TRIGGERED SWEEP OSCILLOSCOPE

CS-1352

DUAL TRACE OSCILLOSCOPE

INSTRUCTION MANUAL

FEATURES

* Vertical axis provides high sensitivity and wide band width, 2 mV/div, 15 MHz (−3 dB).
* Operates on AC, internal DC and external DC, each being selected automatically without using power selector switch.
* The adoption of IC's throughout circuitry assures high performance and improved reliability.
* The high voltage power for CRT as well as the power for other circuits is fully stabilized, thus the sensitivity and luminance are compretely 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 10 mV/div, permitting accurate calibrations.
* Sum and difference between 2 channels can be measured by the use of mode selector switch and CH2 selector switch.
* Time base switch allows changeover between CHOP and ALT and between V (vertical) and H (horizontal) of TV sync separator circuit, automatically and electronically.
* At AUTO position of TRIG LEVEL, it is possible to check the luminance at no-signal time and to adjust triggering level of input waveforms.
* The employment of digital switch circuit and mechanical parts cleverly mounted on circuit boards assure improved reliability.
* The over-discharge protection circuit automatically shuts off the battery circuit when battery voltage is low.
* The built-in charging circuit permits the battery to be charged while the oscilloscope is in use.

CONTENTS

SPECIFICATIONS

Type of Cathod Ray Tube:
C331P31B
Acceleration Voltage:
Approx. 1.5 kV

Vertical Axis (for both CH1 and CH2)

Sensitivity:
2 mV/div~10V/div, ±5% in 1-2-5 sequence (1 div=0.6 cm)
Vernier control for fully adjustable sensitivity between steps.
Input Impedance:
1MΩ ±5%.
Input Capacitance:
Approx. 22pF
Frequency Response:
DC DC-15 MHz (less than −3 dB)
AC 10 Hz-15 MHz (less than −3 dB)
Rising Time:
Less than 23 nsec.
Over-shoot:
Less than 3% (at 100 kHz square wave)
Cross-talk:
Better than 70 dB at 1 kHz
Operating Mode:
CH1: Channel 1 only
CH2: Channel 2 only
DUAL: 2-channel (CHOP and ALT are automatically selected by SWEEP TIME/DIV) 0.5μs/div ~ 0.5 ms/div: ALT (alternate sweep) 1ms/div ~ 0.5s/div: CHOP
ADD: 2-channel algebraic sum (CH1+CH2)
Invert Polarity:
CH2 only
CHOP Frequency:
200 kHz ±20%
Maximum Input Allowable Voltage:
600 Vp-p or 300V (DC + AC peak)

Sweep Circuit

Sweep System:
Triggered and automatic. In automatic mode, sweep is obtained without input signal
Sweep Time:
0.5μs/div~0.5s/div ±5% in 19 ranges and "X-Y", in 1-2-5 sequence. Each overlapping range provides for fine adjustament
Magnifier:
5 times ±5% (PULL × 5 MAG)

Linearity:
Better than 3% (2μs/div ~ 0.5s/div)
Better than 5% (0.5μs/div ~ 1μs/div)

Synchronization

Sync Input:
INT: Mode switch changeover, CH1 at DUAL
EXT
Sync Selection:
NOR: positive and negative
TV: positive and negative
(TVH and TVV are automatically switched by SWEEP TIME/DIV)
TVH (TV - Line): 0.5μs/div ~ 50μs/div
TVV (TV - Frame): 0.1ms/div ~ 50s/div

Sync Range:

Sync Position	Sync Frequency	Min. sync voltage (amplitude)	
		INT	EXT
NOR	20 Hz~ 5 MHz	0.5 div	0.5 Vp-p
	20 Hz~10 MHz	1 div	0.5 Vp-p
	20 Hz~15 MHz	1 div	1 Vp-p
(AUTO)	50 Hz~15 MHz	1 div	1 Vp-p
TV	TV signal	1 div	1 Vp-p

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

Horizontal Axis (CH2 input)

Operating Mode:
X-Y mode is selected by SWEEP TIME/DIV
CH1: Y axis
CH2: X axis
Sensitivity:
Same as CH1
(2 mV/div ~ 10V/div ±5%)
Frequency Response:
DC DC-1 MHz (less then −3 dB)
AC 10 Hz-1 MHz (less than −3 dB)
Input Impedance:
Same as CH1 (1MΩ ±5%)
Input Capacitance:
Same as CH1 Approx. 22pF
Calibrating Voltage:
1 Vp-p ±3% positive, (1 kHz ±5% square wave)

Luminance Modulation

Input Voltage:
Lights at +5V or less

Input Impedance:
10kΩ ±20%
Frequency Response:
DC ~ 1 MHz
Maximum Input Allowable Voltage:
50V (DC + AC peak)

Power Source

AC
Power Supply Voltage:
100/120/220/240V ±10%, 50/60 Hz
Power Consumption:
Approx. 25W

Battery (Option)
Power Supply Voltage:
12V
Continuous Operation Time:
More than 2 hours with fully charged battery

DC
Power Supply Voltage:
11 ~ 15.5V
Power Consumption:
Approx. 20W

Charging
Charging System:
Internal battery is charged by connecting AC line cord
Charging Time:
Charging during operation .... Approx. 28H
Charging only .... Approx. 16H
Ambient Temperature and Humidity:
0 ~ 50°C, 95% or less

Dimensions and Weight

Width:
210 mm
Height:
136 mm
Depth:
348 mm
Projections not included.
Weight:
6.5 kg (without battery)
8.3 kg (with battery)

Accessories

Probe:
PC-29 2
Damping 1/10
Input impedance 10MΩ
Input capacitance .... less than 18 pF
Pin-plug:
.... 1
Replacement fuse:
0.5A 2
1A 2
Hood (BF-6)
.... 1
External power connector plug 1
Instruction Manual:
1 copy
External power connector plug 1
Optional accessories:
Shoulder bag (MC-75)
Battery pack (BP-7E)

CONTROLS ON PANELS

FRONT PANEL

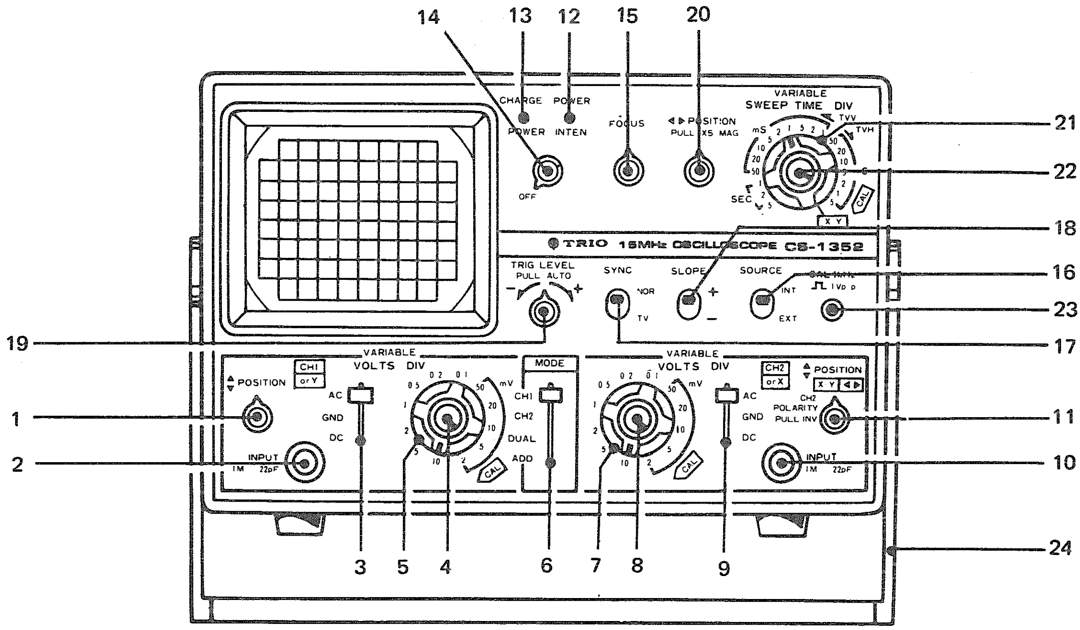


Fig. 1

SIDE PANEL

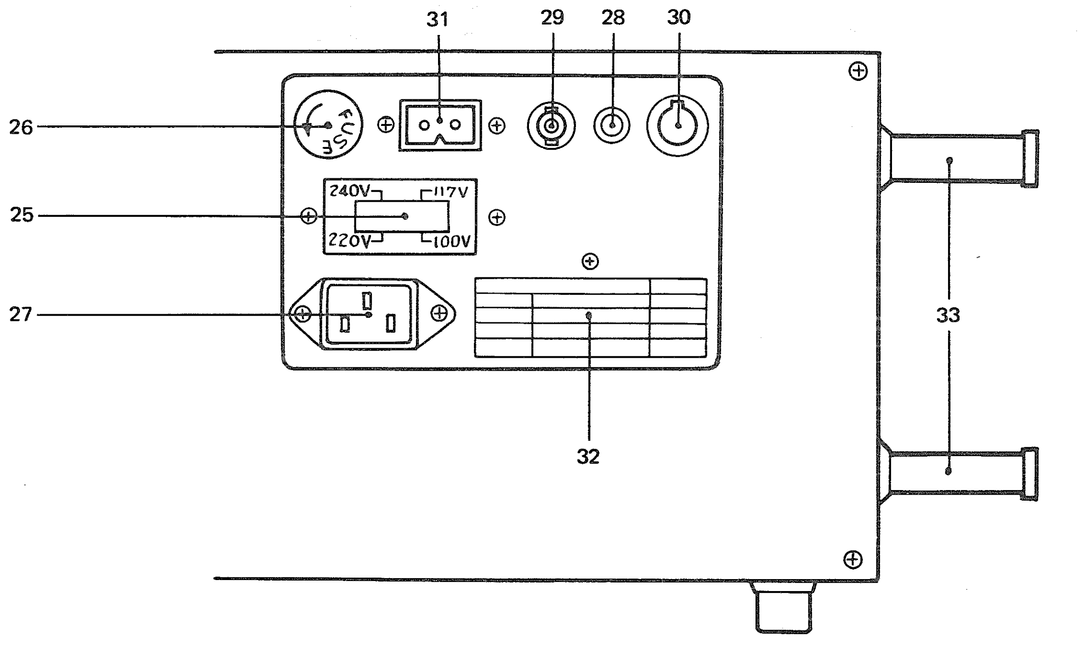


Fig. 2

1. ▲▼ POSITION ▲

Vertical position adjustment for CH1 trace and Y position for X-Y operation. Waveforms can be set to any desired vertical position. Turning this control to the right will shift waveform upward, and vice versa.

2. INPUT

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

3. AC-GND-DC

- **DC** Direct input of AC and 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 measurements.
- **AC** Blocks DC component of input signal.

4. VARIABLE

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

5. VOLTS/DIV

Vertical attenuator for Channel 1; provides coarse adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 12 steps from 2 mV to 10 volts per divisiton when VARIABLE control (4) is set to the CAL position.

6. MODE (CH1, CH2, DUAL, ADD)

- **CH1:** Only the input signal to CH1 is displayed as a single trace.
- **CH2:** Only the input signal to CH2 is displayed as a single trace.
- **DUAL:** In the range of 0.5s/div to 1ms/div, the input signals to both channels are switched by about 200 kHz signal (CHOP operation).
  In the range of 0.5ms/div to 0.5μs/-div, the input signals to both channels are alternately switched for each sweep (ALT operation).
- **ADD:** The waveforms from Channel 1 and Channel 2 inputs are added and the sum is displayed as a single trace. If the channel 2 polarity switch (11) is pulled out (PULL INV), 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 step adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 12 steps from 2 mV to 10 volts per division when VARIABLE control (8) is set to CAL position. This control adjusts horizontal sensitivity when the SWEEP TIME/DIV switch (21) is in the X-Y position.

8. VARIABLE

Vertical attenuator adjustment provides fine control of vertical sensitivity of CH2 (or X). This control becomes the fine horizontal gain control when the SWEEP TIME/DIV switch is in the X-Y position.

9. AC-GND-DC

- **DC** Direct input of AC and 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 measurements.
- **AC** Blocks DC component of input signal.

10. INPUT

Vertical input terminal for CH2 (or X).

11. ▲▼ POSITION, X-Y ◀▶

Vertical position adjustment for Channel 2 trace. Becomes horizontal position adjustment when SWEEP TIME/DIV switch (21) is in the X-Y position. Push-pull switch inverts Channel 2 signal when pulled out (CH2 POLARITY PULL INV), non-inverted signal when pushed in.

12. POWER LAMP

Lights when scope is on, dims when battery is low, goes off when battery is too low for operation.

13. CHARGE LAMP

Lights when battery is charging, goes off when battery is fully charged. Charger operates whenever scope is connected to AC power, regardless of whether scope is turned on or off.

14. POWER/INTEN

Fully counterclockwise rotation of this control (OFF position) turns oscilloscope off. Clockwise rotation turns oscilloscope on. Further clockwise rotation of the control increases the intensity of the trace.

15. FOCUS

Spot focus control to obtain optimum waveform according to brightness.

16. SOURCE

Selects triggering source for sweep.

INT: Sweep is triggered by the waveform being viewed; in DUAL and ADD modes, sweep is triggered by CH1 signal.

EXT: Sweep is triggered by the signal applied to EXT TRIG jack (29).

17. SYNC

Sync separator switch. It picks up sync signal component in TV video signal and applies to sync circuit for complete synchronization of video signal being viewed.

NOR: Used for viewing all waveforms except television composite video.

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

18. SLOPE

Sunc polarity selector switch. At the "+" position, sweep is effected with positive slope, and at the "−" position, it is effected with negative slope.

19. TRIG. LEVEL

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 without an input signal.

20. ◀▶ POSITION

Horizontal position adjuster to shift waveform to any desired horizontal position. A right turn of the adjuster will shift the waveform to right, and vice versa.

PULL X5 MAG:

Sweep magnifier switch. By pulling the knob toward you, waveform is magnified to 5 times in left and right directions. Brightness is slightly decreased.

21. SWEEP TIME/DIV

Horizontal coarse sweep time selector. Selects calibrated sweep times of 0.5 μs/div. 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 CH2 input to provide horizontal sweep.

22. VARIABLE

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

23. CAL 1 Vp-p

Provides calibrated 1 kHz, 1 volt peak-to-peak square wave calibration 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. HANDLE

Use this handle to mount the oscilloscope in a slant position.

25. AC VOLTAGE SELECTOR

The CS-1352 may be operated from 100V, 120V, 220V, 240V, putting the AC VOLTAGE SELECTOR in the place of another.

26. FUSE HOLDER

For 220 ~ 240V operation a 0.5 ampere fuse should be used.

For 100 ~ 120V operation a 1 ampere fuse should be used.

27. POWER CONNECTOR

For connection of the supplied AC power cord.

28. INT MOD

Intensity (brightness) modulation terminal. Intensity is modulated at voltages of +5V.

29. EXT TRIG

External sync input terminal. For external synchronization, set the SOURCE switch (16) to EXT to apply external sync voltage.

30. ASTIG

Astigmatism adjustment provides optimum brightness and spot roundness when used with the Focus knob. Very little readjustment of this control is required after initial adjustment.

31. EXT DC

External DC power jack to supply 11 ~ 15.5V DC power.

32. **VOLTAGE NAMEPLATE**

Be sure to use voltage and fuse specified.

33. **CORD REEL**

Used to wind power cord when the oscilloscope is to be carried or stored. It also serves as a stand when the oscilloscope is used in upright position.

OPERATION

PRELIMAINARY 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.

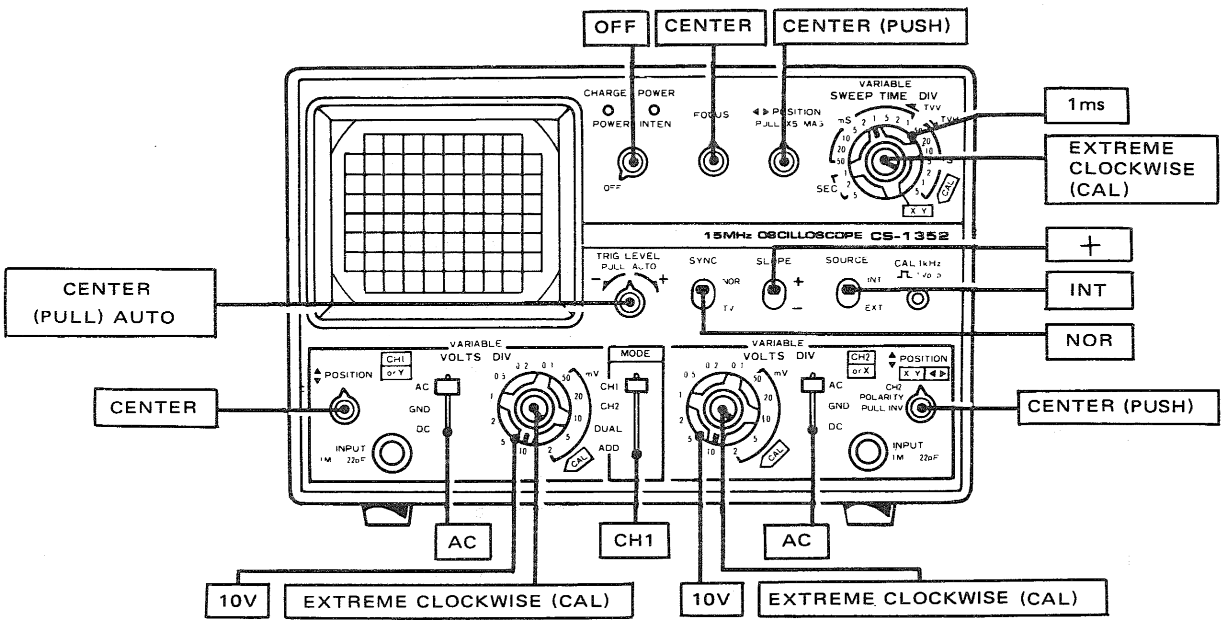


Fig. 3

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/INTEN (14) clockwise. The power is turned to ON and POWER lamp (12) lights.
3. Horizontal axis will be displayed. When flyback line does not appear at the center of the screen, adjust ⬍POSITION (1) and ◀▶POSITION PULL X5 MAG (20).

Adjust brightness by POWER/INTEN (14). If trace line is unclear, adjust FOCUS (15).

4. The oscilloscope is now ready for measurement. For measurement, proceed as follows: Apply signal voltage to the input terminals (2) and (10). Then turn the VOLT/DIV (5), clockwise until the waveform is correctly displayed on the screen. By setting the MODE switch (6) to CH1 and the SOURCE switch (16) to INT, the CH1 input signal to INPUT terminal (2) will appear. When the MODE switch (6) is set to CH2, then the input signal to INPUT terminal (10) will appear on the scope. When the MODE switch (6) is set to DUAL, two waveforms (CH1 and CH2) will appear on the scope, at this time, the CH1 signal to the INPUT terminal (2) is fed to the syncro circuit where the CH1 signal is synchronized. When the MODE switch (6) is set to ADD, the CH1 signal is algebraically added to the CH2 signal (CH1 + CH2). By pulling CH2 POLARITY (11), the CH2 signal in reverse polarity is added to the CH1 signal and the algebraic

difference between CH1 and CH2 is displayed (CH1 − CH2).

5. When the signal voltage is more than 2mV and waveform fails to appear on the screen, the oscilloscope may be checked by feeding input from CAL 1 Vp-p (23). Since calibration voltage is 1 Vp-p, the waveform becomes 5 div high at the 0.2/div position.
6. By pushing TRIG LEVEL (19), 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 mid 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.

POWER SUPPLY

The oscilloscope is designed to operate on AC, internal battery or external DC.

AC operation

For AC operation, first set the power voltage selector switch to the voltage of your local AC current. Then, connect the AC cord. The connection of the AC cord automatically disconnects the internal battery.

Operation on internal battery (option)

Install the battery pack in the oscilloscope accoring to the following sequence (refer to the diagram on the rear of the case):

* Open the package of the battery pack BP-7 (option) and check to make sure that it contains two 6V lead batteries and connecting leads.
* Place the oscilloscope with the up side down, remove the 4 screws on both sides using a screwdriver. Hold the cord reel and pull it out. The battery case cover will be removed.
* Release the lead from the cord clamper and then remove the screw (4 × 40 mm) as shown in the diagram.
* Connect the 2 batteries in series using the connecting leads, then connect the leads (red and black) of the oscilloscope to the batteries. Make sure that the red lead is connected to "+" and the black lead to "−" side.
* After the batteries have been connected, insert the battery case from the rear and replace the battery case cover. The battery leads should be arranged on top of the batteries so that they are not caught between the batteries and the battery case.
* Tighten the 4 screws from each side of the case and the screw (4 × 40 mm) from the rear of the case.

Now, the oscilloscope is ready for operation. Refer to the instructions in the previous paragraph "Controls on Panels". With the internal battery, the oscilloscope can be operated for more than 2 hours, although this depends on the condition of the battery.

When the battery voltage falls down to 10V during operation, the protection circuit is activated to shut off the battery circuit. In this case, the power lamp goes off indicating that the battery is protected against over-discharge. When this happens, the battery should be recharged fully and immediately. (refer to item "Battery Charging")

The power lamp will start blinking to indicate battery voltage drop 10 minutes before the protection circuit operates.

Operation on external DC (11∼15.5V)

Connect a DC power cord from DC 12V receptacle (31) to a nominal 12volt DC power source (11 to 15.5 VDC), such as a vehicle cigarette lighter. Observe proper polarity; the oscilloscope is protected against reverse polarity damage, but will not operate if polarity is reversed.

Turn on POWER/INTEN control (14).

POWER indicator (12) should glow, and the scope is ready for use.

If CHARGE indicator (13) glows, the batteries are charging the indicator goes off when the batteries are fully charged.

BATTERY CHARGING

To charge the internal battery, connect the AC line cord to AC outlet. The battery is charged regardless of the position of the power switch. When battery charge is started, the CHARGE lamp will light. With the power switch set to OFF, the battery is fully charged in about 16 hours. With the switch set to ON, the battery is charged in about 28 hours; the oscilloscope can be used while the battery is being charged. The external power con-

nector plug must be disconnected while the battery is being charged.
When the battery is almost fully charged, the CHARGE lamp becomes dim and finally goes off. Continue charging for about 2 hours, then the battery will have been fully charged.

MOUNTING OF HOOD

The supplied hood can be mounted on the oscilloscope as shown in **Fig. 4**.

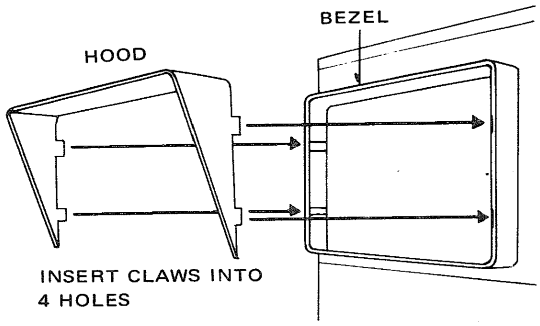


Fig. 4 Mounting of Hood

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. Simultaneous viewing of input and its output is an inbaluable 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 Channel 1 and Channel 2 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 Channel 1 and Channel 2 are desired, the Channel 1 and Channel 2 VARIABLE controls must be placed in the CAL position. The Channel 2 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 negative-going

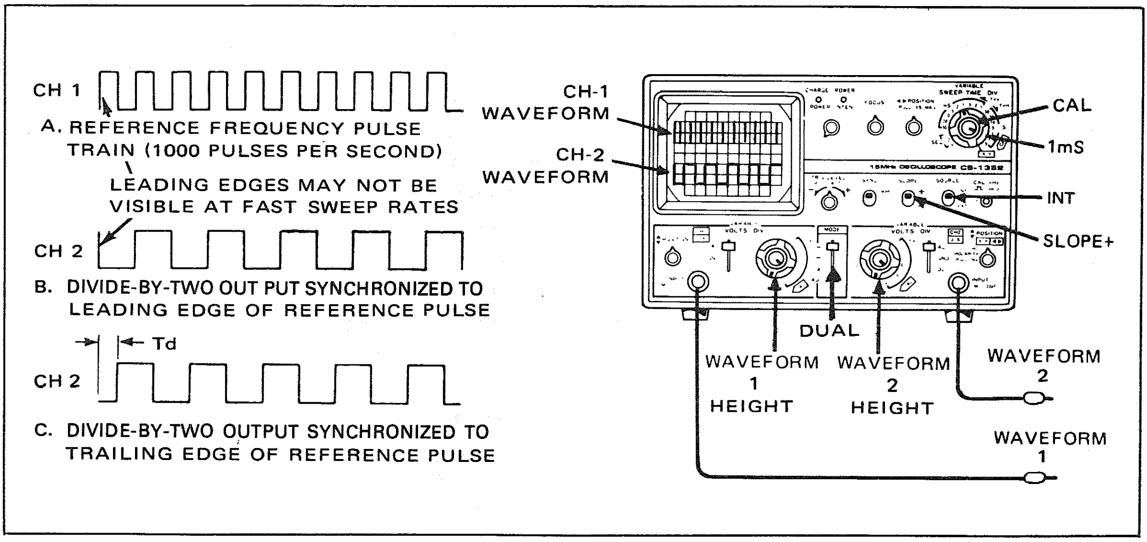


Fig. 5 Waveforms in divide-by-two circuit.

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.

Divide-by-8 Circuit Waveforms:

Fig. 6 indicates waveform relationships for a basic divide-by-eight circuit. The oscilloscope settings are identical to those used in Fig. 5. The reference frequency of **Fig. 6A** is supplied to the Channel 1 input. **Fig. 6B** 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. 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.

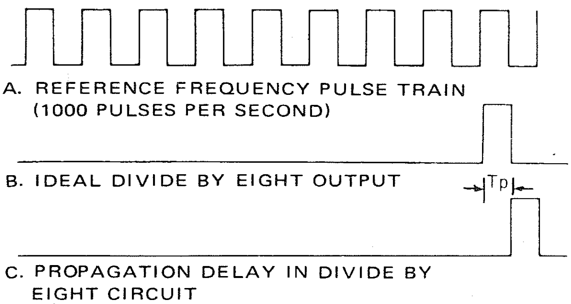


Fig. 6 Waveforms in divide-by-eight circuit

Propagation Delay Time Measurement:

An example of propagation dealy in a divide-by-eight circuit was given in the previous paragraph. Significant propagation delay may occur in any circuit. This oscilloscope has features which simplify measurement of propagation delay. **Fig. 7** shows the resultant waveforms when the dual-trace presentation is combined into a single-trace presentation by selecting the ADD or SUB (CH2 POLARITY PULL INV) position of the MODE switch. In the ADD position the two inputs are algebraically added in a single-trace display. Similarly, in the INV. (pull) position the two inputs are algebraically subtracted. Either position provides a precise display of the propagation time (Tp). Using the procedure given for calibrated time measurement (CAL), Tp can be measured. A more precise measurement 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 X5 MAG control. It also may be possible to view the desired portion of the waveform at a faster sweep speed.

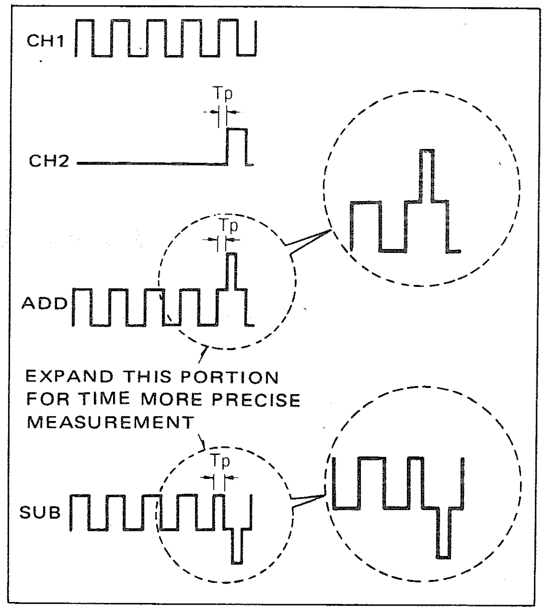


Fig. 7 Using ADD or SUB modes for propagation time measurement

Digital Circuit Time Delay Measurement:

Since a dual-trace oscilloscope has the capability of comparing the timing of one waveform with another, it is necessity in designing, manufacturing and servicing digital equipment. In digital equipment, it is common for a larger number of circuits to be synchronized, or to have a specific time-relationship to end 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 more of operation. **Fig. 8** shows a typical digital cuicuit and identifies several of the points at which waveform measurements are appropriate. The accompanying **Fig. 9** shows the normal waveforms to be expected at each of these points and their timing relationship. 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 1 and

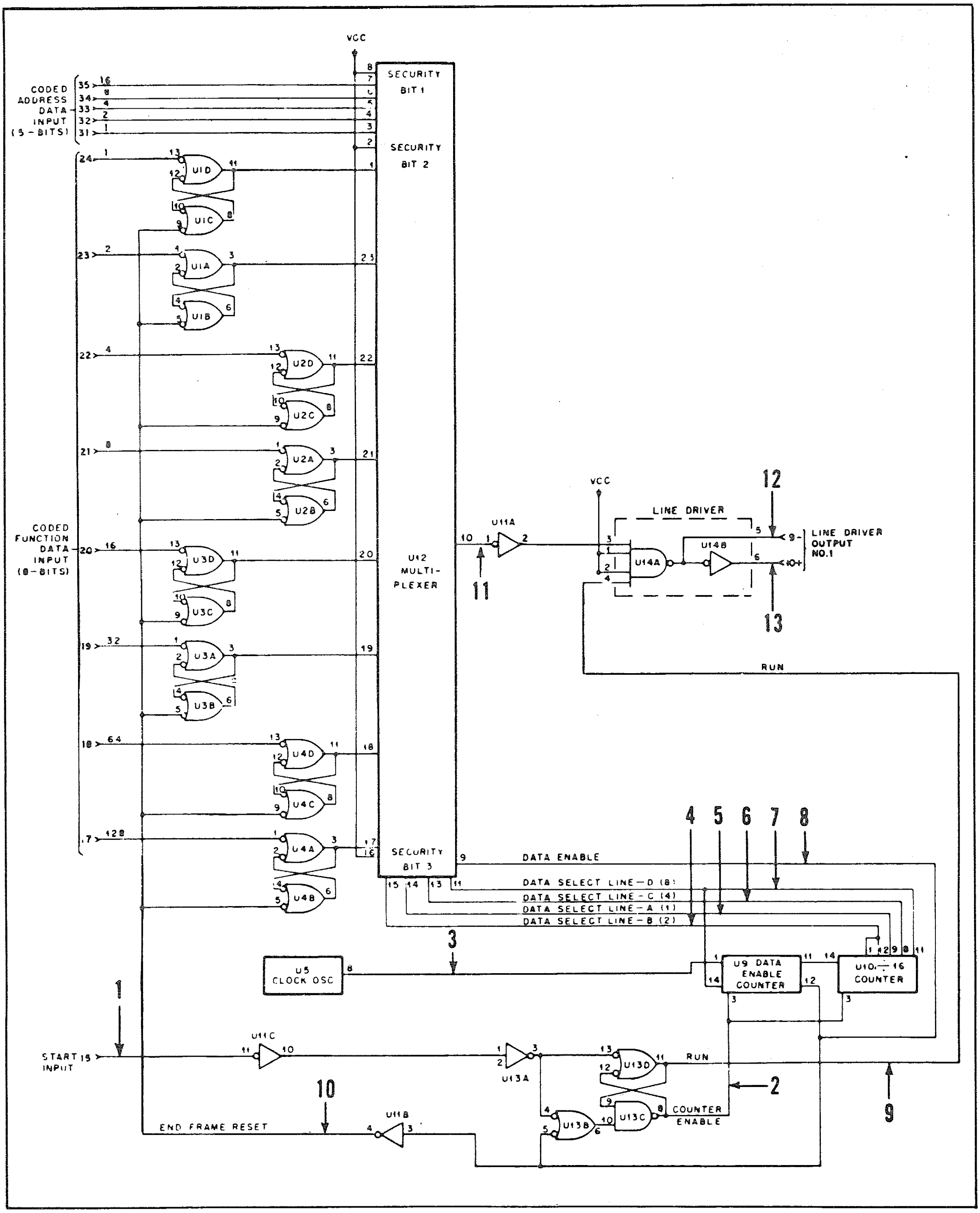


Fig. 8 Typical digital circuit using several time-related waveforms

waveforms No. 4 through No. 8 and No. 10, would be displayed on Channel 2 although other timing comparisons may be desired.

Waveforms No. 11 through No. 13 would probably be displayed on Channel 2 in relationship to waveform No. 8 or No. 4 on Channel 1. In the family of time-related waveforms shows in Fig. 9, 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 desiable.

With No. 8 or No. 10 used as external sync 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 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. 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 X5 MAG control is used to expaned the waveform display.

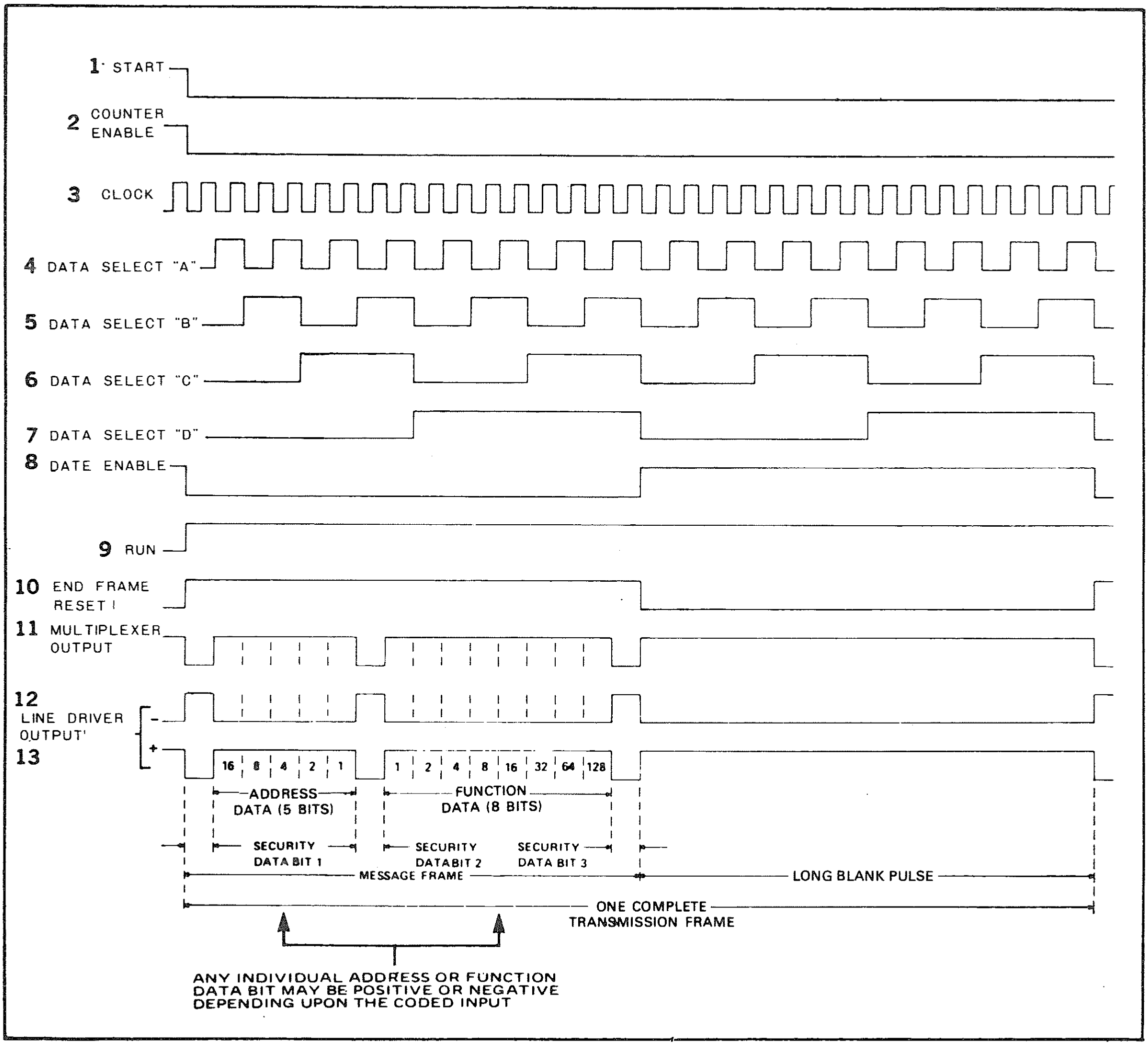


Fig. 9 Family of time-related waveforms from typical digital circuit in Fig. 8

Distortion Measurement:

An amplifier stage, or an entire amplifier unit, may be tested for distortion with this oscilloscope. This measurement is especially variable when the slope of a waveform must be faithfully reproduced by an amplifier. **Fig. 10** shows the testing of such a circuit using a triangular wave, such as is typically encountered in the recovered audio output of a limiting circuit which precedes the modulator of a 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:

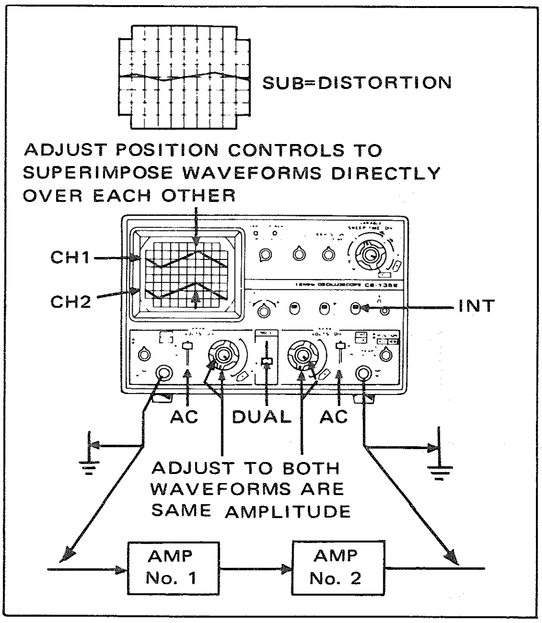


Fig. 10 Distortion measurement

1. Apply the type of signal normally encountered in the amplifier under test.
2. Connect Channel 1 probe to the input of the amplifier and Channel 2 probe to the output of the amplifier. It is preferable if the two signals are not inverted in relationship to each other but inverted signals can be used.
3. Set Channel 1 and Channel 2 DC-GND-AC switches to AC.
4. Set the MODE switch to DUAL.
5. Set SYNC SLOPE switch to INT and adjust controls as described in waveform veiwing 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 hight.
8. Now, set the Mode switch to ADD and CH2 Polarity of INV (if one waveform is inverted in relationship to the other, use the NOR position).

   Adjust the fine vertical sensitivity control (CH2 VARIABLE) slightly for the minimum remaining waveform. Any waveform that remains equals distortion; 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 remain on the screen.

Gated Rising Circuit (burst circuit)

Fig. 11 shows a burst circuit. The basic settings of

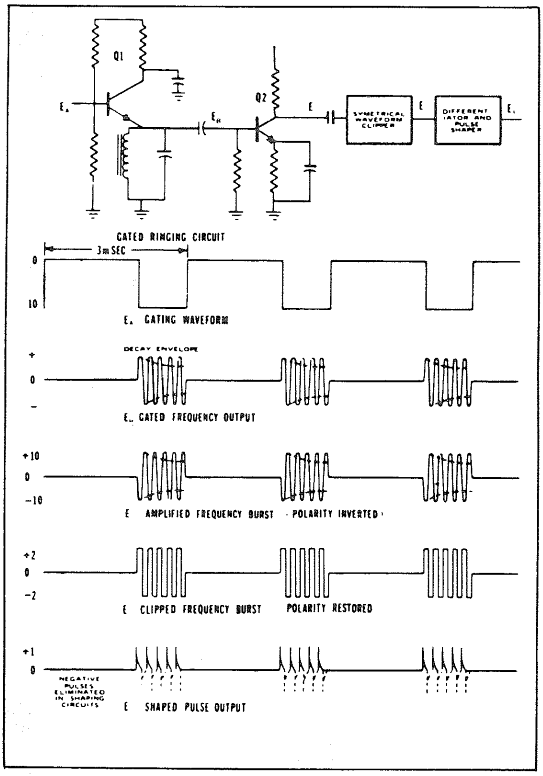


Fig. 11 Gated ringing circuit and waveforms

control knobs are the same as those in **Fig. 5**. The waveform A is the reference waveform and is applied to CH1 input. All other waveforms are sampled at CH2 and compared to the reference waveforms are sampled at CH2 and compared to the reference waveform of CH1. The burst signal can be examined more closely either by increasing the sweep time or by pulling the ◀▶ POSITION control to obtain 5 times magnification.

Delay Line Test:

The dual-trace feature of the oscilloscope also can be used to determine the delay times of transmission type delay lines as well as ultrasonic type delay lines. The output of delay lines can be observed on CH2 while being synchronized with the input pulse of CH1. 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 delay pulse observed on CH2 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. A common application of delay line checks is found in color TV 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 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 reverals any distortion that may be introduced from an impedance mismatch or a greatly attenuated output resulting from an open line.

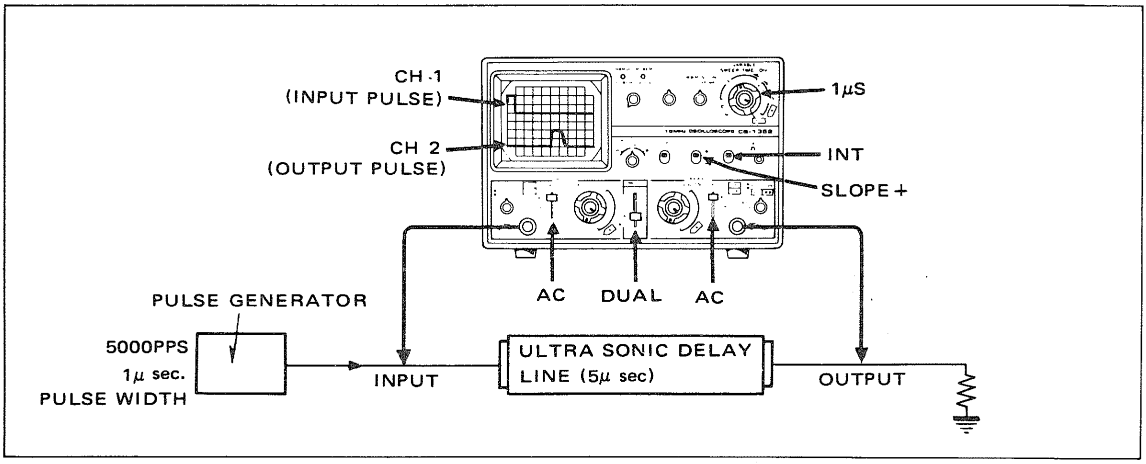


Fig. 12 Delay line measurements

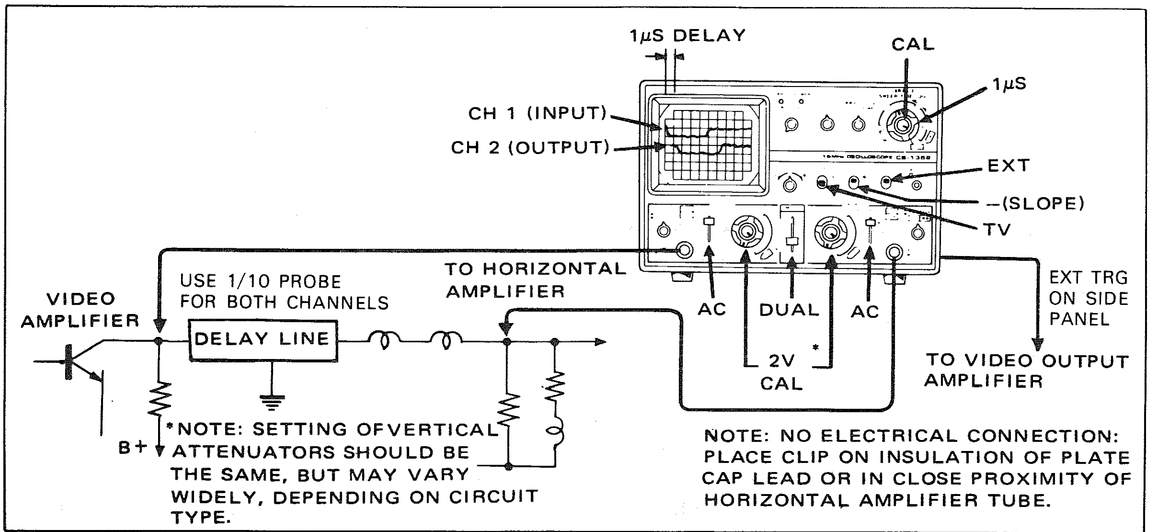


Fig. 13 Checking "Y" delay line in color television receivers

Stereo Amplifier Servicing:

Another convenient use for 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 effects of whatever troubleshooting and repair methods are employed can be observed and analyzed immediately.

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 60 Hz. It is possible to minimize or for practical purpose eliminate the undesired component. **Fig. 14** shows the oscilloscope control settings for such an application. The waveform display of Channel 1 indicates the desired signal and the dotted line indicates the average amplitude variation corresponding to an undesired 60 Hz component. The Channel 2 display indicates a waveform of equal amplitude and identical phase to the average of the Channel 1 waveform. With the MODE switch set to ADD, and the CH2 signal inverted, and by adjusting the CH2 vertical attenuator control, the 60 Hz component of the Channel 1 signal can be cancelled by the Channel 2 input and the desired waveform can be observed.

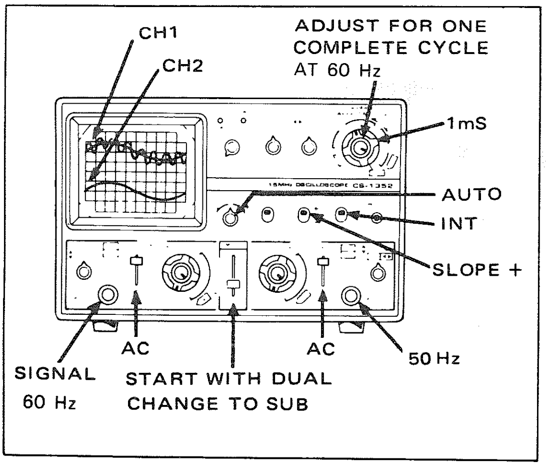


Fig. 14
Improving desired-to-undesired signal radio

Amplifier Phase Shift Measurements:

Phase measurements can be made by several methods using oscilloscope. Typical applications are in circuits designed to procedure a specific shift, and measurement of phase shift distortion in audio amplifiers and networks.

In all amplifiers, a phase shift is always associated with a change in amplitude response. For example, at the −3 dB response point, a phase shift of 45° occurs. **Fig. 15** illustrates a method of determining amplifier phase shift directly. 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 Channel 1 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 centimeter represents 45° of the waveform.

The signal developed across the output of the audio amplifier is applied to the CH2 input jack.

The vertical attenuator controls of Channel 2 are adjusted as required to produce a peak-to-peak waveform of 2 div as shown in **Fig. 15B**. The Channel 2 POSITION control is then adjusted so that the Channel 2 waveform is displayed on the same horizontal axis as the Channel 1 waveform as

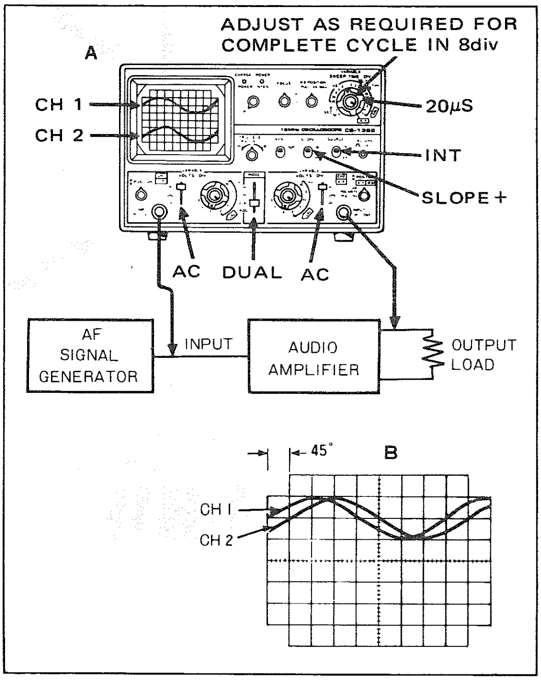


Fig. 15 Measurering amplifier phase shift

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 a phase shift of 45°.

Television 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 operation. 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. 19** and **26**, the information on the Field 1 and Field 2 vertical blanking interval pulse is different. This is shown in detail in **Fig. 19**. 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 built-in test signals (VITS) that can be very valuable tools in troubleshooting and servicing video equipment. The VITS can localize trouble to the antenna, tuner, IF or video sections and shows when realignment may be required. The VITS signal is being used in some television receivers for automatic color correction.

The VITS signal is transmitted during the vertical blanking interval. On the television set, they 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 these signals.)

The transmitted VITS is precision sequences of specific frequencies, amplitudes and waveshapes as shown in **Fig. 16**. 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 frame of VITS at the "B" section (line 18) in **Fig. 16** begins with a white reference

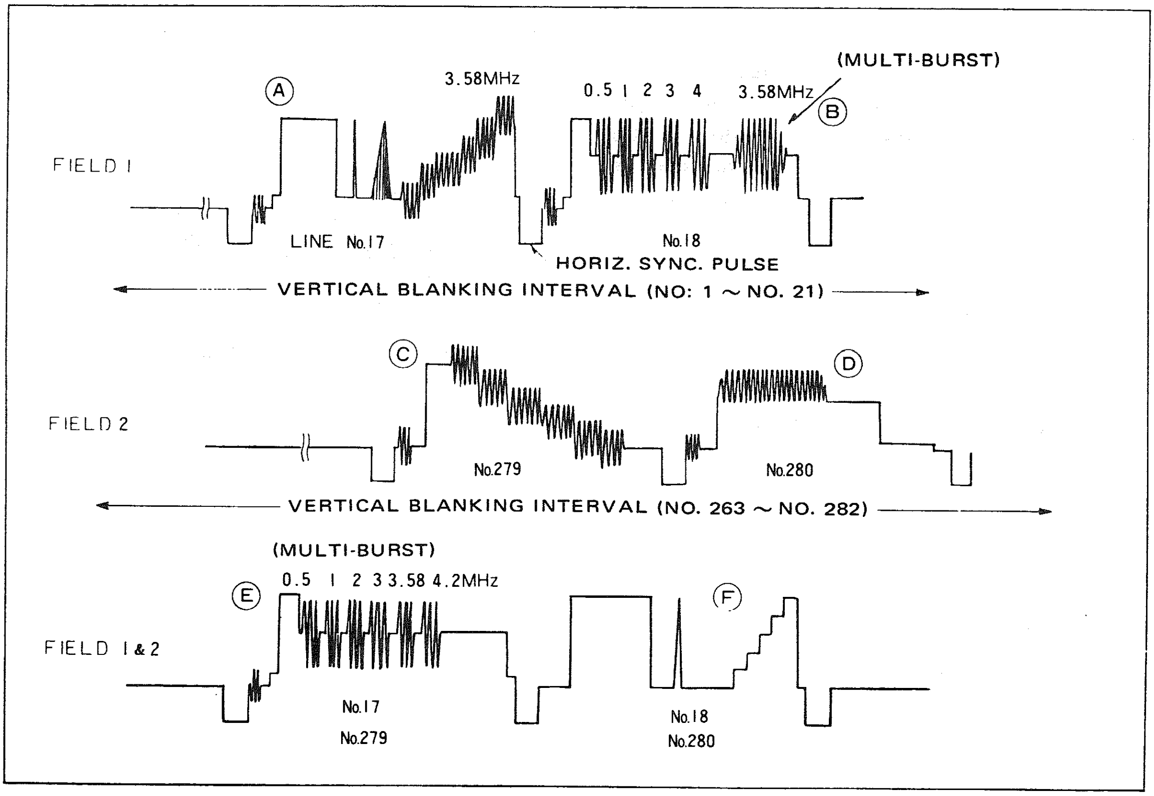


Fig. 16 VITS signal, Fields 1 and 2

signal, followed by sine wave frequencies of 0.5 MHz, 1.0 MHz, 2.0 MHz, 3.0 MHz, 4.0 MHz and 3.58 MHz. This sequence of frequencies is called the "multi-burst".

This multi-burst portion of the VITS is the portion that can be most valuable to the technician. The second frame of the VITS (lines 18 and 280), which contains 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 line 280. The VITS appears at the end of the vertical blanking interval 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. 28** shows the desired response for a good color television receiver, identifying each frequency of the multi-burst and showing the sllowable 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

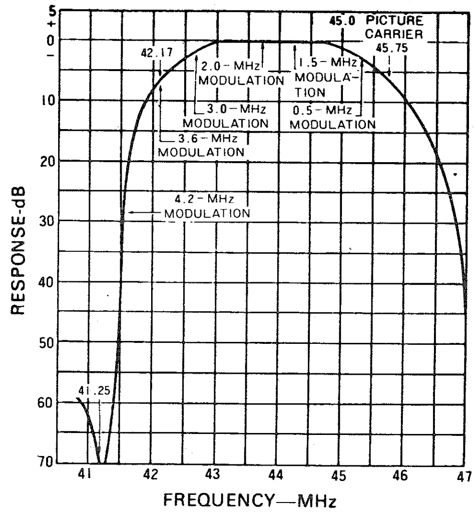


Fig. 17
Color TV IF amplifier response curve

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 channels, carrying VITS. If the same thing is seen,

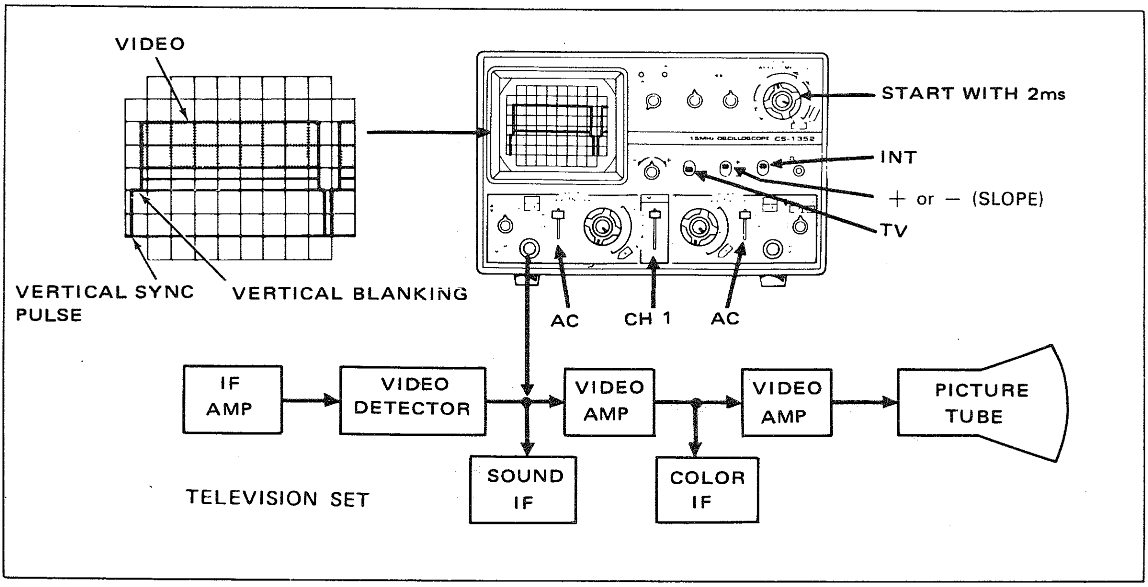


Fig. 18 Set-up for viewing fields 1 and 2 of VITS information

then our reasoning is right, and the IF amplifier requires realignment. If the poor response at 2 MHz

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 tourble will be in the video amplifier. Look for open peaking coils, off-value resistors, 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. The color TV receiver on which the vertical interval information is to be viewed must be set to a station transmitting a color broadcast.
2. The control settings of **Fig. 18** are these required to obtain a 2-Field vertical display on CH1.
3. With the oscilloscope and the TV receiver operating, connect the CH1 probe (set to 10:1) to video detector test point.
4. Set the SYNC and SLOPE switches as follows:
   A. If the sync and blanking pulses of the observed video signal are positive, use the TV, + positions.
   B. If the sync and blanking pulses are negative, use the TV, − positions.
5. Adjust the sweep time VARIABLE control so that 2 vertical fields are displayed on the oscilloscope screen.
6. Connect the CH2 probe (set to 10:1) to the video detector test point.
7. Set the MODE switch to DUAL position.
8. Place the sweep time VARIABLE in the CAL position.
9. Set the SWEEP TIME/DIV control to the 0.1 ms 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 **Fig. 16**. Because there is no provision for synchronizing the oscilloscope display to either of the two fields which comprise a complete vertical frame, if cannot be predicted which field display will appear on the CH1 or CH2 display.
10. Pull the ◄► POSITION control outward to obtain an additional X5 magnification. Rotate the control in a counterclockwise direction moving the traces to the left until the expanded 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 CH2 switch to PULL INV 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 in addition, several features that were incorporated to make television servicing easier and more comprehensive. These feature include:

*With the SYNC switch set to TV position, the SWEEP TIME/DIV control automatically selects the TV vertical sync at sweep speeds appropriate for viewing frames and horizontal 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 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. The schematic diagram or accompanying service data on the equipment being servied usually includes waveform pictures. There waveform pictures include the required sweep time and the normal peak-to-peak voltage. Compare the peak-to-peak voltage readings and waveshape 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 and video servicing is the composite waveform consisting of the video signal, the blanking pedestal signals 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 sync 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, nothing the waveform at varous points in the video amplifier. To set up the oscilloscope for viewing composite video waveforms, use the following procedures:

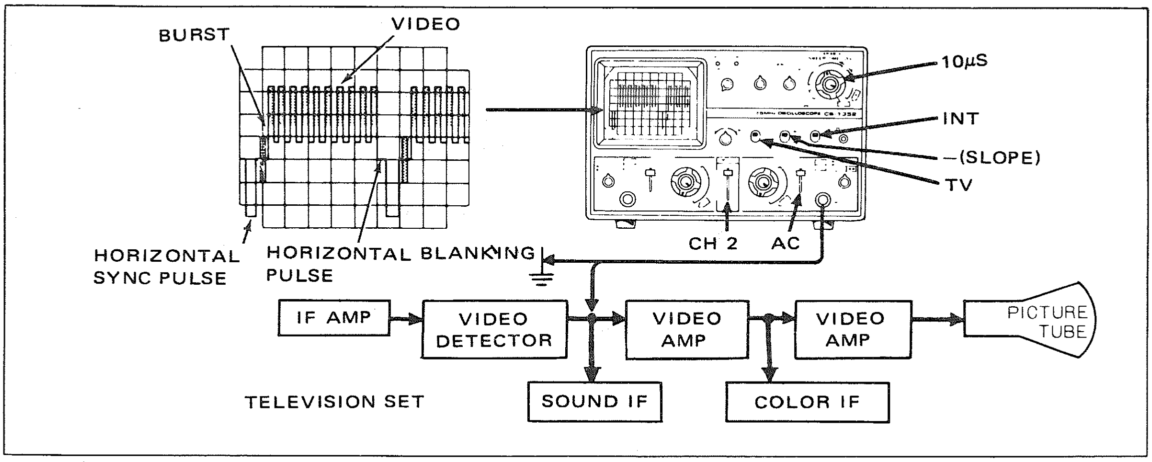


Fig. 19 Set-up for viewing horizontal fields of composite video signal

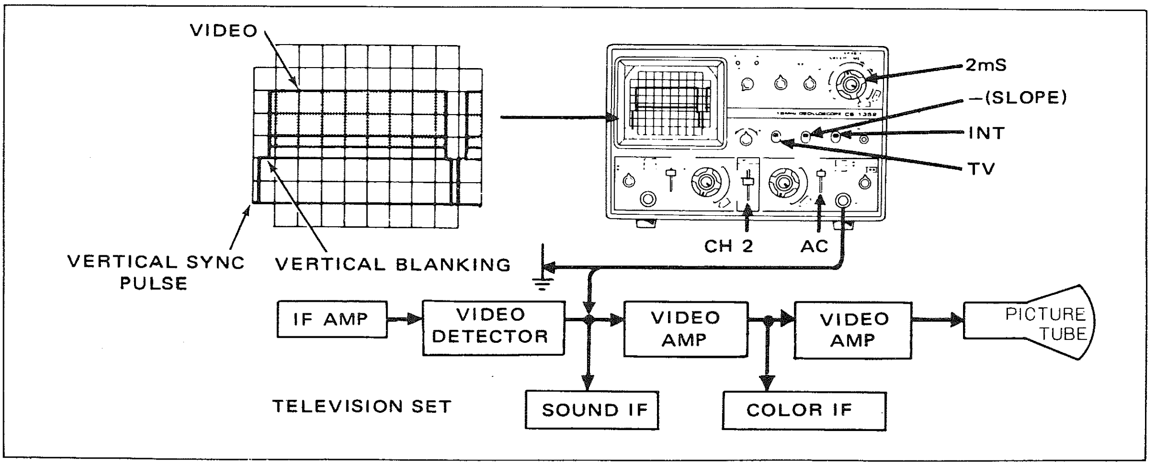


Fig. 20 Set-up for viewing vertical fields of composite video signal

1. Tune the television set or video recorder receiver 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 10μs/div position for observing TV horizontal lines or to the 2 ms/div position for observing TV vertical frames.
4. Set the SYNC switch to TV position, and the Slope switch to the "+" or "−" position (depending on the video signal).
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 comtinous sweep during set-up.
7. Set the CH2 DC-GND-AC switch to the AC position.
8. Connect a probe cable to the CH2 input jack. Connect the ground clip of the probe to the TV set or video recorder 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 off-scale.
10. If necessary rotate the TRIG LEVEL control to a position that provides a synchronized display.
11. Adjust the SWEEP TIME VARIABLE control for two horizontal lines or two vertical frames of composite video display.
12. If the sync and blanking pulses of the displayed video signals are positive, set the SLOPE switch to the "+" position; if the sync and blanking pulses are negative, use the "−" position.
13. Push in the TRIG LEVEL control and rotate to a position that provides a well-synchronized display.
14. Adjust the POWER/INTEN 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 X5 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 on the video circuits by moving the probe tip to those points and changing the VOLTS/DIV control setting as required to keep the display within the limits of the scale, and by readjusting the TRIG LEVEL control to maintain stabilization.

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**.

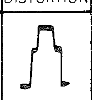
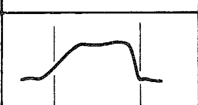
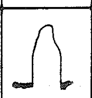
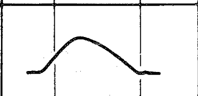
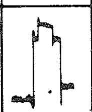
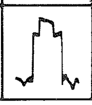
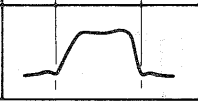
CIRCUIT DEFECT	HORIZONTAL PULSE DISTORTION	OVERALL RECEIVER FREQUENCY RESPONSE	EFFECT ON PICTURE
NORMAL CIRCUIT			PICTURE NORMAL
LOSS OF HIGH FREQUENCY RESPONSE			LOSS OF PICTURE DETAIL
EXCESSIVE HIGH FREQUENCY RESPONSE. NON-LINEAR PHASE SHIFT			FINE VERTICAL BLACK AND WHITE STRIATIONS FOLLOWING A SHARP 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

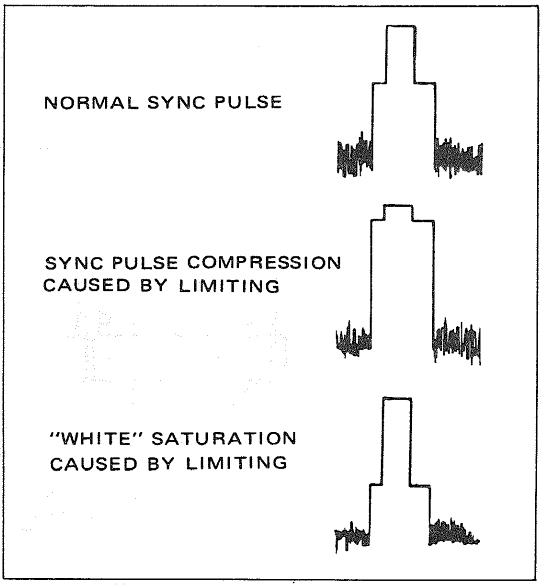


Fig. 22 Sync pulse waveforms

FM RECEIVER ADJUSTMENTS

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 2 input jack of the oscilloscope and set the oscilloscope controls for external horizontal sweep (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 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 equal distance from the center as the marker frequency is increased and decreased equal amount from the 10.7 MHz center frequency.

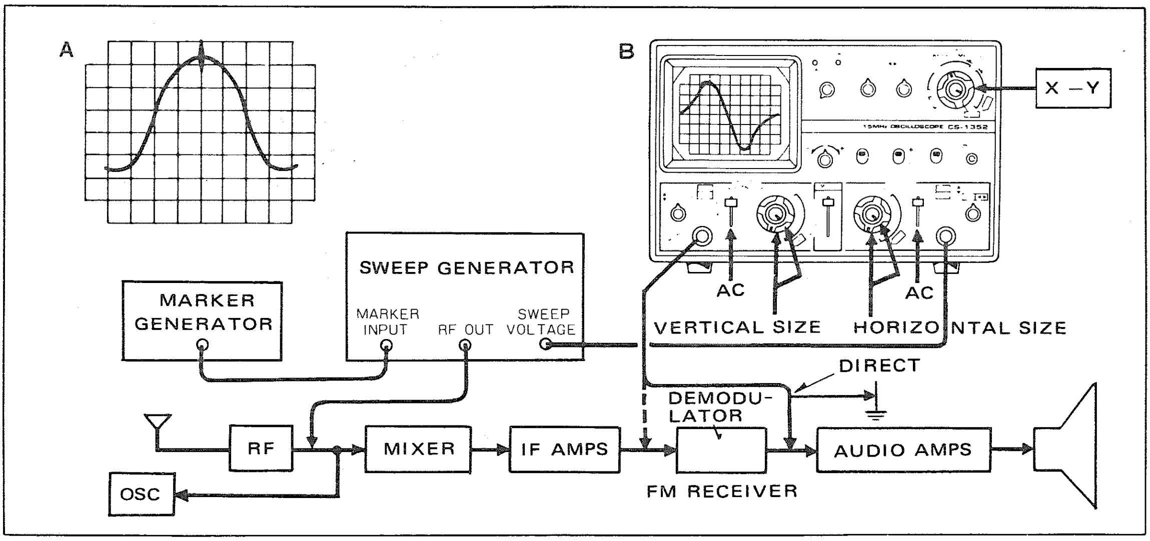


Fig. 23 Typical FM receiver alignment set-up

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**).

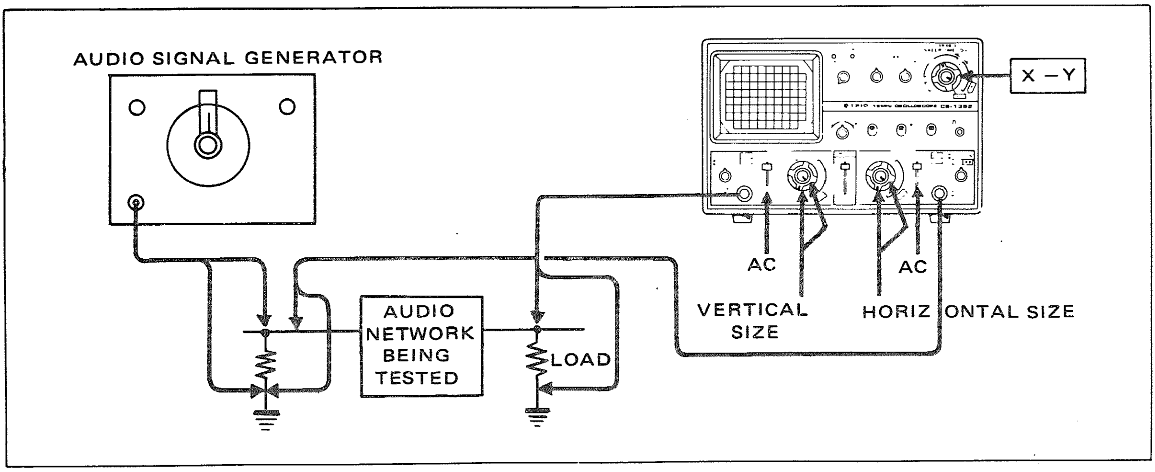


Fig. 24 Typical phase measurement alignment set-up

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 verator 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.
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 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. A 90° phase shift produces a circular oscilloscope pattern. Phase shift of less (or more) than 90° procedures an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in **Fig. 26**.

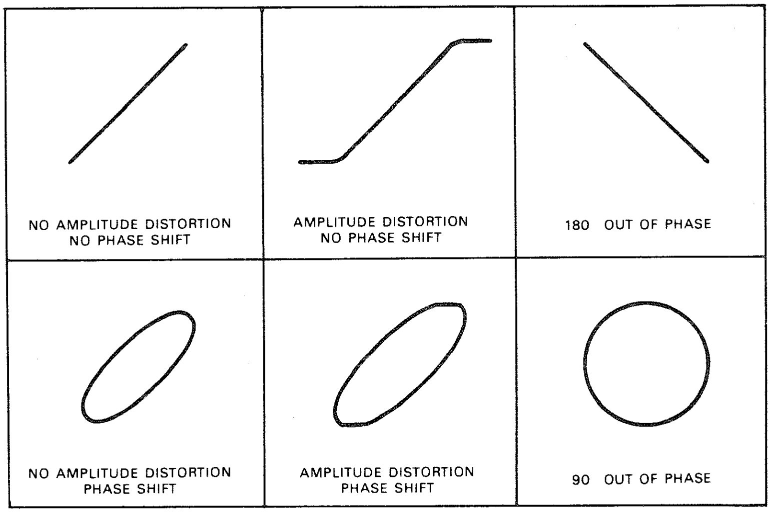


Fig. 25 Typical phase measurement oscilloscope displays

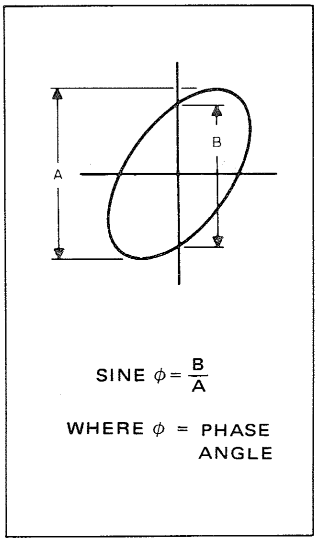


Fig. 26 Phase shift calculation

Frequency Measurement:

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

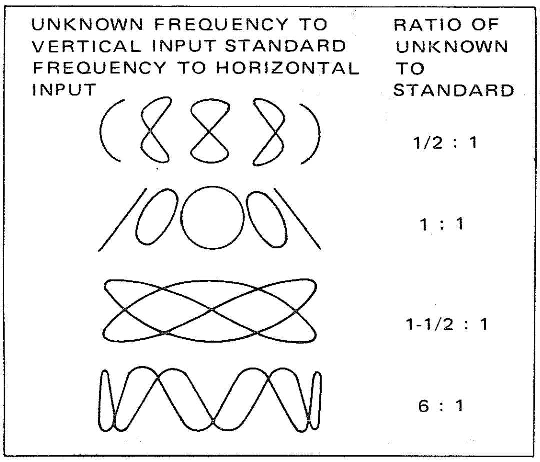


Fig. 27 Lissajous' waveforms used for frequency measurement

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 also are provided. Since vacuum tubes and transistors arenon-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 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 macy frequencies (the harmonics of the square wave) which is what the amplifier sees when amplifying complex wave forms of musical instruments of 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 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 dificiencies 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.

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 sufficiently low, to allow both the AC and DC component to be viewed, use the DC position

of AG-GND-DC switch. However, the AC position may be used without affecting the result except at very low frequency (below 5 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 X5 magnification.

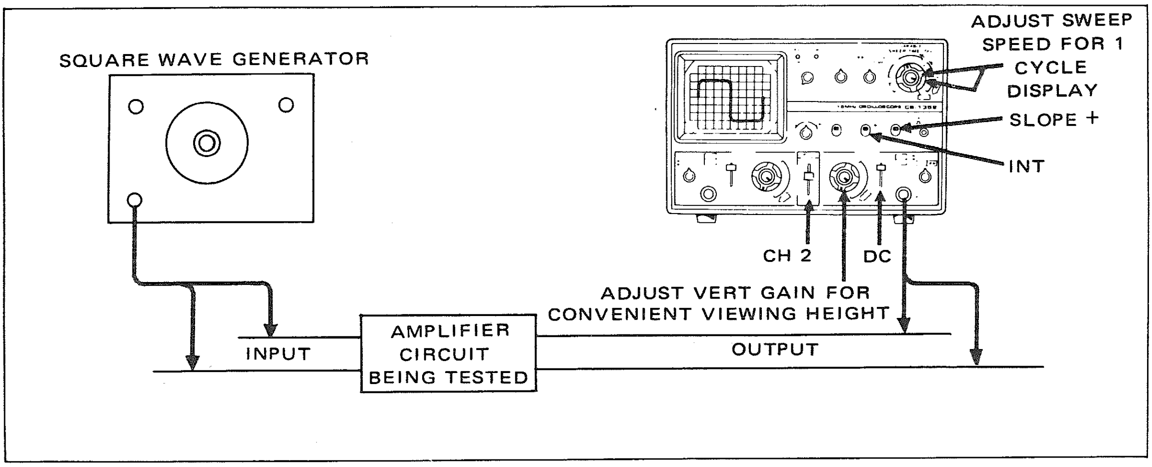


Fig. 28 Equipment set-up for square wave testing of amplifiers

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 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. 29**).
Distortion can be classified into the following three distinct categories:

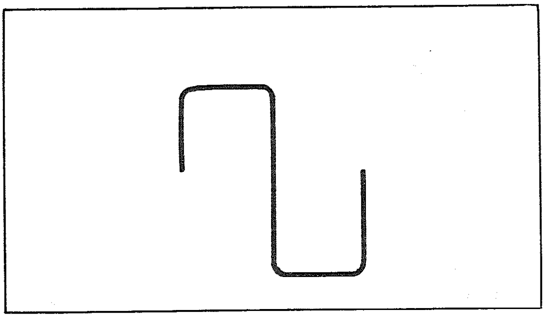


Fig. 29 Square wave response with high frequency loss

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 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 reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in **Fig. 20**. revealing poor low-frequency response along with the overcompensated high-frequency boost. A 100 Hz square wave applied to the input of this 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 the complete spectrum.

In the case illustrated by **Fig. 30**, a 100 Hz square wave will encompass components up to about 4 kHz. To analyze above 4 kHz and beyond 10,000 Hz, a 1 kHz square wave should be used.

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 lower-frequency components in this same square wave will be strongly 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, producting the strong tilt as shown in **Fig. 31A**.

Fig. 33 reveals 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

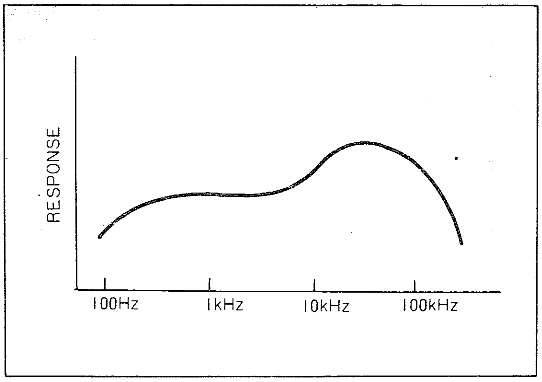


Fig. 30 **Response curve of amplifier with poor low and high ends**

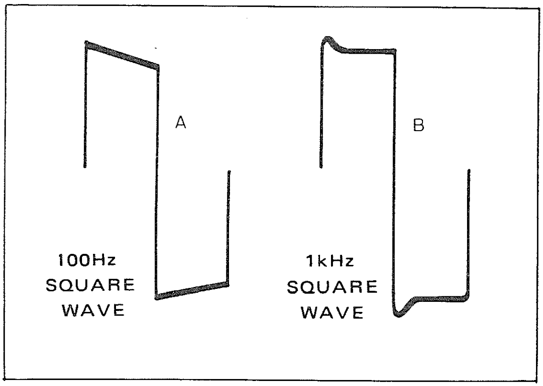


Fig. 31 **Resultant 100 Hz and 1 kHz square waves from amplifier in Fig. 30**

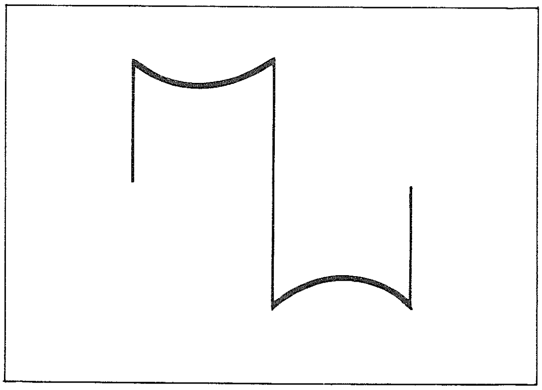


Fig. 32 **Reduction of square wave fundamental frequency component in a tuned circuit**

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 as 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 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 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 gigh frequencies, the high frequency components in the square wave will be amplified disproprotionately greater than other components creating a higher algebraic sum along the leading edge.

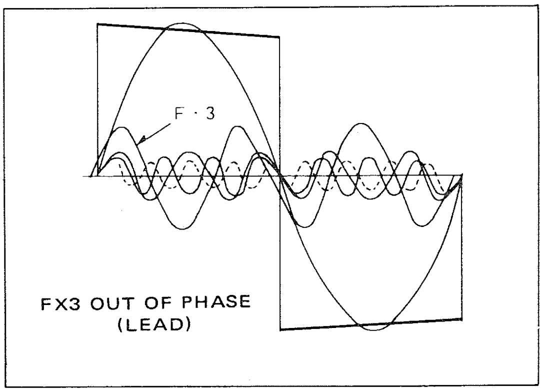


Fig. 33 Square wave tilt resulting from 3rd harmonic phase shift

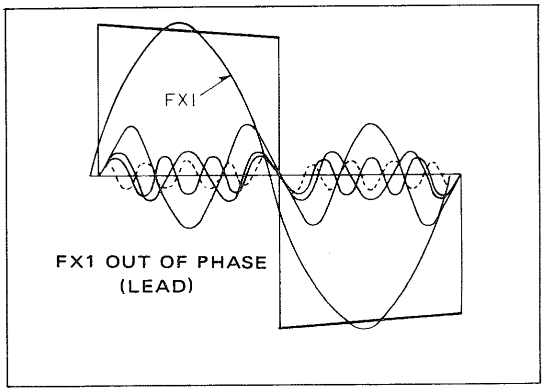


Fig. 34 Tilt resulting from phase shift of fundamental frequency in a leading direction

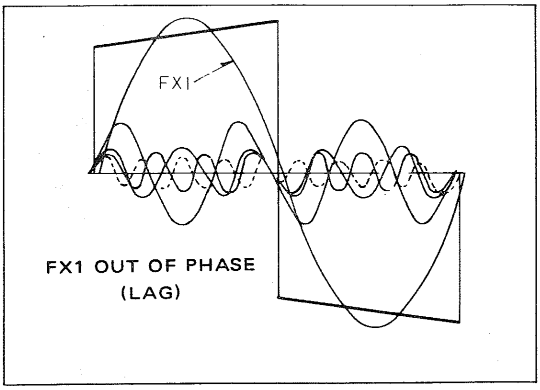


Fig. 35 Tilt resulting from a phase shift of fundamental frequency in a lagging direction

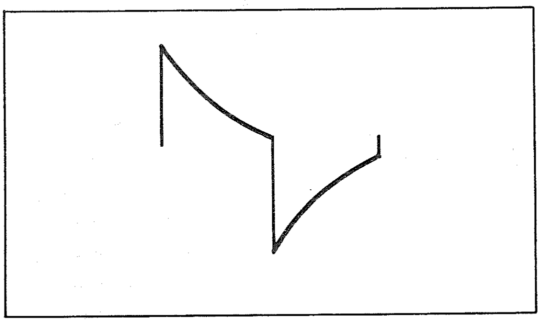


Fig. 36 Low frequency component loss and phase shift

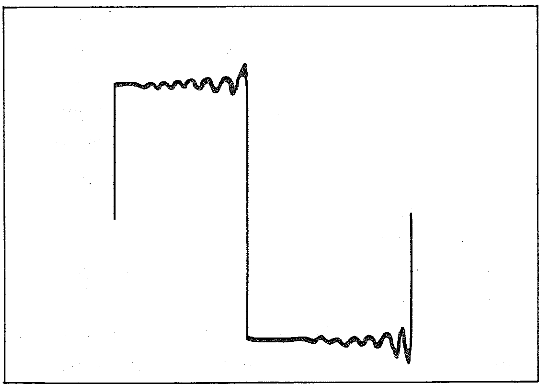


Fig. 37 Effect of high-frequency boost and poor damping

Fig. 37 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 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.

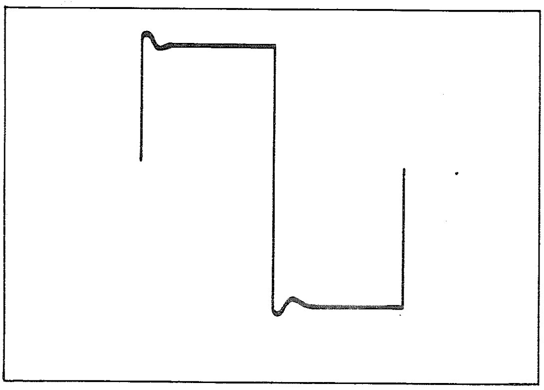


Fig. 38 Effect of high-frequency boost and good damping

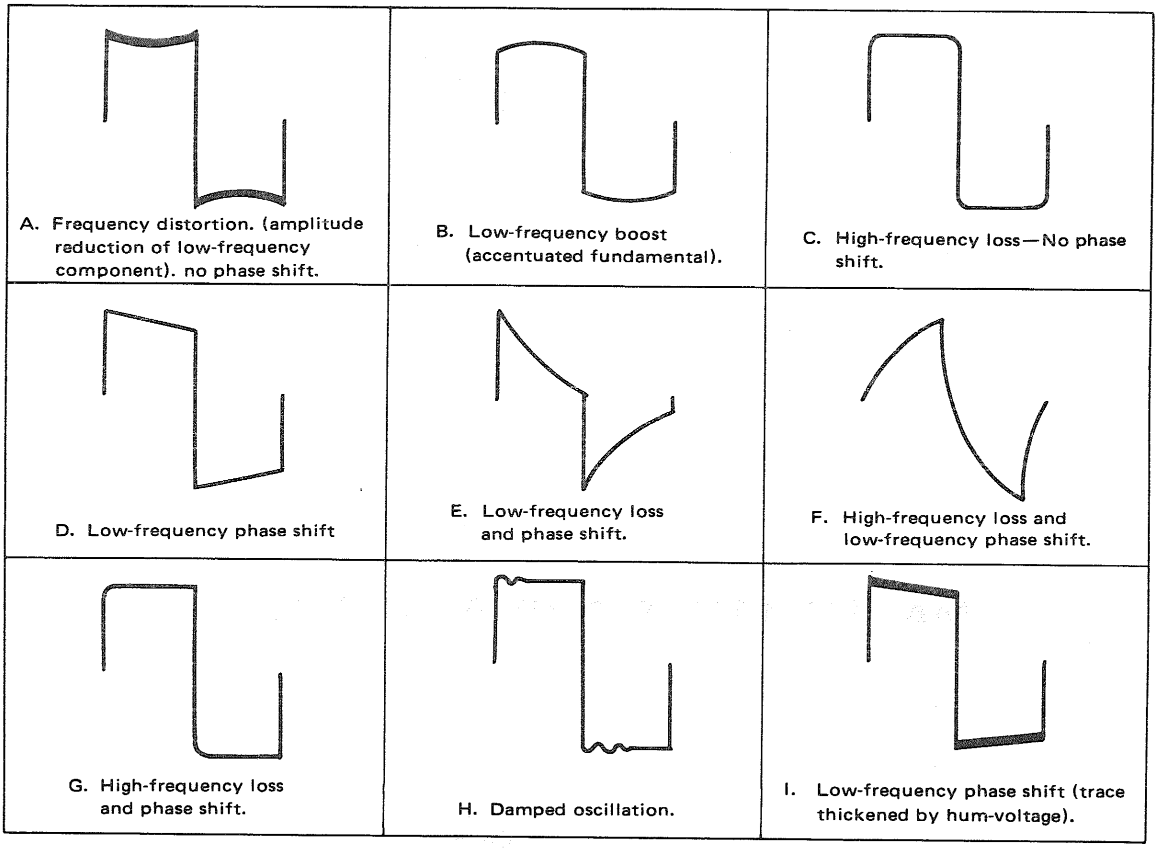


Fig. 39 Summary of waveform analysis for square wave testing of amplifiers

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 100V (DC + AC peak).
4. Never leave a bright spot on the screen of CRT for an extended period of time.
5. For X-Y operation, use the PULL X5 MAG switch in the PUSH position. If it is set in the PULL position, noise may appear in the waveform.
6. When the unit is loaded with battery, always keep it in temperatures of 0°C to +40°C.
7. Installation of oscilloscope
   The carrying handle of the unit turns 90 degree angle in either direction (See **Fig. 40**), permitting the unit to be placed horizontally, vertically or aslant.
   Do not put any objects on the unit or close the ventilation hole, as it will increase the temperature inside the case.

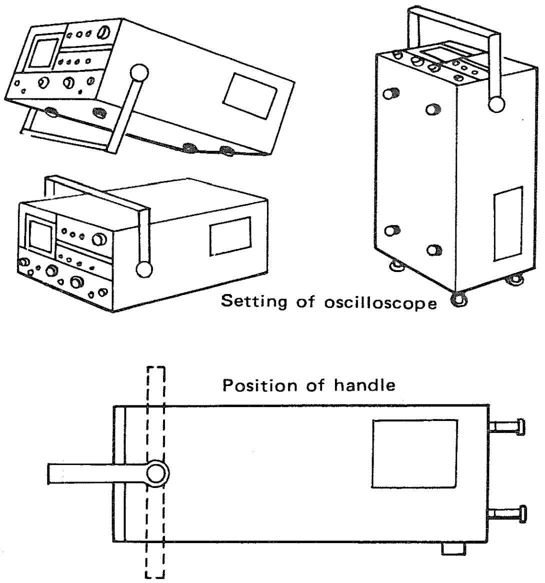


Fig. 40

MAINTENANCE AND ADJUSTMENT

MAINTENANCE

CRT Trace Angle Adjustment:

Using a "cross" head screwdriver, turn the screw in the hole of TRACE ROTATE at the left side of the case.

Removal of Case:

Remove the battery (if provided) from the case.

1. Remove the 4 screws from the top and bottom of the case using a "cross" head screwdriver.
2. The chassis can then be readily removed from the case.

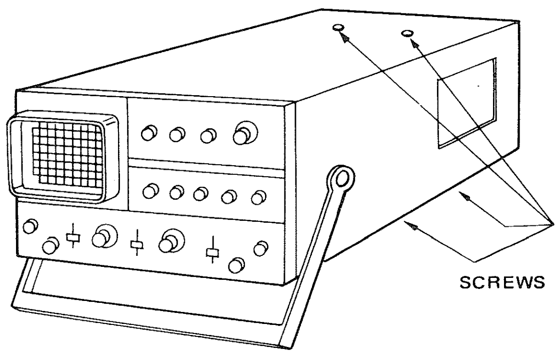


Fig. 41 Removal of case

Caution:

Before removing the case, be sure to turn off the power. Note that a high voltage (1500V max) is present on the CRT socket and the printed circuit board. Keep your hand, screwdriver, etc. away from any part carrying a high voltage after removal of the case.

Removal of CRT Bezel

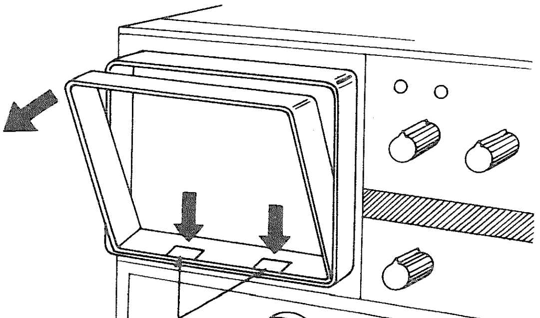


Fig. 42 Removal of CRT bezel

ADJUSTMENT

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 making 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 Trio local service station.

Power Voltage Adjustment:

Remove the bottom shielding plate before power voltage adjustment.

1. Adjustment of Charging Voltage
   Connect a digital voltmeter to the "+" and "−" sides of the battery connecting leads, then adjust VR501 on the power supply circuit board for +13.7V.
2. Adjustment of +10V Output Voltage
   Connect a digital voltmeter to the No. 3 pin of the connector P302 on the horizontal circuit board and to the earth point. Adjust VR504 on the power supply circuit board for +10.0V.
3. Adjustment of Cut-off Voltage
   Connect an external DC power (12V) to the battery connecting leads. Adjust VR502 on the power supply circuit board so that the power lamp goes off when the voltage is dropped from 12V to 10.0V.
4. Adjustment of indication illumination voltage
   Adjust VR503 so that the POWER lamp is illuminated when the voltage drops from 12V to 10.8V by connecting as indicated in Item (3).

Adjustment of Trace OFF Voltage

1. Display a trace by pulling the PULL AUTO Knob.
2. Adjust VR405 on the trigger circuit board so that the trace disappears at 11 o'clock position of the POWER/INTEN knob.

Variable DC BAL Adjustment

Adjust VR102 on the left side of the case (for CH2, use VR107 on the right side) so that the trace stays still even when the vertical attenuator VARIABLE control is turned.

STEP ATT DC BAL Adjustment

Adjust VR101 on the left side of the case (for CH2, use VR106 on the right side) so that the trace stays still even when the vertical attenuator VOLTS/DIV control is turned.

Horizontal Positon Adjustment

With the ◄► POSITION knob set to its mechanical center position, adjust VR304 on the horizontal circuit board so that the trace starts at the left end of the screen.

X Position Adjustment

With the SWEEP TIME/DIV switch set to X-Y position, adjust VR305 on the horizontal circuit board so that the bright spot comes to the center of the screen when the input of X axis (CH2) is grounded.

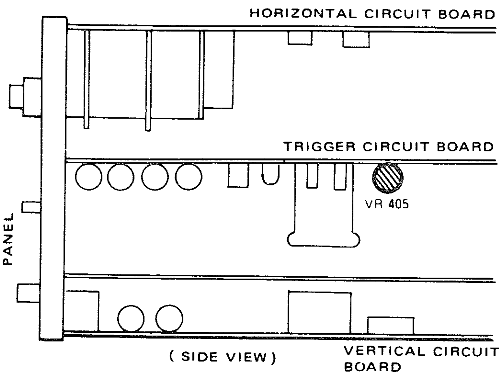


Fig. 43

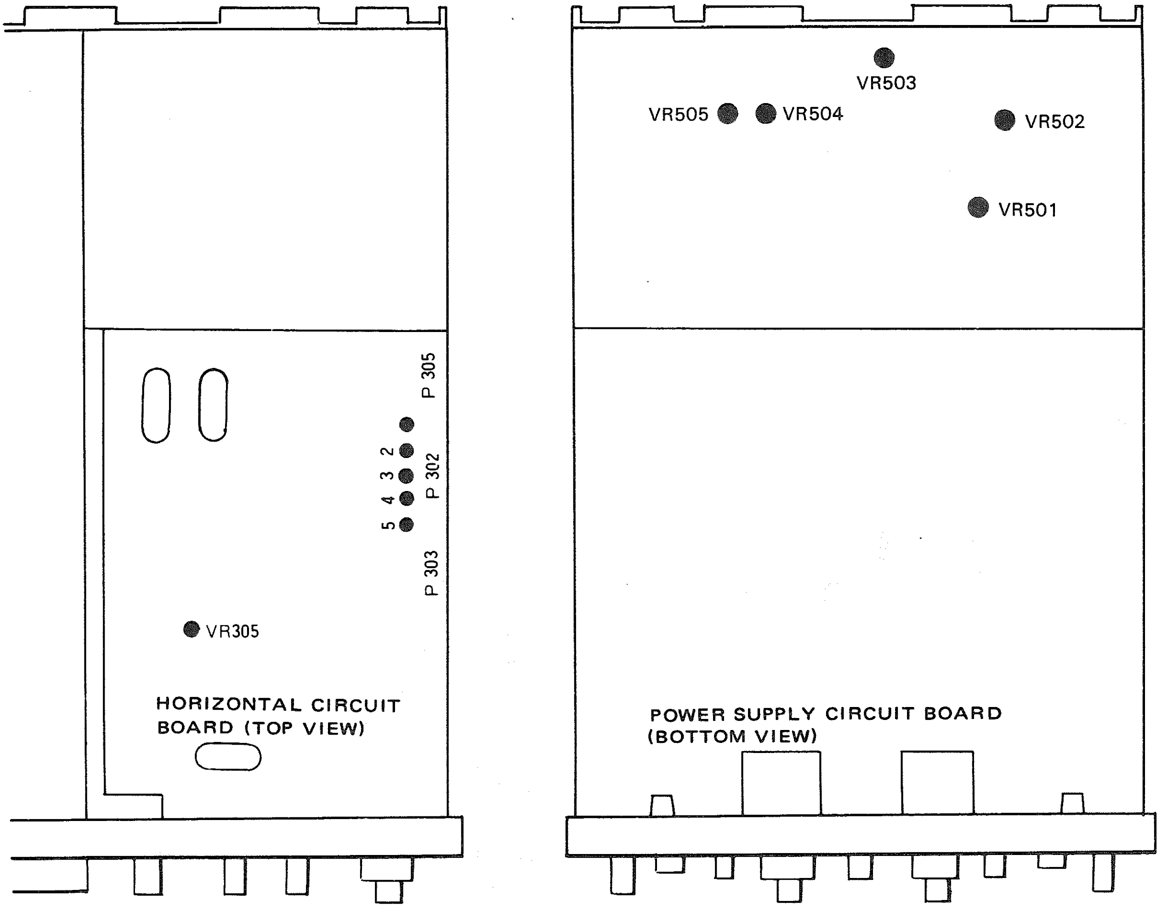


Fig. 44

HOW TO INSTALL THE OPTIONAL SHOULDER BAG

Refer to the following figure for mounting the optional shoulder bag on this equipment.

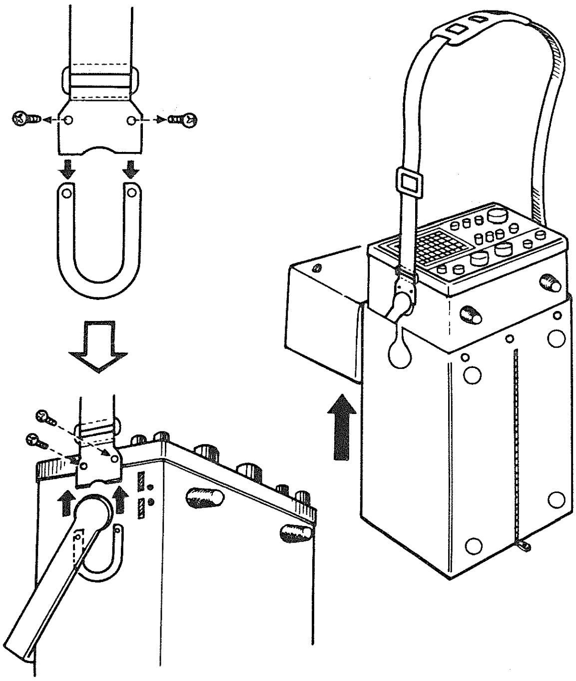
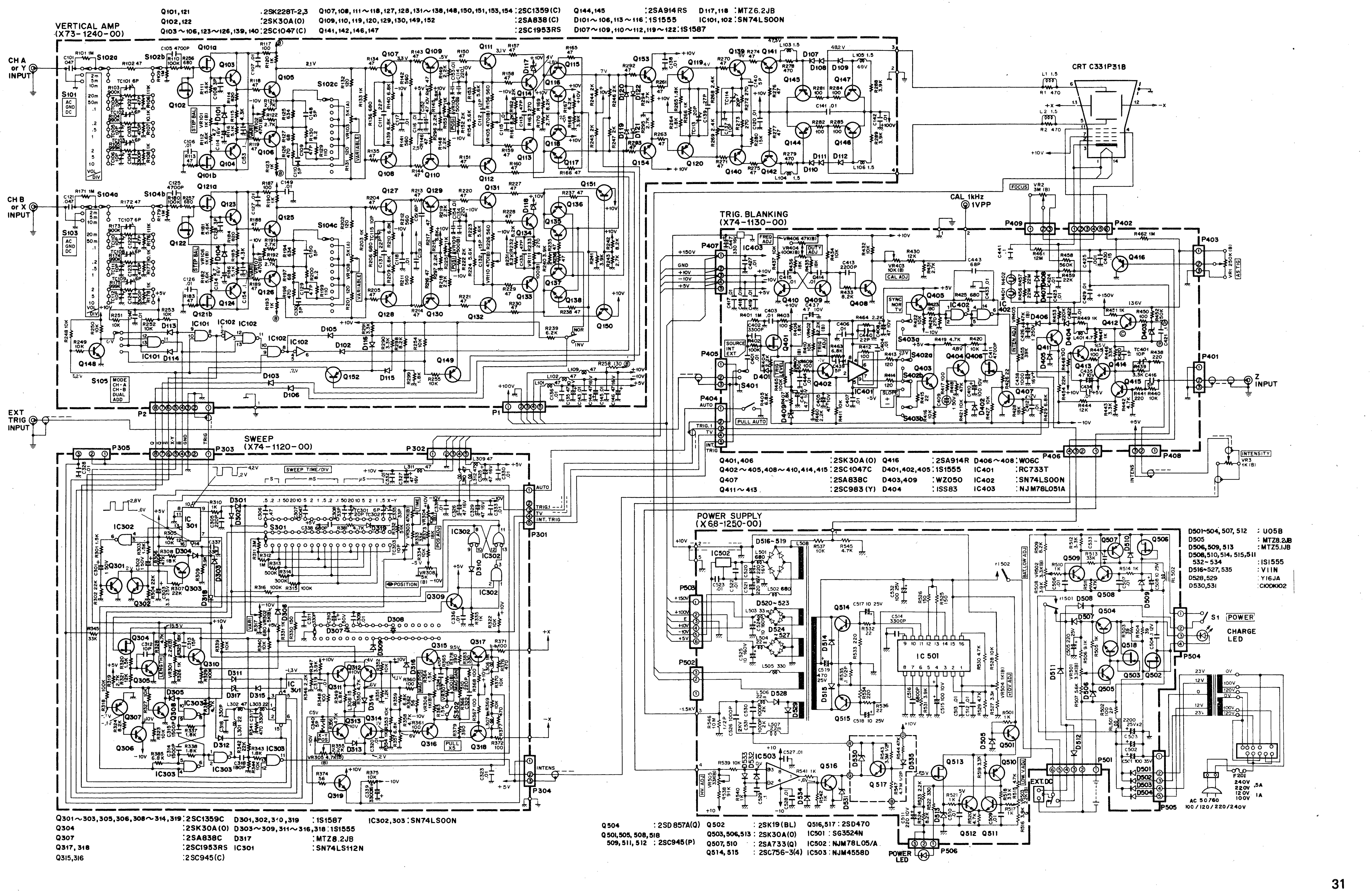


Fig. 45

SCHEMATIC DIAGRAM

CS-1352



A product of

KENWOOD CORPORATION

17-5, 2-chome, Shibuya, Shibuya-ku, Tokyo 150, Japan

© 65708 PRINTED IN JAPAN B50−2853−10 (N)