C102

TRIGGERED SWEEP OSCILLOSCOPE

HIGH STABILITY

CS-1566A

DUAL TRACE OSCILLOSCOPE

INSTRUCTION MANUAL

TRIO

FEATURES

* Vertical axis with wide bandwidth (20 MHz, −3 dB) and high sensitivity (5 mV/div, 1 div = 1 cm).
* Distortion-free display of signals up to 20 MHz on the full area of CRT screen.
* High sensitivity CRT (rectangular with internal graticule) with excellent beam permeability has sufficient brightness for measurements of high-speed pulses of high frequencies.
* The high voltage power for CRT as well the power for other circuits is fully stabilized because of the use of DC-DC converter, thus the sensitivity and brightness are completely free from effects of voltage variations.
* X-Y operation is possible with CH2 amplifier used as X axis. The horizontal axis sensitivity is as high as 5mV/div.
* ALT and CHOP operations for dual-trace observation.
* The time base switch allows changeover between V (vertical) and H (horizontal) of VIDEO sync separator circuit, automatically and electronically.
* INT, CH1, CH2, LINE and EXT can be individually synchronized for selection of desired sync signals.
* At AUTO position of TRIG LEVEL, it is possible to check the brightness at no-signal time and to adjust triggering level of input waveforms.
* The adoption of ICs throughout assures high performance and improved reliability.

CONTENTS

SPECIFICATIONS

Cathode Ray Tube

Type:
C5S106P31B

Acceleration voltage:
2 kV

Scale:
8 div × 10 div (1 div = 9.5 mm)

Vertical Amplifier (for Both CH1 and CH2)

Deflection Factor:
5 mV/div to 20V/div ±5%

Attenuator:
5 mV/div to 20V/div, 1-2-5 sequence
Precisely adjustable in all 12 ranges.
Sensitivity error between ranges is ±5%.

Input impedance:
1 MΩ ±2%

Input capacitance:
Approx. 27 pF

Frequency response:
DC DC to 20 MHz (less than −3 dB) [5 mV/div ~ 10V/div]
AC 2 Hz to 20 MHz (less than −3 dB) [5 mV/div ~ 10V/div]

Risetime:
Less than 17.5 nsec.

Overshoot:
Less than 3% (at 100 kHz square wave)

Cross-talk:
ALT Less than −60 dB
CHOP Less than −50 dB

Operating modes:
CH1 CH1 only
CH2 CH2 only
ALT 2-channel with ALT (alternate sweep)
CHOP 2-channel with CHOP
ADD 2-channel algebraic sum (CH1 + CH2)

CHOP frequency:
Approx. 200 kHz

Maximum input voltage:
600 Vp-p or 300V (DC + AC peak)

Invert polarity:
CH2 only

Sweep Circuit

Sweep system:
Triggering sweep and auto sweep (free-running sweep at no-signal time)

Sweep time:
0.5μs/div to .5s/div ±5% and X-Y, 1-2-5 sequence
Fine adjustment in all 19 ranges

Magnification:
10 times ±5% (PULL × 10 MAG)

Linearity:
Better than 3% (2 μs/div to 0.5s/div)
Better than 5% (0.5 μs/div to 1 μs/div)
Better than 10% (× 10 MAG)

Triggering

Source:
INT, CH1, CH2, LINE, EXT

Slope:
NORM Positive and negative
VIDEO Positive and negative (LINE and FRAME automatically selected by SWEEP TIME/DIV)
LINE (TV-line): 0.5 μs/Div to 50 μs/div
FRAME (TV-Frame): 0.1 ms/div to 0.5s/div

Sensitivity:

Trigger Type	Bandwidth	Minimum Sync Voltage	
		INT	EXT
NOR	50 Hz ~ 15 MHz 20 Hz ~ 20 MHz	0.5 div 1.0 div	0.5 Vp-p 1.0 Vp-p
AUTO	50 Hz ~ 15 MHz 20 Hz ~ 20 MHz	0.5 div 1.0 div	0.5 Vp-p 1.0 Vp-p
VIDEO	VIDEO signal	1.0 div	1.0 Vp-p

External triggering input voltage:
50V (DC + AC peak)

Horizontal Amplifier (CH2 input)

Operating modes: (Except × 10 MAG)
X-Y mode is selected by SWEEP TIME/DIV.
CH1: Y axis
CH2: X axis

Deflection Factor:
Same as CH1 (5 mV/div to 20V/div ±5%)

Frequency response:
DC DC to 2 MHz (less than −3 dB)
AC 2 Hz to 2 MHz (less than −3 dB)

Input impedance:
Same as CH1 (1 MΩ ±2%)

Input capacitance:
Same as CH1 Approx. 27 pF

X-Y phase difference:
Less than 3° at 70 kHz

Calibrating Voltage

0.1V ±3% (at reference level 0V)

1 kHz ±3% (square wave, positive)

Intensity Modulation

Input voltage:

TTL level

Input impedance:

15 kΩ ±20%

Bandwidth:

DC to 5 MHz

Maximum input voltage:

50V (DC + AC peak)

Trace Rotation

Trace angle is adjustable by panel surface adjustor.

Power Requirements

Power supply voltage:

100/120/220/240V ±10%, 50/60 Hz

Power consumption:

47W

Dimensions

Width:

260 mm (277 mm)

Height:

190 mm (204 mm)

Depth:

328 mm (393 mm)

Figures in ( ) show maximum sizes.

Weight:

8.4 kg

Accessories

Probe (PC-22) 2

Damping: 1/10

Input impedance: 10 MΩ

Input capacitance: Less than 18 pF

Instruction manual 1

Replacement fuse:

0.5A 2

0.8A 2

CONTROLS ON PANELS

FRONT PANEL

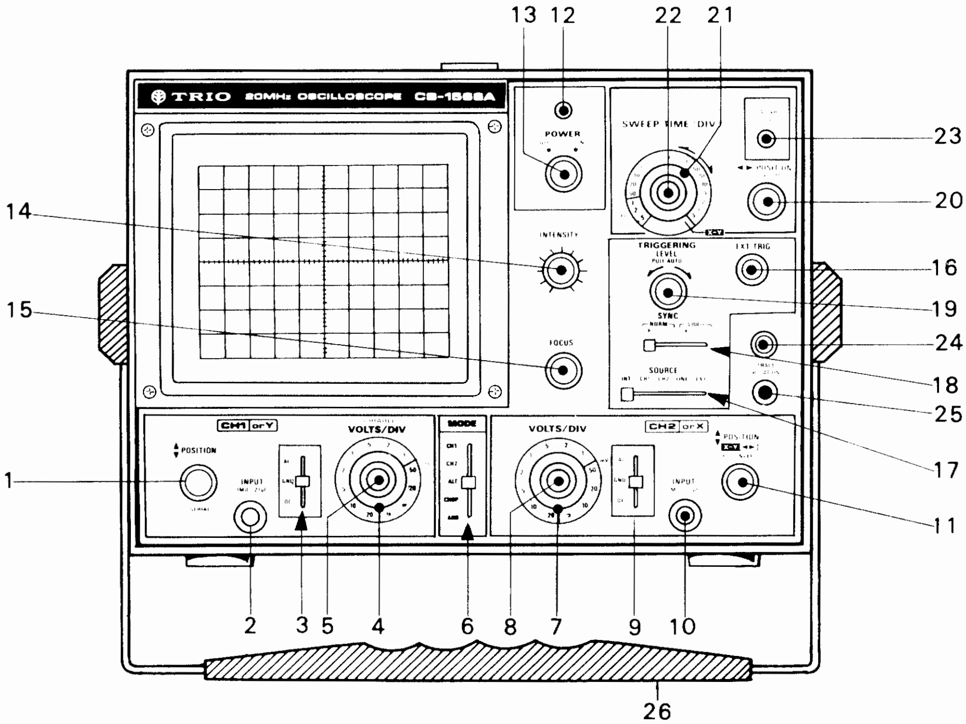


Fig. 1

REAR PANEL

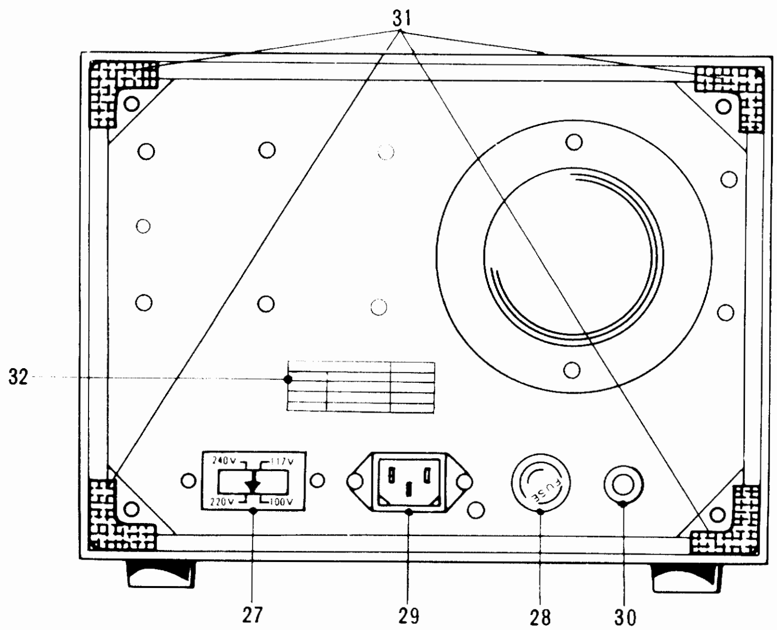


Fig. 2

FRONT PANEL

1. ▲▼ POSITION

Vertical position adjustment for Channel 1 trace. Becomes vertical position adjustment when SWEEP TIME/DIV switch (21) is in the X-Y position (X-Y operation).

2. INPUT

Vertical input terminal for CH1 (or in X-Y mode).

3. AC-GND-DC

AC: Blocks DC component of input signal.

GND: Opens signal path and ground input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing DC measurement.

DC: Direct input of AC and DC component of input signal.

4. VOLTS/DIV

Vertical attenuator for Channel 1 which provides step adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 12 steps from 5 mV to 20 volts per div when VARIABLE control (5) is set to CAL position. This control adjusts vertical sensitivity when the SWEEP TIME/DIV switch (21) is in the X-Y position (X-Y operation).

5. VARIABLE

Vertical attenuator adjustment provides fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated. This control becomes the fine vertical gain control when the SWEEP TIME/DIN switch (21) is in the X-Y position.

6. MODE

Five-position lever switch; selects the basic operating modes of the oscilloscope.

CH 1: Only the input signal to Channel 1 is displayed as a single trace.

CH 2: Only the input signal to Channel 2 is displayed as a single trace.

ALT: Dual-trace operation, in which sweep alternately displays Channel 1, then Channel 2, input signal. Recommended for sweep times of 0.5 ms/div to 0.5 μs/div.

CHOP: Dual-trace operation in which sweep is chopped at approximate 200 kHz rate and switched between Channel 1 and Channel 2 traces. Recommended for sweep times of 0.5 s/div to 1 ms/div.

ADD: The waveforms from Channel 1 and Channel 2 inputs are added and the sum is displayed as a single trace. When the Channel 2 POSITION control is pulled (PULL INVERT), the waveform from Channel 2 is subtracted from the Channel 1 waveform and the difference is displayed as a single trace.

7. VOLTS/DIV

Vertical attenuator for Channel 2 which provides coarse adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 12 steps from 5 mV to 20 volts per div when VARIABLE control (8) is set to the CAL position.

8. VARIABLE

Vertical attenuator adjustment provides fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.

9. AC-GND-DC

AC: Blocks 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.

DC: Direct input of AC and DC component of input signal.

10. INPUT

Vertical input terminal for CH2 or X input terminal for X-Y operation.

11. ▲▼ POSITION, X-Y ◄►, PULL INVERT

Vertical position adjustment for Channel 2 trace. Becomes horizontal position adjustment when SWEEP TIME/DIV switch (21) is in the X-Y position (X-Y operation).
When the knob is pulled (PULL INVERT), the CH2 polarity is inverted.

12. POWER LAMP

Glows when oscilloscope is turned on.

13. POWER

Power ON/OFF switch. The power is ON when the knob is set to right.

14. INTENSITY

Adjusts the brightness of spots and waveforms for easy viewing. When turned to the left waveform will disappear.

15. FOCUS

Spot focus control to obtain optimum waveform according to brightness.

16. EXT TRIG

External trigger terminal. For external triggering, set SOURCE (17) to EXT and apply external triggering voltage.

17. SOURCE

Five-position lever switch selects triggering source for sweep.

INT: In CH 2 mode, Channel 2 signal becomes trigger. In CH 1, ALT, CHOP, and ADD mode, Channel 1 signal becomes trigger.

CH 1: Channel 1 signal becomes trigger in all modes.

CH 2: Channel 2 signal becomes trigger in all modes.

LINE: Line voltage becomes trigger.

EXT: Signal applied at EXT TRIG jack becomes trigger.

18. SYNC

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.

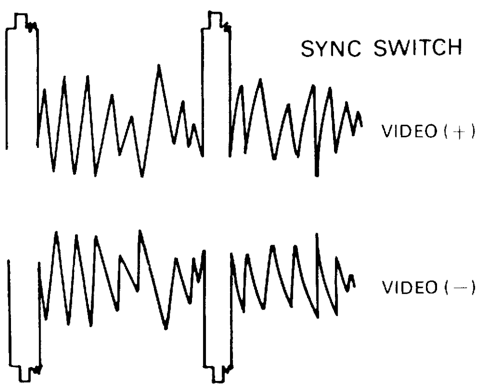


Fig. 3

VIDEO: In the VIDEO positions, the sync pulses of a composite video signal are used to trigger the sweep; the vertical sync pulses (frame) are automatically selected for sweep times of 0.5 s/div to 0.1 ms/div, and horizontal sync pulses (line) are automatically selected for sweep times of 50 μs/div to 0.5 μs/div.

(+): Sweep is triggered on positive-going sync pulse.

(−): Sweep is triggered on negative-going sync pulse.

19. LEVEL, PULL AUTO

Sync level adjustment determines points on waveform slope where sweep starts; (−) equals most negative point of triggering and (+) equals most positive point of triggering.

PULL AUTO:

Push-pull switch selects automatic triggering when pulled out (PULL AUTO). When automatic triggering, a sweep is generated even without an input signal.

20. ◂▸ POSITION, PULL X10 MAG

Rotation adjusts horizontal position of traces (both traces when operated in the dual trace mode).

PULL X10 MAG:

Push-pull switch selects X10 magnification when pulled out (PULL X10 MAG); normal when pushed in.

21. SWEEP TIME/DIV

Horizontal coarse sweep time selector. Selects calibrated sweep times of 0.5 μs/div (microsecond per division) to 0.5 s/div in 19 steps when VARIABLE control (22) is set to the CAL position (fully clockwise). In the X-Y position, this switch disables the internal sweep generator and permits the CH 2 input to provide horizontal deflection (X-Y operation). The Channel 1 input signal produces vertical deflection (Y axis) and the Channel 2 input signal produces horizontal deflection (X axis).

22. VARIABLE

Fine sweep time adjustment. In the extreme clockwise (CAL) position the sweep time is calibrated.

23. CAL 1 kHz, 0.1 Vp-p

Provides calibrated 1 kHz, 0.1 volt peak-to-peak square wave input signal. This is used for calibration of the vertical amplifier attenuators and to check the frequency compensation adjustment of the probes used with the oscilloscope.

24. GND

Ground terminal for the oscilloscope.

25. TRACE ROTATION

Used to adjust the position of horizontal trace.

26. HANDLE

This handle also serves as a stand of the oscilloscope.

REAR PANEL

27. AC VOLTAGE SELECTOR

Plug type AC voltage selector to operate the oscilloscope on specific power supply voltage, 100/117/220/240V.

28. FUSE HOLDER

Fuse rated at 1A should be used for 100/117V operation. For operation on 220/240V, be sure to use a 0.5A fuse.

29. POWER CONNECTOR

For connection of the supplied AC power cord.

30. Z AXIS INPUT

Intensity modulation terminal. TTL logic-compatible, high logic increase brightness low logic decrease brightness.

31. CORD REEL

Wind power cord when the oscilloscope is to be carried or stored. They also serve as a stand when the oscilloscope is used in upright position.

OPERATION

PRELIMINARY OPERATION

When operating this oscilloscope, refer to panel controls and their functions. When starting this oscilloscope set initially, set the operating controls as follows and the set may be turned on safely.

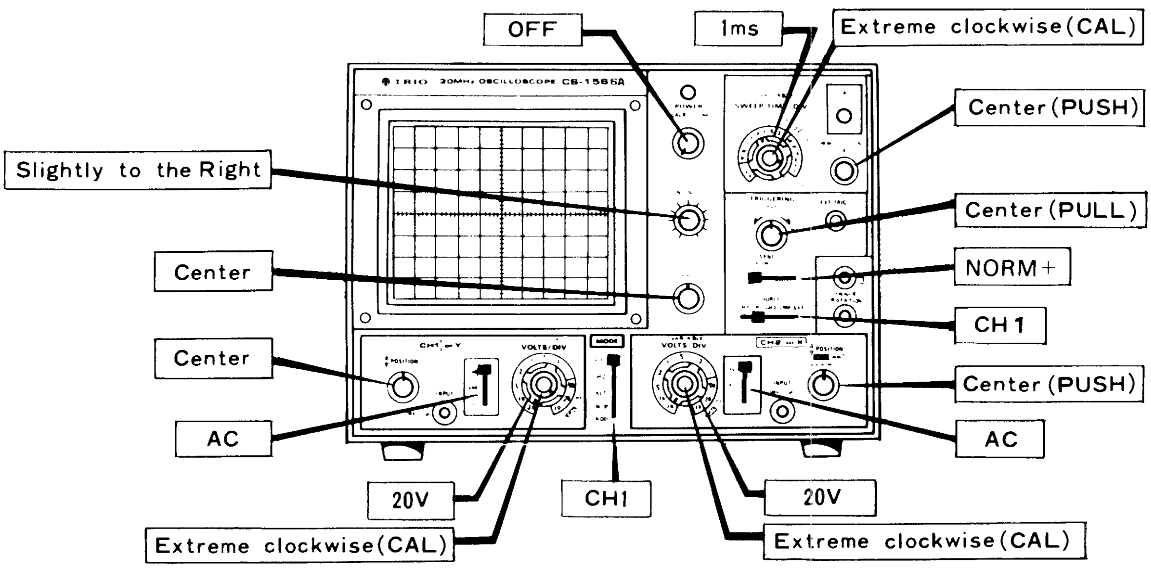


Fig. 4

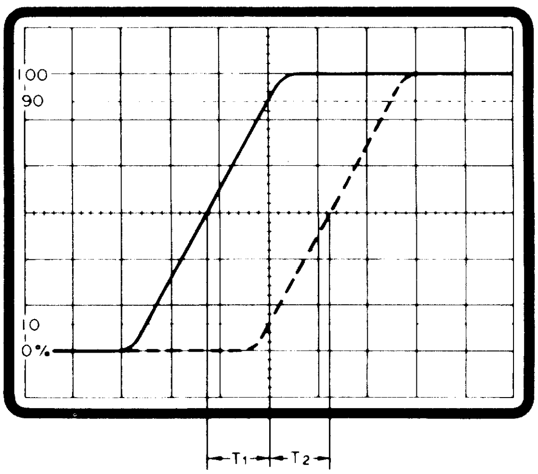
OPERATING PROCEDURES

1. Select the position of the power voltage selector plug as indicated by the arrow marks. Then insert the supplied power cord to the power connector.
2. Turn POWER/SCALE ILLUM (13) clockwise. The power is turned to ON and POWER lamp (12) lights.
3. Horizontal axis will be displayed. When trace does not appear at the center of the screen, adjust ▲▼ POSITION (1) and ◄► POSITION (20). Adjust brightness with INTENSITY (14). If trace is unclear, adjust FOCUS (15).
4. The oscilloscope is now ready for measurement. For measurement, proceed as follows: Apply signal voltages to the INPUT terminals (2), (10). Then turn VOLTS/DIV (4) clockwise until the waveform is correctly displayed on the scope. By setting MODE (6) and SOURCE (17) to CH1, the CH1 input signal to the INPUT terminal (2) will appear. Similarly, by setting MODE and SOURCE to CH2, then the input signal to the CH2 terminal (10) will appear, at ALT or CHOP position, two waveforms (CH1 and CH2) will appear on the scope. With SOURCE (17) set to CH1, the CH1 input signal from the INPUT terminal (2) is fed to the trigger circuit where the CH1 signal is triggered. Similarly, when SOURCE is set to CH2, the CH2 signal is triggered.
   Use either method for easier observation.
   At ADD position, algebraic sum of CH1 and CH2 is obtained. When PULL INVERT (11) knob is pulled, the CH2 signal in reverse polarity is added to the CH1 signal in reverse polarity is added to the CH1 signal and the algebraic difference between CH1 and CH2 is displayed (SUB).
5. When the signal voltage is more than 5 mV and waveform fails to appear on the screen, the oscilloscope may be checked by feeding input from CAL 1 kHz, 0.1 Vp-p (23). Since calibration voltage is 1 Vp-p, the waveform becomes 5 div high at the 20 mV/div position.
6. By pushing TRIG LEVEL (20), the free-running auto function is released. The waveform disappears when the knob is turned clockwise, and appears again when it is returned to its approximate middle position of it. Sync phase is also adjustable in this case. The waveform will again disappear when the knob is turned counterclockwise from the middle position.
7. When DC component is measured, set AC-GND-DC (3) or (9) to DC position. If, in this case, the DC component contains plus "+" potential, the waveform moves upward and if it contains minus "−" potential, the waveform moves downward.
   The reference point of "0" potential can be checked at GND position.

MEASUREMENTS OF PULSE RISING (FALLING) TIME

The scales 10% and 90% on the CRT screen are used for accurate measurements of pulse rising (falling) time. To measure pulse rising time, proceed as follows:

1. With a pulse signal applied to the input terminal, adjust VOLTS/DIV (4) [7] and VARIABLE (5) [8] so that the pulse amplitude is set to the 0 and 100% scales.
2. Turn SWEEP TIME/DIV (21) to magnify the rising portion of the waveform as large as possible [VARIABLE (22) should be set to CAL position].
3. Adjust ◄► POSITION (20) to set the waveforms at 10% and 90% to the vertical center scale respectively, then measure T1 and T2 using the horizontal center scale. The pulse rising (falling) time is T1 + T2.



APPLICATIONS

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 simultaneously viewing two waveforms that are frequency or phase-related, or that have a common synchronizing voltage, such as in digital circuitry. Simultaneously viewing of input and its output 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 Viewing:

Fig. 5 illustrates the waveform 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. 5** 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 CH1 and CH2 vertical position controls should be set as required to produce suitable displays. In the drawing of **Fig. 5**, the waveform levels of 2 div are indicated. If exact voltage measurements of CH1 and CH2 are desired, the CH1 and CH2 VARIABLE controls must be placed in the CAL position. The CH2 waveform may be either that indicated in **Fig. 5B** or **Fig. 5C**. In **Fig. 5C**, 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

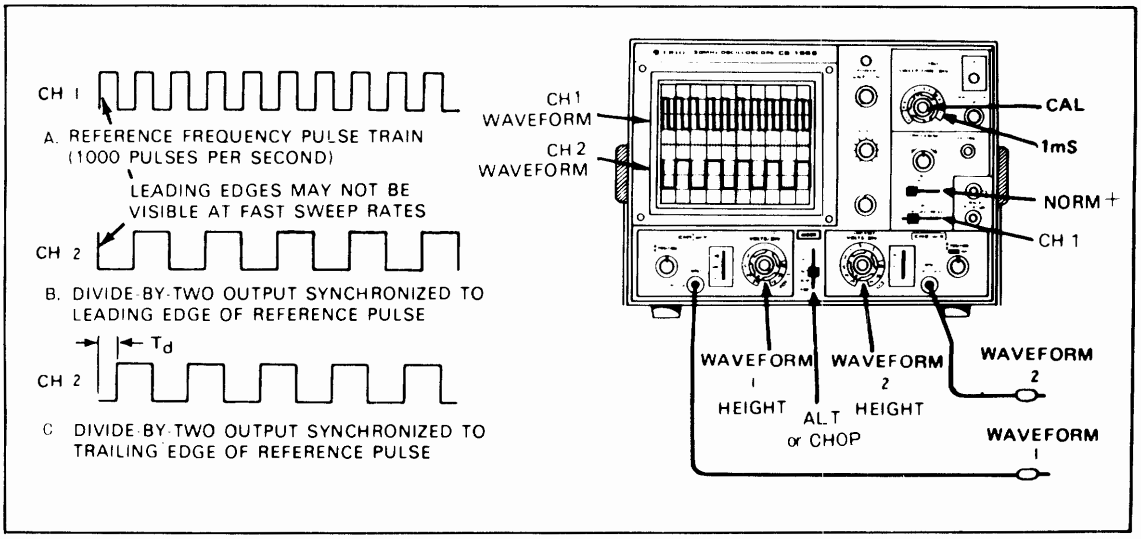


Fig. 5 Waveforms in divide-by-two circuit

reference frequency pulse by a time interval corresponding to the pulse width. When observing two signals having different cycle similtaneously, the signal having low cycle should be triggered.

Divide-by-8 Circuit Waveforms:

Fig. 6 indicates waveform relationships for a basic divide-by-eight circuit. The basic oscilloscope settings are identical to those used in **Fig. 5**. The reference frequency of **Fig. 6A** is supplied to the Channel 1 input, and the divide-by-eight output is applied to the CH2 input. **Fig. 6** indicates the time relationship between the input pulses and output pulses.

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. 6C** 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 (ADD or SUB) to determine the exact amount of propagation delay that occurs.

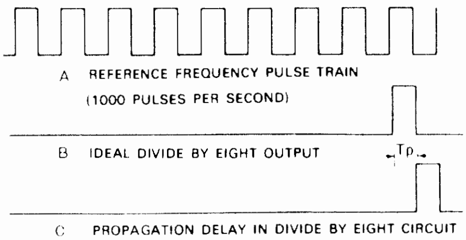


Fig. 6 Waveforms in divide-by-eight circuit

Propagation Delay Time Measurement:

An example of propagation delay in a divide-by-eight circuit was given in the previous paragraph. Significant propagation delay may occur in any circuit with several consecutive stages. This oscilloscope has features which simplify measurement of propagation delay time. **Fig. 7** shows the resultant waveforms when the dual-trace presentation is combined into a single-trace presentation by selecting the ADD position of the MODE switch. With CH2 PULL INVERT switch in the normal position (pushed in) the two inputs are algebraically added in a single-trace display. Similarly, in the inverted position (pulled out) the two inputs are algebraically subtracted. Either position provides a precise display of the propagation time (Tp). Using procedures given for calibrated time measurement,

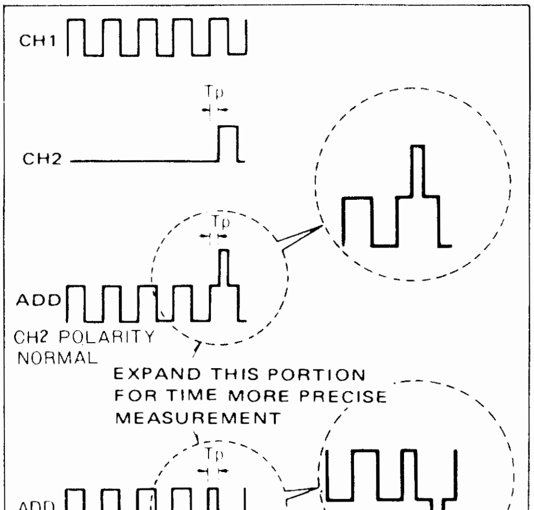


Fig. 7 Using ADD mode propagation time measurement

Tp can be measured. A more precise measurement can be obtained if the Tp portion of the waveform is expanded horizontally. This may be done by pulling the X10 MAG control. It also may be possible to view the desired portion of the waveform at a faster sweep speed.

Digital Circuit Time Delay Measurement:

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 priviously described, but waveforms are of ten time-related in many other combinations. In the dynamic state, some of the waveforms change, depending upon the input or more mode of operation.

Fig. 8 shows a typical digital circuit and identifies several of the points at which waveform measurement are appropriate. The accompanying **Fig. 8** 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 CH1 and waveform No. 4 through No. 8 and No. 10, would be displayed on CH2 although other timing comparisons may be desired. Waveforms No. 11 through No. 13 would probably be displayed on CH2.

In the family of time-related waveforms shown in **Fig. 9**, waveform No. 8 or No. 10 is excellent sync source for viewing all of the waveforms; there is but one triggering pulse per frame. For convenience, external sync, any of the waveforms may be displayed without readjustment of the sync controls.

With No. 8 or No. 10 used as external triggering source, any of the waveforms may be displayed without readjustment of the TRIG LEVEL control. Waveforms No. 4 through No. 7 should not be used as the triggering 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. 9** 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 X10 MAG used be to expaned the waveform display.

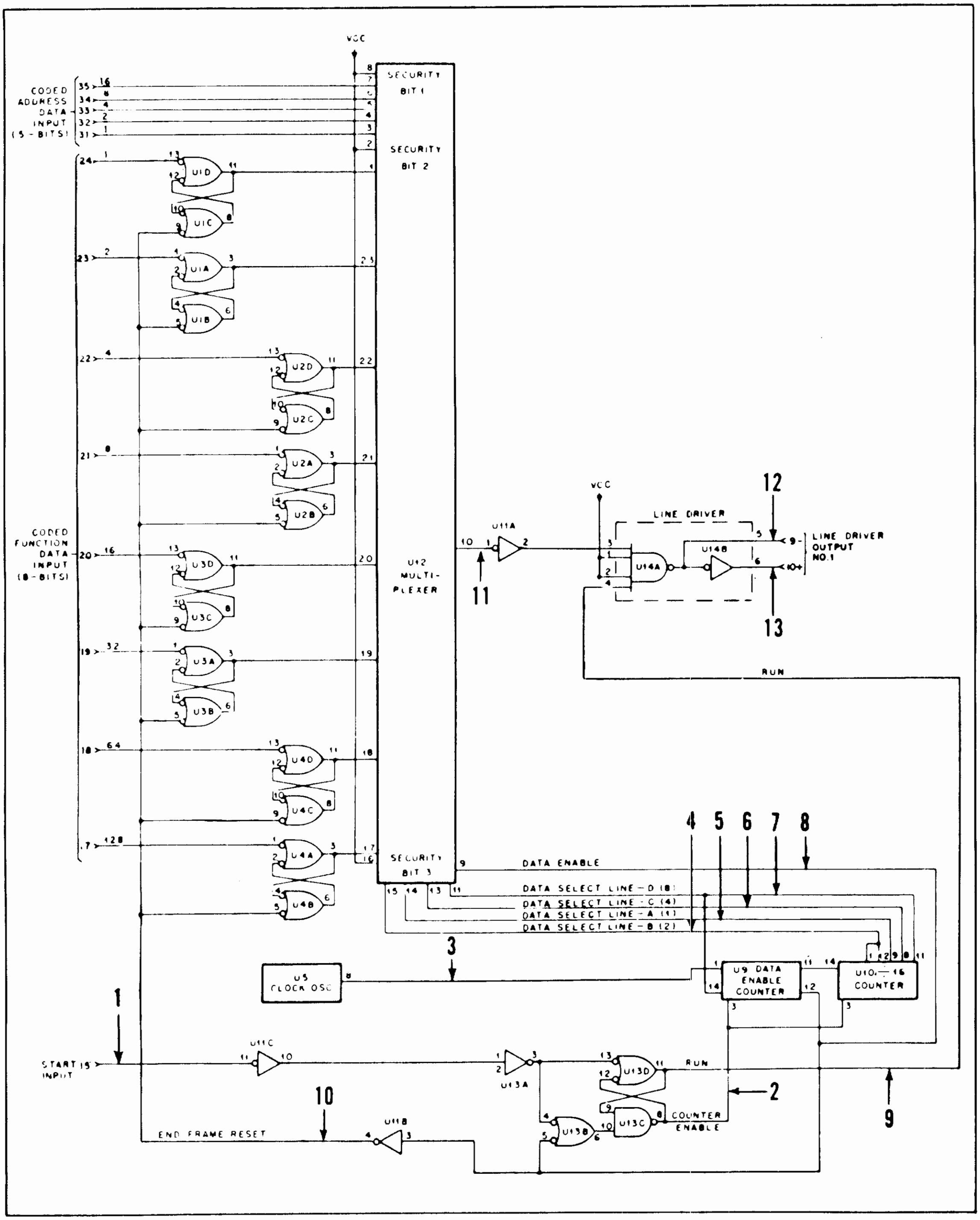


Fig. 8 Typical digital circuit using several time-related waveforms

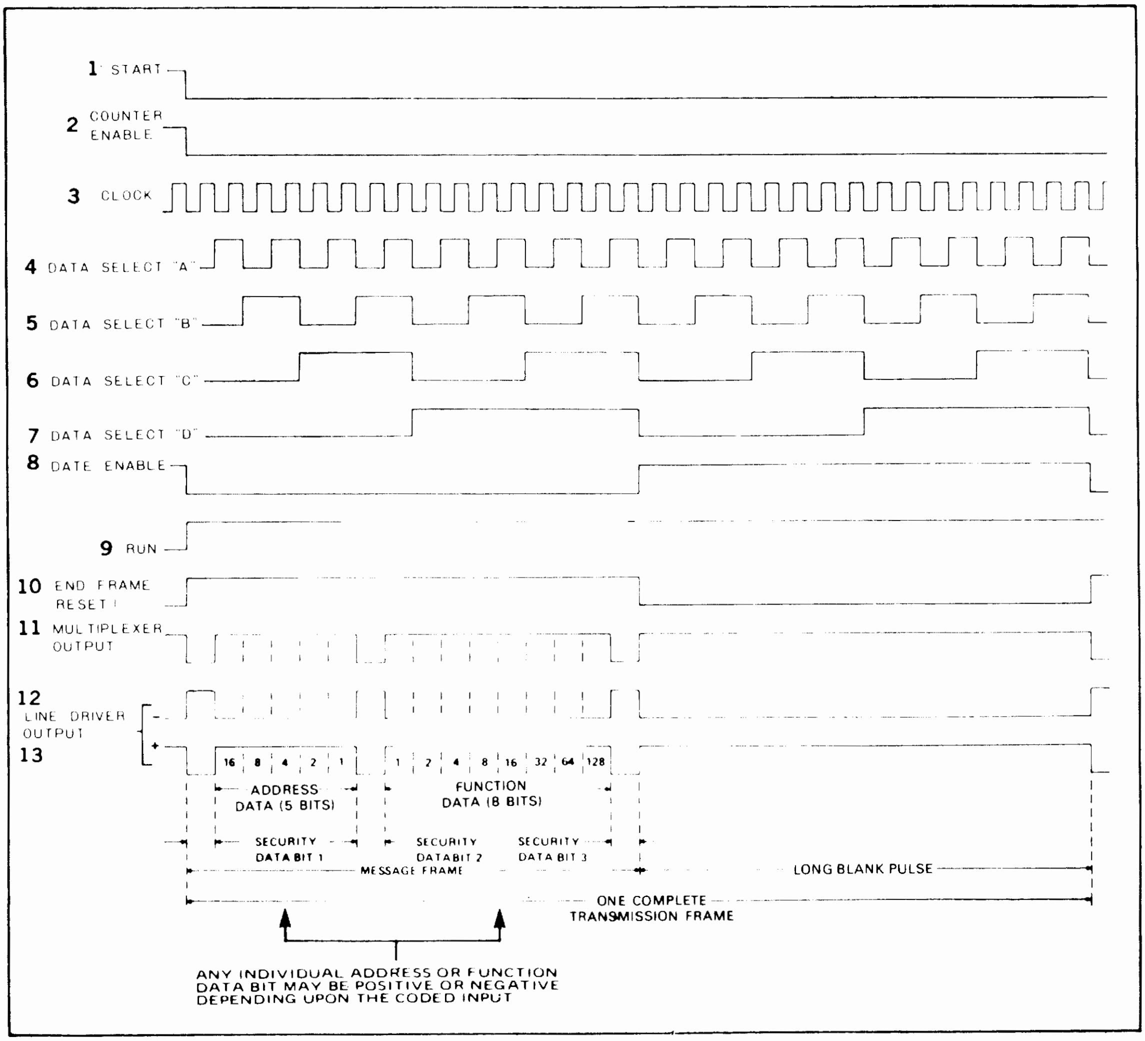


Fig. 9 Family of time-related waveforms from typical digital circuit in Fig. 8

Distortion Measurement:

An amplifier stage or an entire amplifier unit may be measured for distortion with this oscilloscope. This type of measurement is especially variable when the slope of a waveform must be faithfully reproduced by an amplifier. **Fig. 10** shows the testing of a circuit using a triangular wave, such as is typically encountered in the recovered audio output of limiting circuit which procedes the modulator of transmitter. The measurement may be made using any type of signal; merely use the type of signal for testing that is normally applied to the amplifier during normal operation. The procedure for distortion testing is as follows.

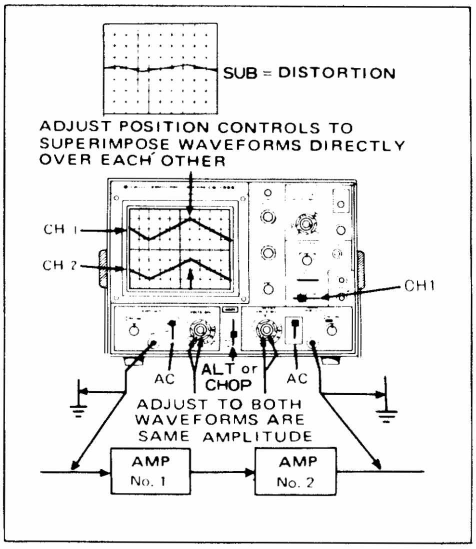


Fig. 10 Distortion measurement

1. Apply the type of signal normally encountered in the amplifier under test.
2. Connect CH1 probe to the input of the amplifier and CH2 probe to the output of the amplifier. It is preferable if the two signals are not inverted in relationships to each other, but inverted signals can be used.
3. Set CH1 and CH2 AC-GND-DC switches to AC.
4. Set the MODE switch to ALT or CHOP.
5. Set SOURCE switch to CH1 and adjust controls as described in the procedure for synchronizing waveforms.
6. Adjust CH1 and CH2 POSITION controls to superimpose the waveforms directly over each other.
7. Adjust CH1 and CH2 vertical sensitivity controls (VOLTS/DIV and VARIABLE) so that the waveforms are as large as possible without exceeding the limits of the scale, and so that both waveforms are exactly the same height.
8. Now, set the Mode switch to ADD and the CH2 polarity switch to the PULL INVERT position. (If one waveform is inverted in relationships to the other, use the normal CH2 polarity.)
   Adjust the vertical sensitivity control (CH2 VARIABLE) for the minimum remaining waveform. Any waveform that remains equals distortions; if the two waveforms are exactly the same amplitude and same waveform and there is no distortion, the waveforms will cancel and there will be only a straight horizontal line will remaining on the screen.

Gated Ringing Circuit (burst circuit)

The circuit and waveform 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.
Fig. 11 shows a burst circuit. The basic settings are identical to those of in **Fig. 5**.

Waveform EA is the reference waveform and is applied to CH1 input. All other waveforms are sampled at CH2 and compared to the reference waveform of CH1. The frequency burst signal can be examined more closely either by increasing the sweep time per division to 0.5 ms per division or by pulling the ◀▶ POSITION control to obtain 10 times magnification. This control can then be rotated as desire to center the desired waveform information on the oscilloscope screen.

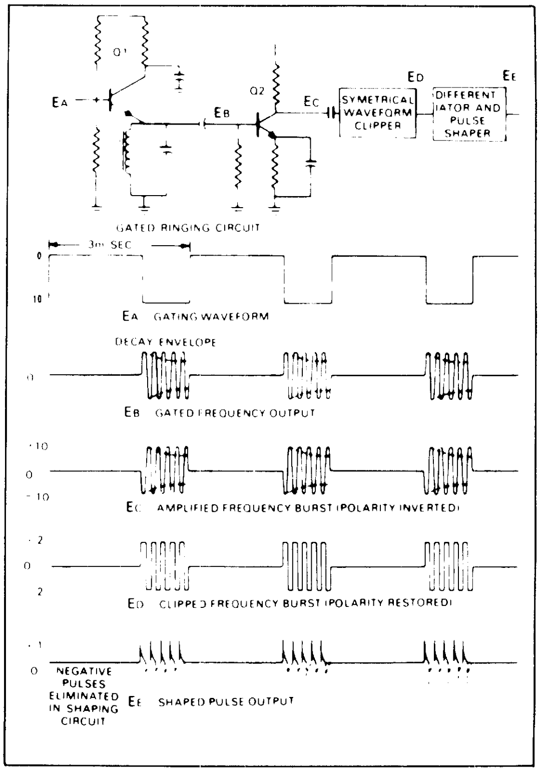


Fig. 11 Gated ringing circuit and waveforms

Delay Line Test:

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 synchronized the CH1 display and the delay line output can be observed on CH2. The interval between repetitive pulses should be large compared to the delay time to be observed. In addition to determining delay time, the pulse distortion inherent in the delay line can be determined by examination of the delay pulse observed on CH2 waveform display.
Fig. 12 shows 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 to check the "Y" delay line employed in the video amplifier section. The input waveform and 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. The 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 greatly attenuated output resulting from an open line.

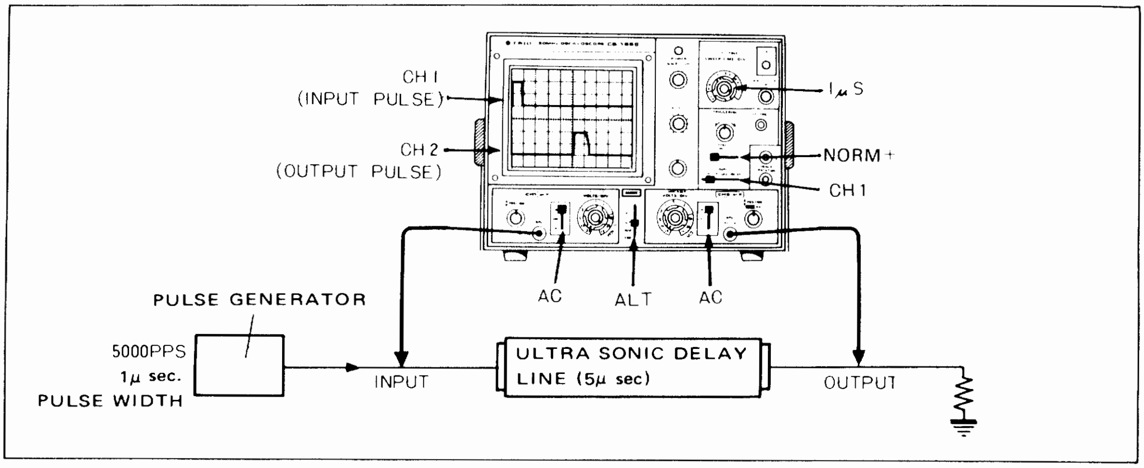


Fig. 12 Delay line measurements

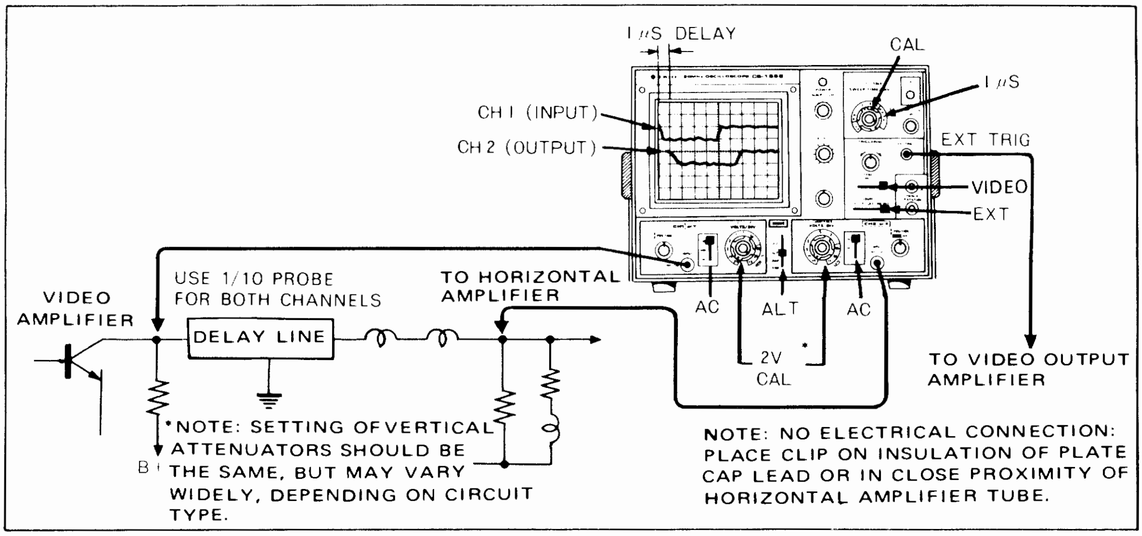


Fig. 13 Checking "Y" delay line in color television receivers

Improving the Ratio of Desired to Undesired Signals:

In some applications, the desired signal may be riding on a large undesired signal component such as 50 Hz. It is possible to minimize or for practical purpose eliminate the undesired component. **Fig. 14** shows the oscilloscope settings for such an application. The waveform display of CH1 indicates the desired signal and the dotted line indicates the average amplitude variation

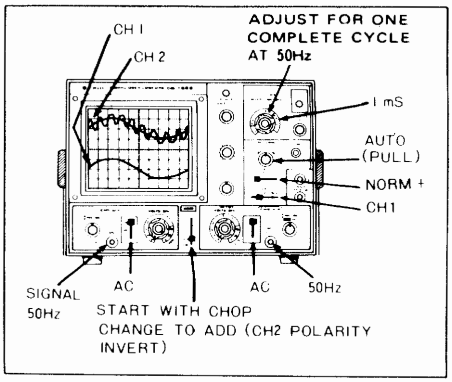


Fig. 14
Improving desired-to-undesired signal radio

corresponding to the undesired 50 Hz component. The CH2 display indicates a waveform of equal amplitude and identical phase to the average of the CH1 waveform. With the MODE switch set to ADD and the CH1 signal inverted, and by adjusting the CH2 vertical attenuator control, and 50 Hz component of the CH1 signal can be cancelled by the CH2 input and the desired waveform can be observed.

Stereo Amplifier Servicing:

Another convenient use for a dual-trace oscilloscope is in troubleshooting stereo amplifiers. If identical 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 effect of whatever troubleshooting and repair methods are employed can be observed can be observed and analyzed immediately.

Amplifier Phase Shift Measurements:

Phase measurements can be made by several method using oscilloscopes. Typical applications are in circuits designed to produce a specific phase shift, and measurement of phase shift distortion in audio amplifiers and network. In all amplifiers, a phase shift is always associated with a change in amplitude response. For example, at the −3 dB response points, a phase shift of 45° occurs. Phase measurements can be performed by operating the oscilloscope either in the dual-trace mode to measure amplifier phase shift directly.
Fig. 15 illustrates this method. In this case, the measurements are being made at approximately 5000 Hz. The input signal to the audio amplifier is used as a reference and is applied to the CH1 input jack.

The VARIABLE control is adjusted as required to provide a complete cycle of the input waveform displayed on 8 div horizontally. A waveform height of 2 div is used. The 8 div display represents 360° at the displayed frequency and each division represents 45° of the waveform.
The signal developed accross the output of the audio amplifier is applied to the CH2 input jack.
The vertical attenuator controls of CH2 are adjusted as required to produce a peak-to-peak waveform of 2 div amplitude as shown in **Fig. 15B**. The CH2 POSITION control is then adjusted so that the CH2 waveform is displayed on the same horizontal axis as the CH1 waveform as shown in **Fig. 15B**. The distance between corresponding points on the horizontal axis for the two waveforms then represents the phase shift between the two waveforms. In this case, the zero crossover points of the two waveforms are compared. It is shown that a difference of 1 div exists. This is then interpreted as means a phase shift of 45°.

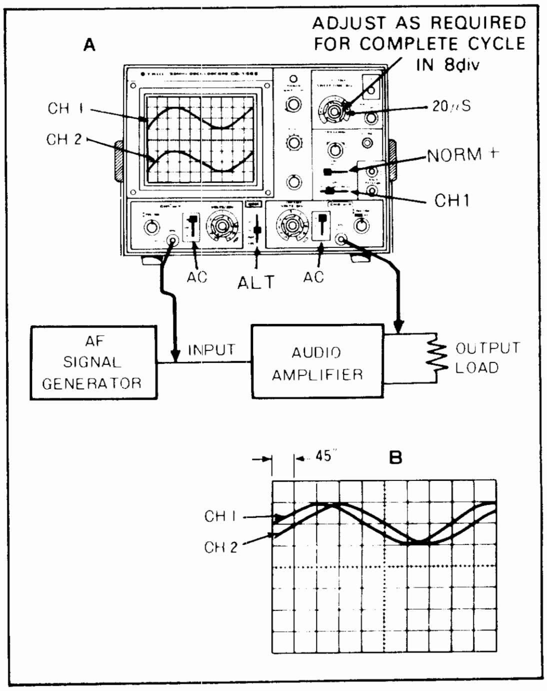


Fig. 15 Measurering amplifier phase shift

Television Servicing:

Many of the television 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. 16**, the information on the Field 1 and Field 2 vertical blanking interval pulse is different. This is shown in detail in **Fig. 16**. 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. With dual-trace operation, the signal information on each blanking pulse can be viewed separately without overlapping. **Fig. 18** indicates the oscilloscope control setting for viewing the alternate VITS.

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 shown 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).

The transmitted VITS is precision sequence of a specific frequences, amplitudes and waveshapes as shown in **Fig. 16**.

Television networks use the precision signals for adjustment and checking of network transmission equipment, but the technician can use them to evaluate television multiburst signal in VITS can also be set performance.

The first frame of VITS at the "B" section (line 18) in **Fig. 16** begins with a white reference signal, followed by sine wave frequencies of 0.5 MHz, 1.0 MHz, 2 MHz, 3 MHz, 4 MHz and 3.58 MHz. This sequence of frequencies is called the "multi-burst".

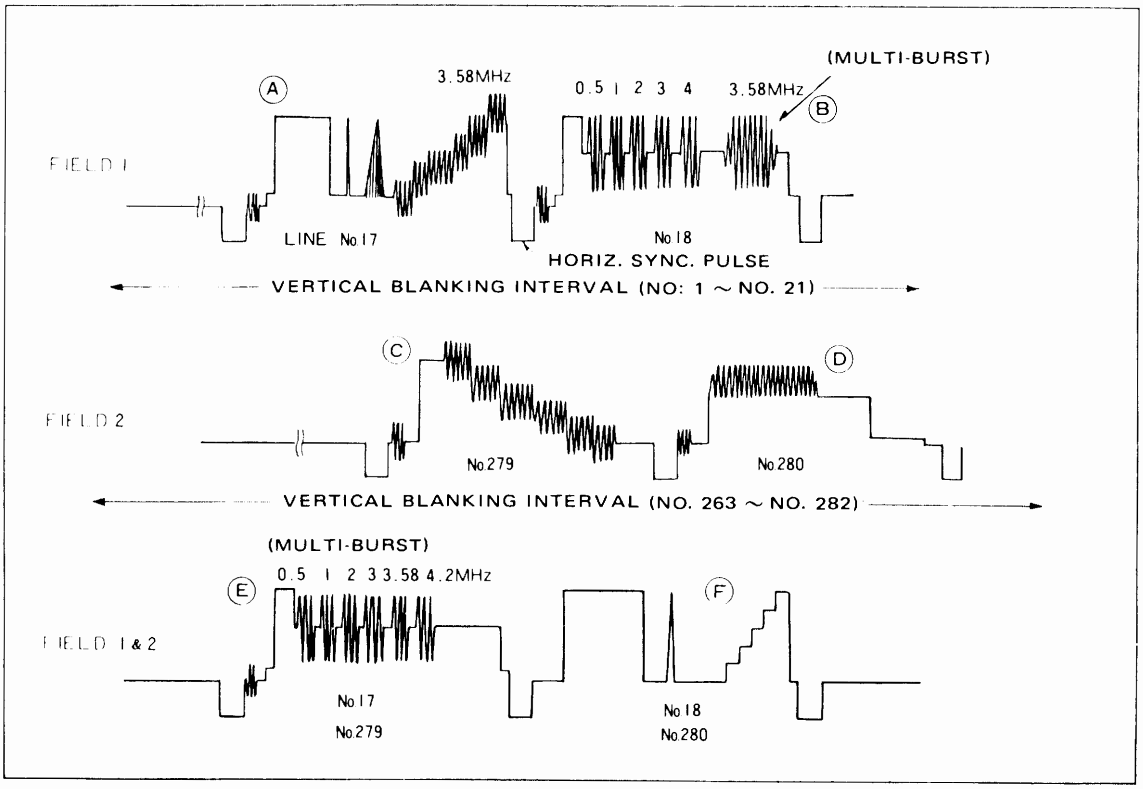


Fig. 16 VITS signal, Fields 1 and 2

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 the second line of Field 2 (lines 18 and 280) may contain the sine-squared pulse, window pulse and the staircase of 3.58 MHz burst at progressively lighter shading. These 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 line 280. The entire VITS appears at the bottom of the vertical blanking pulse and just before the first line of video.

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. 24** 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).

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 shown 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, may be 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,

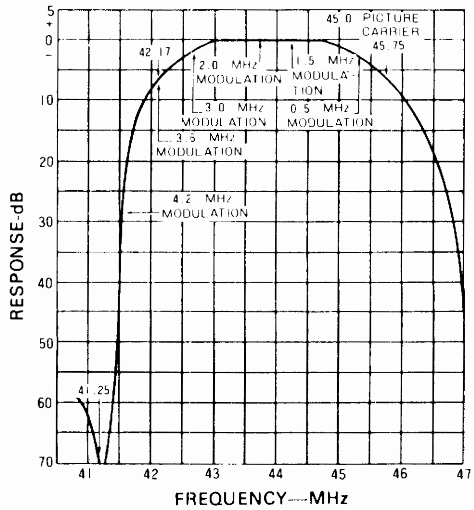


Fig. 17
Color TV IF amplifier response curve

solder bridges across foil patterns, etc.

With dual-trace oscilloscope operation, the signal information on each vertical blanking interval can be viewed separately without trace overlapping, although the information alternates with each field. **Fig. 18** indicates the oscilloscope control setting for viewing the alternate vertical blanking intervals.

1. Set a color TV receiver to the station transmitting color signals containing VITS.
2. The method shown in **Fig. 18** is used to obtain Field 2 vertical sign on CH1.
3. Set the oscilloscope and the receiver for operation. Connect the CH1 probe to the test point of video detector or other desired test point in the video section of the television receiver.
4. Set the SYNC switche as follows:
   A. If the sync and blanking pulses of the observed video signal are positive, use the VIDEO + position.
   B. If the sync and blanking pulses are negative, use the VIDEO − position.
5. Adjust the sweep time VARIABLE control so that 2 vertical fields are displayed on the oscilloscope screen.
6. Connect the CH2 probe to the same test point as does the CH1 probe.
7. Set the MODE switch to ALT position.
8. Place the sweep time VARIABLE in the CAL position.
9. Set the SWEEP TIME/DIV control to the 0.1 ms position to expand the display by increasing the sweep speed. The VITS

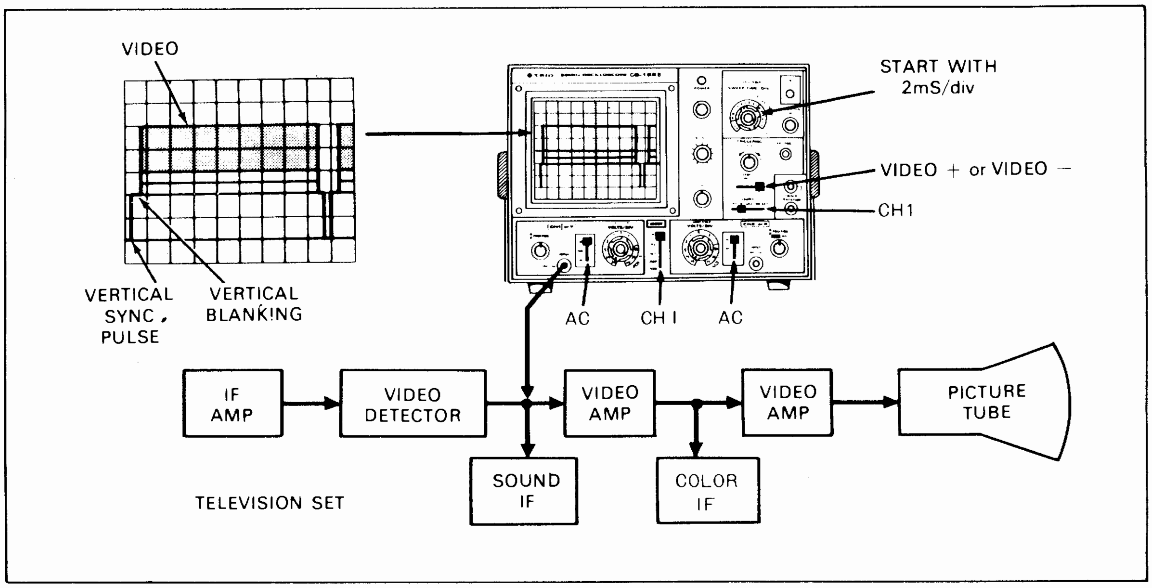


Fig. 18 Set-up for viewing fields 1 and 2 of VITS information

information will appear toward the right hand portion of the expaned waveform displays. The waveform information on each trace may appear as shown in **Fig. 16**. 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 CH1 or CH2.

10. Pull the ◀▶ POSITION control outward to obtain an additional X10 magnification. Rotate the control in a counterclockwise direction moving the trace to the left until the expanded VITS information appears as shown in **Fig. 16**. Because of the low repetition rate and the high sweep speed combination, the brightness level of the signal displays will be reduced.

11. Once the CH1 and CH2 displays have been identified as being either Field 1 or Field 2 VITS information, the probe corresponding to the waveform display which is to be used for signal-tracing and troubleshooting can be used, and the remaining 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 be reversed because, as previously explained, there is no provision in the oscilloscope to identify either of the two vertical fields which comprise a complete frame.

SINGLE-CHANNEL APPLICATIONS

Introduction.

In addition to the dual-trace applications previously outlined, there are, of course, many servicing and laboratory applications where only single-trace or single-channel operation of the oscilloscope is required. By setting the MODE switch to CH2 and using the CH2 amplifier, many flexible operations will be achieved; and, in addition, by placing the MODE switch to ADD and the CH2 polarity switch to the PULL INVERT position. Whatever waveform is obtained can be inverted in polarity if desired by the operator.

Television Servicing:

A triggered sweep oscilloscope is advantageous in servicing and aligning television receivers. This oscilloscope also includes several features that were incorporated to make television servicing and VIDEO signal observation easier and more comprehensive.

These feature inc ude:

* With the SYNC switch set to VIDEO position, the SWEEP TIME/DIV control automatically selects the VIDEO-FRAME sync at sweep speeds appropriate for viewing frame and VIDEO-LINE sync at sweep speeds appropriate for viewing lines.
* Wide bandwidth for high resolution video and high speed pulse presentation.

Single-trace Operation and Peak-to-Peak Voltage Readings:

For general troubleshooting and isolation of troubles in almost any electronic equipment, the oscilloscope is an indispensable instrument. It provides a visual display of the 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 shown much more than the mere presence or absence of signals. It provides a peak-to-peak voltage measurement. The schematic diagram or accompanying service data on the equipment being serviced usually includes waveform pictures. There waveform picture 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.

Composite Video Waveform Analysis

Probably the most important waveform in television servicing is the composite waveform consisting of the video signal, the blanking pedestal signal and the sync pulses. **Fig. 19** and **Fig. 20** 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 cause 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 condition, noting the waveform at various points in the video amplifier. To set up the oscilloscope for viewing composite video waveforms, use the following procedures:

1. Turn the television set to a local channel. A test tape or a signal generator also can be used for service work.
2. Set the MODE switch to CH2 position.
3. Set the SWEEP TIME/DIV switch to the 10 μs position for observing TV horizontal lines or to the 2 ms position for observing TV vertical frames.
4. Set the SYNC switch to VIDEO + or VIDEO − position.
5. Set the SOURCE switch to INT position.
6. Best overall sync performance is obtained when the TRIG LEVEL/PULL AUTO control is pushed in. It may be pulled out initially to provide continuous sweep during set-up.
7. Set the CH2 AC-GND-DC switch to the AC position.
8. Connect the ground clip of the probe to the chassis. With the probe set for 10 : 1 attenuation, connect the tip of the probe to the video detector output.
9. Set the CH2 VOLTS/DIV switch for the largest vertical deflection possible without going offscale.
10. If necessary, rotate the TRIG LEVEL control to a position that provides a synchronized display.
11. Adjust the sweep time VARIABLE for two horizontal lines or two vertical frames of

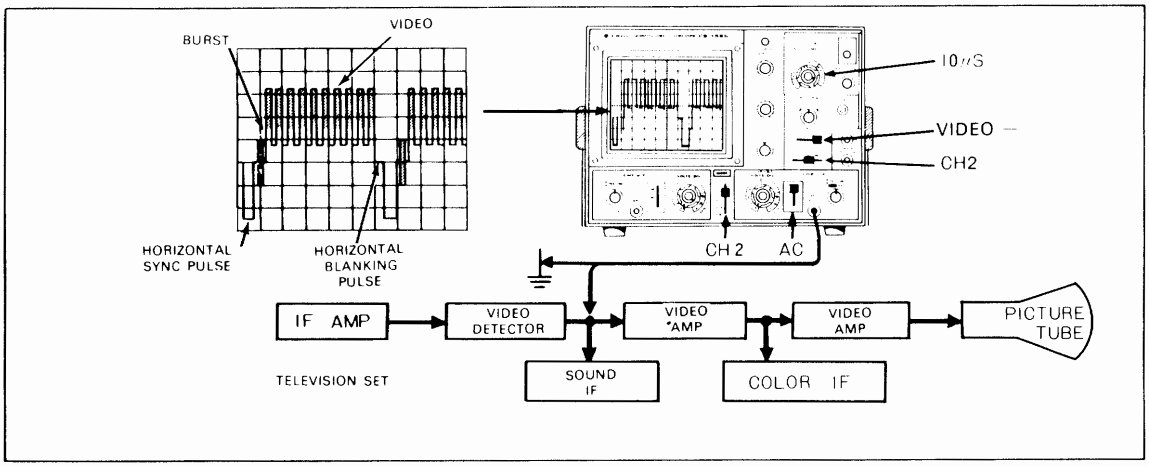


Fig. 19 Set-up for viewing horizontal fields of composite video signal

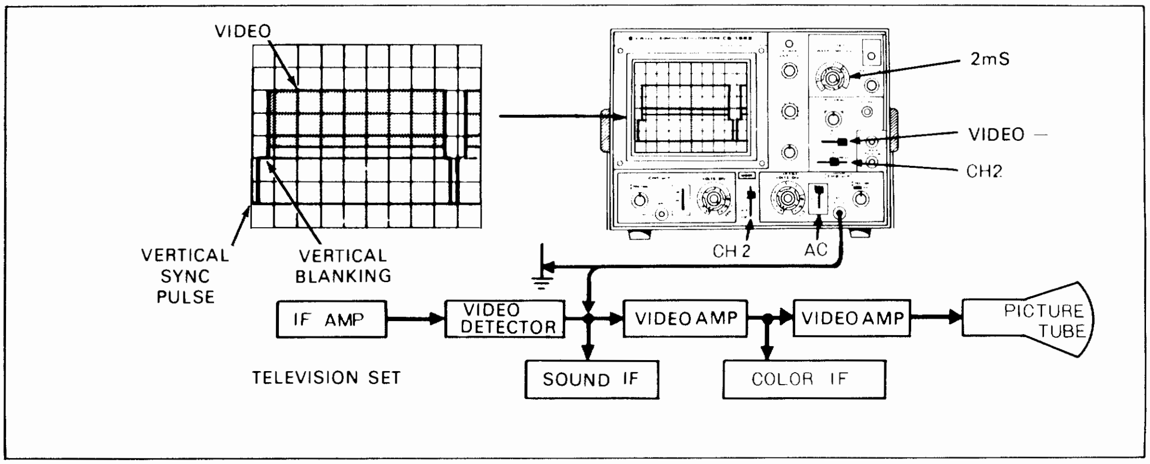


Fig. 20 Set-up for viewing vertical fields of composite video signal

composite video display.

12. 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.
13. Push in the TRIG LEVEL control and rotate to a position that provides a well synchronized display.
14. Adjust the INTENSITY and FOCUS controls for the desired brightness and best focus.
15. To view a specific portion of the waveform, such as the color burst, pull outward on the ◀▶ POSITION control for X10 magnification. Rotate the same control left or right to select the desired portion of the waveform to be viewed.
16. Composite video waveforms may be checked at other points in the video circuits by moving the probe tip to those points and changing the VOLTS/DIV control setting as required to the display within the limits of scale, and by readjusting the TRIG 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 switch from VIDEO + to VIDEO – sync, or vice versa.

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. 21**. Sync pulse waveform distortions produced by positive or negative limitting in IF overload conditions are shown in **Fig. 22**.

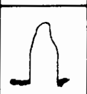
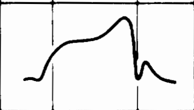
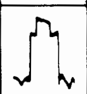
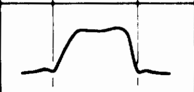
CIRCUIT DEFECT	HORIZONTAL PULSE DISTORTION	OVERALL RECEIVER FREQUENCY RESPONSE	EFFECT ON PICTURE
NORMAL CIRCUIT			PICTURE NORMAL
LOSS OF HIGH FREQUENCY RESPONSE			LOSS OF PICTURE DETAIL
EXCESSIVE HIGH FREQUENCY RESPONSE NONLINEAR PHASE SHIFT			FINE VERTICAL BLACK AND WHITE STRIATIONS FOLLOWING A SHARP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

Fig. 21 Analysis of sync pulse distortion

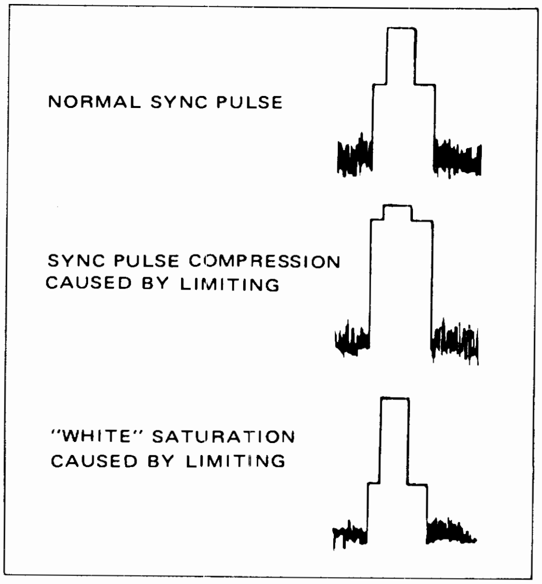


Fig. 22 Sync pulse waveforms

FM RECEIVER ADJUSTMENTS

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 CH2 input jack of the oscilloscope and set the oscilloscope controls for X-Y operation (SWEEP TIME/DIV to X-Y).
3. Connect the vertical input probe to the demodulator input of the FM receiver.
4. Adjust the oscilloscope vertical and horizontal gain controls for a display similar to that shown in **Fig. 23A**.
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. 23B**).
   Adjust the demodulator according to the manufacturer's instructions so the marker moves an equal distance from the center as the marker frequency is increased and decreased an equal amount from the 10.7 MHz center frequency.

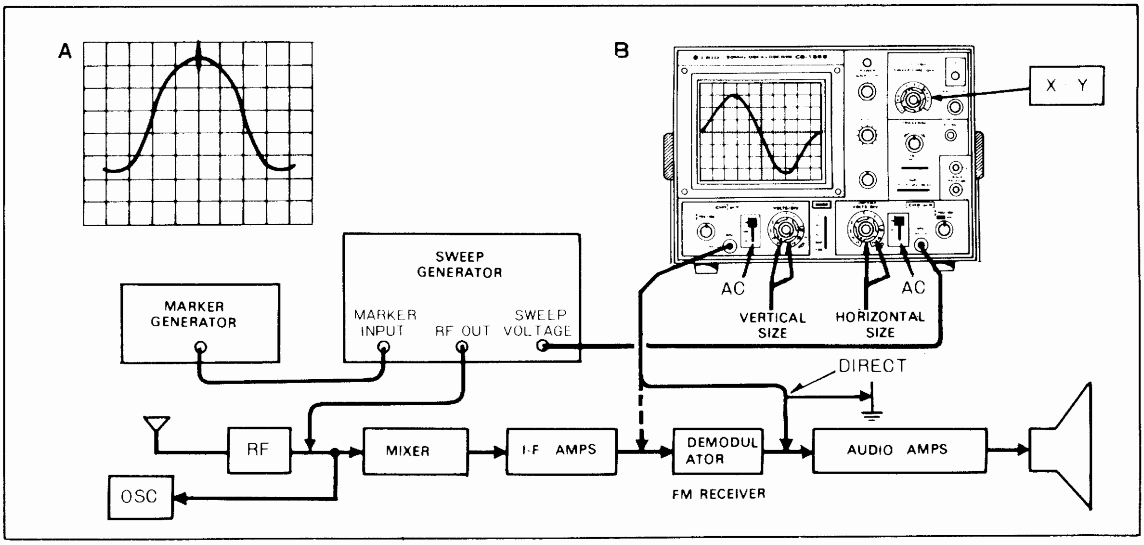


Fig. 23 Typical FM receiver alignment set-up

X-Y OPERATION APPLICATIONS

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, using the following procedures (refer to **Fig. 24**).

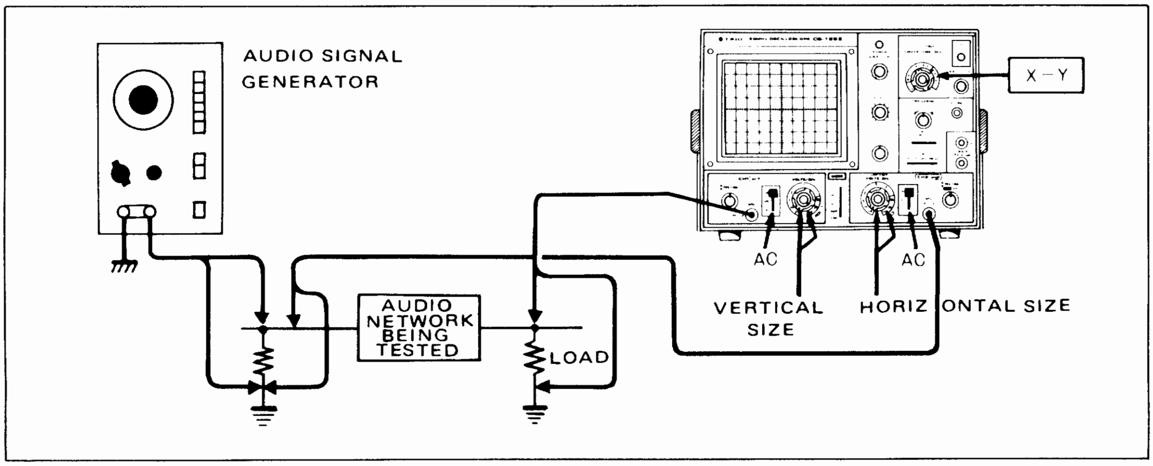


Fig. 24 Typical phase measurement alignment set-up

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.
2. 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 is clipped and the signal level must be reduced.
3. Connect the CH1 probe to the output of the test circuit.
4. Set the SWEEP TIME/DIV to X-Y.
5. Connect the CH2 probe to the input of the test circuit. The input and output test connections to the vertical and horizontal oscilloscope inputs may be reversed.)
6. Adjust the CH1 and CH2 gain controls for a suitable viewing size.
7. Some typical results are shown in **Fig. 25**. If the two signals are in phase, the oscilloscope trace is a straight line. If the vertical and horizontal gain are properly adjusted, this line is at 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. 26**.

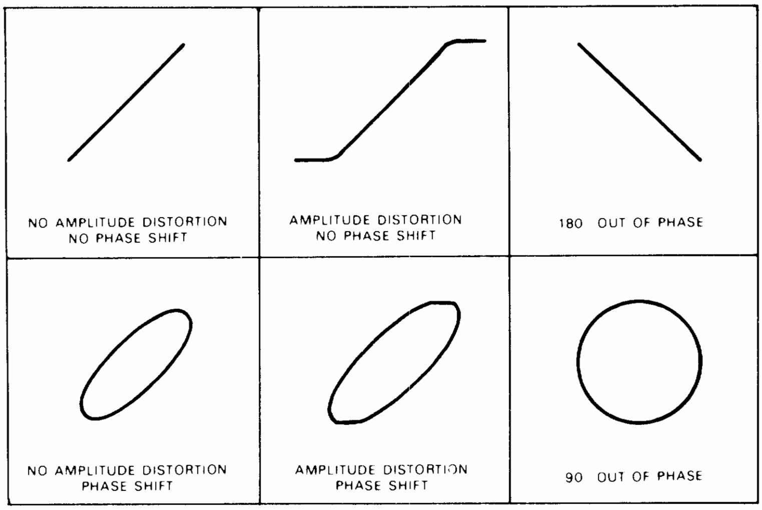


Fig. 25 Typical phase measurement oscilloscope displays

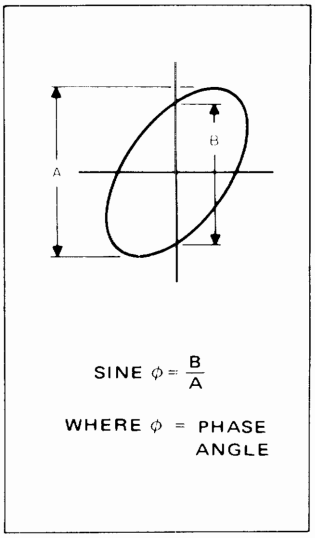


Fig. 26 Phase shift calculation

Frequency Measurement:

1. Connect the sine wave of known frequency to the CH2 input of the oscilloscope and set the SWEEP TIME/DIV control to X-Y.
2. Connect the vertical input probe (CH1 input) to the unknown frequency.
3. Adjust the CH1 and CH2 size controls for a convenient, easy-to-read size of display.
4. The resulting, called Lissajous' pattern, shows the ratio between the two frequencies (see **Fig. 27**).

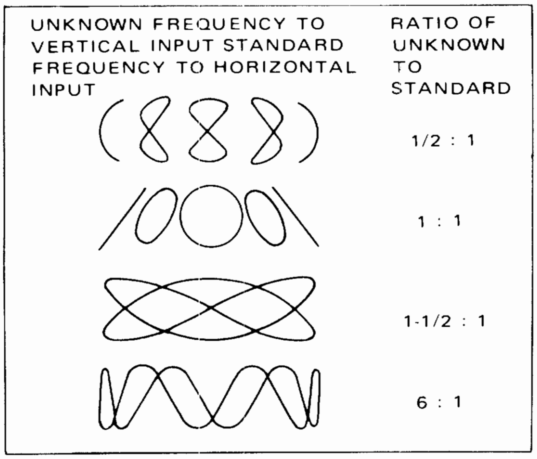


Fig. 27 Lissajous' waveforms used for frequency measurement

AMPLIFIER SQUARE WAVE TEST

Introduction:

A square wave generator and the oscilloscope, such as this oscilloscope 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 and 3.5 kHz are also 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 devices and transformer response are a few of 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 response 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 harmoniques of the square wave which is what the amplifier sees when amplifying complex wave forms 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 an limited bandwidth amplifier. (voice amplifier.)

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 judgement of its performance.

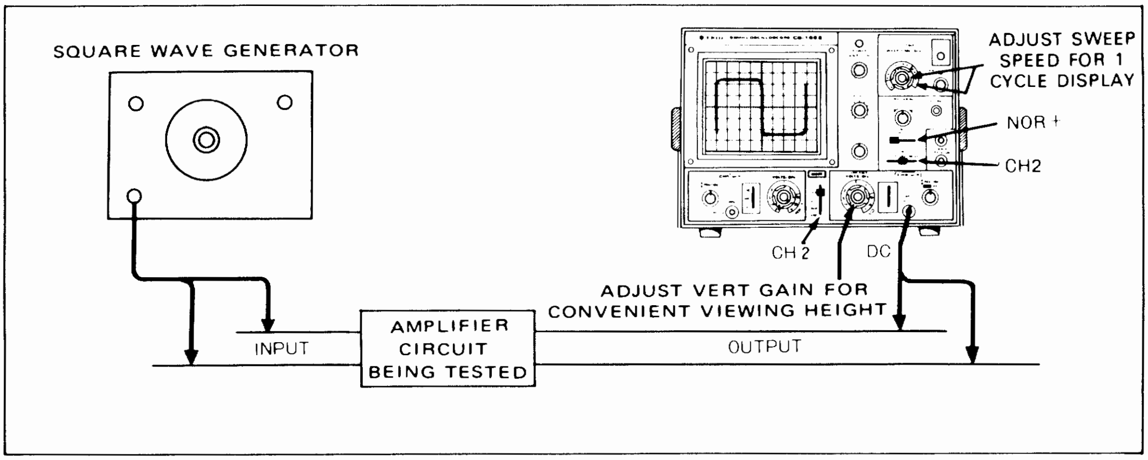


Fig. 28 Equipment set-up for square wave testing of amplifiers

Testing Procedure (refer to Fig. 28):

1. Connect the output of the square wave generator to the input of the amplifier being tested.
2. Connect the CH2 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 components to be viewed, use the DC position of AC-GND-DC switch. However, the AC position may be used without affecting the results except at very low frequencies. (below 10 Hz)
4. Adjust the vertical gain controls for a convenient viewing height.
5. Adjust the sweep time controls for one cycle of square wave display on the screen.
6. For a close-up view of portion of the square wave, use the $\times 10$ magnification.

Analysing 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 time at the end of the half cycle from maximum amplitude to zero amplitude at the 180° or half-cycle point. Therefore, theoretical reduction in amplitude alone of the high frequency components should produce a rounding of the square corner at all four points of one square wave cycle (see **Fig. 29**).

Distortion can be classified into the following three distinct categories:

1. The first is frequency distortion and refers to the change in the amplitude of a component of a complex waveform. In other words, the introduction in an amplifier circuit of reasonant 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 tube, 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.

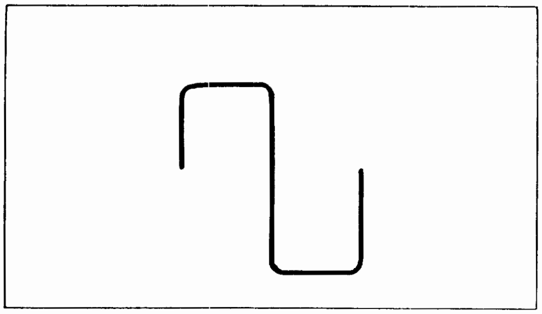


Fig. 29 Square wave response with high frequency loss

In actual practice, a reduction in amplitude of a square wave component 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 distortion and phase distortion clues.

In a typical wide band amplifier, a square wave check reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in **Fig. 30**, revealing poor low-frequency response along with the overcompensated high-frequency boost. A 100 Hz square wave applied to the amplifier will appear as in **Fig. 31A**. This figure indicates satisfactory medium frequency response (approximately 1 kHz to 2 kHz) but shows poor low frequency response. Next, a 1 kHz square wave applied to the input of the amplifier will appear as in **Fig. 31B**. This figure displays good frequency response in the region of 1000 to 4000 Hz but clearly reveals the over compensation 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 wideband circuitry will require at least two frequency check points to properly analyze complete spectrum.

In the case illustrated by **Fig. 30**, a 100 Hz square wave will encompass components up to about 4 kHz.

Now, the region between 100 Hz and 4000 Hz in **Fig. 30** shows a rise from poor low-frequency (100

Hz to 1 kHz) 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 low-frequency components "B" in this same square wave will be modified by the poor low-frequency response of this amplifier (see **Fig. 31**).
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. 32** would be obtained. However, reduction in amplitude of the components is usually caused by a reactive element, causing, in turn, a phase shift of the components, producing the tilt strong as shown in **Fig. 31A**.
Fig. 33 shows a 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. 34 indicates the tilt in square wave produced by a 10° phase shift of a low-frequency element in a leading direction. **Fig. 35** 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 that can be checked through algebraic addition of components. **Fig. 36** 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 characterize by a change in shape of the flat top portion of the square wave.
Fig. 31B previously discussed, revealed a high-frequency overshoot produced by rising amplifier response at high frequencies. It should again be noted that this over shoot 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 larger than other components creating a higher algebraic sum along the leading edge.

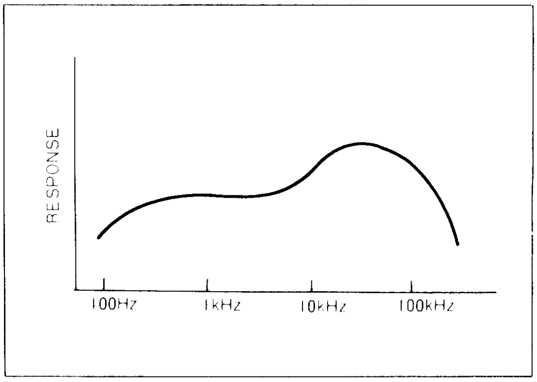


Fig. 30 Response curve of amplifier with poor low and high ends

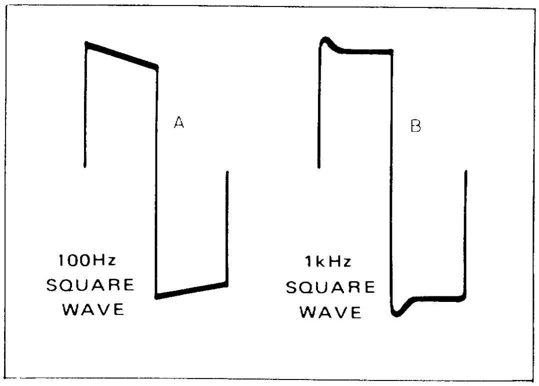


Fig. 31 Resultant 100 Hz and 1 kHz square waves from amplifier in Fig. 30

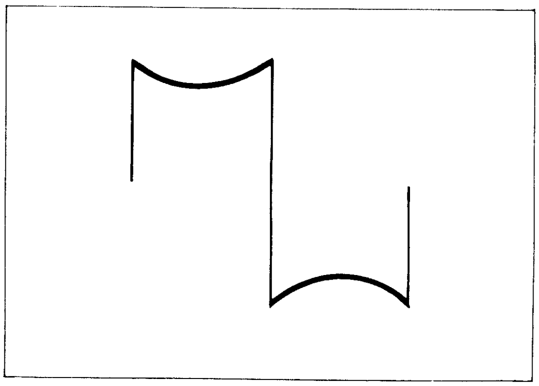


Fig. 32 Reduction of square wave fundamental frequency component in a tuned circuit

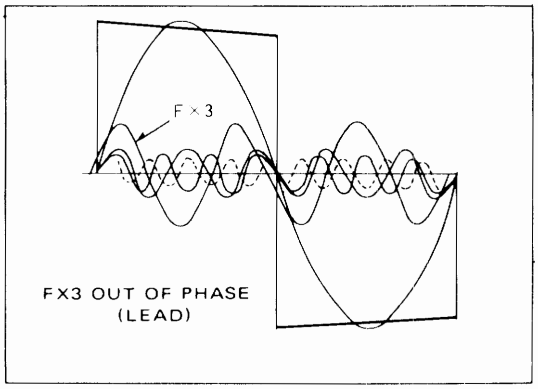


Fig. 33 Square wave tilt resulting from 3rd harmonic phase shift

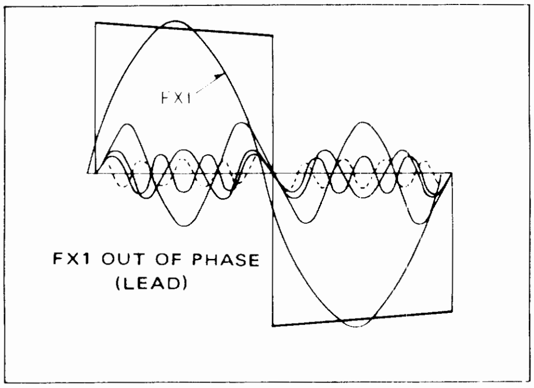


Fig. 34 Tilt resulting from phase shift of fundamental frequency in a leading direction

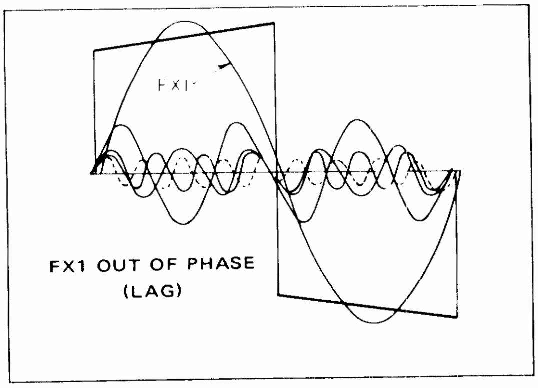


Fig. 35 Tilt resulting from a phase shift of fundamental frequency in a lagging direction

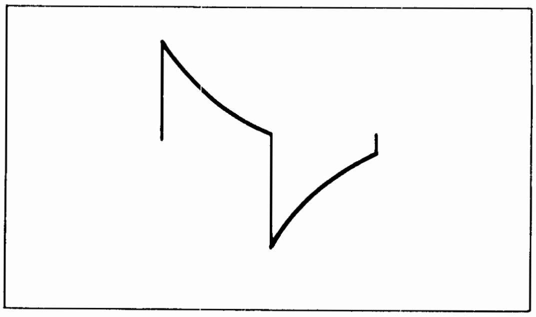


Fig. 36 Low frequency component loss and phase shift

Fig. 37 indicated high-frequency boost in an amplifier accompanied by a lightly damped "shock" trasient. The sinuoscidal 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 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. 38**.

Fig. 39 summarizes the preceding explanations and serves as a handy reference.

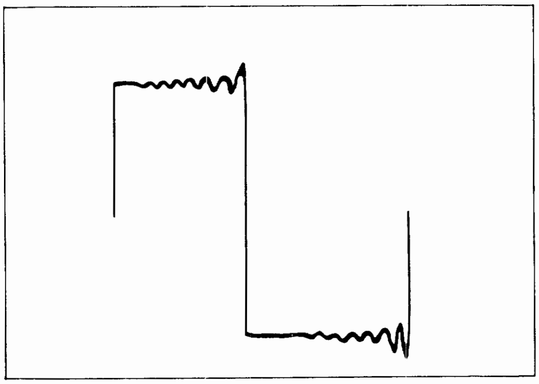


Fig. 37 Effect of high-frequency boost and poor damping

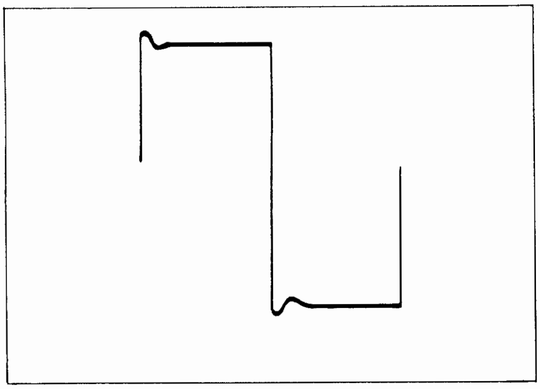


Fig. 38 Effect of high-frequency boost and good damping

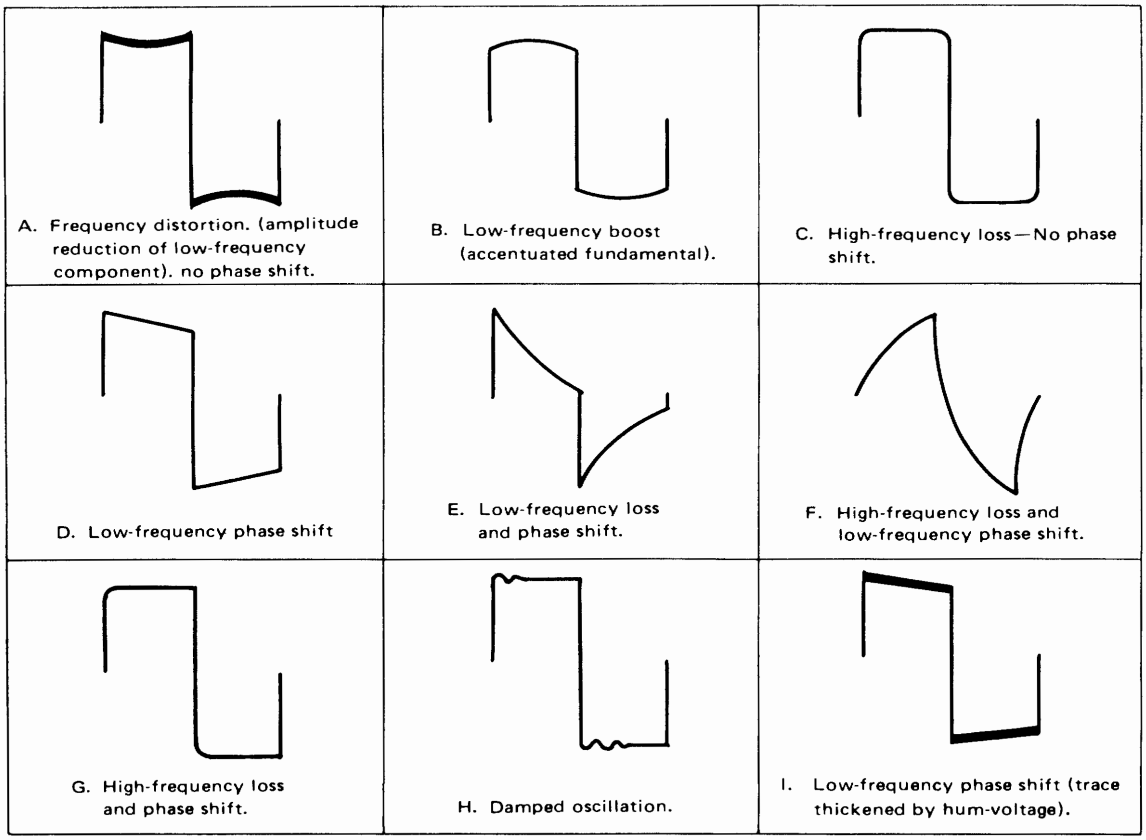


Fig. 39 Summary of waveform analysis for square wave testing of amplifiers

PRECAUTIONS

1. Do not use the unit in any of the following locations:
   * Places where the unit is exposed to direct sunlight.
   * Places where temperature and humidity are high.
   * Places where there are mechanical vibration.
   * Places near equipment generating strong lines of magnetic force or impulse voltages.
2. When operating the unit on voltages other than 240V, set the AC voltage selector switch to 100V, 117V or 220V according to your local AC current. The voltage selector switch is located on the side panel of the unit.
   When operating on 100V or 117V, remove the 0.5A fuse and replace it with one rated at 1A.
3. Do not apply input voltages exceeding their maximum ratings. The input voltage to the vertical amplifier is up to 300V (DC + AC peak), the input for EXT TRIG is up to 50V (DC + AC peak), and the input to Z AXIS is up to 50V (DC + AC peak).
4. Do not increase the brightness of the CRT unnecessarily.
5. Do not leave the oscilloscope for a long period with a bright spot displayed on CRT. Reduce the brightness and soften the focus.
6. For X-Y operation, use the PULL X10 MAG switch in the PUSH position. If it is set in the PULL position, noise may appear in the waveform.
7. Installation of oscilloscope
   Pull the stand in the "arrow" direction until it locks. Do not place any object on the oscilloscope or cover the ventilation holes of the case with a cloth or the like, as it will increase the temperature inside the case.

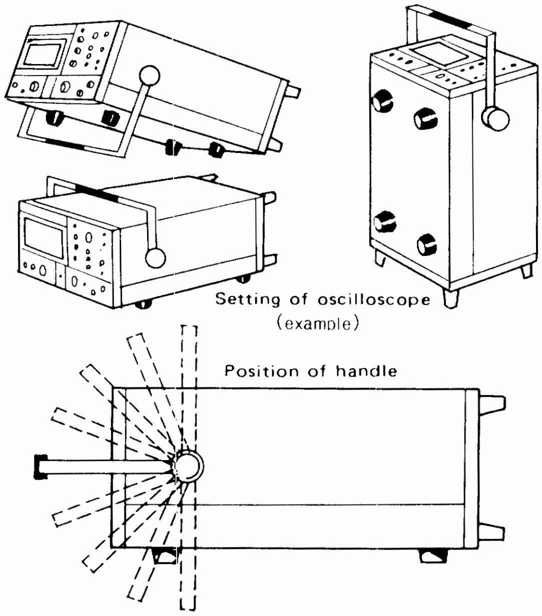


Fig. 39

MAINTENANCE AND ADJUSTMENT

MAINTENANCE

Removing the case:

1. Remove the seven screws from the top and side walls of the case, using a Phillips head screwdriver.

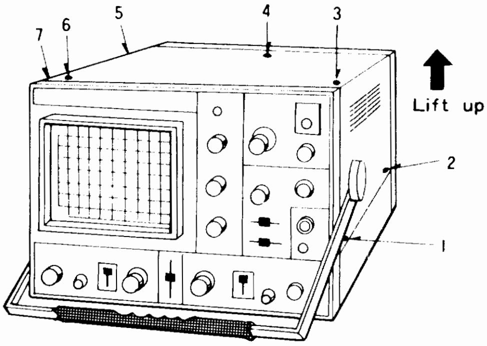


Fig. 40

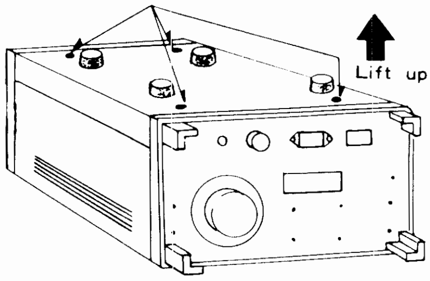


Fig. 41

2. Hold the handle and lift up. The case is now ready for removal.
3. To remove the bottom case, unscrew the four screws using a Phillips head screwdriver.

Caution:
A high voltage (2000V) is present at the CRT socket and the lower printed circuit board. Before removing the case, be sure to turn off the power, and do not touch these parts with your hand or a screwdriver even after the case has been removed.

or a screwdriver even after the case has been removed.

ADJUSTMENT

Observe the following before making adjustments:

The oscilloscope is factory adjusted prior to shipment. If readjustment becomes necessary, the following points should be observed.

1. Check the power supply is the correct voltage.
2. For adjustments, use a well insulated screwdriver.
3. Before marking adjustments, be sure to turn on the power and wait until the unit is stabilized.
4. For adjustment follow the procedures described below.
5. If special test instruments are required for adjustments, contact your local Trio's service station.

−10V Adjustment:

Turn VR401 so that −10V is obtained on the No. 3 pin of the power circuit board connector P403.

AC Voltage selector:

The oscilloscope may be operated from 100V, 117V, 220V, 240V, putting the AC voltage selector in place of another. (Refer to Fig. 42)

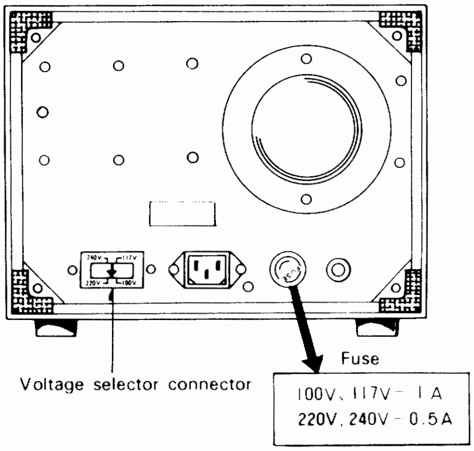


Fig. 42

Blanking Voltage Adjustment

1. Pull the PULL AUTO knob to display a trace on CRT.
2. Adjust VR403 so that the trace disappears at 9-11 o'clock position of the INTENSITY knob.

ASTIG Adjustment

Adjust VR404 on the cabinet bottom until the waveform line offers the same thickness. This adjustment should be made in conjunction with the FOCUS knob.

CRT Bright Line Angle Adjustment

Adjust the TRACE ROTATION (front panel) until the trace is aligned with the horizontal line marked on the CRT scale.

CRT Centering Adjustment

1. Short the terminals of the vertical circuit board connector P104.
2. With horizontal line displayed, adjust VR107 so that the trace comes to the vertical center position.

VARIABLE DC BAL ADjustment

Adjust VR103 (VR113 for CH2) so that the trace stays still when the VARIABLE of VOLT/DIV is turned in either direction.

STEP ATT DC BAL Adjustment

Adjust VR101 (VR111 for CH2) on the cabinet bottom so that the trace stays still when VOLTS/DIV is turned in either direction.

NOR-INV POSITION Adjustment

Adjust VR114 on the vertical circuit board so that the trace comes to the position of the line in CH2 NOR mode when the CH2 polarity is inverted.

Horizontal Position Adjustment

1. To adjust the horizontal position under the normal sweep condition, set the ◄► POSITION to its mechanical center position and then adjust VR316 on the horizontal circuit board until the waveform starts at the left end of the scale.
2. To adjust the horizontal position when the SWEEP TIME/DIV is in X-Y position, perform the same adjustment and then adjust VR307 on the same circuit board until the spot comes to the center of the scale.

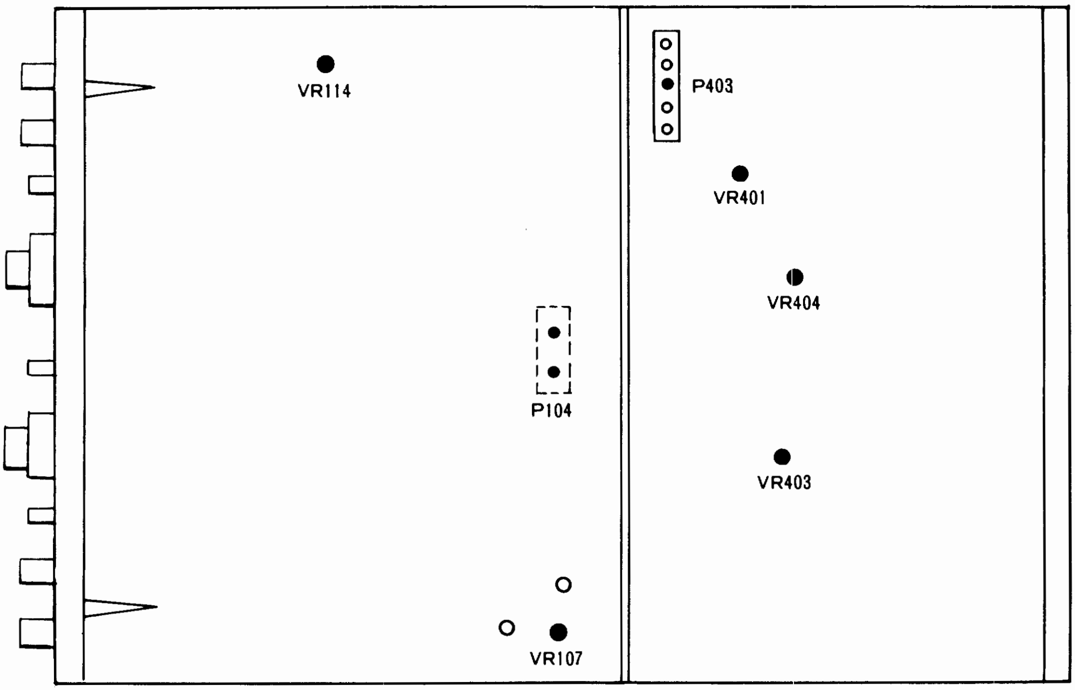


Fig. 43

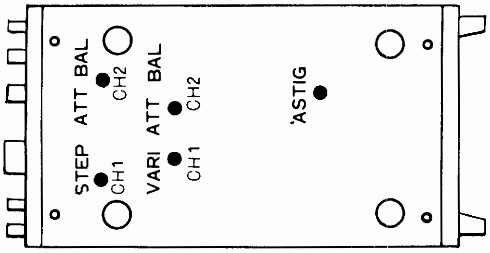


Fig. 44

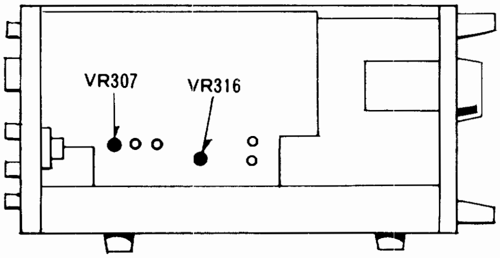


Fig. 45

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