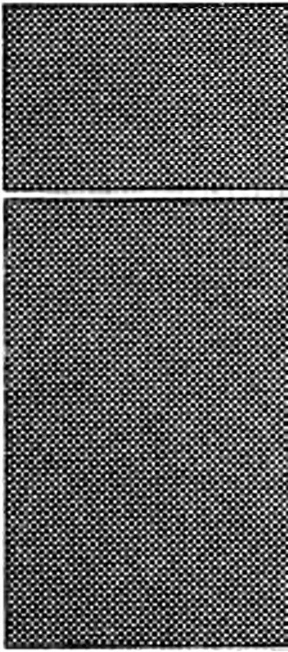

TEKTRONIX®

314
STORAGE OSCILLOSCOPE

OPERATORS

WARRANTY

Tektronix warrants that this product is free from defects in materials and workmanship. The warranty period is one (1) year from the date of shipment. Tektronix will, at its option, repair or replace the product if Tektronix determines it is defective within the warranty period and if it is returned, freight prepaid, to a service center designated by Tektronix.

Tektronix is not obligated to furnish service under this warranty:

a. to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair, or service the product;
b. to repair damage resulting from improper use or from connecting the product to incompatible equipment;
c. if personnel other than Tektronix representatives modify the hardware or software.

There is no implied warranty of fitness for a particular purpose. Tektronix is not liable for consequential damages.

070-1823-00

First Printing Jan 1975

TABLE OF CONTENTS

TABLE OF CONTENTS (cont)

TABLE OF CONTENTS (cont)

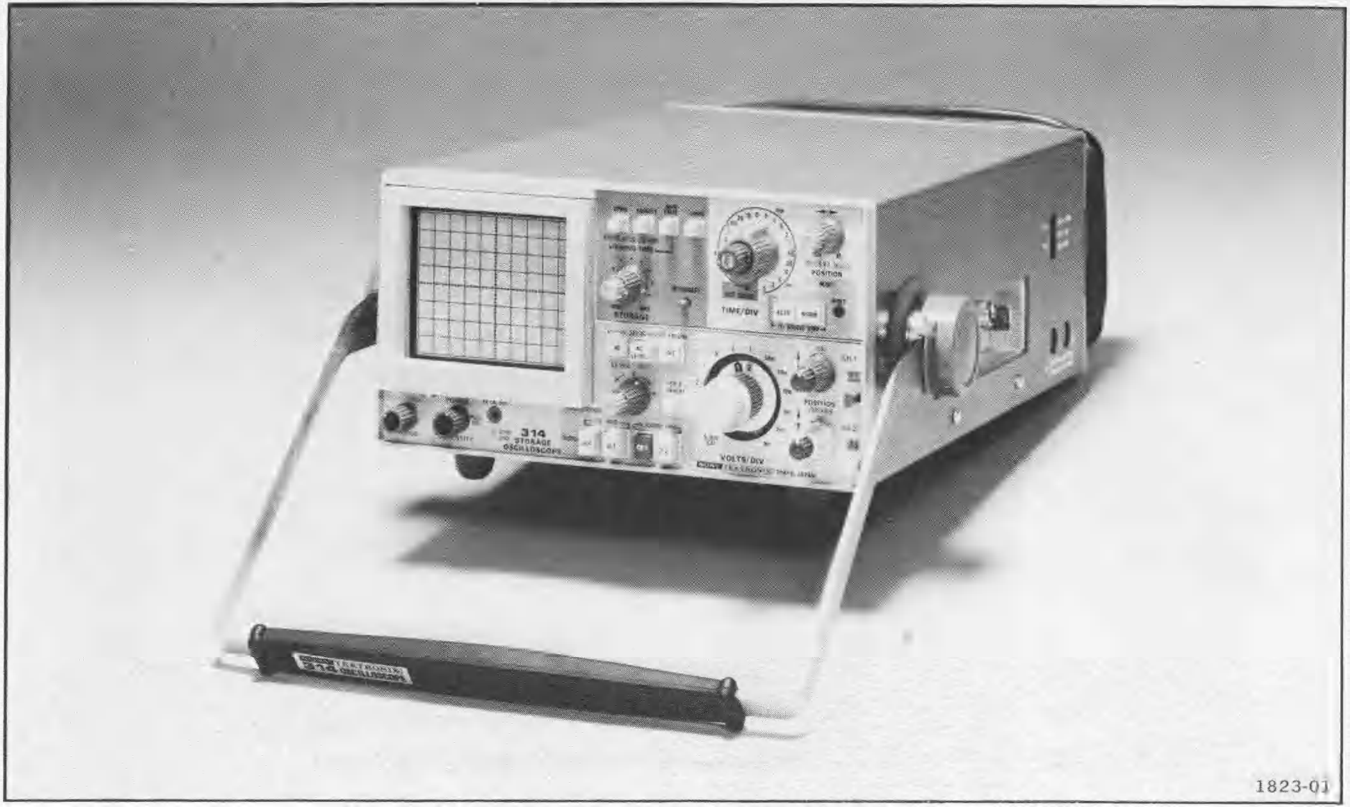

Fig. 1. Sony-Tektronix 314 Storage Oscilloscope.

OPERATING INFORMATION

INTRODUCTION

The Sony-Tektronix 314 is a dual-channel, 10 MHz portable storage oscilloscope.

The dc to 10 MHz vertical bandwidth provides calibrated deflection factors from 1 mV to 10 V/graticule div (25 V/div, or greater, uncalibrated, with VOLTS/DIV VARIABLE in fully counterclockwise position). A delay line in the vertical system permits observation of that part of the signal which triggers the sweep.

The horizontal deflection system provides calibrated sweep rates from 5 s/div to 1 μs/div; and a 10X sweep magnifier to increase the fastest sweep rate to 0.1 μs/div. Three sweep modes are available: AUTO, NORM, and SINGLE SWEEP. The trigger circuit provides a stable display over the full vertical bandwidth.

External horizontal input provides deflection factors of 20 mV to 2 V/div for X-Y operation.

The crt is a direct-view bistable storage device having an 8 x 10 div internal graticule. Each graticule div equals 0.25 inch. An enhance mode increases single-sweep writing speed.

An internal 1 kHz calibrator is connected internally to the vertical inputs and to a front-panel connector.

The 314 is operated from a line voltage of 100, 115, 120, 200, 230, or 240 V ac, 48 to 440 Hz, or from a +12 or +24 V dc source.

NOTE

The 314 automatically reduces the display intensity level when sweep speeds of 10 ms and slower are selected. This reduces the possibility of accidentally burning the sensitive storage crt phosphor at slower sweep speeds.

When changing from sweep speed settings faster than 10 ms to settings of 10 ms and slower, readjust the INTENSITY control setting as necessary for a visible display.

SAFETY INFORMATION

The instrument is designed to operate from a single-phase power source having one of the current-carrying conductors (the neutral conductor) at ground (earth) potential. Operation from power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a three-wire system) is not recommended since only the line conductor has overcurrent (fuse) protection within the instrument.

The instrument has a three-wire power cord with a three-terminal polarized plug for connection to the power source and safety earth. The ground (earth) terminal of the plug is directly connected to the instrument frame. For electric shock protection, insert this plug into only a mating outlet with a safety earth contact.

POWER-SOURCE REQUIREMENTS

The instrument may be operated on 100, 115, 120, 200, 230, or 240 V ac, from 48 to 440 Hz, or from a +12 or +24 V dc source.

The 115 to 230 V Line-Voltage and Regulating Range Selectors are located on the rear panel, as shown in Fig. 2. The AC-DC Selector switch is located on the right-side panel, as shown in Fig. 3.

AC Power Source Selection

CAUTION

This instrument may be damaged if operated with the Line-Voltage and Regulating-Range Selector switches set for the wrong applied line voltage.

To convert from one nominal line-voltage range to the other, move the Line-Voltage and Regulating-Range Selector

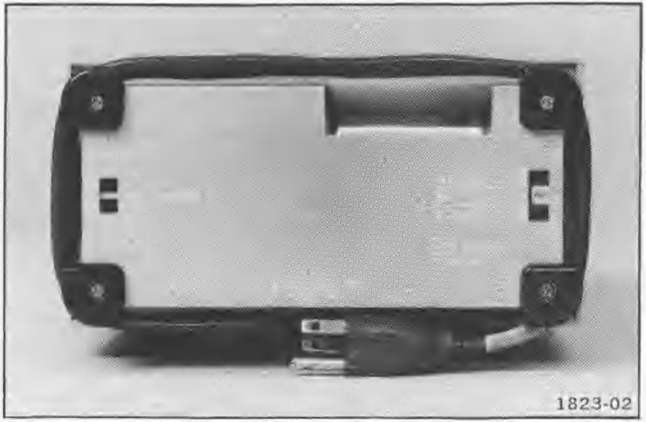

Fig. 2. Line Voltage and Range Selector switches.

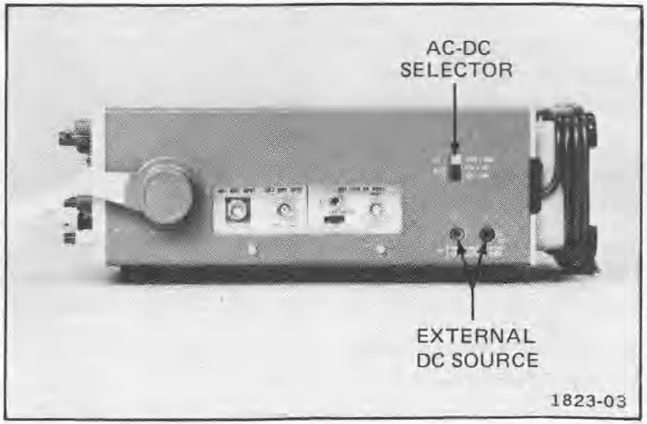

Fig. 3. AC-DC Selector and DC Power-Source input.

switches (see Fig. 2) to indicate the correct nominal ac line voltage. Be sure that the AC-DC Selector switch (see Fig. 3) is in the 115 V/230 V position. See Table 1 for regulating ranges. A 115 to 230 V adapter may be required for the power-line cord.

CAUTION

The internal line voltage fuse value must be changed when changing the nominal line voltage setting.

WARNING

Dangerous potentials exist at several points throughout the interior of this instrument. Refer to the 314 Service manual for precautions and procedures concerning cabinet removal, fuse replacement, and nominal line voltage selection. Only qualified service personnel should attempt fuse replacement or other internal maintenance procedures.

TABLE 1

Regulating-Range Selector Position	Nominal Regulating Range	
	115 V	230 V
LO	100 V ±10 V	200 V ±20 V
M	115 V ±11.5 V	230 V ±23 V
HI	120 V ±12 V	240 V ±24 V

DC Power Source Selection

Move the AC-DC Selector switch (see Fig. 3) to the appropriate DC position (11 V–14 V or 22 V–28 V). Connect the DC Input connectors (+ and –) to the dc power source.

FUNCTIONS OF CONTROLS, CONNECTORS, AND INDICATORS

VERTICAL

(1) **CH 1 VOLTS/DIV (charcoal gray knob).** Selects calibrated deflection factors from 1 mV/div to 10 V/div in a 1-2-5 sequence.

Accuracy: Within 3% over calibrated range.

CH 2 VOLTS/DIV (silver gray knob). Selects calibrated deflection factors from 1 mV/div to 10 V/div in a 1-2-5 sequence.

Accuracy: Within 3% over calibrated range.

(2) **CH 1 and CH 2 VARIABLE (CAL).** Provides uncalibrated variable deflection factors between calibrated ranges. Extends uncalibrated range to 25 V/div.

(3) **CH 1 and CH 2 POSITION.** Vertically positions the display.

(4) **CH 1 and CH 2 Input Coupling Switch and Indicator.**

AC(out position). Blocks dc component of input signal. Low frequency −3 dB point is about 10 Hz.

GND(middle position). Grounds vertical amplifier input.

DC(in position). Presents all components of input signal to the vertical amplifier.

(5) **CH 2 INVERT.** Button pushed in inverts channel 2 input signal (inverts display).

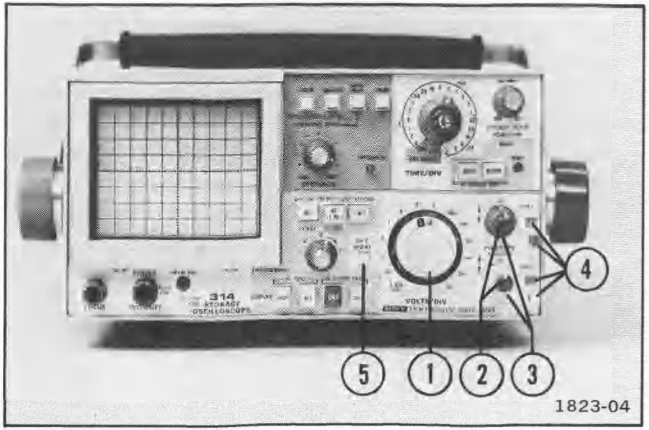

Fig. 4. Front panel.

(6) **CH 1 and CH 2 VERT INPUT.** Signal input connector for channels 1 and 2.

(7) **Chassis Ground.** Provides a common-signal ground return to the signal source. Operating the 314 ungrounded on +12 V or +24 V dc isolates the instrument from ground-loop currents and conducted radio frequency interference (rfi). However, this ungrounded operation permits the instrument case to rise to the signal source potential.

DISPLAY

(8) **FOCUS, INTENSITY.** Adjust for a sharp, bright display.

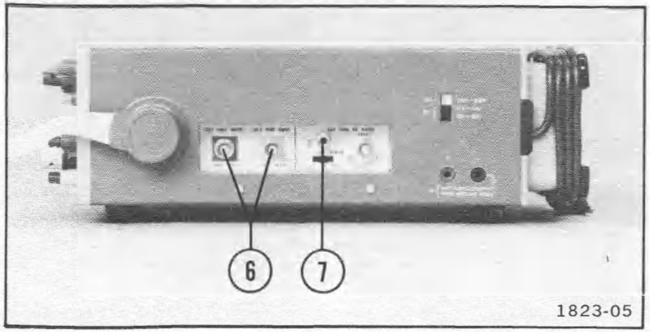

Fig. 5. Side panel.

(9) **CHOP.** Displays signals from both channels simultaneously (dual trace). Display is switched between channels at a 100 kHz rate. See NOTE following ALT.

(10) **ALT.** Signals from both vertical channels are displayed alternately (dual trace). Display is switched after each sweep. See NOTE.

NOTE

When both CHOP and ALT buttons are pushed in, display is the algebraic sum of the vertical-channel input signals.

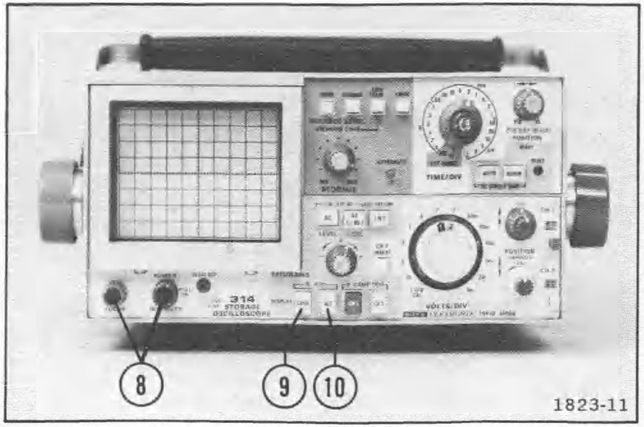

Fig. 6. Front panel.

(11) **CH 1.** Selects channel 1 vertical input for display. Channel 1 is the triggering signal. See NOTE following CH 2.

(12) **CH 2.** Selects channel 2 vertical input for display. Channel 2 is the triggering signal. See NOTE.

NOTE

When CH 1 and CH 2 buttons are pushed in to display both channel 1 and channel 2, signal generates an internal composite trigger signal.

(13) **STORE.** Instrument is in storage mode with button pushed in, and in non-store mode with button out.

(14) **ENHANCE.** Increases single-sweep writing speed.

(15) **AUTO ERASE.** Erases stored display after each sweep when both AUTO and NORM buttons are pushed in.

(16) **ERASE.** Erases the stored display.

(17) **ENHANCE LEVEL.** Adjusts the single-sweep stored writing speed.

(18) **VIEWING TIME.** Adjusts the viewing time from about 1 s after end of sweep to about 5 s after end of sweep.

(19) **INTEGRATE.** Permits charge to build up on target before the display is stored. For repetitive signals, parts of which are too fast to store normally.

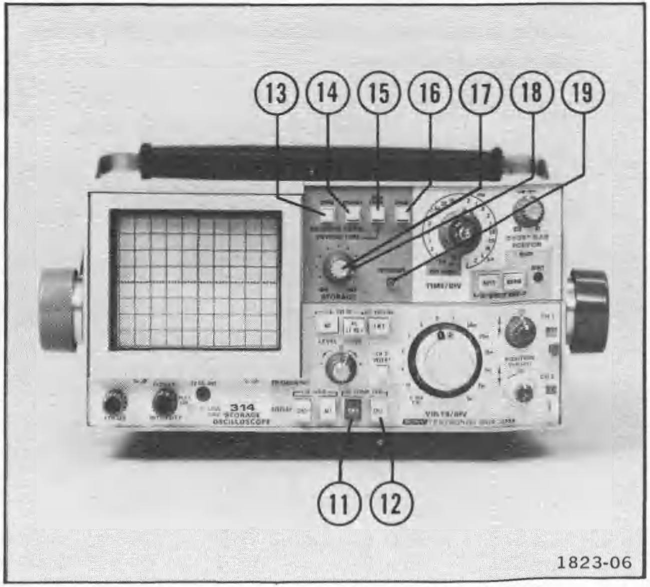

Fig. 7. Front panel.

(20) **EXT BLANK.** Input connector for external crt blanking signal.

TRIGGERING

(21) **AC.** Rejects dc components and attenuates triggering signals below about 50 Hz. See NOTE following AC LF REJ.

(22) **AC LF REJ.** Rejects dc and attenuates triggering signals below about 50 kHz. Accepts triggering signals between 50 kHz and 10 MHz.

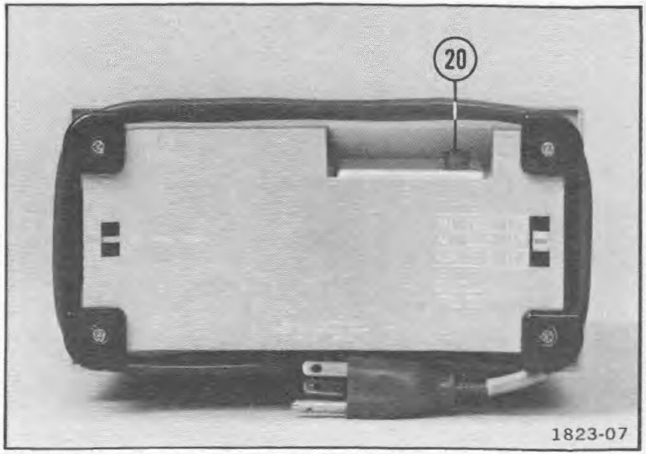

Fig. 8. Rear panel.

NOTE

With AC and AC LF REJ buttons pushed in (EXT DC), accepts all triggering signals from dc to 10 MHz.

(23) **INT.** Obtains triggering signal from vertical deflection system (CH 1 or CH 2, or both) when button is pushed in. Obtains triggering signal from EXT TRIG OR HORIZ INPUT connector (right-side panel) when button is out.

(24) **LEVEL.** Selects the amplitude of the signal on which the sweep is triggered.

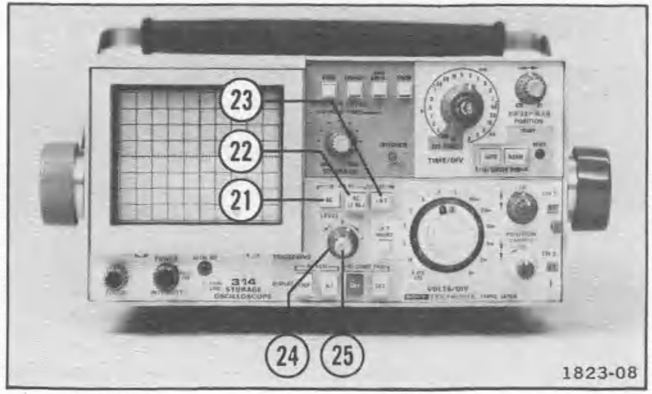

Fig. 9. Front panel.

(25) **SLOPE.** Selects the slope of the signal on which triggering occurs; positive going (+) or negative going (−).

(26) **External Trigger Attenuator-Line Trigger Selector.** In the 10X position, an external signal connected to EXT TRIG OR HORIZ INPUT is attenuated by a factor of 10. In the 1X position, the external signal is not attenuated. In the LINE position, a sample of the ac power line is used as triggering signal.

(27) **EXT TRIG OR HORIZ INPUT.** BNC connector for applying either an external triggering signal or an external horizontal signal.

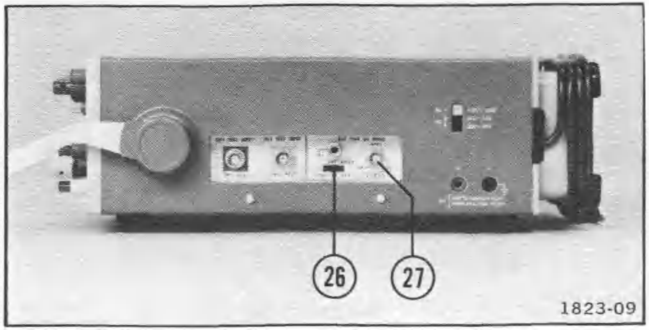

Fig. 10. Side panel.

HORIZONTAL, CALIBRATOR, AND POWER

(28) **TIME/DIV.** Selects calibrated sweep rates from 5 s to 1 μs/div, in a 1-2-5 sequence.

Accuracy, calibrated ranges: Unmagnified, 5 s/div to 0.5 s/div, within 4%, over center 8 div and within 5% over any 2 div interval with 8 center div; 0.2 s/div to 1 μs, within 3%, over center 8 div and within 4% over any 2 div interval within center 8 div.

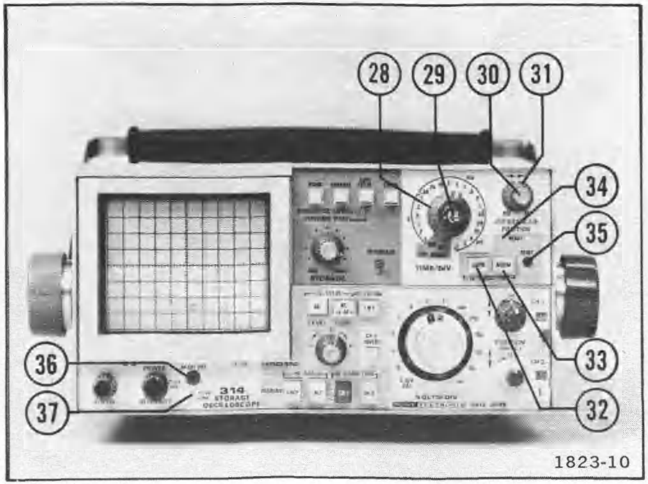

Fig. 11. Front panel.

Accuracy, calibrated ranges: Magnified, 0.5 s/div to 50 ms/div, within 5% over center 8 div, and within 6% over any 2 div interval within center 8 div; 20 ms/div to 0.5 μs/div, within 4% over center 8 div, and within 5% over any 2 div interval within center 8 div; 0.2 μs and 0.1 μs/div, within 5% over center 8 graticule divisions. Within 6% over any 2 division interval within center 8 divisions, excluding first and last 2 divisions of magnified sweep.

(29) **CAL.** Varies time/div between calibrated steps. Range, at least 2.5X. Uncalibrated sweep rate is extended to 12.5 s/div.

(30) **SWEEP MAG.** Sweep is unmagnified in X1 position. In X10 position, the horizontal gain increases by a factor of 10 (sweep expands from graticule center). X10 magnifier extends fastest displayed sweep rate to 0.1 μs/div.

(31) **Horizontal POSITION.** Positions the display horizontally.

(32) **AUTO.** Sweep free runs in the absense of a triggering signal. See NOTE following NORM.

(33) **NORM.** Sweep generator requires a triggering signal to generate a sweep.

NOTE

With AUTO and NORM buttons in, sweep runs once on the first triggering event after RESET button is pressed.

(34) **READY.** Lights when single sweep has been reset and waiting for a triggering signal to start the sweep generator.

(35) **RESET.** When pressed, single sweep function is armed; READY indicator lights.

(36) **.5 V CAL OUT.** Provides a 0.5 V square-wave calibrator signal.

(37) **LOW LINE.** Lights when instrument is on. Flashes when power supply goes out of regulation due to low source voltage.

MEASUREMENT TECHNIQUES

The following procedure describes a few operational techniques and measurements that can be made or used with the 314.

TRIGGERING THE SWEEP

The 314 sweep can be triggered from an internal or external source. Internal triggering is used for most applications involving time, frequency, and amplitude measurements. At least 0.3 div of deflection is required to trigger the sweep.

After selecting the triggering source, the method of coupling must be determined. Frequency limitations or ranges of the coupling methods are described under Function of Controls and Connectors. Use AC LF REJ (ac low-frequency reject) to improve trigger stability when a trigger signal above 50 kHz contains low-frequency components that interfere with triggering. Use dc coupling for the external trigger if a very low frequency is the triggering source.

Either manual (NORM) or automatic triggering (AUTO) mode can be used with a choice of triggering on the (+) positive-going or (–) negative-going slope of the triggering signal. For most applications, automatic triggering is used because a sweep is generated even when a trigger signal is absent.

In AUTO mode, the displayed signal locks to the trigger rate when a trigger signal is present to produce a stable display. AUTO mode covers a wide amplitude range and permits rapid observation of many signals and frequencies.

Manual (NORM) triggering is used when the exact triggering point is important, or for triggering on signal frequencies below about 30 Hz. Manual triggering can also be used to trigger on single-shot or random events. Triggering occurs in manual operation when the signal amplitude passes through a reference level set by the LEVEL control. Changing the trigger signal amplitude or LEVEL control setting affects the sweep start.

Triggering Internally on the Input Signal

a. Press INT and AC buttons in. Set LEVEL control to midrange and SLOPE switch to +. Press AUTO button in.

b. Connect a low-frequency, sine-wave signal to CH 1 VERT INPUT connector (right-side panel). Press CH 1 button in.

c. Set CH 1 VOLTS/DIV to .1. Adjust Sine-Wave Generator output for approximately 4 div of vertical display.

d. Set TIME/DIV switch to .2 ms and Sine-Wave Generator frequency to 1 kHz.

e. Turn 314 LEVEL control through its range and note that the triggering point on the displayed signal changes. Note that the triggering occurs on the positive-going slope of the displayed signal.

f. Set SLOPE switch to –. Note that triggering occurs on the negative-going slope of the displayed signal. Turn LEVEL control to either extreme position and note that the triggering point reaches either a peak or a valley, and that the sweep is no longer triggered (free runs).

g. Press NORM button in.

h. Turn LEVEL control throughout its range and note that when the sweep is not triggered, the signal is not displayed. When the sweep is triggered the LEVEL control sets the point at which triggering occurs.

Triggering from an External Source

a. Connect the Sine-Wave Generator signal through a tee connector to CH 1 VERT INPUT connector and to the EXT TRIG OR HORIZ INPUT connector on the right-side panel.

b. Set EXT ATTEN switch (side panel) to X10 and set INT button to the out (EXT/LINE) position.

c. Set SLOPE switch to + and LEVEL control to midrange.

d. Press AUTO button in.

e. Set CH 1 VOLTS/DIV switch to .5.

f. Adjust Sine-Wave Generator for a 4 div vertical display (200 mV, p-p) into EXT TRIG OR HORIZ INPUT connector.

g. Turn LEVEL control and note that the sweep is triggered on the positive-going slope.

h. If manual triggering is desired, press NORM button in and check triggering as in part h.

i. Set SLOPE switch to – and check triggering as in part h.

INTERNAL AND EXTERNAL SWEEP

As with triggering, most applications call for operation using internal sweep. The internal sweep rate is set by the TIME/DIV switch, which permits accurate time and frequency measurements when the TIME/DIV VARIABLE control is in the calibrated (CAL) position.

External sweep or horizontal deflection for the 314 can be used for X-Y displays or for mating the oscilloscope to a swept-frequency device such as a Spectrum Analyzer. The external horizontal sensitivity ranges from approximately 20 mV/div (with 1X attenuation and Horizontal Magnification on) to 2 V/div (with 10X attenuation and Horizontal Magnifier off).

The TIME/DIV VARIABLE control provides an additional 10:1 range with which exact adjustment or calibration of horizontal deflection can be made.

X-Y Displays

One signal (vertical input) viewed with respect to another (external horizontal input) displays patterns that show phase and frequency relationships.

a. Set TIME/DIV switch to X1, EXT HORIZ. Press AC button in and set INT button to the out position if the signal has a dc component. Press AC and LF REJ buttons in (EXT DC) if the signal frequency is 30 Hz or less (within the input frequency limitations).

b. Set the ATTEN switch (X1-X10 on side panel) to the appropriate position for the voltage level of the external horizontal signal.

c. Set VOLTS/DIV switch to an appropriate position for the vertical signal voltage.

d. Apply both X (horizontal) and Y (vertical) signals to their respective input connectors and observe the display.

NOTE

The vertical and horizontal amplifier characteristics must be considered in X-Y operation because of bandwidth and input impedance differences. To determine phase difference, apply the same signal to both inputs and calculate the difference.

Using External Sweep Voltage

a. Perform the steps under X-Y Displays.

b. Calibrate the horizontal sweep for frequency per div by adjusting the TIME/DIV VARIABLE control.

SELECTING SWEEP RATE AND USE OF THE MAGNIFIER

The sweep rate depends on the desired observation or measurement to be made. For frequency measurements, several cycles or events are usually displayed and the time of 1 cycle or the time between 2 or more events is measured (see Frequency Measurements). A portion of 1 cycle, or a full cycle is usually displayed when measuring or observing small portions of a wave train (such as risetime, pulse duration, and aberrations). When part of a wave train or waveform that occurs later than the sweep trigger are to be examined, the X10 position of the SWEEP MAG switch can be used to expand the center portion of the display. The effective sweep rate for the expanded portion is decreased by a factor of 10; therefore, timing measurements must be divided by 10. Portions of the display to be expanded should be centered with the POSITION control before switching to the X10 position.

SIGNAL APPLICATION TO VERTICAL INPUT

For most applications, the P6049B, or similar probe, should be used as an interface between the signal source and the oscilloscope vertical input. The probe increases the input resistance of the oscilloscope system to about 10 MΩ and decreases the effective capacitive loading to about 13.5 pF. The higher the impedance ratio between the input to the oscilloscope system and the signal source, the less the circuit under test is loaded, and the more accurate the measurement. Because of circuit loading considerations, all measurements should be made at low impedance points in the circuit being tested.

NOTE

To insure that measurements are accurate, always compensate the probe before using. To compensate the probe, touch the probe tip to the .5 V CAL OUT connector on the 314 front panel and adjust the compensation for the best front-corner response to the square wave signal (set VOLTS/DIV switch to 10 m and TIME/DIV switch to 1 ms).

For applications in which the source, such as the output of a signal generator, is a coaxial connector, use a coaxial cable between the oscilloscope and the signal source. In this application, loading is not a problem; however, to preserve signal fidelity, the cable impedance should equal the source impedance and the cable should be terminated in its characteristic impedance at the oscilloscope input.

Use a common-ground return between the signal source and the oscilloscope. When a probe is used, connect the shortest possible ground lead near the signal source to avoid a long signal path to ground.

WARNING

If the 314 is powered from an external dc source (not connected to an ac power source) provide *a ground return to earth to prevent the instrument case from rising to the signal source potential to become a potential safety hazard. Connect the grounding lead to the chassis ground connector on the 314 side panel.*

HOW TO MEASURE VOLTAGE

If a coaxial cable is used, terminate the cable in its characteristic impedance at the oscilloscope input.

Compensate the probe, if used, before connecting to the signal source.

AC Signals

a. Set Input Coupling switch to GND (both switches in the middle position) and VOLTS/DIV switch to an appropriate setting. Vertical deflection factor equals the product of the VOLTS/DIV switch setting and the probe or signal transporting lead attenuation factor. Connect the signal source to a VERT INPUT connector and set Input Coupling switch to AC.

b. Set TIME/DIV switch for desired deflection factor and press appropriate CH 1 or CH 2 button. Adjust LEVEL control for a triggered display. Position display within the graticule area for measurement.

c. Measure peak-to-peak, or peak-to-trough amplitude of the display, or waveform, in graticule div. See Figure 12. Voltage (peak-to-peak) = measured amplitude in div, multiplied by the deflection factor (VOLTS/DIV switch setting times probe attenuation factor).

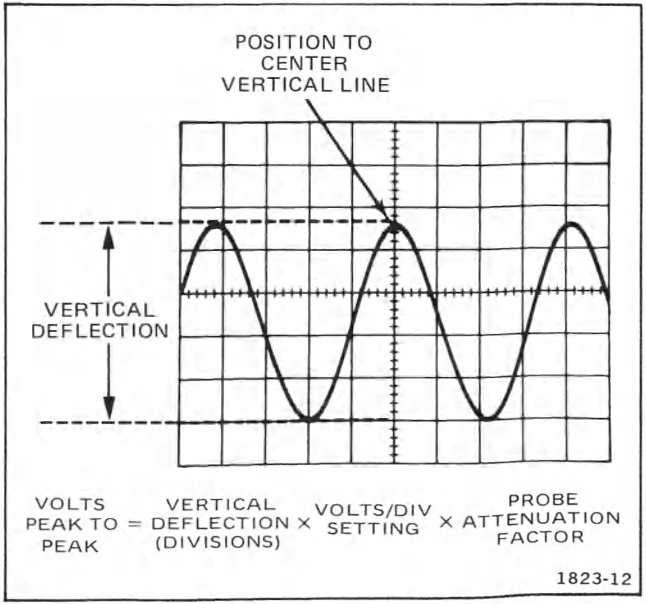

Fig. 12. Measuring peak-to-peak voltage.

Instantaneous Voltage Measurement

Instantaneous voltage is measured with respect to some reference potential (usually ground). This reference level is first established by positioning the trace along a graticule line with the reference potential applied to the input. If using a P6049B Probe, press the GND REF button on the probe body to obtain the ground reference. Then, the instantaneous voltage is applied and measured above or below the reference line. In this type of measurement, the Input Coupling switch must be in the DC position. This method can also be used to measure the dc component of a waveform, since the average or dc value can be measured as a voltage above the reference level.

a. Set the vertical deflection factor to an appropriate setting for the voltage to be measured; set the LEVEL control to midrange and press AUTO button in.

b. Set Input Coupling switch to DC. Touch the probe tip to the reference voltage and vertically position the trace to graticule center. Press the P6049B Probe GND REF button and position the trace to a reference (any convenient horizontal graticule line). Release the GND REF button. Do not change the POSITION control setting after the reference has been set.

c. Set TIME/DIV switch, LEVEL control and SLOPE switch for the desired display.

d. Using the graticule, measure the vertical amplitude (in div) from the reference line to the point to be measured.

e. Voltage level equals measured amplitude (in div) multiplied by the deflection factor.

Voltage Comparison

For applications in which the signal voltage is to be compared to some signal reference, it may be desirable to establish a different deflection factor than those available with the VOLTS/DIV switch. A deflection factor conversion factor, based on a specific reference amplitude is established as follows:

a. Apply a reference signal of known amplitude to the input.

b. Adjust the display amplitude to an exact number of graticule div using the VOLTS/DIV switch and its VARIABLE control. Do not change this setting after the reference has been established.

c. Deflection factor conversion constant equals:

$$\frac{\text{Reference Signal Voltage}}{\text{VOLTS/DIV setting} \times \text{Display Amplitude (in div)}}$$

d. Adjusted deflection factor for any setting of the VOLTS/DIV switch equals the VOLTS/DIV switch setting multiplied by the conversion factor.

e. The peak-to-peak amplitude of any signal compared to this reference is measured as follows:

Set the VOLTS/DIV switch to provide sufficient deflection to make a measurement. Do not move the VARIABLE control setting.

Signal Amplitude = Adjusted Deflection Factor x Signal Deflection (in div).

HOW TO MEASURE TIME

The time base is accurately calibrated; therefore, any horizontal graticule distance represents time. Time between two or more events is measured directly on the graticule as follows:

a. Using the graticule, measure the horizontal distance between two events.

b. Multipiy the distance measured by the TIME/DIV switch setting to obtain the apparent time interval. The TIME/DIV VARIABLE control must be in the CAL position.

c. Divide the apparent time interval by the SWEEP MAG switch setting to obtain the actual time interval.

Risetime

Risetime is defined as the time between the 10% vertical amplitude point and the 90% vertical amplitude point. See Figure 13.

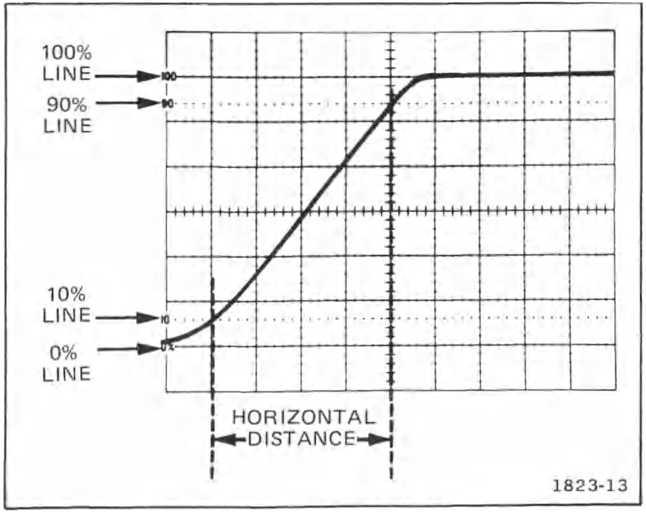

Fig. 13. Measuring risetime.

$$\text{Risetime } (t_r) = \frac{\text{Horizontal Distance (in divisions)} \times \text{TIME/DIV setting}}{\text{SWEEP MAG setting}}$$

Delay Time

Time between any 2 events (delay) is normally measured between the 50% amplitude points. See Figure 14.

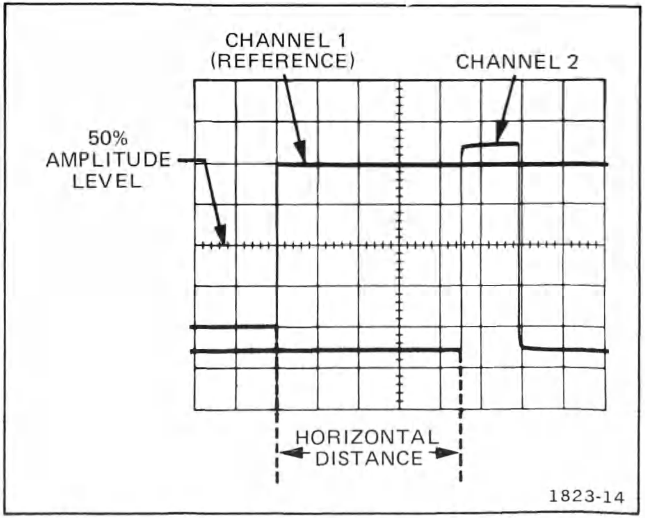

Fig. 14. Measuring time between two pulses at 50% amplitude points.

$$\text{Time Delay} = \frac{\text{TIME/DIV Setting} \times \text{Horizontal Distance (in divisions)}}{\text{SWEEP MAG setting}}$$

HOW TO MEASURE FREQUENCY

Using the method described in the preceding application, you can measure the period (time required for 1 cycle or time for a given number of cycles) of a recurrent waveform. The frequency of the waveform can be calculated since frequency is the reciprocal of the time period. For example, if the period of a recurrent waveform is accurately measured and found to be 20 μs, the frequency is 50 kHz. If the time for 10 cycles is 10 ms, the frequency is:

$$\frac{1 \times 10}{10 \text{ ms}} = 1 \text{ kHz}$$

To calculate the period of a known frequency:

$$\text{TIME} = \frac{1}{\text{Frequency (in Hz)}}$$

HOW TO MEASURE PHASE

Since a complete cycle of a sinusoidal waveform represents 360°, the oscilloscope graticule can be calibrated in degrees/div by using the TIME/DIV switch and its VARIABLE control. Adjust the span of a reference waveform so that 1 cycle covers a given number of div. Figure 15 illustrates how the graticule can be calibrated for 45°/div. The phase difference of the signal from the reference equals the displacement from the calibrated point on the graticule.

When making phase measurements, maintain a constant amplitude point on the input trigger signal so that the two input signals are compared indirectly to this reference and directly to each other. The trigger signal must have sufficient amplitude to insure stable triggering and must be frequency related to the waveforms on which the phase measurements are being made; however, the phase of the triggering signal is not critical. It is essential that after triggering conditions have been established, there is no change during any phase measurement.

The display amplitude should be large for maximum accuracy. Accuracy of measurement also depends on keeping the waveform centered about the graticule horizontal centerline.

HOW TO MAKE DUAL-TRACE PHASE MEASUREMENTS

Phase comparison between two signals of the same frequency can be made (up to the frequency limits of the vertical system) using the dual-trace feature of the 314 as follows:

a. Press ALT or CHOP buttons in, depending on the frequency of the signal being measured.

b. Set the VOLTS/DIV switches and VARIABLE controls of both channels to display 4 or 5 div of vertical display.

c. Connect the reference signal to CH 1 input and press INT and AC buttons in.

d. Connect the signal to be compared to CH 2. If the signals are of opposite polarity, press CH 2 INVERT button in (take the polarity inversion into consideration when calculating total phase difference).

e. Set LEVEL control for a stable display and set TIME/DIV switch to display about 1 cycle of the signal. Position the display to graticule center.

f. Turn TIME/DIV VARIABLE control until 1 cycle of the reference signal (CH 1) occupies exactly 8 horizontal div.

See Figure 15. Each graticule div now represents 45° of the displayed 360° (8 div).

g. Measure the horizontal distance between corresponding points on the display. Multiply the measured distance in div by 45°/div to obtain the phase difference.

HOW TO MAKE HIGH-RESOLUTION PHASE MEASUREMENTS

More accurate dual-trace measurement can be made by increasing the sweep rate. Switch SWEEP MAG to X10 without changing the TIME/DIV VARIABLE (as set in the preceding description). The magnified sweep rate is the sweep rate from the preceding description divided by 10 (X10 SWEEP MAG). The new sweep rate is 4.5°/horizontal div.

HOW TO MEASURE COMMON-MODE REJECTION

The ADD function of the 314 can be used to display signals that contain undesirable components as follows:

a. Connect the signal containing both the desired signal and the undesired signal to CH 1 VERT INPUT connector. Connect a signal identical to the unwanted portion of CH 1 signal to CH 2 VERT INPUT connector.

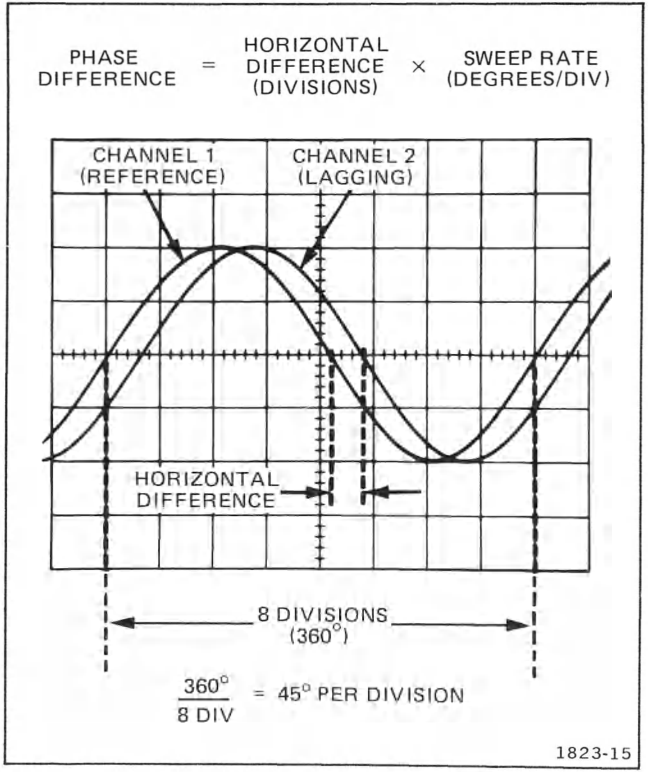

Fig. 15. Measuring phase difference.

b. Set both Input Coupling switches to DC (AC if dc component of signal is too large).

c. Press ALT button in and set VOLTS/DIV switches to produce displays equal in amplitude. Press ADD button in (press CH 2 INVERT button in, if necessary, so that the common-mode signals are of the same displayed polarity).

d. Set CH 2 VOLTS/DIV switch and VARIABLE control for maximum cancellation of the common mode signal. See Figure 16 for typical displays of input signals and resultant display.

HOW TO USE EXTERNAL BLANKING (Z-AXIS OR INTENSITY MODULATION)

Intensity modulation can supply additional information to a display without changing the X-Y information. Blanking is accomplished by applying a positive-going signal having

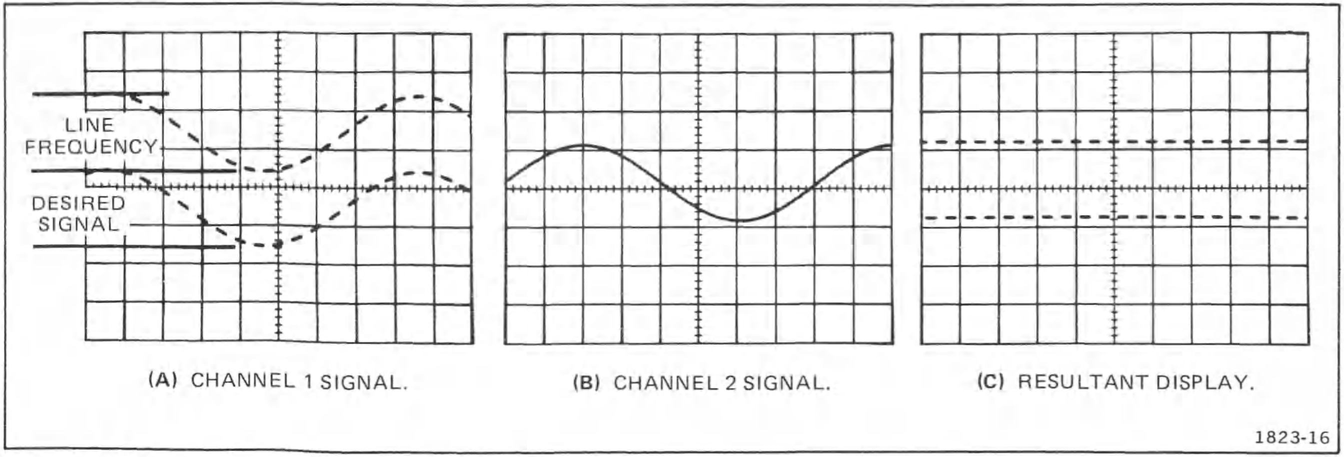

Fig. 16. Using the ADD feature for common-mode rejection. (A) Channel 1 signal contains desired information along with line frequency components, (B) Channel 2 signal contains line-frequency only, (C) Crt display using common-mode rejection.

an amplitude between 5 V and 20 V to the EXT BLANK connector (rear panel). An example of this application is the use of an accurate frequency, applied to the Z axis to serve as timing information on an uncalibrated horizontal sweep. However, the blanking frequency must be time related to the displayed waveform to produce a stable display.

HOW TO STORE A DISPLAY

a. Turn INTENSITY control fully counterclockwise and press STORE button in. Note background light level, then press ERASE button. Notice that the normal storage background light level is present on the storage screen.

b. Turn INTENSITY control slowly clockwise to produce a display of normal intensity, then return the INTENSITY control fully counterclockwise. Notice a stored display of moderate brightness.

c. Press ERASE button and note that the crt display can be erased.

d. Set STORE button to the out (non-store) position. Set triggering and intensity for a stable display of normal brightness.

e. Set the time base for single-sweep operation and press STORE button in. Then press ERASE button.

f. Apply a single-sweep trace by pressing RESET button. Note a stored display on the storage area. If the display is not stored, increase the intensity (INTENSITY control clockwise) and repeat the check.

g. Press AUTO ERASE button in. Note that the sweep is displayed on the crt and further sweeps are locked out until the stored display is erased.

h. Slowly rotate VIEWING TIME control throughout its range and note that the control varies the time that the display remains stored before automatic erase.

i. Turn VIEWING TIME control fully clockwise. As soon as the display is automatically erased, and another trace is stored, press ERASE button. Note that the display is erased and other sweeps are locked out during the period selected by the VIEWING TIME control. Release AUTO ERASE and STORE buttons.

j. Set TIME/DIV switch to 1 μs and SWEEP MAG switch to X10 and turn INTENSITY control fully clockwise.

k. Position the rising portion of the waveform within the graticule area. Readjust INTENSITY control so that the trace is just visible. Press STORE button in, then press ERASE button. Note normal storage mode background light on crt.

I. Press INTEGRATE button momentarily (a fraction of a second to several seconds is reasonable). Note a fully-stored display. If the trace does not store fully on the first attempt, repeat the integration for a longer time, or with a higher intensity. Press ERASE button and release STORE button.

The ENHANCE button provides a method of storing single-sweep or low repetition-rate displays that exceed the normal writing speed of the crt. The ENHANCE mode is not normally used for repetitive sweeps.

NOTE

After sustained use (6 hours, or more) in the non-store mode or in the store mode with nothing written, the writing speed may be improved by leaving the target fully stored for 5 to 15 minutes. This procedure may be repeated every few hours to refresh the storage target in applications requiring maximum stored writing rate.

Using Enhanced Mode

To use the enhance feature, first obtain the best possible display of the signal in the normal store mode. Then press ENHANCE button in and set the ENHANCE LEVEL control to about midrange. Apply a single-sweep display. If ENHANCE LEVEL control is properly set, the display will be stored with minimum background luminance. The INTENSITY level may have to be set quite high in ENHANCE mode.

If ENHANCE LEVEL control is set too high, the background luminance may obscure the desired display. If ENHANCE LEVEL control is set too low, the display may not be adequately stored. Therefore, experimentation is necessary for an optimum enhanced display.

Integrated Fast-Rise Waveforms

The Integrate circuit permits storage of waveforms of relatively fast sweep rates with relatively low repetition rates. Waveforms that might be difficult to see because of the low sweep duty cycle, or have poor resolution, due to the required high setting of the INTENSITY control, can often be stored using the Integrate method to produce brightness or better resolution.

CAUTION

Do not attempt to store extremely fast-rising or fast-falling portions of waveforms viewed at relatively slow sweep rates. The high trace intensity required (due to the intensity difference between the horizontal and vertical segments) could cause storage target damage.

To use the Integrate function, first obtain a triggered, well-defined display. Then press INTEGRATE button in (a fraction of a second to several seconds is reasonable). If all portions of the display are not properly stored, repeat the integrate period with higher trace intensity.

Example: Set VOLTS/DIV switch to 5 DIV CAL and TIME/DIV switch to .1 ms. Set INTENSITY control for normal display of square wave. Press STORE button in, then erase stored display.

Reduce intensity so that the display is just visible (erase display each time intensity is adjusted). Press INTEGRATE button in and note that the stored trace is brightened.

Low trace intensity and long integration periods produce optimum resolution on jitter-free signals. However, if integration period is too long, the stored image may broaden and obscure the desired display. Use of integrate function in AUTO ERASE mode is not recommended.

CARE OF STORAGE CRT

To prolong the useful life of the storage screen, the following precautions should be observed:

1. Use minimum beam intensity required to produce a clear, well-defined display. Care must be exercised in the degree of writing beam intensity used, particularly when using slow sweep rates.

2. Do not increase beam intensity to store fast changing portions of the display. See Integrated Fast-Rise Waveforms.

3. Avoid repeated use of the same area of the screen.

4. Do not leave a display on screen (either written or stored) when the display is not needed.

5. Do not leave the STORE button in when the STORAGE mode is not needed.

SOME COMMON OPERATIONAL ERRORS

If the instrument fails to function properly, it may be due to some operational oversight. The following checks will help assure that this is not the problem.

1. Check position of the AC-DC Selector switch (ac or external dc, +12 V or +24 V nominal).

2. Check the external dc source if using external dc supply.

3. Check external supply fuse, F605. See Figure 17 for location.

4. Check for proper line voltage and range if using dc power supply line.

5. Check line fuse, F600. See Figure 17 for location.

6. Compare control settings and cable connections with the setup instructions given in the Performance Check in the Service manual.

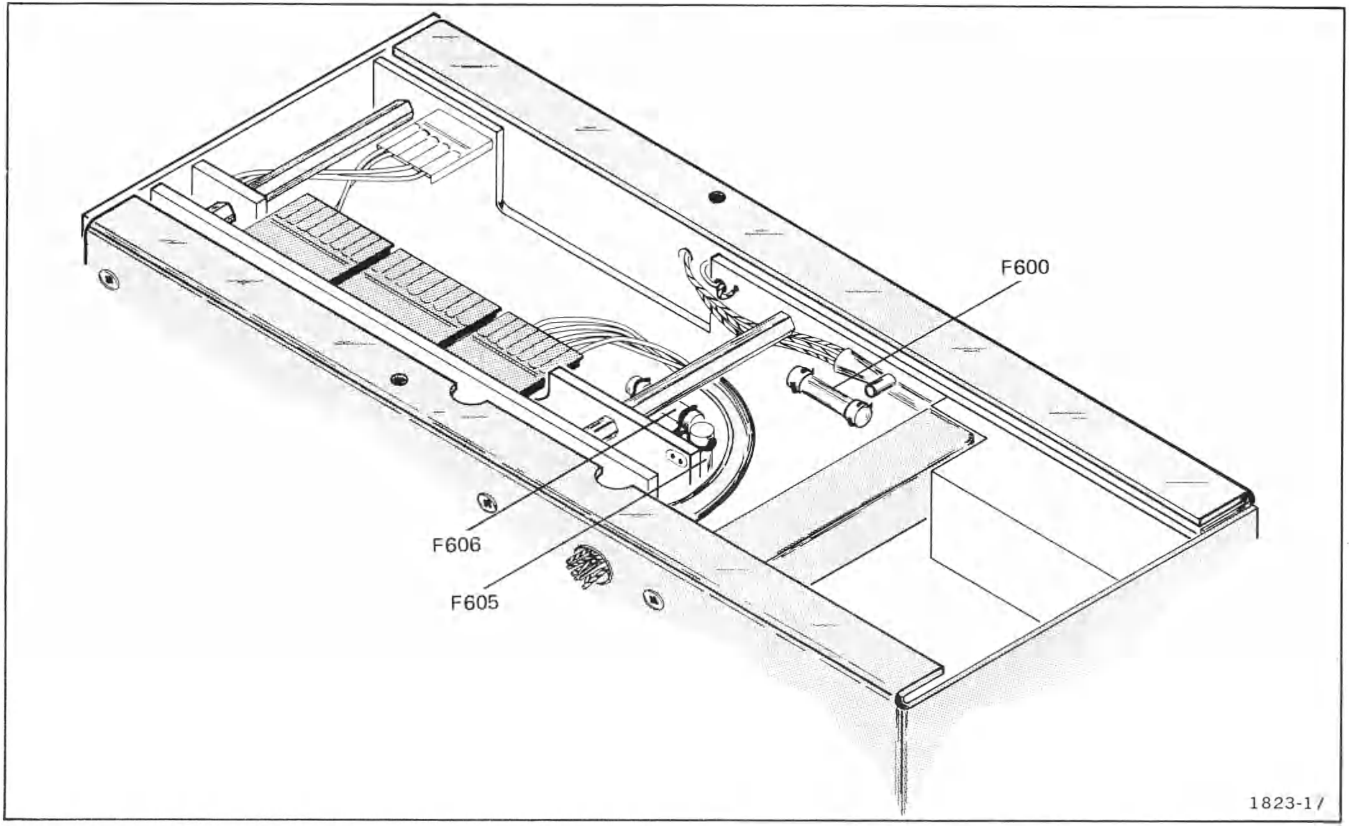

Fig. 17. Location of fuses F600, F605, and F606.

NOTES

NOTES

NOTES