilloscope for vertical composite video waveform analysis as previously described. Two vertical frames will be visible.
5. Reduce sweep time to .1 millisecond per centimeter (.1 ms/CM) with the SWEEP TIME/CM switch. This expands the display by increasing the sweep speed. The VITS information will appear to the right on the expanded waveform display.
6. Further expand the sweep with the 5X magnification (pull outward on the ▶ POSITION control). Rotate the ▶ POSITION control in a counterclockwise direction, moving the trace to the left, until the expanded VITS appears.

NOTE

The brightness level of the signal display will be reduced because, although the repetition rate is only 60 Hz (a 16,000 μ SEC period) the writing speed is 20 μ SEC/cm (.1 mSEC/cm magnified five times).

7. The waveform should be similar to that shown in Fig. 22. For the oscilloscope display, each vertical sync pulse starts a new sweep. This causes line 17 and line 279 (multi-burst) to be superimposed, as are lines 18

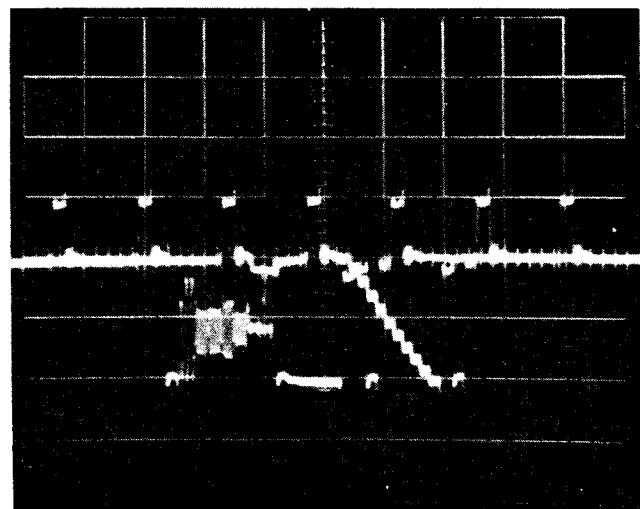


Fig. 22. Oscilloscope presentation of VITS information, single-trace operation.

and 280. The multi-burst signals are identical, which reinforces the trace. However, lines 18 and 280 are not identical and both signals are superimposed over each other.

- The presentation of the preceding paragraphs (Fig. 22) is the limit of observation possible with a single-trace oscilloscope. With the Model 1476 oscilloscope, however, a single-field VITS presentation can be oscilloscope position. This causes the Channel B information to be displayed on alternate sweeps, as are Field #1 and Field #2 VITS. Because there is no provision for preselecting Field #1 or Field #2 information, either Field #1 or Field #2 (Fig. 15) will appear. The multi-burst information in the VITS is the most valuable for troubleshooting television receivers and, because it is present on both Field #1 and Field #2 VITS, either can be used for troubleshooting and signal tracing.

Now to analyze the waveform. All frequencies of the multi-burst are transmitted at the same level, but should not be equally coupled through the receiver due to its response curve. Fig. 23 shows the desired response for a good color television receiver, identifying each frequency of the multi-burst and showing the allowable amount of attenuation for each. Remember that -6 dB equals half the reference voltage (the 2.0 MHz modulation should be used for reference).

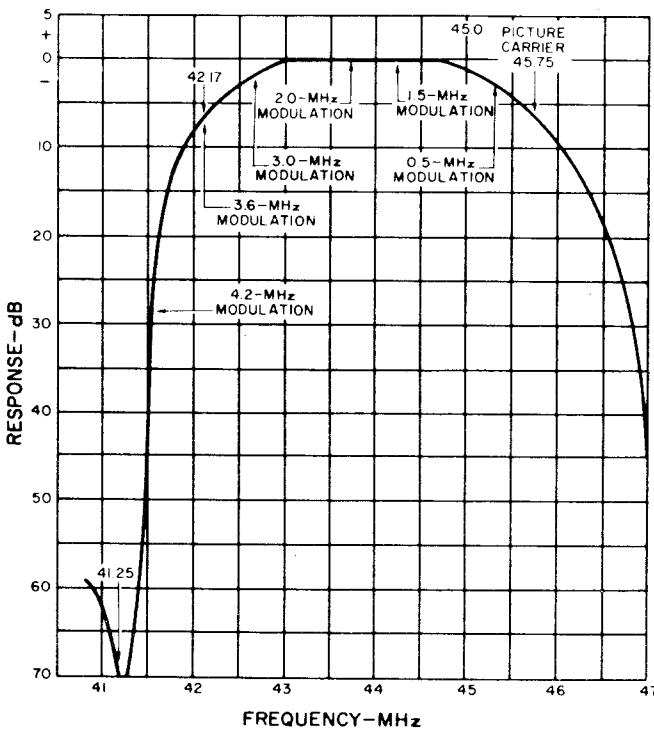


Fig. 23. Color TV IF amplifier response curve.

To localize trouble, start by observing the VITS at the video detector. This will localize trouble to a point either before or after the detector. If the multi-burst is normal at the detector, check the VITS on other channels. If some channels look okay but others do not, you probably have tuner or antenna-system troubles. Don't overlook the

chance of the antenna system causing "holes" or tilted response on some channels. If the VITS is abnormal at the video detector on all channels, the trouble is probably in the IF amplifier stages.

As another example, let us assume that we have a set on the bench with a very poor picture. Our oscilloscope shows the VITS at the video detector to be about normal except that the burst at 2.0 MHz is low compared to the bursts on either side. This suggests an IF trap is detuned into the passband, chopping out frequencies about 2 MHz below the picture carrier frequency. Switch to another channel carrying VITS. If the same thing is seen, then our reasoning is right, and the IF amplifier requires realignment. If the poor response at 2 MHz is not seen on other channels, maybe an FM trap at the tuner input is misadjusted, causing a bite on only one channel. Other traps at the input of the set could similarly be misadjusted or faulty.

If the VITS response at the detector output is normal for all channels, the trouble will be in the video amplifier. Look for open peaking coils, off-value resistors, solder bridges across foil patterns, etc.

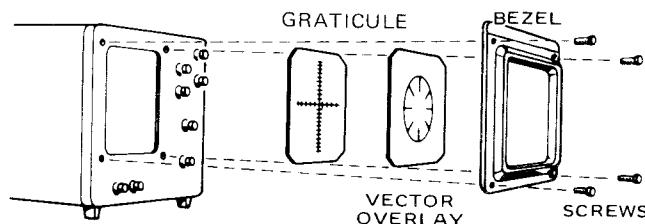


Fig. 24. Installation of vector overlay.

VECTORSCOPE OPERATION

Performance testing and adjustment of the color circuits in color television receivers is simplified by using the vectorscope operation of the oscilloscope. The additional equipment needed is a color bar generator. The B & K-Precision color bar generators are ideally suited for this.

First the horizontal and vertical gain of the oscilloscope must be equalized (see Fig. 25).

- Attach vector overlay to scope. Remove bezel, insert overlay and re-attach bezel (see Fig. 24).
- Connect the color bar generator to the television set and tune in the color bar pattern.
- Adjust the television set's hue and brilliance controls to mid-range.
- Set SWEEP TIME/CM control to the CH B position.
- Connect probe cables to the CH A and CH B INPUT jacks. Channel A is the vertical input and Channel B is the horizontal input. Connect both probe tips to the driven element of the red gun, usually the grid. If the cathode is the driven element, then connect to the cathode. (The driven element is the element to which the output signal of the color amplifier is applied.)
- Adjust the CH A (vertical gain) and CH B (horizontal gain) VOLTS/CM controls to obtain a compressed 45° pattern that approximately fills the vector overlay. The oscilloscope is now set up for vectorscope operation.

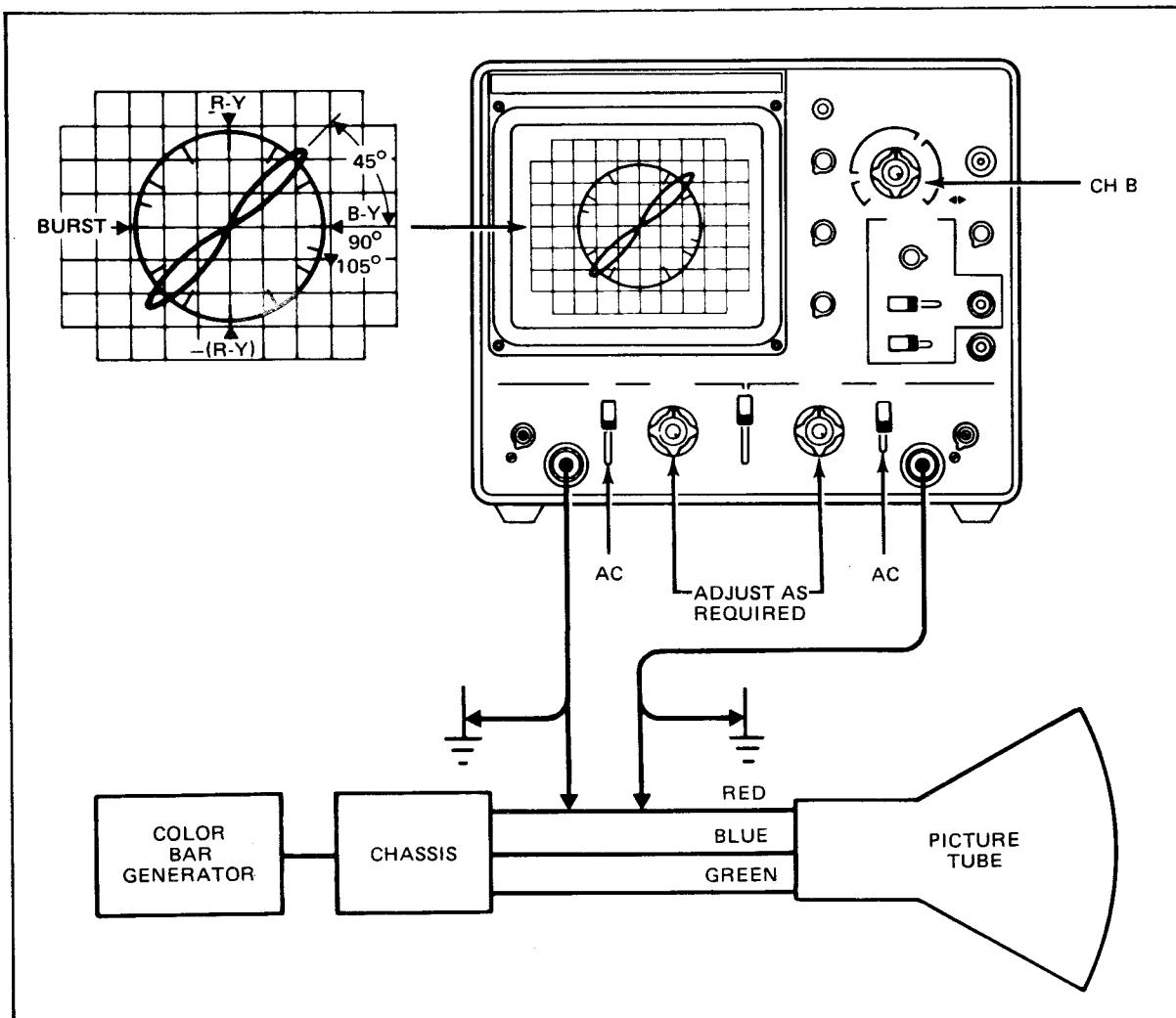


Fig. 25. Equalizing horizontal and vertical gain for Vector-scope operation.

- For vector presentation, merely move the horizontal probe to the driven element of the blue gun. The color vector pattern is the same type as given by the television set manufacturer. Fig. 26 shows typical displays obtained for sets using 105° systems and 90° systems with either grid drive or cathode drive.

NOTE

If the picture tube uses cathode drive, the burst will appear on the right side of the screen. Just rotate the vector overlay 180° so the BURST label is on the right side. The color bars will then align with the vector overlay.

The vector display provides a very quick measurement of the functions of the demodulators in a color TV set. The serviceman should familiarize himself with the effect on the pattern produced by the color controls. He should observe that the color amplitude control will vary the size of the petals but not their position. The hue control changes the position of the petals but not their amplitude. Lastly, 105° sets will have a more elliptical pattern than 90° sets. The table below

lists some common troubles and their effect on the pattern.

The vector display can be used to check the range of the color set's hue control. It should be possible to rotate the R-Y petal about the vertical axis. At the center of the hue control the R-Y petal should be vertical. If it is not, locate the CHROMA reference oscillator. In most sets this oscillator is transformer-coupled to the demodulators.

A slight touch-up of this transformer is all that is necessary to bring the R-Y petal to a vertical position. Do not attempt to make any adjustments on the chroma bandpass amplifiers. These amplifiers are aligned by a sweep generator and cannot in general be aligned by just a vector display.

If the set has adjustable demodulators, the vector display can also be used for demodulator alignment. Follow the manufacturer's alignment procedure to locate the proper coils and instead of counting bars simply adjust for the correct angle between R-Y and B-Y.

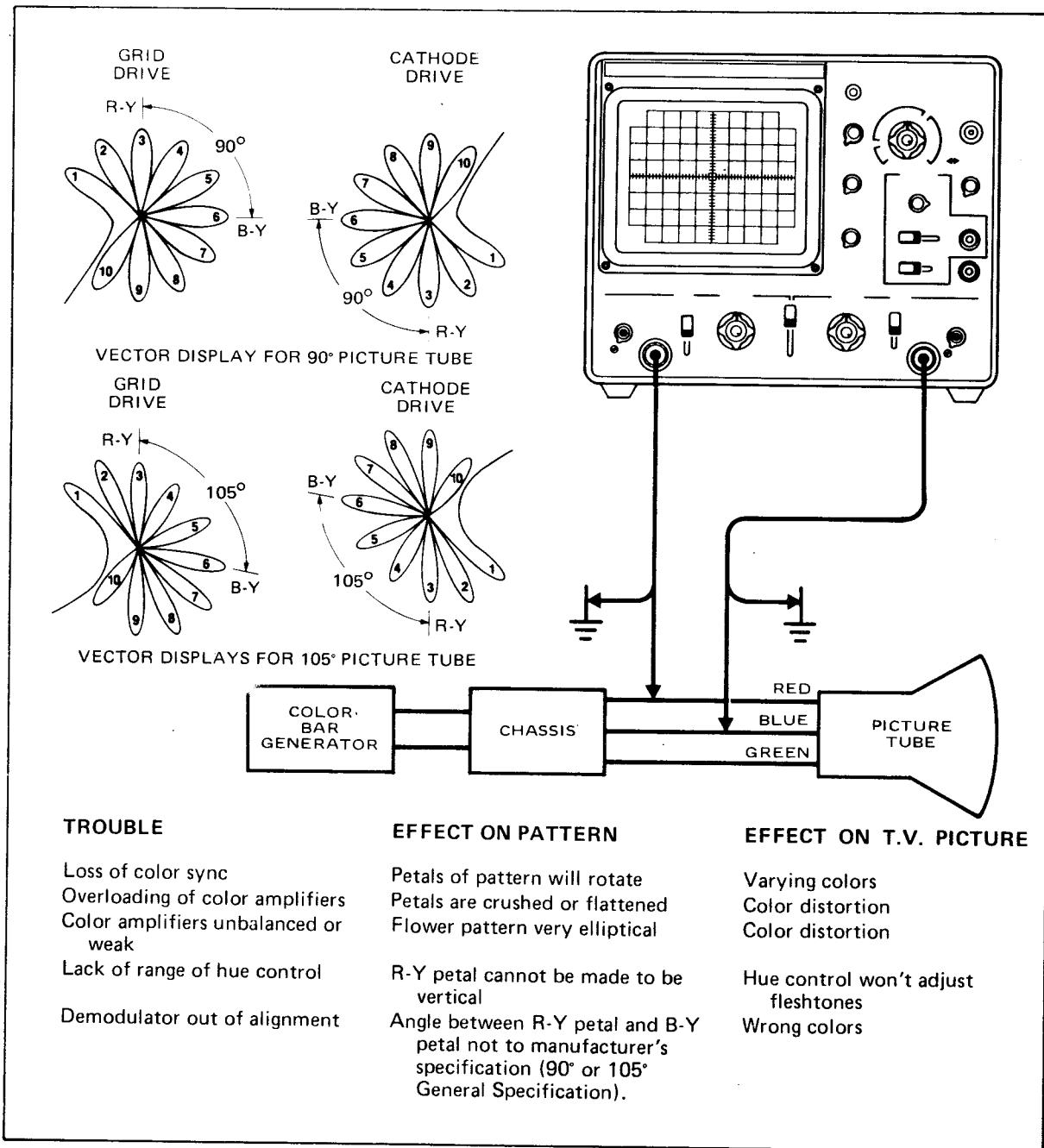


Fig. 26. Vectorscope operation and patterns.

TELEVISION ALIGNMENT

INTRODUCTION

Alignment of tuners, the video IF strip, and chroma circuits in television receivers required a high-quality oscilloscope, such as this instrument. The additional pieces of test equipment required are sweep generators for video sweep, IF sweep and RF sweep, marker generators, DC bias supplies and a VTVM. The sweep generator method of alignment displays a bandpass response curve on the screen of the oscilloscope of the type always shown in theory books and in the television set manufacturer's alignment instructions (typical response curves are shown in Fig. 27).

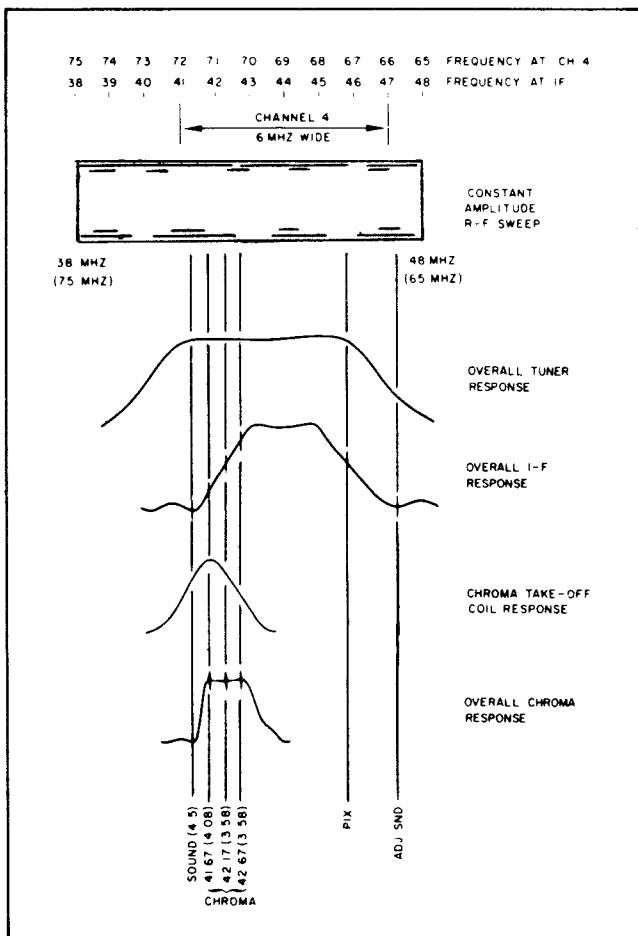


Fig. 27. TV response curves obtained by sweep-frequency technique.

The ideal instruments for television alignment are this oscilloscope and the B & K-Precision Sweep/Marker Generator. The B & K-Precision Sweep/Marker Generator provides all necessary sweep ranges, markers and DC bias voltages, all from one instrument. The simplified operating procedure and calibrated accuracy of the instrument results in precision alignment.

For complete alignment instructions of each particular television set, follow the manufacturer's instructions. However, the following general set-up instructions demonstrates use of the oscilloscope for sweep-frequency alignment.

In this manual, only the proper use of the oscilloscope is emphasized. Proper use of the sweep generator and other equipment required for alignment should be provided in the instruction manuals for those instruments.

NOTE

For a comprehensive analysis of television alignment, we recommend the instruction manual for the B & K Model 415 Sweep/Marker Generator. This "handbook of television alignment" includes not only the procedures for using the instrument, but all the how and why answers about television alignment in general. Even if you use other sweep generators, this comprehensive manual provides valuable procedures, insights and tips that will make alignment easier and more professional. The many illustrations and easy-to-understand step-by-step approach qualify it as the "how to align" textbook. Copies are available from your B & K-Precision distributor or the factory.

IMPORTANCE OF SWEEP ALIGNMENT

The most rapid way to determine the overall condition of the tuner, IF and chroma portions of the television receiver is to provide a constant-amplitude signal which sweeps through the entire bandwidth of a given television channel at a controlled, repetitive rate. As this signal is processed through the tuned portions of the receiver, it is shaped by the gain and bandpass properties of the various sections. Because the signal is channeled from one series of tuned circuits to another it is important that each section has the proper characteristics. If the signal is demodulated at certain points and the envelope observed, the gain and bandwidth properties up to that point can be determined.

Fig. 27 shows the sweep signal with basic response curves of the tuner, IF amplifiers and chroma bandpass circuits below it. The bandwidths shown are approximately to scale. These outlines are similar to the curves that would be obtained if the outputs of the various sections of the TV receiver were demodulated and the curve observed on an oscilloscope. Because of the relative bandwidths, the tuner response is least critical.

Some reference frequencies are identified to show the importance of proper alignment. Notice that the chroma frequencies are on the slope of the IF response curve. This area is the most critical because improper IF alignment in this area will affect the amplitude and shape of the chroma response curve and this in turn affects color picture quality.

Notice that the chroma information is located on a constant-amplitude portion of the transmitted television spectrum. Notice that the relative amplitudes of the chroma information are modified by passing through the tuned circuits of the television receiver tuner and IF amplifiers. This is shown by reference to the overall IF response curve. Notice that the signal information at the upper end of the chroma frequency range (4.08 MHz) is reduced in amplitude with respect to the signal level at the lower end of the chroma frequency range (3.08 MHz). To compensate for this frequency-versus-amplitude characteristic of the overall IF response curve, a chroma takeoff coil is used between the IF output and the bandpass amplifier of the chroma portion of the receiver. The chroma takeoff coil is tuned to the upper end of the chroma frequency range usually 4.08 MHz and provides a response as shown in Fig. 27. This compensates for the amplitude-versus-frequency characteristic of the chroma portion of the overall IF response curve. The result of combining the response of the

IF curve and the response of the chroma takeoff coil is to produce a flat overall response in the chroma frequency range (3.08 MHz to 4.08 MHz). The resultant signal is then applied to the bandpass amplifier which has the response indicated by the overall chroma response curve.

Alignment of the chroma takeoff coil is sometimes specified as a separate step in manufacturer's test procedures. In other procedures, adjustment of the chroma takeoff coil is performed together with the adjustment of the bandpass transformer.

SWEET ALIGNMENT METHODS

The best method of checking alignment and determining which stages require alignment is to inject an RF sweep frequency signal at the tuner antenna terminals. The AGC bias line must be clamped by application of bias or grounding the AGC line. The outputs of the IF and chroma circuits are then observed on an oscilloscope and compared to the manufacturer's recommended response curve.

The technician can then decide which portions of the receiver require alignment. For example, if the IF response is satisfactory but the chroma response is not, then the problem is between the video detector output of the IF strip and the output of the bandpass amplifier. If the IF response and the chroma response are poor then it is most likely that the IF requires touch-up, particularly if the response is poor on the slope affecting chroma response.

The RF portion of the tuner seldom creates an alignment problem because the passband is so much greater than that of the IF section; however, the mixer output circuit, which is located on the tuner, may require attention. This is part of the tuned matching network between the tuner and the first IF stage. A separate pre-alignment procedure is given for the link circuits by some manufacturers.

Once the deficient portion of the receiver is determined, an alignment check of that section can be performed. The alignment procedures vary with manufacturers. Some suggest signal combinations at the tuner antenna terminals which can generate IF and video sweep frequencies in the receiver so that overall alignment can be done by selecting the right combination of input signals. One way of doing this is to first connect an RF sweep generator for IF alignment. After this is complete, the picture carrier frequency for the channel being used is selected and this is modulated by a video sweep signal (this is the VSM, or video sweep modulation method). This video sweep modulation is demodulated at the video detector of the TV receiver and applied to the chroma bandpass circuits for the alignment of these stages.

Other manufacturers recommend an IF sweep frequency injected at the mixer grid (or base, if transistorized) for IF alignment. The IF picture carrier frequency (45.75 MHz) is then modulated with a video sweep voltage (VSM again). As before this is detected at the video detector of the TV receiver and the recovered sweep voltage is used for the chroma circuit alignment.

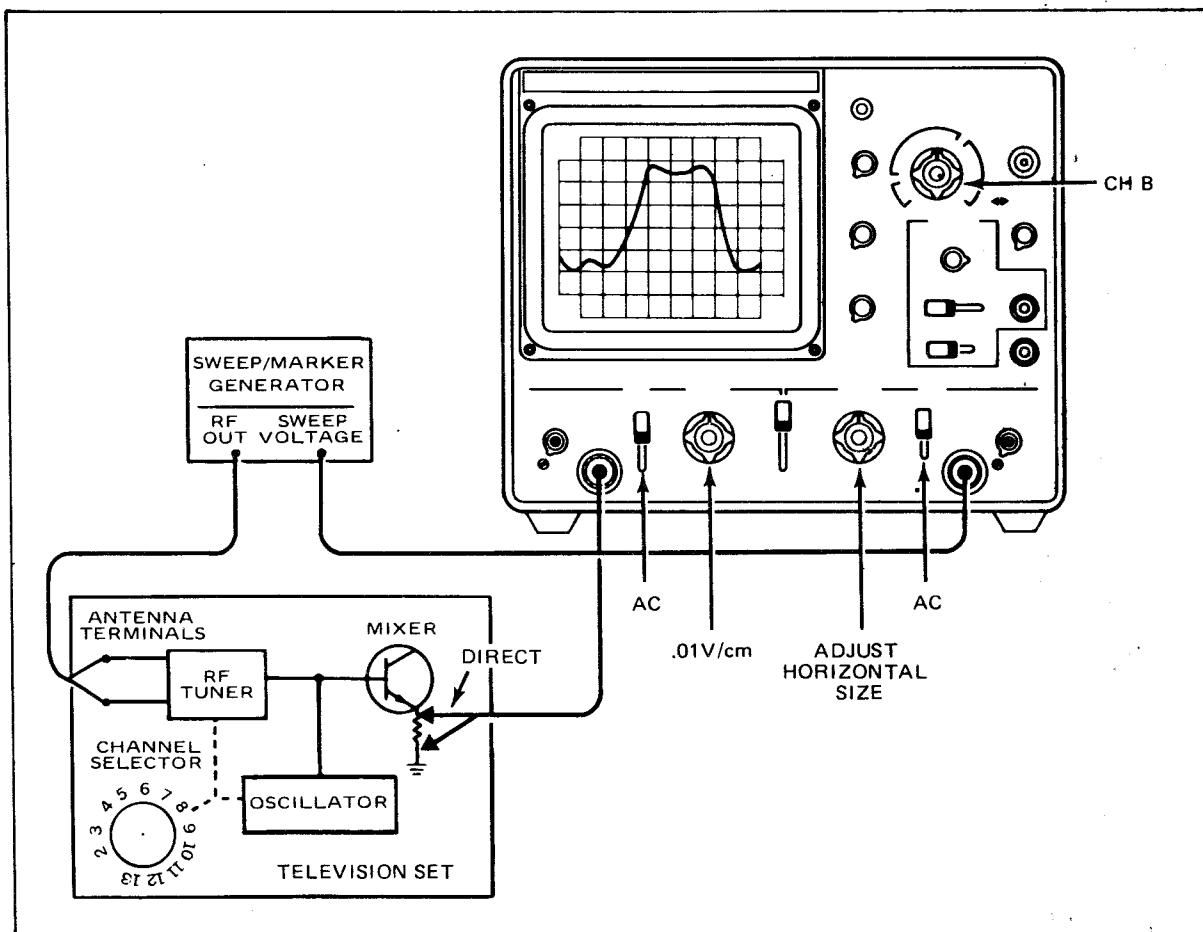


Fig. 28. Typical tuner alignment set-up.

Another method is to first video-sweep align the chroma circuits directly. The IF is then aligned and video sweep modulation of the IF pix frequency (45.75 MHz) is used to check the combined effect of the chroma response of IF alignment and chroma alignment. Usually a touch-up of the chroma circuits is necessary to obtain the desired final overall chroma response.

In conjunction with IF alignment, practically all manufacturers recommend pre-tuning IF traps by injecting spot frequencies into the IF (usually at a specified tuner test point). Other procedures outline a prealignment of all tuned circuits in the IF before sweep alignment procedures.

In all cases the manufacturer's method is the best for his particular receiver and the manufacturer's service manual is preferred for alignment. SAMS PHOTOFACt procedures are also reliable and in most cases repeat the manufacturer's procedure. If complete realignment of an apparently deficient receiver does not restore the required response, the technician must then consider that a component failure has occurred and must employ standard troubleshooting procedures.

TUNER ALIGNMENT (Refer to Fig. 28)

1. Connect the output of the sweep generator to the antenna terminals of the television set. Adjust the sweep generator to sweep one of the TV channels.
2. Tune the TV set to the same channel.

3. Connect the ground clip of the oscilloscope probe directly to the tuner shield to minimize hum pickup. Connect the Channel A (Vertical) probe (set to DIRECT) to the tuner test point. The tuner test point is normally the grid of the mixer tube or equivalent, where a demodulated signal is present.
4. Set the CH A VOLTS/CM control for maximum sensitivity and operate the sweep generator at low level to avoid overloading the television receiver, which would distort the response curve and provide an erroneous picture of alignment on the oscilloscope screen.
5. The oscilloscope sweep and sweep generator must be in exact synchronization and phase with each other for proper presentation of the response curve. This is easily accomplished for sinusoidal or sawtooth sweep by setting the oscilloscope for external horizontal input (SWEEP TIME/CM to CH B position) and connecting the horizontal sweep voltage from the sweep generator to the Channel B input terminal on the oscilloscope.
6. Select the marker generator frequencies required to measure the upper and lower response of the tuner.
7. The tuner response curve is now displayed on the oscilloscope. See the manufacturer's instructions for the response curve specifications and the necessary adjustments for realignment.

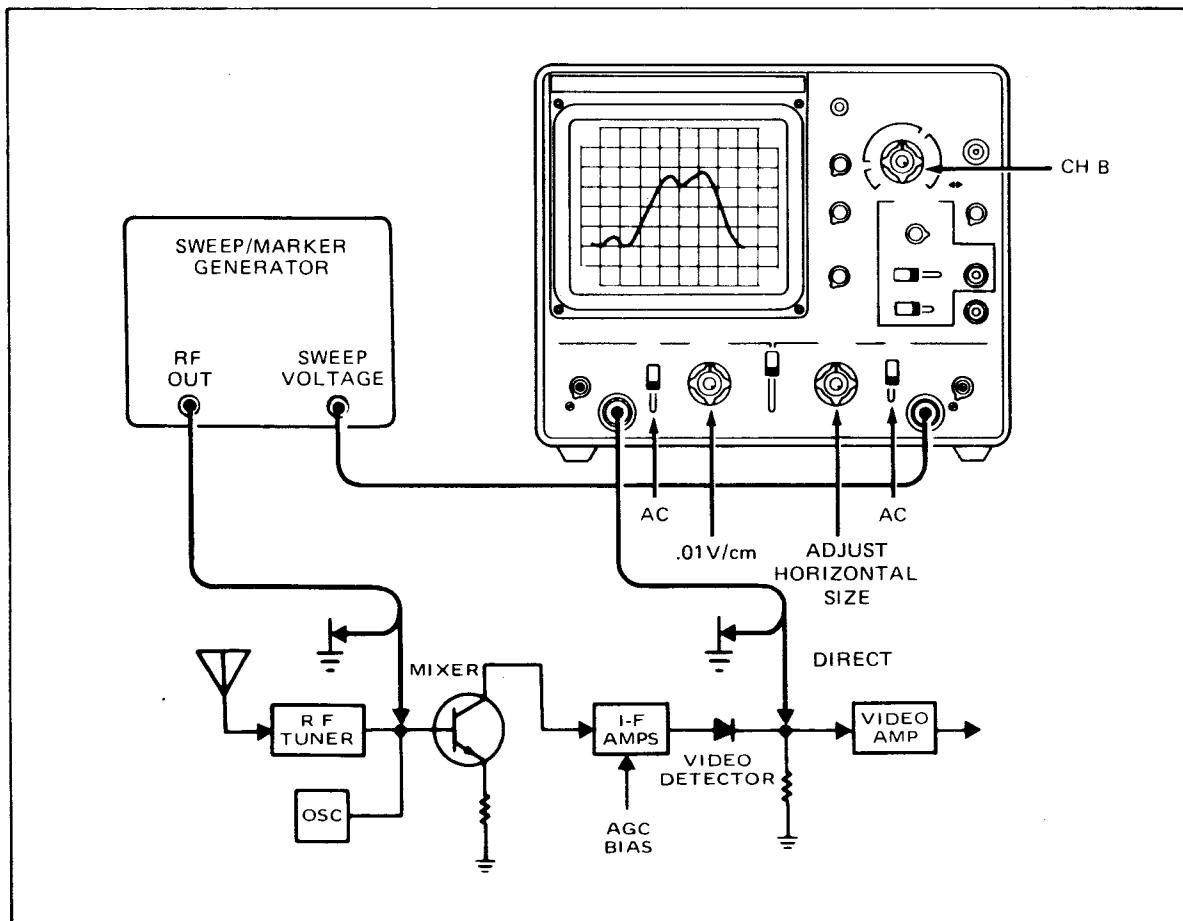


Fig. 29. Typical IF alignment set-up.

IF ALIGNMENT (Refer to Fig. 29)

1. Connect the output of the sweep generator to the signal injection point of the mixer. Adjust the sweep generator to sweep the IF frequency band. (If the tuner has been properly aligned, RF sweep may be applied at the antenna terminals.)
2. Synchronize the oscilloscope sweep with the sweep generator as previously described in the TUNER ALIGNMENT procedure.
3. Connect the ground clip of the oscilloscope vertical probe to the television set chassis.
4. Connect the vertical probe of the oscilloscope to the video detector output.
5. Set the CH A VOLTS/CM gain control for suitable viewing of the response curve.
6. Keep the sweep generator output level low to prevent overloading. Follow the manufacturer's recommendations on disabling AGC.
7. Select the marker generator frequencies required to check the critical frequencies of interest (see Fig. 30.) A sweep and marker generator capable of displaying all the markers simultaneously, such as the B & K-Precision Model 415, is a big advantage.
8. Follow the manufacturer's instructions for evaluating the response curve and making the alignment.

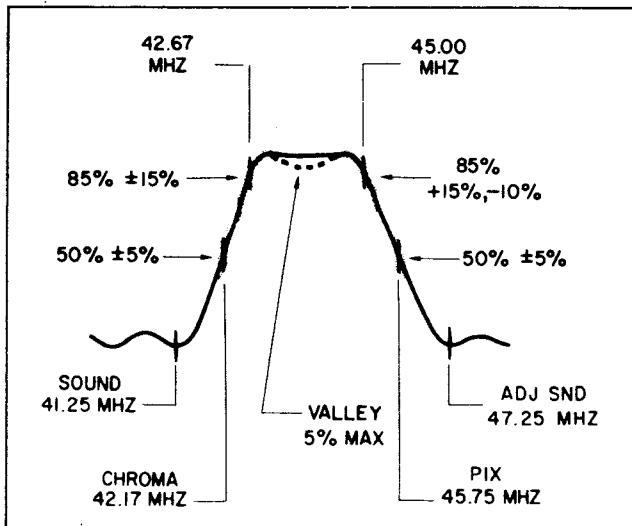


Fig. 30. Typical IF response curve, showing tolerance ranges of response levels.

CHROMA ALIGNMENT (Refer to Fig. 32)

The IF alignment must be satisfactorily completed before starting this chroma alignment procedure. If direct injection of video sweep is used rather than the IF sweep injection specified herein, the response curve is altered drastically. Follow the manufacturer's procedure explicitly for such direct injection of video sweep for chroma alignment.

1. Leave the sweep/marker generator and AGC bias connected as for IF alignment. Set the sweep generator

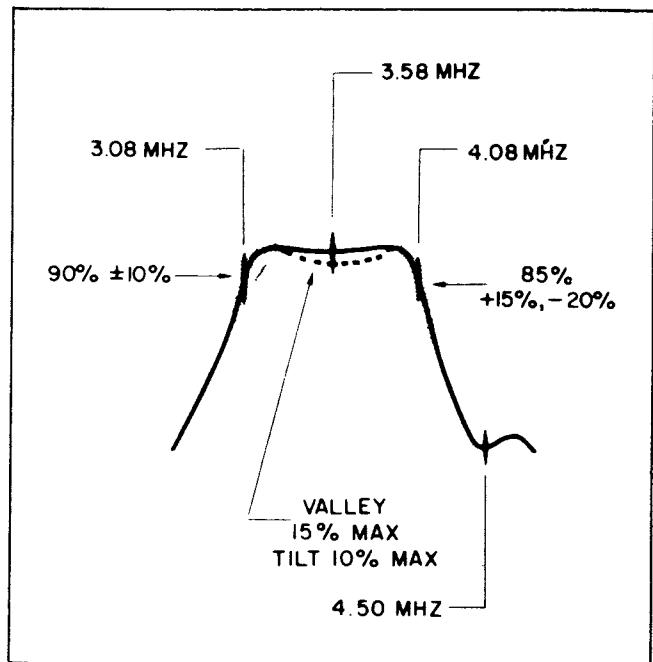


Fig. 31. Typical chroma response curve, showing tolerance ranges of response levels.

to sweep approximately the 41 to 44 MHz band of frequencies. Use the same IF injection level that was used for IF alignment.

2. Apply the proper DC bias to the color killer to enable the color amplifiers (bandpass amplifiers). Refer to the manufacturer's instructions for the correct bias level.
3. Synchronize the oscilloscope sweep as previously described for tuner alignment.
4. Use a demodulator probe for the vertical input (Channel A) to the oscilloscope. Measure the response curve at the input to the demodulators.
5. Set the vertical gain controls of the oscilloscope CH A (VOLTS/CM) for a convenient viewing size on the screen.
6. A response curve similar to that shown in Fig. 31 should be seen. Select the marker generator frequencies of interest. Refer to the manufacturer's instructions for bandpass specifications and alignment procedure.

NOTES

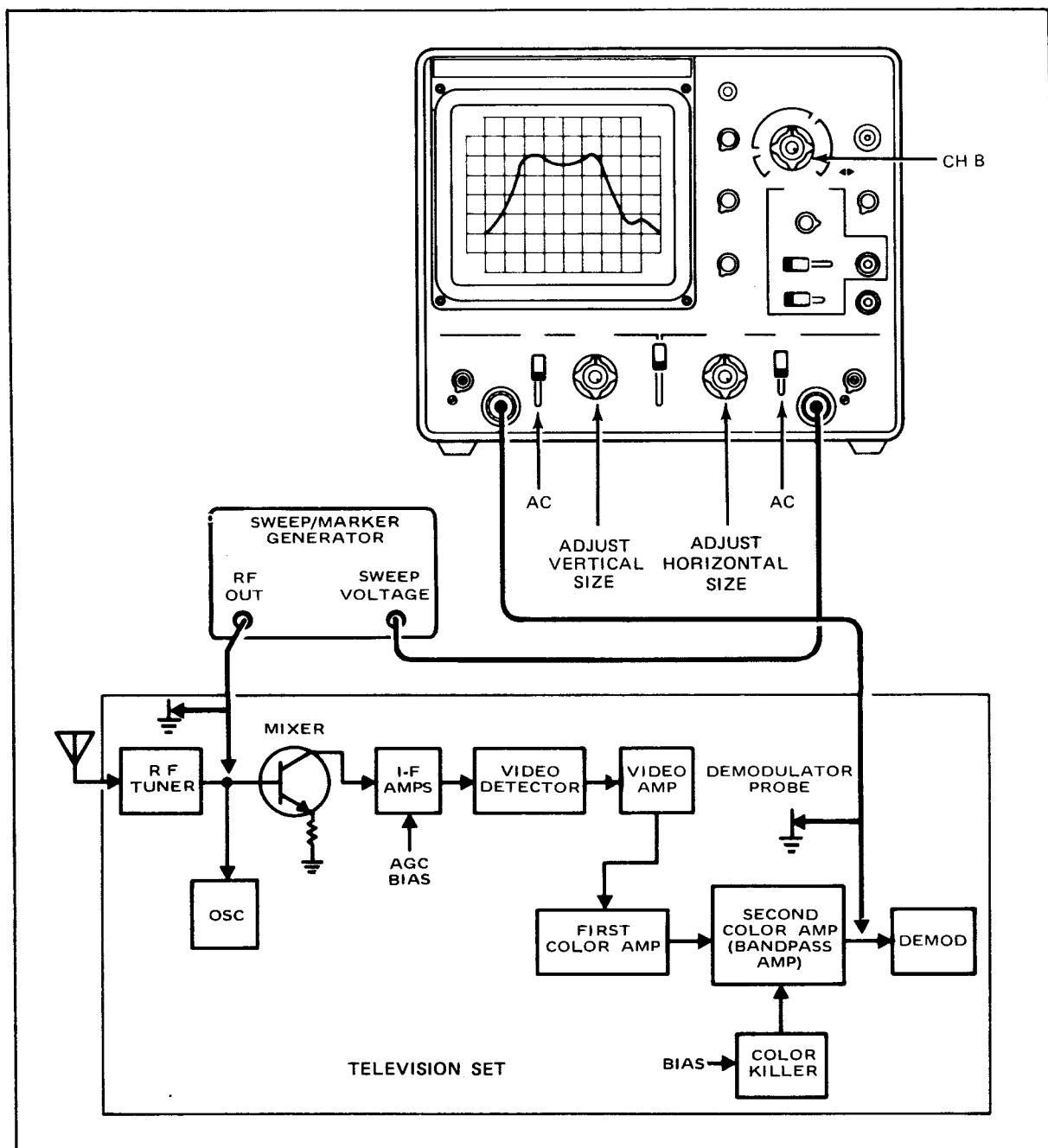


Fig. 32. Typical chroma alignment set-up.

FM RECEIVER ALIGNMENT

Refer to Fig. 33

Procedure:

1. Connect a sweep generator to the mixer input of the FM receiver. Set the sweep generator for a 10.7 MHz centered sweep.
2. Connect the sweep voltage output of the sweep generator to the Channel B input jack of the oscilloscope and set the oscilloscope controls for external horizontal sweep (SWEEP TIME/CM to CH B).
3. Connect the vertical input probe to the demodulator input of the FM receiver.
4. Adjust the oscilloscope vertical and horizontal gain controls for display similar to that shown in Fig. 33A.
5. Set the marker generator precisely to 10.7 MHz. The marker "pip" should be in the center of the bandpass.
6. Align the IF amplifiers according to the manufacturer's specifications.
7. Move the probe to the demodulator output. The "S" curve should be displayed, and the 10.7 MHz "pip" should appear exactly in the center (See Fig. 33B).

Adjust the demodulator according to the manufacturer's instructions so the marker moves equal distances from center as the marker frequency is increased and decreased equal amounts from the 10.7 MHz center frequency.

PHASE MEASUREMENT

Phase measurements may be made with an oscilloscope. Typical applications are in circuits designed to produce a specific phase shift, and measurement of phase shift distortion in audio amplifiers or other audio networks. Distortion due to non-linear amplification is also displayed in the oscilloscope waveform.

A sine wave input is applied to the audio circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.

To make phase measurements, use the following procedure (Refer to Fig. 34).

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.

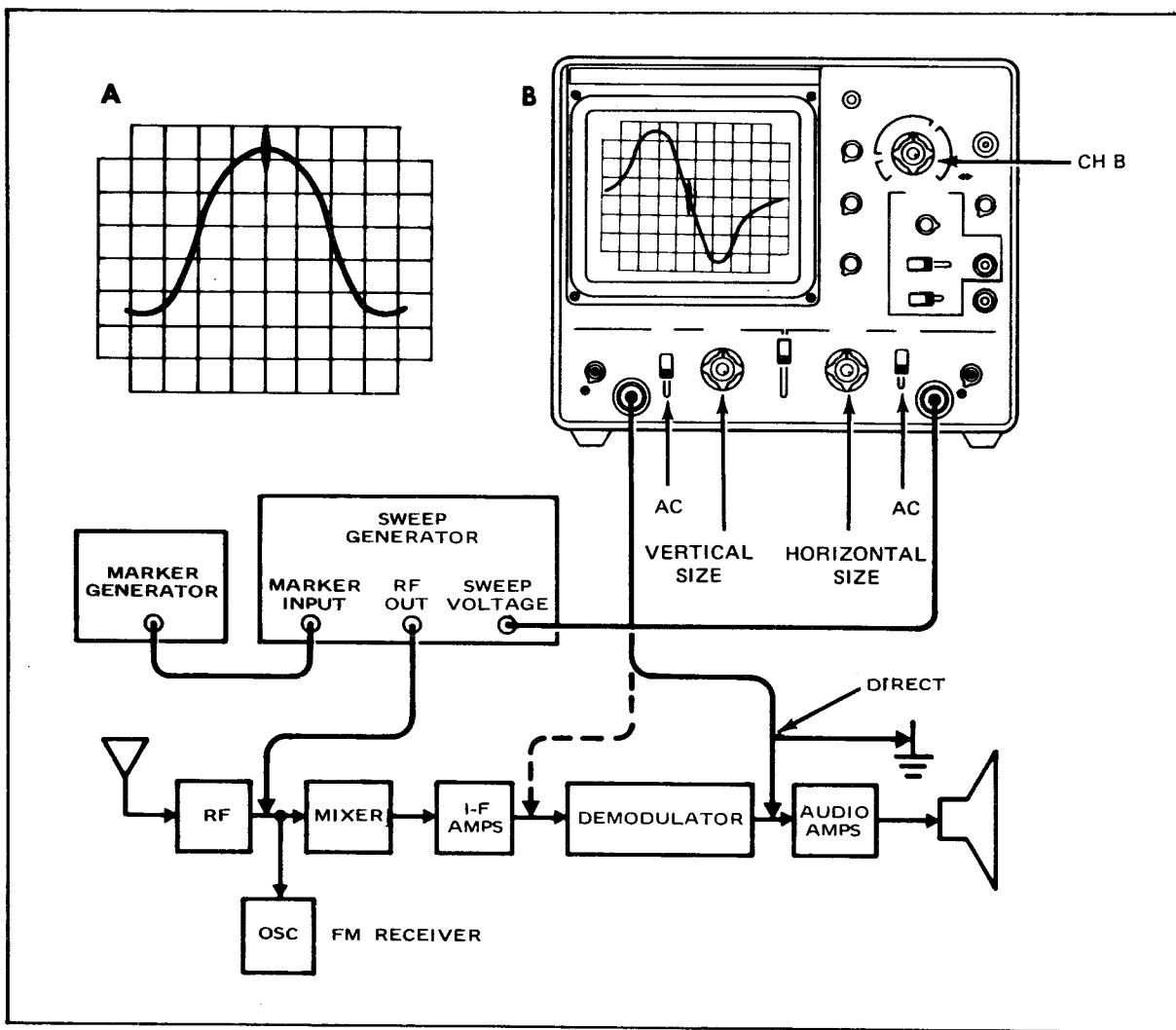


Fig. 33. Typical FM receiver alignment set-up.

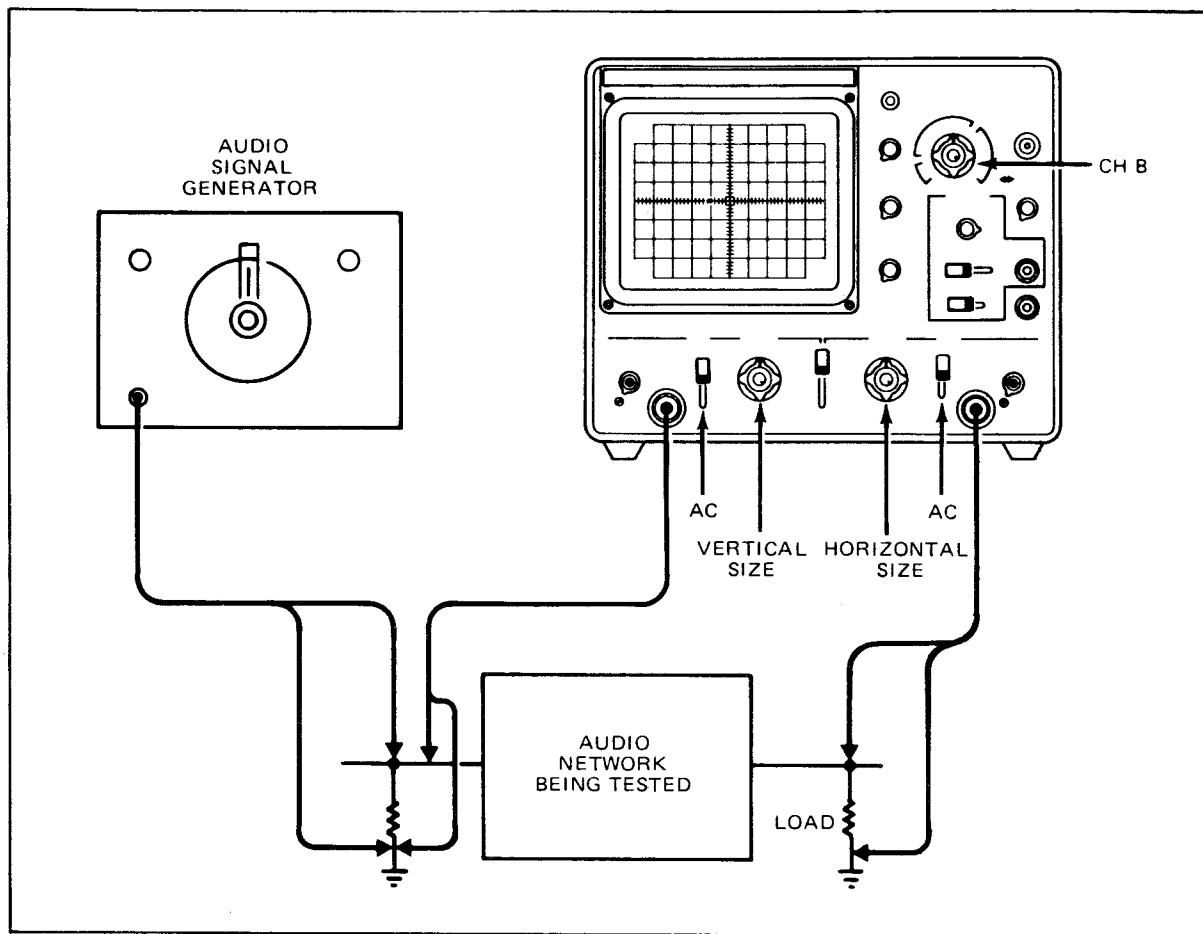


Fig. 34. Typical phase measurement alignment set-up.

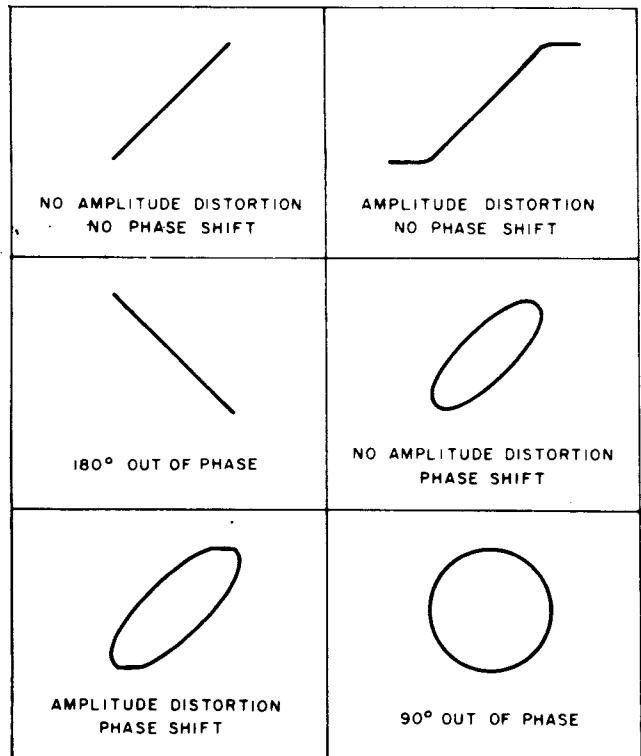


Fig. 35. Typical phase measurement oscilloscope displays.

- Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.
- Connect the Channel B probe to the output of the test circuit.
- Set the SWEEP TIME/CM control to CH B.
- Connect the Channel A INPUT probe to the input of the test circuit. (The input and output test connections to the vertical and horizontal oscilloscope inputs may be reversed.)
- Adjust the Channel A and B gain controls for a suitable viewing size.
- Some typical results are shown in Fig. 35. If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle.

A 90° phase shift produces a circular oscilloscope pattern.

Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. 36.

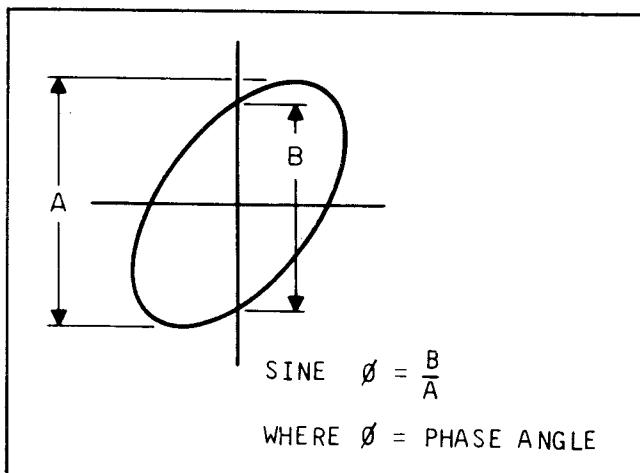


Fig. 36. Phase shift calculation.

FREQUENCY MEASUREMENT

Procedure:

- Connect the sine wave of known frequency to the CH B INPUT jack of the oscilloscope and set the SWEEP TIME/CM control to CH B. This provides external horizontal input.
- Connect the vertical input probe (CH A INPUT) to the unknown frequency.
- Adjust the Channel A and B gain controls for a convenient, easy-to-read display.
- The resulting pattern, called a Lissajous pattern, shows the ratio between the two frequencies. See Fig. 37.

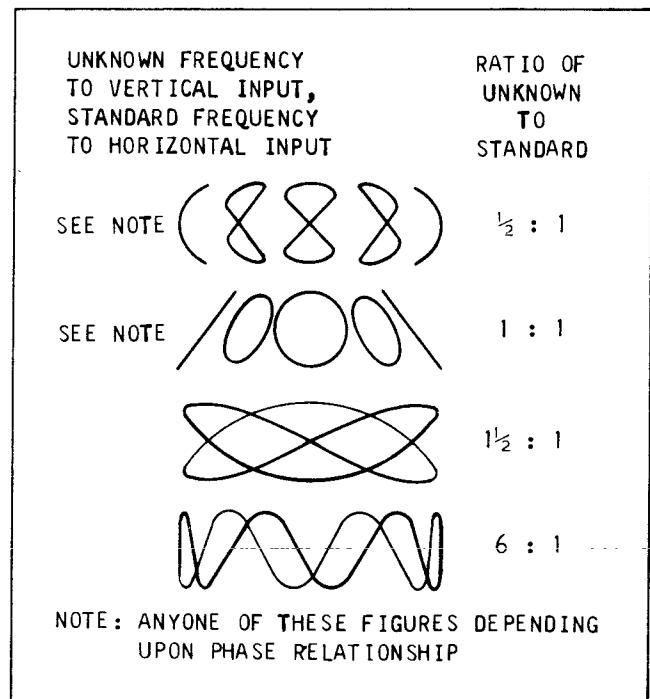


Fig. 37. Lissajous waveforms used for frequency measurement.

SQUARE WAVE TESTING OF AMPLIFIERS

INTRODUCTION

A square wave generator and a low-distortion oscilloscope, such as this instrument, can be used to display various types of distortion present in electronic circuits. A square wave of a given frequency contains a large number of odd harmonics of that frequency. If a 500 Hz square wave is injected into a circuit, frequency components of 1.5 kHz, 2.5 kHz, 3.5 kHz, also are provided. Since vacuum tubes and transistors are non-linear, it is difficult to amplify and reproduce a square wave which is identical to the input signal. Interelectrode capacitances, junction capacitances, stray capacitances as well as limited device and transformer response are a few of the factors which prevent faithful reproduction of a square wave signal. A well-designed amplifier can minimize the distortion caused by these limitations. Poorly designed or defective amplifiers can introduce distortion to the point where their performance is unsatisfactory.

As stated before, a square wave contains a large number of odd harmonics. By injecting a 500 Hz sine wave into an amplifier, we can evaluate amplifier response at 500 Hz only, but by injecting a square wave of the same frequency we can determine how the amplifier would respond to input signals from 500 Hz up to the 15th or 21st harmonic.

The need for square wave evaluation becomes apparent if we realize that some audio amplifiers will be required during normal use to pass simultaneously a large number of different frequencies. With a square wave, we have a controlled signal with which we can evaluate the input and output quality of a signal of many frequencies (the harmonics of the square wave) which is what the amplifier sees when amplifying complex waveforms of musical instruments or voices.

The square wave output of the signal generator must be extremely flat so that it does not contribute to any distortion that may be observed when evaluating amplifier response. The oscilloscope vertical input should be set to DC as it will introduce the least distortion, especially at low frequencies. When checking amplifier response, the frequency of the square wave input should be varied from the low end of the amplifier bandpass up toward the upper end of the bandpass; however, because of the harmonic content of the square wave, distortion will occur before the upper end of the amplifier bandpass is reached.

It should be noted that the actual response check of an amplifier should be made using a sine wave signal. This is especially important in limited bandwidth amplifiers (voice amplifiers). The square wave signal provides a quick check of amplifier performance and will give an estimate of overall amplifier quality. The square wave also will reveal some deficiencies not readily apparent when using a sine wave signal. Whether a sine wave or square wave is used for testing the amplifier, it is important that the manufacturer's specifications on the amplifier be known in order to make a better judgment of its performance.

TESTING PROCEDURE (Refer to Fig. 38)

1. Connect the output of the square wave generator to the input of the amplifier being tested.
2. Connect the CH B test probe of the oscilloscope to the output of the amplifier being tested.

3. If the DC component of the circuit being tested is sufficiently low to allow both the AC and DC component to be viewed, use the DC position of the AC-GND-DC switch. However, the AC position may be used without affecting the results except at very low frequencies (below 5 Hz).
4. Adjust the vertical gain control for a convenient viewing height.
5. Adjust the sweep time control for one cycle of square wave display on the screen.
6. For a close-up view of a portion of the square wave, use the 5X magnification.

ANALYZING THE WAVEFORMS

The short rise time which occurs at the beginning of the half-cycle is created by the in-phase sum of all the medium and high frequency sine wave components. The same holds true for the rapid drop at the end of the half-cycle from maximum amplitude to zero amplitude at the 180° or half-cycle point. Therefore, a theoretical reduction in amplitude alone of the high frequency components should produce a rounding of the square corners at all four points of one square wave cycle (See Fig. 39).

Distortion can be classified into three distinct categories:

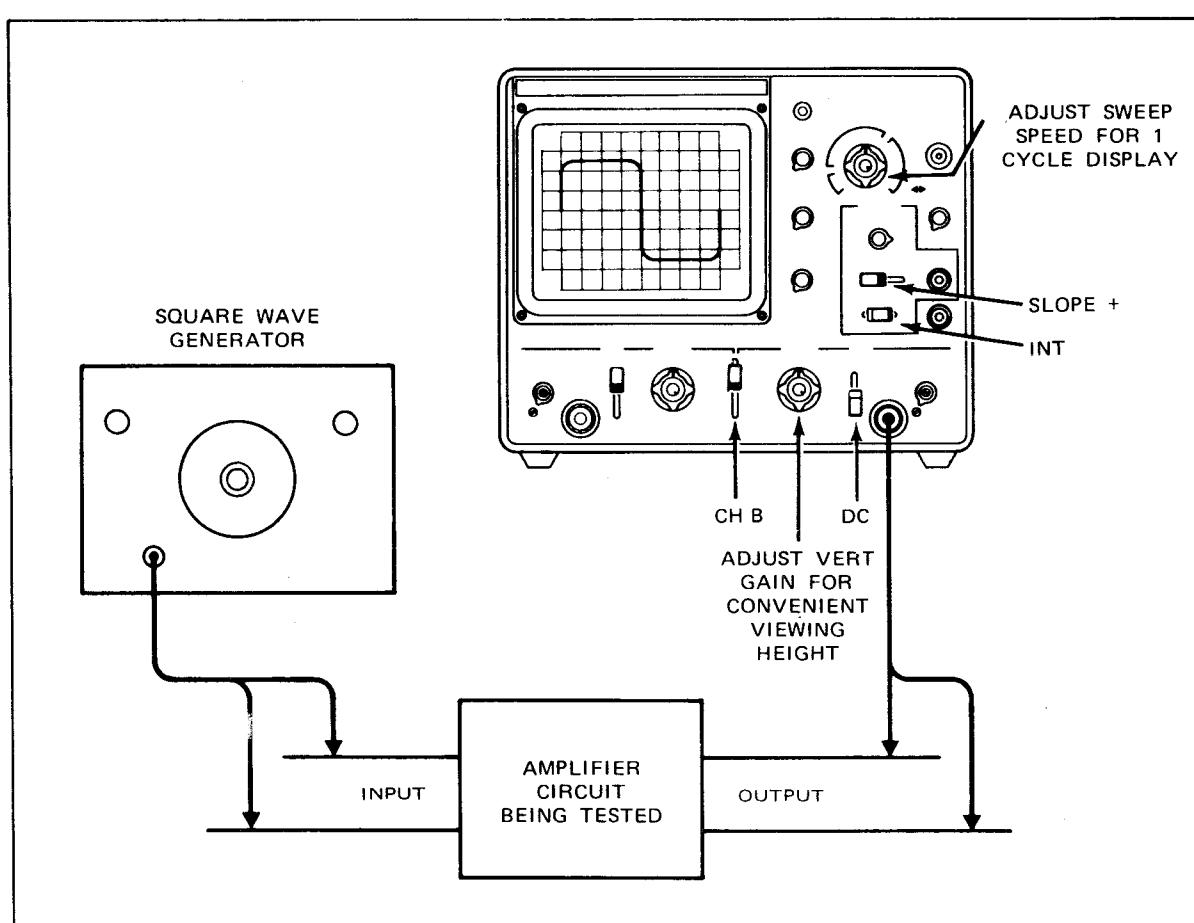


Fig. 38. Equipment set-up for square wave testing of amplifiers.

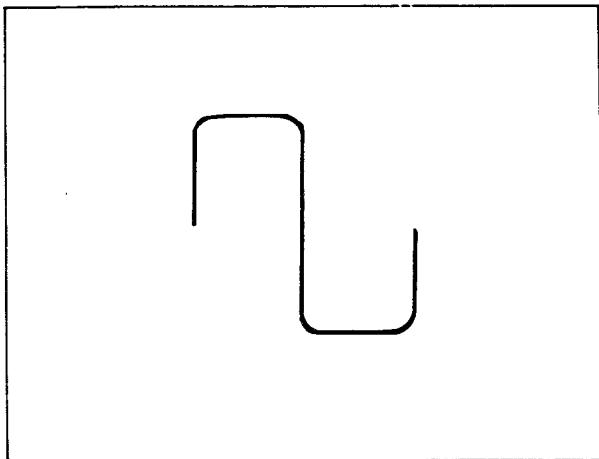


Fig. 39. Square wave response with high frequency loss.

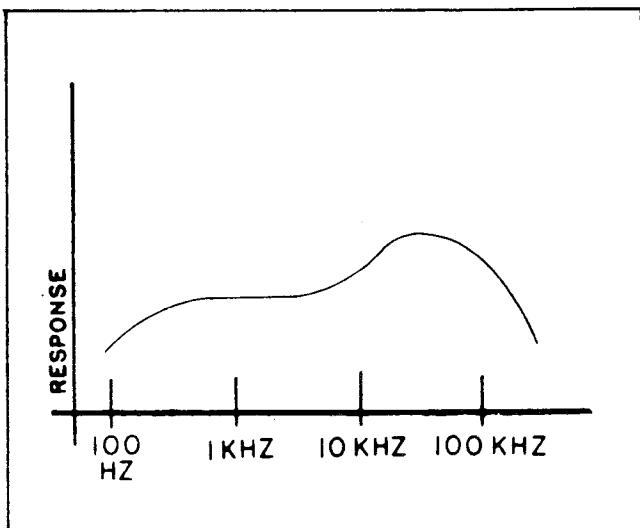


Fig. 40. Response curve of amplifier with poor low and high ends.

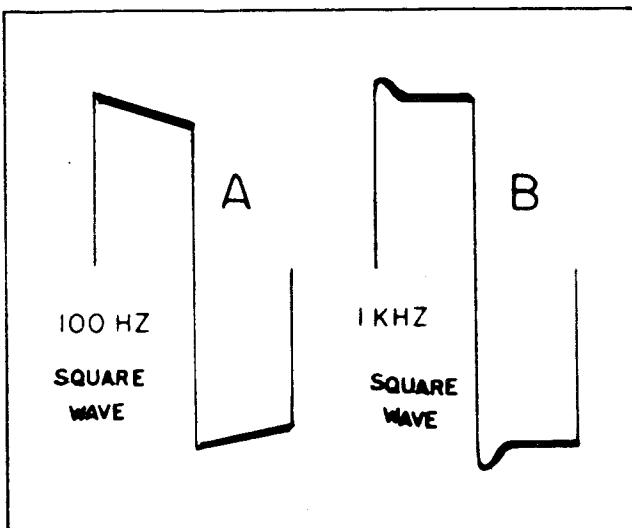


Fig. 41. Resultant 100 Hz and 1 kHz square waves from amplifier in Fig. 45.

1. The first is frequency distortion and refers to the change from normal amplitude of a component of a complex waveform. In other words, the introduction in an amplifier circuit of resonant networks or selective filters created by combination of reactive components will create peaks or dips in an otherwise flat frequency response curve.
2. The second is non-linear distortion and refers to a change in waveshape produced by application of the waveshape to non-linear components or elements such as vacuum tubes, an iron core transformer, and in an extreme case, a deliberate non-linear circuit such as a clipper network.
3. The third is delay or phase distortion, which is distortion produced by a shift in phase between one or more components of a complex waveform.

In actual practice a reduction in amplitude of a square wave component (sinusoidal harmonic) is usually caused by a frequency-selective network which includes capacity, inductance or both. The presence of the C or L introduces a difference in phase angle between components, creating phase distortion or delay distortion. Therefore, in square wave testing of practical circuitry, we will usually find that the distorted square wave includes a combination of amplitude and phase distortion clues.

In a typical wide band amplifier, a square wave check accurately reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in Fig. 40, revealing poor low-frequency response along with overcompensated high-frequency boost. A 100 Hz square wave applied to the input of this amplifier will appear as in Fig. 41A. This figure indicates satisfactory medium frequency response (approximately 1 kHz to 2 kHz) but shows poor low frequency response. Next, a 1000 Hz square wave applied to the input of this same amplifier will appear as in Fig. 41B. This figure displays good frequency response in the region of 1000 to 4000 Hz but clearly reveals the overcompensation at the higher 10 kHz region by the sharp rise at the top of the leading edge of the square wave.

As a rule of thumb, it can be safely said that a square wave can be used to reveal response and phase relationships up to the 15th or 20th odd harmonic or up to approximately 40 times the fundamental of the square wave. Using this rule of thumb, it is seen that wide-band circuitry will require at least a two-frequency check to properly analyze the complete spectrum. In the case illustrated by Fig. 40, a 100 Hz square wave will encompass components up to about 4000 Hz. To analyze above 4000 Hz and beyond 10,000 Hz, a 1000 Hz square wave should be satisfactory.

Now, the region between 100 Hz and 4000 Hz in Fig. 40 shows a rise from poor low-frequency response to a flattening out from beyond 1000 and 4000 Hz. Therefore, we can expect that the higher frequency components in the 100 Hz square wave will be relatively normal in amplitude and phase but that the lower frequency components in this same square wave will be strongly modified by the poor low-frequency response of this amplifier. See Fig. 41A.

If the combination of elements in this amplifier were such as to only depress the low frequency components in the square wave, a curve similar to Fig. 42 would be obtained. However, reduction in amplitude to a component, as already noted, is usually caused by a reactive element, causing, in turn, a phase shift of the component, producing the strong tilt of Fig. 41A. Fig. 43 reveals a

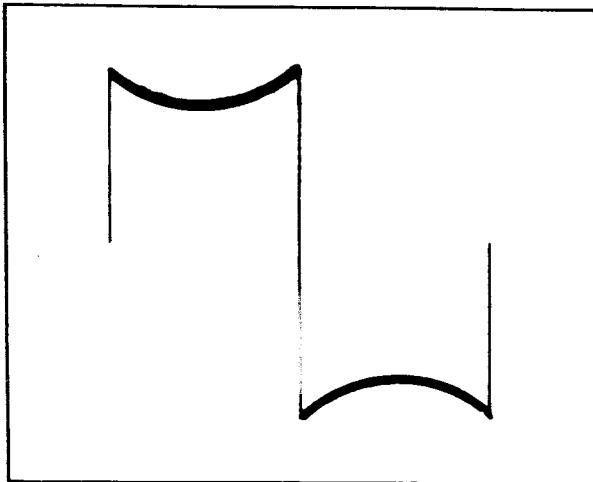


Fig. 42. Reduction of square wave fundamental frequency component in a tuned circuit.

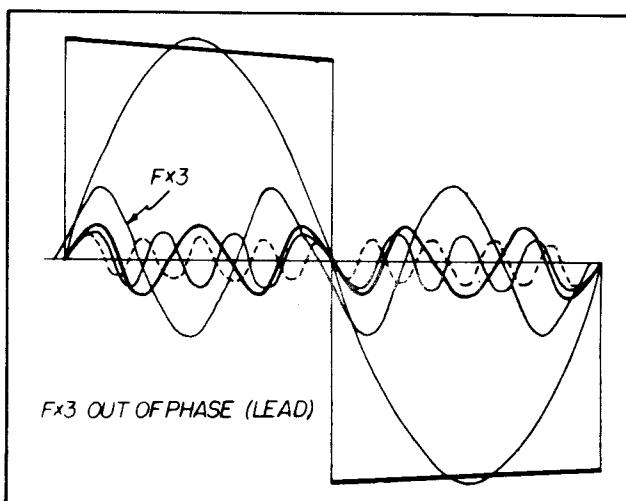


Fig. 43. Square wave tilt resulting from 3rd harmonic phase shift.

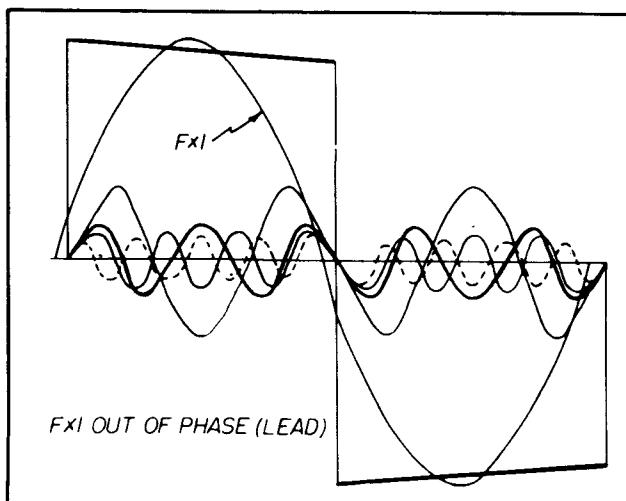


Fig. 44. Tilt resulting from phase shift of fundamental frequency in a leading direction.

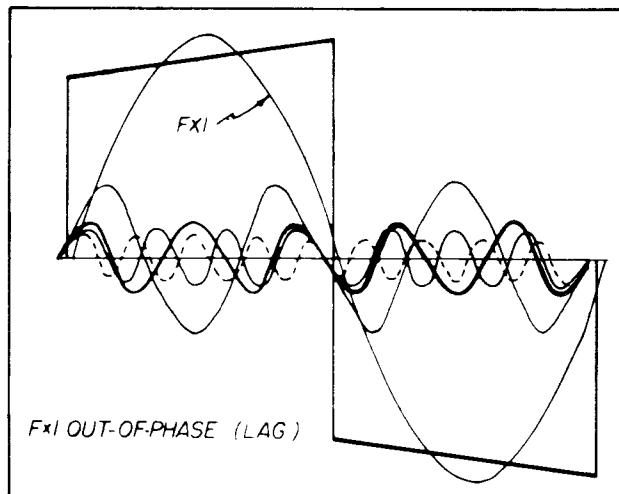


Fig. 45. Tilt resulting from phase shift of fundamental frequency in a lagging direction.

graphical development of a similarly tilted square wave. The tilt is seen to be caused by the strong influence of the phase-shifted 3rd harmonic. It also becomes evident that very slight shifts in phase are quickly shown up by tilt in the square wave.

Fig. 44 indicates the tilt in square wave shape produced by a 10° phase shift of a low-frequency element in a leading direction. Fig. 45 indicates a 10° phase shift in a low-frequency component in a lagging direction. The tilts are opposite in the two cases because of the difference in polarity of the phase angle in the two cases as can be checked through algebraic addition of components.

Fig. 46 indicates low-frequency components which have been reduced in amplitude and shifted in phase. It will be noted that these examples of low-frequency distortion are characterized by change in shape of the flat top portion of the square wave.

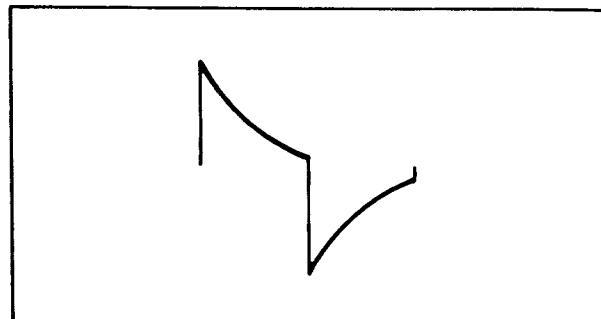


Fig. 46. Low-frequency component loss and phase shift.

Fig. 41B, previously discussed, revealed high-frequency overshoot produced by rising amplifier response at the higher frequencies. It should again be noted that this overshoot makes itself evident at the top of the leading edge of the square wave. This characteristic relationship is explained by remembering that in a normal well-shaped square wave, the sharp rise of the leading edge is created by the summation of a practically infinite number of harmonic components. If an abnormal rise in amplifier response occurs at high frequencies, the high-frequency components in the square wave will be amplified disproportionately greater than other components creating a higher algebraic sum along the leading edge.

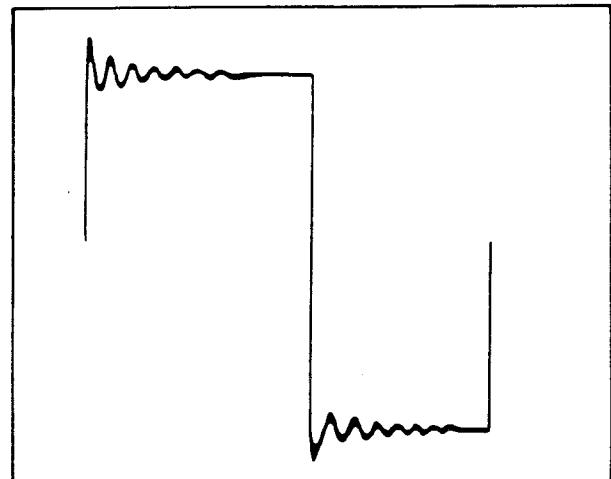


Fig. 47. Effect of high-frequency boost and *poor damping*.

Fig. 47 indicates high-frequency boost in an amplifier accompanied by a lightly damped "shock" transient. The sinusoidal type of diminishing oscillation along the top of the square wave indicates a transient oscillation in a relatively high "Q" network in the amplifier circuit. In this case, the sudden transition in the square wave potential from a sharply rising, relatively high-frequency voltage, to a level value of low-frequency voltage, supplies the energy for oscillation in

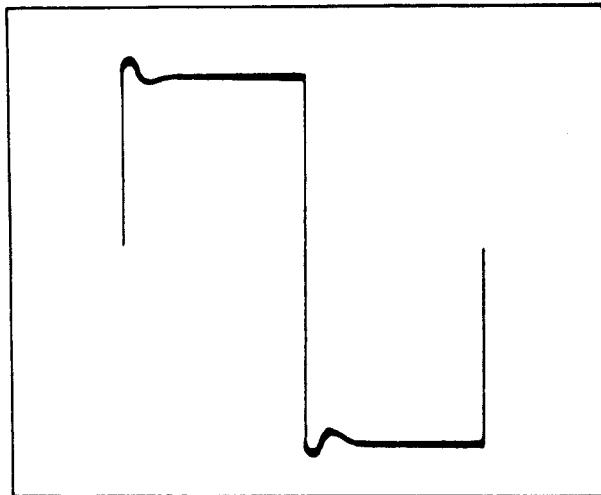


Fig. 48. Effect of high-frequency boost and *good damping*.

the resonant network. If this network in the amplifier is reasonably heavily damped, then a single cycle transient oscillation may be produced as indicated in Fig. 48.

Fig. 49 summarizes the preceding explanations and serves as a handy reference.

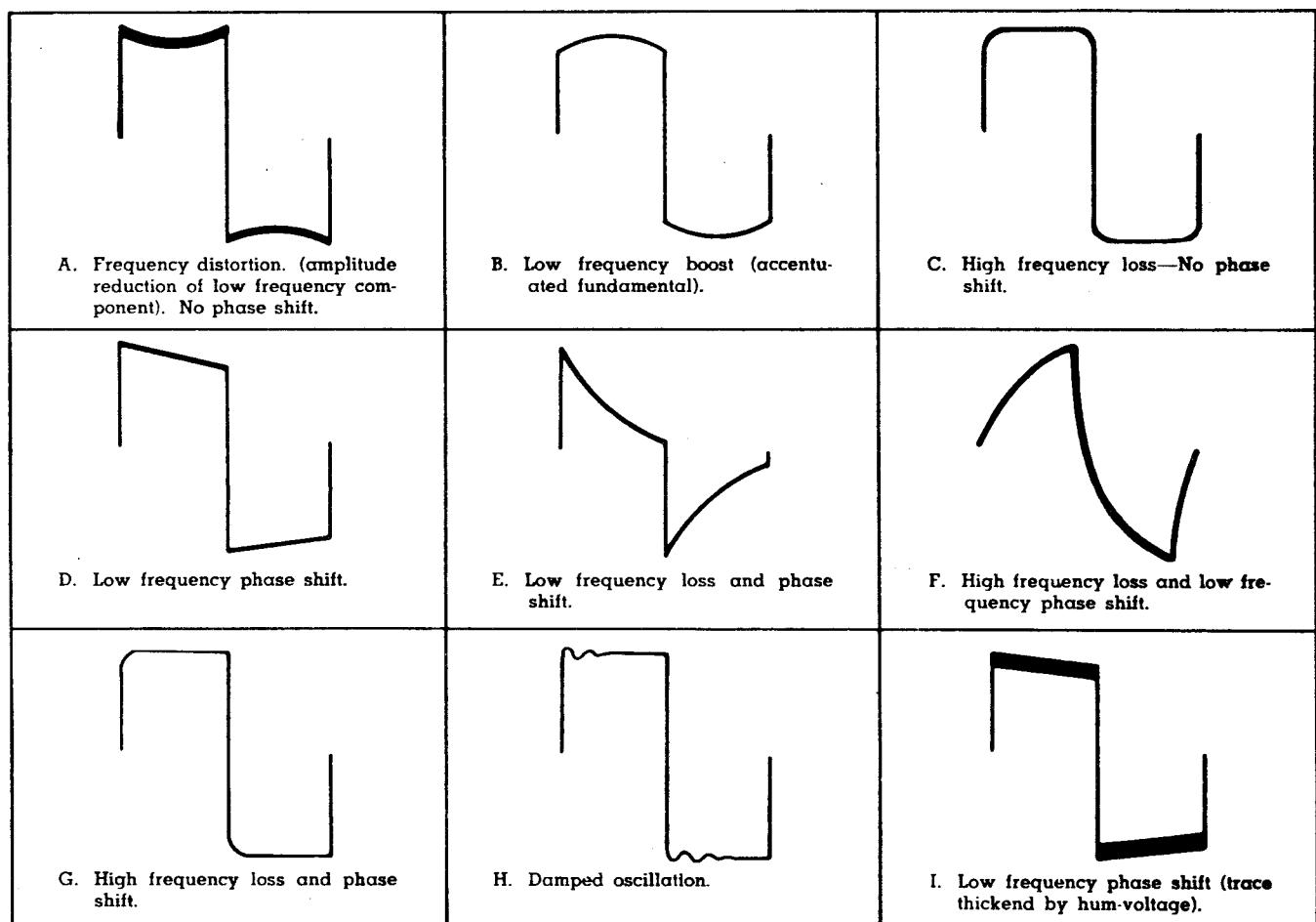


Fig. 49. Summary of waveform analysis for square wave testing of amplifiers.

CIRCUIT DESCRIPTION

The block diagram, Fig. 50, outlines the circuit breakdown of the oscilloscope. Circuit details are obtained by reference to the schematic diagram.

GENERAL

Basically, the oscilloscope consists of two identical vertical preamplifiers, each having its own input attenuator network. The outputs of the vertical preamplifiers can be switched, as desired, into the main vertical amplifier. The switching of the CH A and CH B preamplifiers is determined by the position of the MODE switch and MODE LOGIC. The main vertical amplifier feeds the VERTICAL OUTPUT AMPLIFIER, which drives the vertical deflection plates of the CRT.

Horizontal deflection is provided by the horizontal amplifier. Drive to the horizontal amplifier is furnished by calibrated sweep speed circuits or by the signal from the CH B preamplifier when X-Y operation is selected.

All supply voltages are fully regulated and a DC-to-DC converter provides a regulated, 2kV, accelerated potential to the CRT.

VERTICAL PREAMPLIFIERS

Channel A and Channel B preamplifiers contain identical circuitry and circuit operation is the same for both. CH A will be described below.

The vertical preamplifier consists of dual FET input transistor Q101 which forms a balanced differential amplifier with output signals of opposite polarity. VR101 is the side panel DC BAL control. Emitter followers Q103 and Q104 drive the differential amplifier Q105 and Q106. Stage gain is changed in the emitters of Q105 and Q106 to provide gains of 5, 2, and 1. The front panel POSITION control VR102 provides a DC component to move the trace vertically across the screen.

Transistor array IC101 is turned on or off by the MODE LOGIC circuitry.

Trigger amplifier Q107 and Q108 buffers the signal from IC101 and delivers the signal to the trigger amplifier.

MODE LOGIC

The mode of operation (CH A, CH B, and DUAL) is controlled by IC103 and IC104. When CH A is selected by the front panel MODE switch, the Q output of IC103 goes LOW, turning on the CH A preamplifier and trigger amplifier. When CH B is selected the Q output of IC103 goes low turning on the CH B preamplifier and trigger amplifier. When DUAL is selected the Q and \bar{Q} outputs of IC103 are switched on and off at a 200 kHz rate for the CHOPPED mode, and after each sweep when in ALTERNATE mode. When in DUAL, the CH A trigger amplifier is turned on, providing a trigger signal to the sweep circuits.

When the SWEEP TIME/CM switch is in CH B position, the CH B trigger amplifier signal is applied to the horizontal amplifier.

VERTICAL AMPLIFIER

The selected signal from the preamplifiers is applied to the vertical output stage consisting of transistors Q113 to

Q120, which amplifies the signal to the levels required to drive the vertical deflection plates of the CRT. VR105 is a DC balance control, while VR104 and TC113 are high-frequency compensation adjustments.

TRIGGER CIRCUIT

The trigger source, either CH A or CH B, is selected by MODE switch S105. Selecting either CH A or DUAL enables trigger amplifier Q107 and Q108, and CH B enables trigger amplifier Q127 and Q128. The trigger amplifier output is fed thru transistor switch Q313. Q313 is turned on in all positions of the SWEEP TIME/CM switch except CH B.

SYNC AMPLIFIER AND INVERTER

Source switch S303 selects either INTERNAL (from preamplifiers) or EXTERNAL triggering. The trigger signal is then fed to differential amplifier IC305. Either the inverted (SLOPE -) or non-inverted (SLOPE +) signal is selected by SYNC switch S304. LEVEL control VR310 adds a DC COMPONENT to the output of IC305.

SYNC SEPARATOR

When VIDEO+ or - is selected, the output of IC305 is routed to the SYNC SEPARATOR circuit consisting of Q320 and Q319. Q320 is held at cutoff by a negative voltage developed across C332 corresponding to an average value of the input signal. Positive-going pulses drive Q320 out of cutoff. The output of Q320 corresponds to the sync tips of the composite video signal.

When in the FRAME positions of the SWEEP TIME/CM switch (.1mS to .5 sec), Q319 is on; this allows C331 to filter out the horizontal sync pulses, permitting only vertical sync pulses to pass to the sweep circuit. In the LINE positions, 50 μ SEC to 1 μ SEC, Q319 is turned off, removing C331 and allowing horizontal sync pulses to pass to the sweep circuit.

SWEEP CIRCUIT

The trigger signal passes thru emitter follower Q303, and to the SCHMITT TRIGGER circuit consisting of two gates of IC303. The output pulses from IC303 clock the SWEEP CONTROL flip-flop IC301. On the negative edge of the clock waveform, the Q output of IC301 goes low, turning off Q307 to initiate the sweep.

Transistors Q308 and Q309 and the timing capacitors and resistors selected by the SWEEP TIME/CM switch, form a MILLER INTEGRATING circuit to provide a linear ramp voltage. The sweep ramp from the collector of Q309 is fed to the holdoff circuit IC302 and IC303.

As soon as the Q output of IC301 goes low, the reset of IC301 is held low by IC303 to exclude any new clock pulses until the sweep ramp is terminated. When the sweep ramp exceeds the level set by VR309 (SWEEP LENGTH), IC 302 places a low on the set input of IC301. A low on the set input forces the Q output of IC301 high which turns on Q307, terminating the sweep.

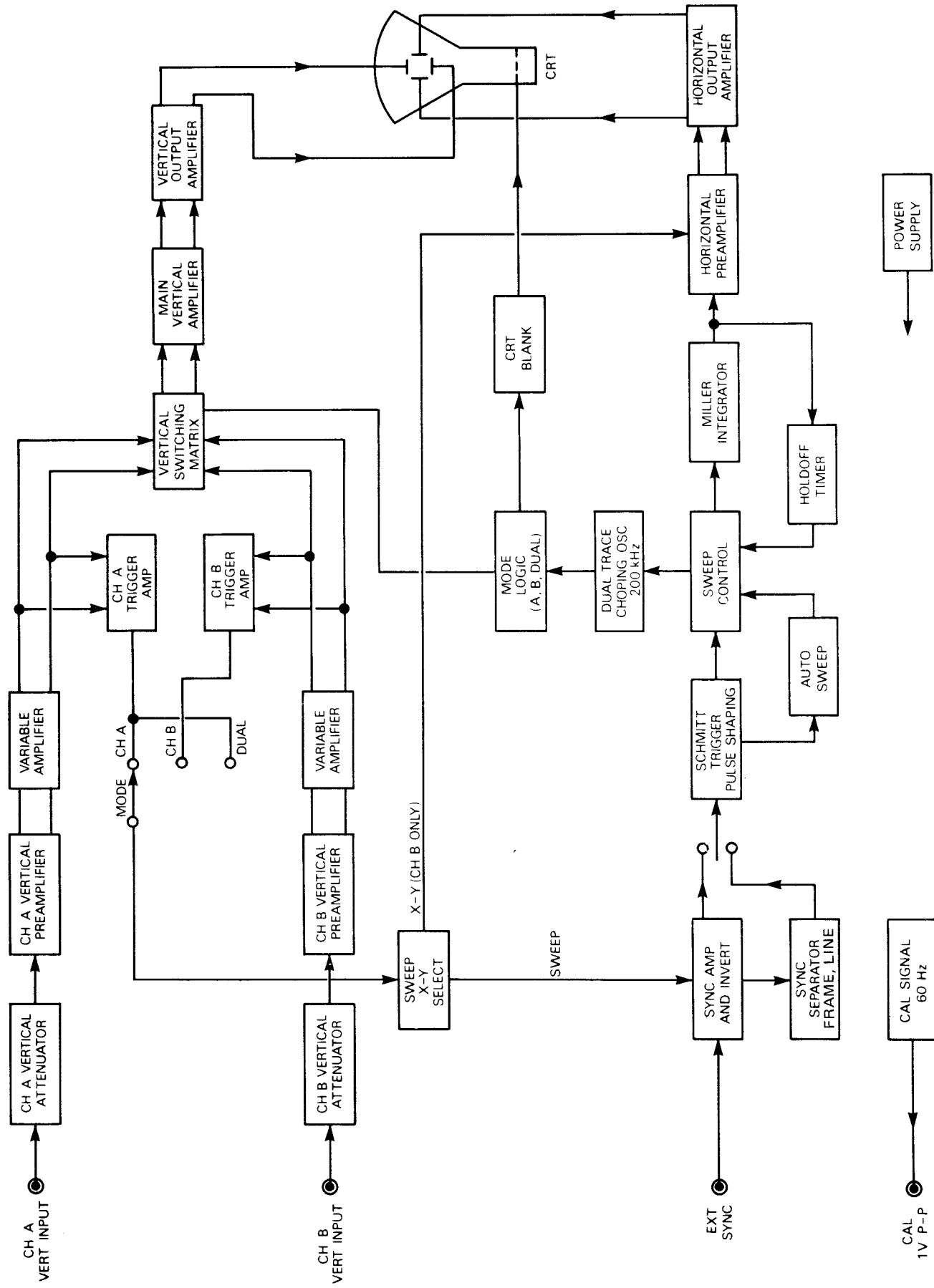


Fig. 50. Block diagram.

AUTO SWEEP

Transistors Q304, Q305, and Q306 form the AUTO SWEEP circuit. When the trigger level control is pulled out (AUTO) and no signal is present at the trigger amplifier, C303 charges and turns Q306 on, this places a low on the reset of IC301 and allows a sweep to recirculate at a rate determined by the resistor and capacitor selected by the SWEEP TIME/CM switch. When a trigger signal is present, transistors Q304 and Q305 discharge C303, turning Q306 off and enabling the sweep to trigger on the incoming signal.

HORIZONTAL AMPLIFIER

The sweep ramp from the collector of Q309 is applied thru VR306 (timing adj.) to the input of the horizontal amplifier consisting of Q314, Q315, Q317, and Q318. VR305 is a horizontal centering adjustment and VR3 is the horizontal position control.

When in the X-Y mode, transistor Q313 is turned off thru IC303 and the CH B signal is applied to both Q312 and the horizontal amplifier. The output of transistors Q317 and Q318 is applied to the horizontal deflection plates of the CRT. VR303 is the X5 magnification adjustment and VR304 is the magnification centering adjustment.

WARNING

High voltage up to 2000 volts is present on the CRT and vertical amplifier & power supply board when the oscilloscope is operating. Up to 180 volts dc is present on the sweep board. Line voltage (120 or 240 VAC) is present on the vertical amplifier & power supply board, power transformer, and the POWER on-off switch any time the oscilloscope is connected to an ac power source, even if turned off. Always observe caution when the housing is removed from the unit. Contacting exposed high voltage could result in fatal electric shock.

HOUSING REMOVAL

1. Remove 6 screws; 2 on left side, 2 on right side, and 2 on top.
2. Lift cover off scope.

240 VAC OPERATION

1. Remove housing from scope.
2. Remove plug from P101.
3. Rotate plug 180° and reinsert on P101.
4. Replace 0.7A fuse with 0.3A fuse.
5. Replace housing.

The calibration adjustments outlined here are those which can be performed with a minimum of specialized test equipment. Additional internal adjustments of frequency compensation and horizontal sweep linearity should not be attempted without complete service information and specified test equipment. Requests for complete service information for this oscilloscope should be addressed to:

CHOPPING OSCILLATOR

Two NAND gates from IC304 and IC305 form a 200 kHz CHOPPING OSCILLATOR activated in the CHOP positions of the SWEEP TIME/CM switch when DUAL is selected. IC304 provides a pulse for blanking the trace during retrace and when chopping.

1 VOLT CAL SIGNAL

Transistors Q301 and Q302 provide a 60 Hz square wave. VR301 adjusts the amplitude of the CAL SIGNAL.

POWER SUPPLY

The power supply provides all voltages necessary for operating the oscilloscope.

Regulated output voltages of +10, and -8, and +5 are provided for all logic and amplifier circuits. Amplifier output stages require the 180V.

The accelerating voltage for the CRT is derived from a DC-to-DC converter consisting of Q142 and T101. The output of T101 is rectified and filtered and applied thru voltage dividers to the CRT. A portion of the high voltage is fed to a regulator circuit consisting of Q129 and Q130 to provide a constant accelerating potential under varied operating conditions.

MAINTENANCE AND CALIBRATION

SERVICE DEPARTMENT
B & K-PRECISION TEST EQUIPMENT
DYNASCAN CORPORATION
2815 W. Irving Park Road
Chicago, Illinois 60618

Internal adjustments outlined in the calibration procedure can be located by reference to Fig. 51 and 52.

CRT ROTATION ADJUSTMENT

1. Loosen two screws on rear panel with adjustment slots.
2. Grasp cover and rotate to align horizontal trace with horizontal graticule line.
3. Tighten two screws.

DC BALANCE ADJUSTMENT

1. Adjust controls to obtain a horizontal trace. (CH A or CH B).
2. Adjust Δ POSITION control to center the trace vertically on the CRT.
3. Rotate the VOLTS/CM switch from 1V/CM to 2V/CM to 5V/CM while observing the trace.
4. If the trace moves vertically more than 5mm while performing STEP 3, adjust the CH A or CH B DC BAL (side panel screwdriver adjustment) so that the vertical movement of the trace does not exceed 5mm while performing STEP 3.

VERTICAL GAIN ADJUSTMENT

The following adjustments should be attempted only if a square wave generator with 1% or better amplitude accuracy is available.

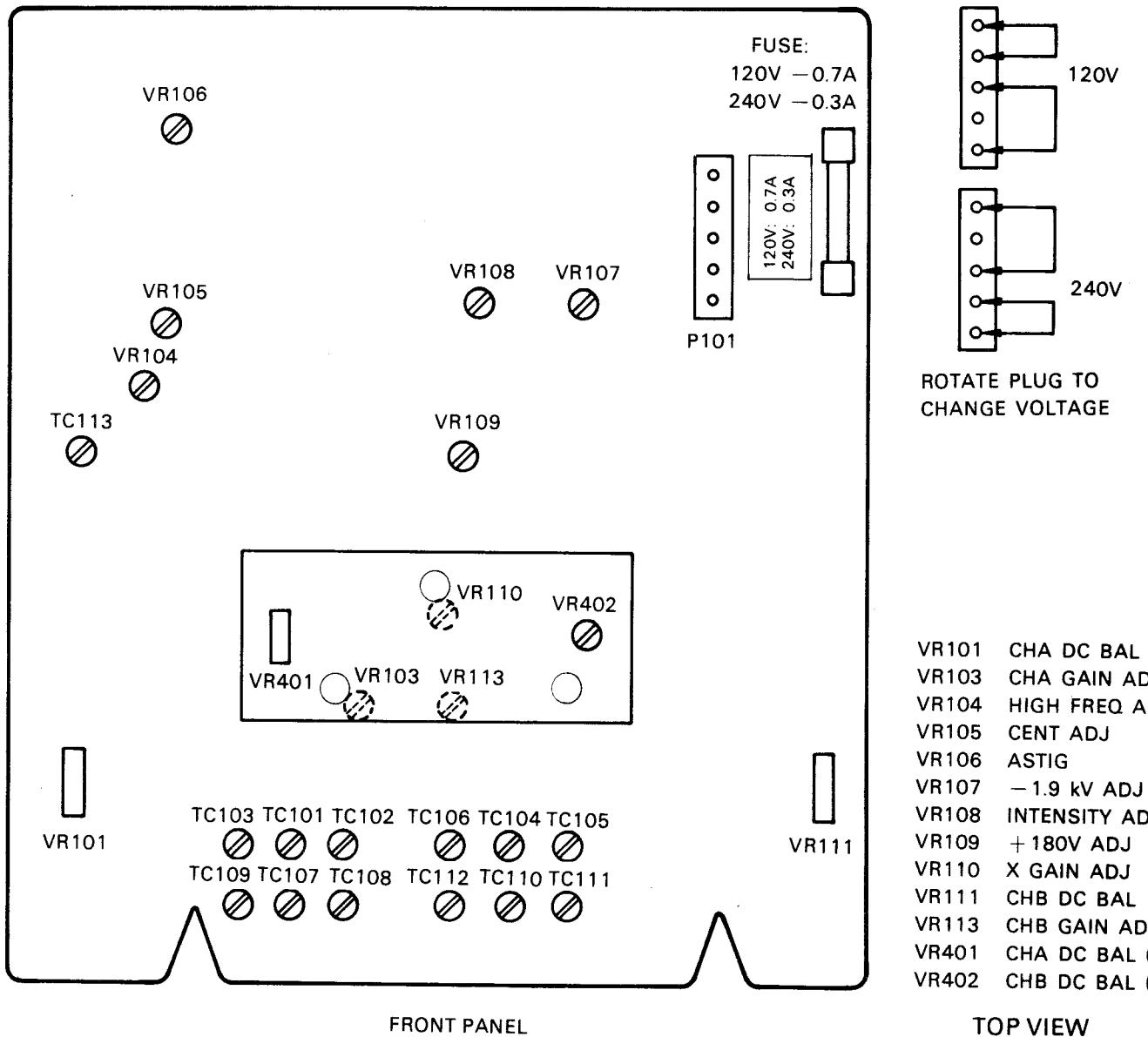


Fig. 51. Calibration diagram, vertical amplifier and power supply board.

Procedure

1. Set CH A and CH B VOLTS/CM switch to .01V/CM.
2. Apply 1 kHz square wave of 50mV peak-to-peak into CH A input connector. Set mode switch to CH A.
3. Adjust VR103 for exactly 5 cm of deflection on CRT.
4. Repeat steps 2 and 3 for CH B and adjust VR113 for 5cm deflection.

HORIZONTAL POSITION ADJUSTMENT

1. Set $\blacktriangleleft\triangleright$ POSITION control to the mechanical center of rotation.

2. Set SWEEP TIME/CM switch to 1mS/CM.
3. Adjust VR305 so that the line on the scope is horizontally centered on CRT.
4. Turn the $\blacktriangleleft\triangleright$ POSITION control full CW and CCW. The amount of deflection in both directions should be a minimum of 4 cm.

ASTIGMATISM ADJUSTMENT

1. Rotate SWEEP TIME/CM switch to EXT H. position.
2. Adjust FOCUS control and VR106 (ASTIG.) for a small, bright spot with INTENSITY set at midrange.

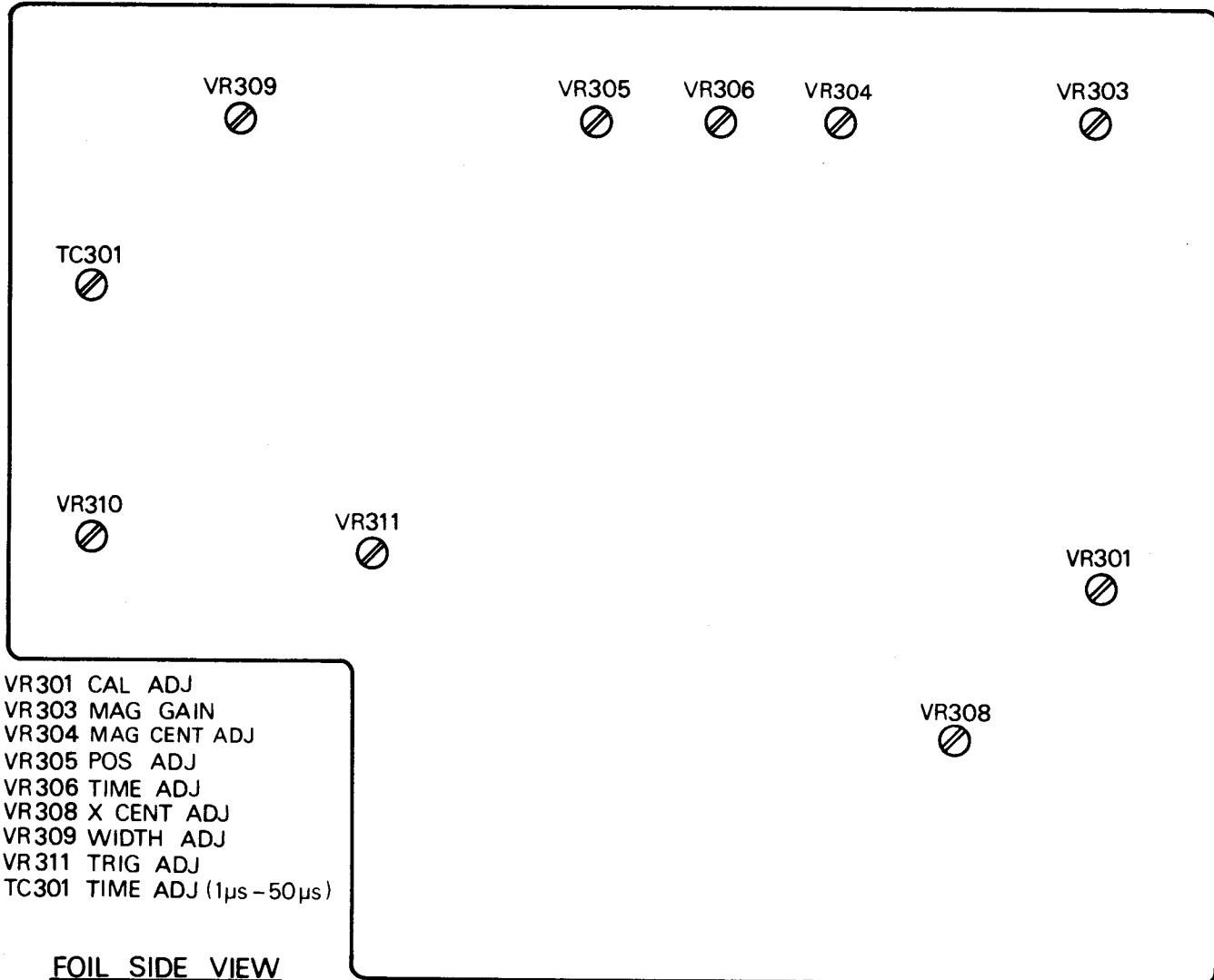


Fig. 52. Calibration diagram, horizontal amplifier board.

WARRANTY SERVICE INSTRUCTIONS

1. Refer to the MAINTENANCE section of your B & K-Precision instruction manual for adjustments that may be applicable.
2. If the above-mentioned procedures do not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred) to the nearest B & K-Precision authorized service agency (see list enclosed with unit).

If your list of authorized B & K-Precision service agencies has been misplaced, contact your local distributor for the name of your nearest service agency, or write to:

Service Department

B & K-Precision Product Group
DYNASCAN CORPORATION
2815 West Irving Park Road
Chicago, Illinois 60618

LIMITED ONE-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its B & K-PRECISION product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized B & K-PRECISION service contractor or the factory service department, accompanied by proof of the date of purchase in the form of a sales receipt.

To obtain warranty coverage, this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, B & K-PRECISION, P.O. Box 35080, Chicago, Illinois 60635 within five (5 days) from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your B & K-PRECISION distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to B & K-PRECISION Service Department, 2815 West Irving Park Road, Chicago, Illinois 60618, properly packaged to avoid damage in shipment.

OPTIONAL ACCESSORIES

The following **B & K-PRECISION** accessories are available to complement your Model 1476 Oscilloscope.

MODEL LC-74 PROTECTIVE COVER

This rugged grained leatherette cover provides convenience and protection when transporting the oscilloscope. A handy pocket provides stowage for probes.

MODEL RM-14 RACK MOUNTING KIT

This kit includes everything needed to mount the oscilloscope in a standard 19" rack, including panel, hardware, and complete instructions.

INSTRUMENT CONNECTING CABLES

The following **B & K-PRECISION** cables, which may be purchased separately, may be useful for connecting your oscilloscope directly to other equipment:

Model CC-41. 36" RG/58U with a BNC connector on each end.

Model CC-42. 36" RG/58U with BNC connector and UHF connector (PL-259).

Model CC-43. 36" RG/58U with BNC connector and banana plugs.

Model CC-44. 36" RG/58U connector and coaxial microphone connector.

Model CC-45. 36" RG/58U with BNC connector and type N connector.

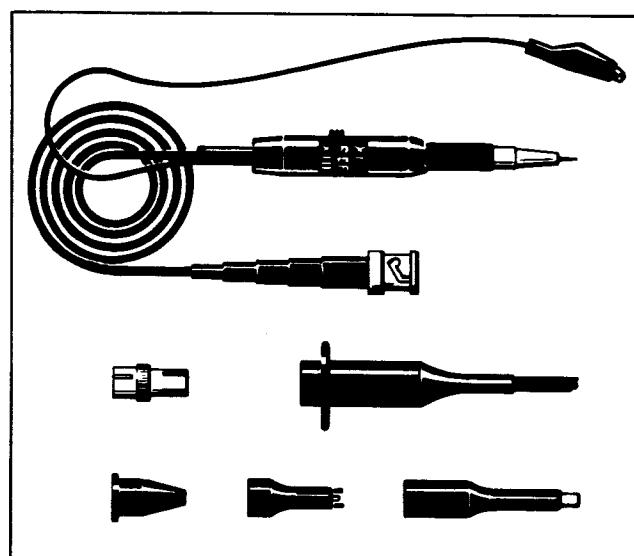
MODEL PR-32 RF DEMODULATOR PROBE

This probe permits display and analysis of the modulation envelope of RF signals to 250 MHz (-6 dB @ 250 MHz). Input impedance is 30 k Ω minimum, shunted by 4.5 pF maximum. Internal shielding protects against stray RF pickup.

MODEL PR-37 DELUXE PROBE

The **B & K-PRECISION** Model PR-37 deluxe probe is designed for use with wideband oscilloscopes to 100 MHz. The PR-37 is a slim-body probe of precision lightweight construction. A three-position switch select 10:1 or direct modes, or a reference position that grounds the tip through a 9M resistor. The 52" coaxial cable is extremely flexible. Accessories included with the PR-37 are a spring-loaded retractable tip cover, insulating tip BNC tip adapter, IC tip and an insulated compensation capacitor adjustment tool. The insulating tip is designed for probing dense solid-state circuitry with no danger of shorting nearby components.

The BNC adapter tip converts the probe tip into a push-on BNC fitting, ideal for interface with test points or output jacks. The IC tip guides the probe contact into any pin of a standard DIP, making it almost impossible to short two pins of an IC. The PR-37 is available in both grey and red colors. Probes of different colors are particularly useful with a dual-trace scope for instant identification of the channel to which a probe is connected. The PR-37 and accessories come in convenient zippered vinyl case. Model PR-37G is grey and PR-37R is red.





6460 West Cortland Street
Chicago, Illinois 60635