TEKTRONIX®

5110 OSCILLOSCOPE

INSTRUCTION MANUAL

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All Tektronix instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with your Tektronix Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

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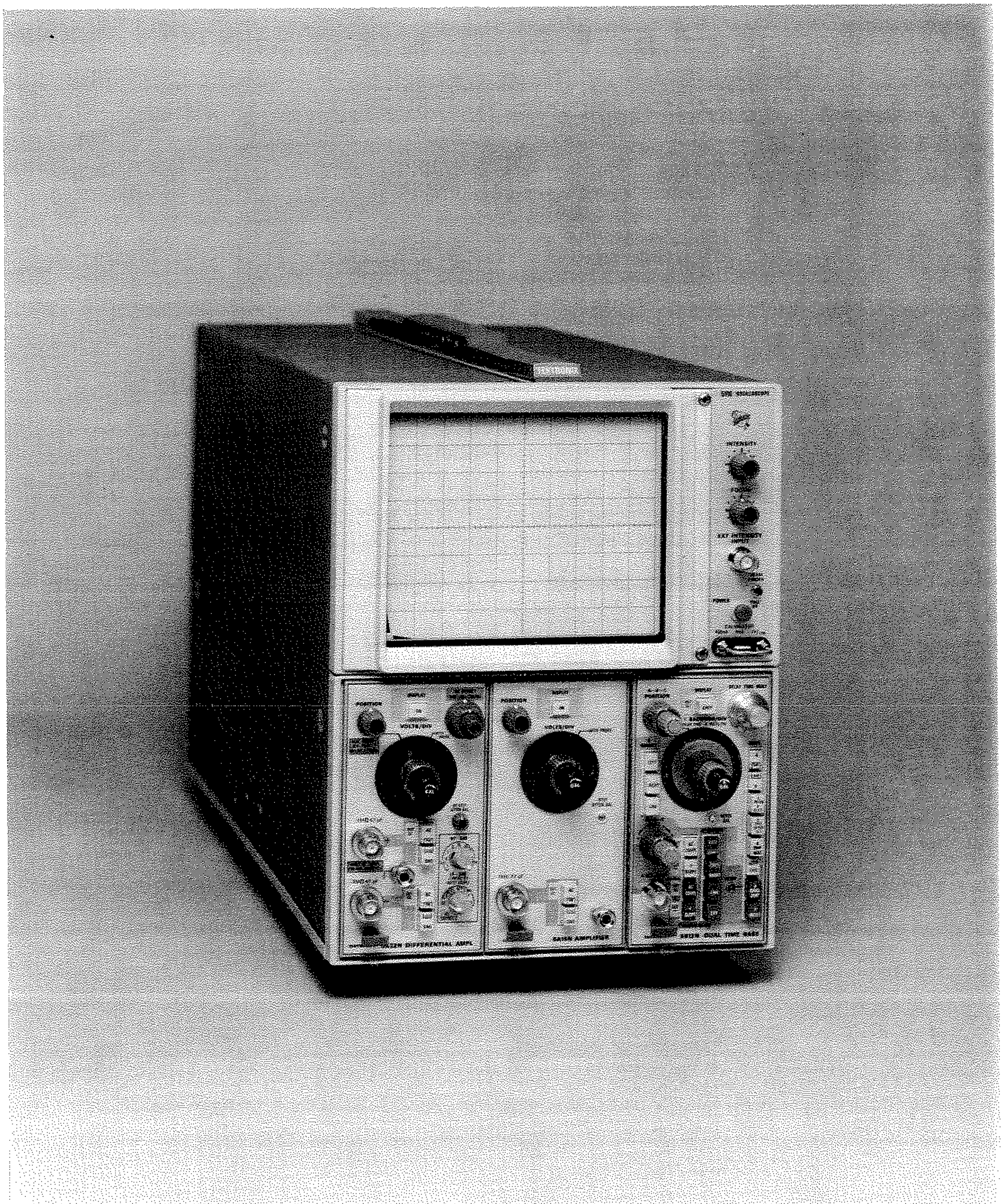

2134-01

Fig. 1-1. 5110 Oscilloscope.

OPERATING INSTRUCTIONS

This instruction manual provides both operating and servicing information for the 5110 Oscilloscope. The manual is divided into nine sections. Operating, specification, and performance check information is covered in the first two sections, and is intended for operating and service personnel. Servicing information is covered in the remaining sections of the manual, and is intended for qualified service personnel only.

PRELIMINARY INFORMATION

Oscilloscope Features

The oscilloscope is a solid state, light weight instrument designed for general-purpose measuring applications. This instrument has three plug-in compartments that accept plug-in units to form a complete measurement system. The two-plug-in compartments on the left are connected to the vertical deflection system. The right plug-in compartment is connected to the horizontal deflection system. Electronic switching between the vertical plug-in compartments allows a multi-trace vertical display. The flexibility of this plug-in feature and the variety of plug-in units available allow this system to be used for many measurement applications.

This instrument features a large-screen, 8 X 10 division display; each division equals 0.5 inch (1.27 centimeter). Regulated dc power supplies ensure that performance is not affected by variations in line voltage and frequency, or by changes in the load due to the varying power requirements of the plug-in units.

Safety Information

This instruction manual contains warning information which the user must follow to ensure safe operation of the instrument. Warning information is intended to protect the operator and Caution information is intended to protect the instrument.

WARNING

High voltage is present inside the instrument. To avoid electric-shock hazard, operating personnel must not remove the protective instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

OPERATING POWER

This instrument can be operated from either a 120-volt or 240-volt nominal line-voltage source, 48 to 440 hertz. In addition, three regulating ranges are provided for each nominal line-voltage source.

CAUTION

To prevent damage to the instrument, always check the line-voltage information recorded on the rear panel before applying power to the instrument.

WARNING

This instrument is intended to be operated from a single-phase earth-referenced power source having one current-carrying conductor (the Neutral Conductor) near earth potential. Operation from power sources where both current-carrying conductors are live with respect to earth (such as phase-to-phase on a three-wire system) is not recommended, since only the Line Conductor has over-current (fuse) protection within the instrument.

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

Do not defeat the grounding connection. Any interruption of the grounding connection can create an electric-shock hazard. Before making external connections to this instrument, always ground the instrument first by connecting the power-cord to a proper mating power outlet.

OPERATING TEMPERATURE

The instrument can be operated where the ambient air temperature is between 0° C and +50° C. The instrument can be stored in ambient temperature between −40° C and +70° C. After storage at a temperature beyond the operating limits, allow the chassis temperature to come within the operating limits before power is applied.

A thermal cutout in the display module provides thermal protection and disconnects the power to the instrument if the internal temperature exceeds a safe operating level. This device will automatically re-apply power when the temperature returns to a safe level.

PLUG-IN UNITS

The oscilloscope is designed to accept up to three Tektronix 5000-series plug-in units (use only "N" suffix plug-in units unless otherwise specified). This plug-in feature allows a variety of display combinations and also allows selection of bandwidth, sensitivity, display mode, etc., to meet the measurement requirements. In addition, it allows the oscilloscope system to be expanded to meet future measurement requirements. The overall capabilities of the resultant system are in large part determined by the characteristics of the plug-ins selected.

Installation

To install a plug-in unit into one of the plug-in compartments, align the slots in the top and bottom of the plug-in with the associated guides in the plug-in compartment. Push the plug-in unit firmly into the plug-in compartment until it locks into place. To remove a plug-in, pull the release latch on the plug-in unit to disengage it and pull the unit out of the plug-in compartment. Plug-in units should not be removed or installed without turning off the instrument power. It is not necessary that all of the plug-in compartments be filled to operate the instrument, the only plug-ins needed are those required for the measurement to be made.

When the oscilloscope is adjusted in accordance with the adjustment procedure given in this manual, the vertical and horizontal gain are standardized. This allows adjusted plug-in units to be changed from one plug-in compartment to another without readjustment. However, the basic adjustment of the individual plug-in units should be checked when they are installed in this system to verify their measurement accuracy. See the plug-in unit manual for verification procedure.

Selection

The plug-in versatility of the oscilloscope allows a variety of display modes with many different plug-ins. The following information is provided here to aid in plug-in selection.

NOTE

Use only "N" suffix plug-in units with the oscilloscope unless otherwise specified.

To produce a single-trace display, install a single-channel vertical unit (or dual-channel unit set for single-channel operation) in either of the vertical (left or center) compartments and a time-base unit in the horizontal (right) compartment. For dual-trace displays, either install a dual-channel vertical unit in one of the vertical compartments or install a single-channel vertical unit in each vertical compartment. A combination of a single-channel and a dual-channel vertical unit allows a three-trace display; likewise, a combination of two dual-channel vertical units allows a four-trace display.

To obtain a vertical sweep with the input signal displayed horizontally, insert the time-base unit into one of the vertical compartments and the amplifier unit in the horizontal compartment. If a vertical sweep is used, there is no retrace blanking; however, if used in the right vertical (center) compartment, internal triggering is provided.

For X-Y displays, either a 5A-series amplifier unit or a 5B-series time-base unit having an amplifier channel can be installed in the horizontal compartment to accept the X signal. The Y signal is connected to a 5A-series amplifier unit installed in a vertical compartment.

Special purpose plug-in units may have specific restrictions regarding the compartments in which they can be installed. This information will be given in the instruction manuals for these plug-ins.

CONTROLS AND CONNECTORS

Controls and connectors necessary for operation of the oscilloscope are located on the front and rear panels of the instrument. To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of each external control and connector. A brief description of the controls and connectors is given here. More detailed information is given under General Operating Information (later in this section). See Fig. 1-2 for the location and description of the controls and connectors.

FIRST TIME OPERATION

The following procedure provides an operational checkout as a means of verifying instrument operation and basic calibration without removing the cabinet or making internal adjustments. Since it demonstrates the use of front-panel controls and connectors, it can also be used to provide basic training on the operation of this instrument. If recalibration of the oscilloscope or plug-ins appears to be necessary, refer the instrument system to qualified service personnel. If more familiarization with a plug-in unit is needed, see the instruction manual for the appropriate plug-in unit. Refer to Fig. 1-2 for the oscilloscope control and connector locations.

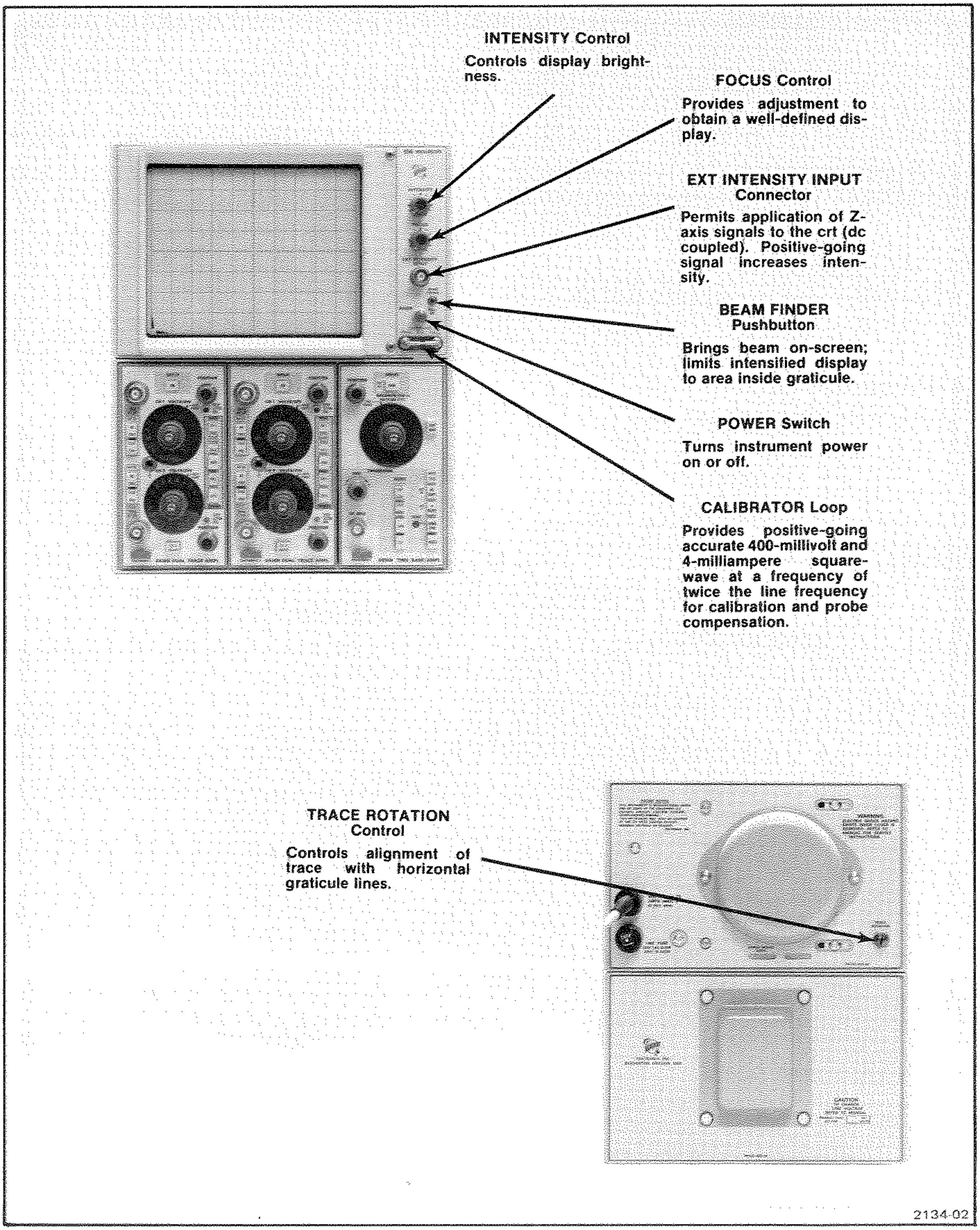

Fig. 1-2. Front-and rear-panel controls and connectors.

CHECKOUT PROCEDURE

1. For the following procedure, an amplifier plug-in should be in one of the vertical (left or center) plug-in compartments and a time-base plug-in should be in the horizontal (right) compartment.

2. Set the POWER switch to off (pushed in) and connect the oscilloscope to a power source that meets the voltage and frequency requirements of this instrument.

3. Turn the INTENSITY control counterclockwise and pull the POWER switch out to turn the instrument on.

Initial Control Settings

Set the front-panel controls as follows:

NOTE

Titles for external controls of the oscilloscope are capitalized in this procedure (e.g. INTENSITY, POWER).

AMPLIFIER PLUG-IN

Display	On
Position	Centered
Volts/Div	.1
Volts/Div Cal	Fully clockwise
Input coupling	dc

TIME-BASE PLUG-IN

Display	Chop
Position	Centered
Seconds/Div	2 ms
Seconds/Div Cal	Fully clockwise
Swp Mag	Off
Triggering	+ Slope, Auto Trig, ac Coupl
Triggering Source	Composite

Intensity Adjustment

4. Advance the INTENSITY control until the trace is at the desired viewing level. Set the trace near the graticule center line.

Focus Adjustment

5. Adjust the FOCUS control for a sharp, well-defined trace over the entire trace length.

Trace Alignment Adjustment

6. If a free-running trace is not parallel with the horizontal graticule lines, set the TRACE ROTATION control (rear-panel adjustment) as follows: Position the trace to the center horizontal line and adjust the TRACE ROTATION control so that the trace is parallel with the horizontal graticule lines.

Calibration Check

7. Connect a 1X probe, or a test lead from the amplifier plug-in connector to the CALIBRATOR loop.

8. Set the time-base unit triggering level for a stable triggered display. Adjust the vertical and horizontal position controls so that the display is centered vertically and starts at the left edge of the graticule.

9. The display should be four divisions in amplitude with approximately 2.5 complete cycles over 10 divisions (for 60-hertz line frequency) shown horizontally. An incorrect display indicates that the Oscilloscope or plug-ins need to be recalibrated.

Beam Finder Check

10. Move the display off-screen with the vertical position control.

11. Push the BEAM FINDER button and observe that the display compresses into the screen area. Reposition the display to screen center and release the BEAM FINDER button. Disconnect the 1X probe or test lead.

External Intensity Input

12. Connect a 5-volt, 1-kHz sine-wave or square-wave signal to the EXT INTENSITY INPUT connector. Also, use the signal to externally trigger the time-base plug-in.

13. Slowly rotate the INTENSITY control counterclockwise until the trace appears to be a series of dimmed and brightened segments. The brightened segments correspond with the tops of the signal input waveform.

14. Disconnect the signal setup.

This completes the checkout procedure for the oscilloscope. Instrument operations not explained here, or operations that need further explanation, are discussed under General Operating Information.

GENERAL OPERATING INFORMATION

Intensity Control

The setting of the INTENSITY control may affect the correct focus of the display. Slight adjustment of the FOCUS control may be necessary when the intensity level is changed. To protect the crt phosphor, do not turn the INTENSITY control higher than necessary to provide a satisfactory display.

WARNING

Damage to the crt phosphor can occur under adverse conditions. Avoid any condition where an extremely bright, sharply focused spot exists on the crt.

Apparent trace intensity can be improved by reducing the ambient light level or using a viewing hood. Also, be careful that the INTENSITY control is not set too high when changing the time-base unit sweep rate from a fast to a slow sweep rate, or when changing to the X-Y mode of operation.

Display Focus

If a well-defined display cannot be obtained with the FOCUS control, even at low INTENSITY control settings, re-setting of the internal astigmatism adjustment may be required (adjustment must only be made by qualified service personnel).

To check for proper setting of the astigmatism adjustment, slowly turn the FOCUS control through the optimum setting with a signal displayed on the crt screen. If the astigmatism adjustment is correctly set, the vertical and horizontal portions of the trace will come into sharpest focus at the same position of the FOCUS control.

Trace Alignment

If a free-running trace is not parallel with the horizontal graticule lines, set the TRACE ROTATION adjustment (rear-panel adjustment) as follows: Position the trace to the center horizontal line and adjust the TRACE ROTATION adjustment so that the trace is parallel with the horizontal graticule lines.

Beam Finder

The BEAM FINDER switch provides a means of locating a display that overscans the viewing area either vertically or horizontally. When the BEAM FINDER switch is pressed, the display is compressed within the graticule area and the display intensity is increased. To locate and reposition an overscanned display, use the following procedure:

1. Press the BEAM FINDER switch, hold it in, then increase the vertical and horizontal deflection factors until the display is within the graticule area.

2. Adjust the vertical and horizontal position controls to center the display about the vertical and horizontal centerlines.

3. Release the BEAM FINDER switch; the display should remain within the viewing area.

Graticule

The graticule of the oscilloscope is marked on the inside of the faceplate of the crt providing accurate, no-parallax measurements. The graticule is divided into eight vertical and ten horizontal divisions; each division is 0.5-inch (1.27 centimeters) square. In addition, each major division is divided into five minor divisions. The vertical gain and horizontal timing of the plug-in units are calibrated to the graticule so accurate measurements can be made from the crt.

When making time measurements from the graticule, the center eight divisions provide the most accurate time measurements. Position the start of the timing area to the second vertical graticule line and set the time-base unit so the end of the timing area falls between the second and tenth vertical graticule lines.

Calibrator Signal

The internal calibrator of the oscilloscope provides a convenient signal source for checking basic vertical gain and sweep timing. The calibrator signal is also very useful for adjusting probe compensation, as described in the probe instruction manual. The output square-wave voltage is 400 millivolts, within 1%, and the square-wave current is 4 milliamperes, within 1%. The frequency of the square-wave signal is twice the power-line frequency. The signal is obtained by clipping the probe to the loop.

Intensity Modulation

Intensity (Z-Axis) modulation can be used to relate a third item of electrical phenomena to the vertical (Y-Axis) and the horizontal (X-Axis) coordinates without affecting the waveshape of the displayed signal. The Z-Axis modulating signal, applied to the EXT INTENSITY INPUT, changes the intensity of the displayed waveform to provide this type of display. The voltage amplitude required for visible trace modulation depends on the setting of the INTENSITY control. About +5 volts will turn on the display to a normal brightness level from an off level, and about −5 volts will turn the display off from a normal brightness level. "Gray scale" intensity modulation can be obtained by applying signals between these levels. Maximum safe input voltage is ±50 volts. Usable frequency range of the Z-Axis circuit is dc to one megahertz.

Time markers applied to the EXT INTENSITY INPUT provide a direct time reference on the display. With uncalibrated horizontal sweep or X-Y operation, the time markers provide a means of reading time directly from the display. However, if the markers are not time-related to the displayed waveform, a single-sweep display should be used (for internal sweep only) to provide a stable display.

X-Y Operation

In some applications, it is desirable to display one signal versus another (X-Y) rather than against an internal sweep. The flexibility of the plug-in units available for use with the oscilloscope provides a means for applying a signal to the horizontal deflection system for this type of display. Some of the 5B-series time-base units can be operated as amplifiers, in addition to their normal use as time-base generators.

Another method of obtaining an X-Y display is to install amplifier units in vertical and horizontal compartments (check amplifier unit gain as given in the amplifier unit instruction manual to obtain calibrated horizontal deflection factors). This method provides the best X-Y display, particularly if two identical amplifier units are used, since both the X and Y input systems will have the same delay time, gain characteristics, input coupling, etc.

Raster Display

A raster-type display can be used to effectively increase the apparent sweep length. For this type of display, the trace is deflected both vertically and horizontally by sawtooth signals, and is accomplished by installing a 5B-series time-base unit in the left vertical compartment, as well as one in the horizontal compartment. Normally, the unit in the vertical compartment should be set to a slower sweep rate than the one in the horizontal compartment; the number of horizontal traces in the raster depends upon the ratio between the two sweep rates. Information can be displayed on the raster using the Ext Intensity Input to provide intensity modulation of the display. This type of raster display can be used to provide a television-type display.

Option 7 Rear Panel Signal Outputs

Option 7 provides cathode-ray tube-related signals to standard connectors at the rear of the instrument. This option is particularly well suited for use in the physical life sciences. By using differential amplifiers, the oscilloscope can become a signal conditioner for other devices. Outputs may be used for driving counters or X-Y plotters in conjunction with the oscilloscope.

Display Photography

A permanent record of the crt display can be obtained with an oscilloscope camera system (see the current Tektronix catalog for a complete listing of oscilloscope cameras and mounting adapters). The instruction manuals for the Tektronix oscilloscope cameras include complete instructions for obtaining waveform photographs.

The crt bezel of the oscilloscope provides integral mounting for a Tektronix oscilloscope camera. However, no voltage is provided at the bezel for camera power. The camera selected for use with the oscilloscope may require battery operation.

Display Switching Logic

The electronic switching for time-shared displays is produced at the plug-in interface within the mainframe; however, the switching logic is selected in the plug-in units. The system allows any combination of plug-ins and Display switch settings. Refer to the individual plug-in manuals for specific capabilities and operating procedures.

Vertical Plug-In Compartments. When a vertical plug-in is in the active mode (Display button pushed in), a logic level is applied to the switching circuit in the mainframe and a display from this plug-in will occur. When two plug-ins are both active in the vertical compartments, a multitrace display will occur (Alternate or Chopped). When no plug-in is in the active mode, the signal from the left compartment will be displayed. A time-base unit operated in one of the vertical compartments has a permanent internal connection to apply a logic level to the switching circuit; thus, a vertical trace produced by this unit will always be displayed.

Horizontal Plug-In Compartment. Alternate or Chopped display switching is selected on a time-base unit operated in the horizontal compartment. When the Display switch is out (Alt), a negative impulse is supplied at the end of the sweep to allow alternate switching between plug-ins and plug-in channels. When the Display switch is pushed in (Chop), a chopped display will appear if a multi-trace display is required by the plug-ins in the vertical compartments. A vertical plug-in unit operated in the horizontal compartment has a permanent internal connection to provide a chopped display if it is required.

Switching Sequence. Four display time slots are provided on a time-sharing basis. When two vertical plug-ins are active, each receives two time slots, so the switching sequence is: left, left, center, center, etc. The two time slots allotted to each plug-in are divided between amplifier channels in a dual-trace unit; if two dual-trace plug-ins are active, then the switching sequence is: left Channel 1, left Channel 2, center Channel 1, center Channel 2, etc. If only one vertical plug-in is active, it receives all four time slots. The switching sequence is the same for both the Alternate and Chopped display modes.

Vertical Display Mode

Display On. To display a signal, the Display button of the applicable vertical plug-in unit must be pushed in to activate the unit. If two plug-ins are installed in the vertical compartments and only the signal from one of the units is wanted, set the Display switch of the unwanted unit to Off (button out). If neither plug-in is activated, the signal from the left unit is displayed. Both plug-ins can be activated for multi-trace displays.

Alternate Mode. The alternate position of the time-base unit Display switch produces a display that alternates between activated plug-ins and amplifier channels with each sweep of the crt. The switching sequence is described under Display Switching Logic in this section. Although the Alternate mode can be used at all sweep rates, the Chop mode provides a more satisfactory display at sweep rates from about one millisecond/division to five seconds/division. At these slower sweep rates, alternate-mode switching becomes difficult to view.

Chopped Mode. The Chop position of the time-base unit Display switch produces a display that is electronically switched between channels at a 100-kilohertz rate. The switching sequence is discussed earlier. In general, the Chop mode provides the best display at sweep rates slower than about one millisecond/division or whenever dual-trace, single-shot phenomena are to be displayed. At faster sweep rates, the chopped switching becomes apparent and may interfere with the display.

Dual-Sweep Displays. When a dual-sweep time-base unit is operated in the horizontal compartment, the alternate and chopped time-shared switching for either the A or B sweep is identical to that for a single time-base unit. However, if both the A and B sweeps are operating, the oscilloscope operates in the independent pairs mode. Under this condition, the left vertical unit is always displayed at the sweep rate of the A time base and the right vertical unit is displayed at the sweep rate of the B time-base. This results in two displays that have completely independent vertical deflection and chopped or alternate sweep switching.

BASIC OSCILLOSCOPE APPLICATIONS

The oscilloscope and its associated plug-in units provide a very flexible measurement system. The capabilities of the overall system depend mainly upon the plug-ins that are chosen. The following information describes the techniques for making basic measurements. These applications are not described in detail, since each application must be adapted to the requirements of the individual measurement. Specific applications for the individual plug-in units are described in the manuals for these units. Contact your local Tektronix Field Office or representative for additional assistance.

The following books describe oscilloscope measurement techniques which can be adapted for use with this instrument.

John D. Lenk, *"Handbook of Oscilloscopes, Theory, and Application"*, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1968.

J. Czech, *"Oscilloscope Measuring Techniques"*, Springer-Verlag, New York, 1965.

J.F. Golding. *"Measuring Oscilloscopes"*, Transatlantic Arts, Inc., 1971.

Charles H. Roth Jr., *"Use of the Oscilloscope"*, A programmed Text, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1970.

Peak-to-Peak Voltage Measurements—AC

To make peak-to-peak voltage measurements, use the following procedure:

1. Set the input coupling on the vertical plug-in unit to Gnd and connect the signal to the input connector.

2. Set the input coupling to ac and set the Volts/Div switch to display about 5 or 6 vertical divisions of the waveform. Check that the variable Volts/Div control (red knob) is in the Cal position.

3. Adjust the time-base triggering controls for a stable display and set the Seconds/Div switch to display several cycles of the waveform.

4. Turn the vertical Position control so that the lower portion of the waveform coincides with one of the graticule lines below the center horizontal line, and the top of the waveform is in the viewing area. Move the display with the horizontal Position control so that one of the upper peaks is aligned with the center vertical reference line (see Fig. 1-3).

5. Measure the vertical deflection from peak to peak (divisions).

NOTE

This technique may also be used to make measurements between two points on the waveform, rather than peak-to-peak.

6. Multiply the distance (in divisions) measured in step 5 by the Volts/Div switch setting. Also include the attenuation factor of the probe, if applicable.

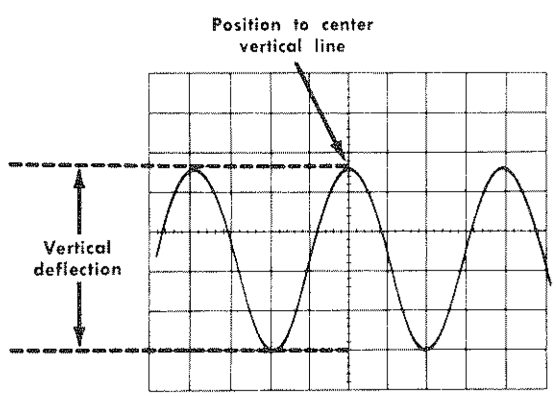

Fig. 1-3. Measuring peak-to-peak voltage of a waveform.

EXAMPLE: Assume a peak-to-peak vertical deflection of 4.6 divisions and a Volts/Div switch setting of 5 V.

$$\text{Peak-to-peak volts} = 4.6\ (\text{divisions}) \times 5\ (\text{Volts/Div setting}) = 23\ \text{volts}$$

NOTE

If an attenuator probe is used that cannot change the scale factor readout (Volts/Div), multiply the right side of the above equation by the attenuation factor.

Instantaneous Voltage Measurement—DC

To measure the dc level at a given point on a waveform, use the following procedure:

1. Set the input coupling of the vertical plug-in unit to Gnd and position the trace to the bottom line of the graticule (or other selected reference line). If the voltage to be measured is negative with respect to ground, position the trace to the top line of the graticule. Do not move the vertical Postion control after this reference has been established.

NOTE

To measure a voltage level with respect to a voltage other than ground, make the following changes to step 1: Set the input coupling switch to dc and apply the reference voltage to the input connector, then position the trace to the reference line.

2. Connect the signal to the input connector. Set the input coupling to dc (the ground reference can be checked at any time by setting the input coupling to Gnd).

3. Set the Volts/Div switch to display about 5 or 6 vertical divisions of the waveform. Check that the variable Volts/Div control (red knob) is in the Cal position. Adjust the time-base triggering controls for a stable display.

4. Measure the distance in divisions between the reference line and the point on the waveform at which the dc level is to be measured. For example, in Fig. 1-4 the measurement is made between the reference line and point A.

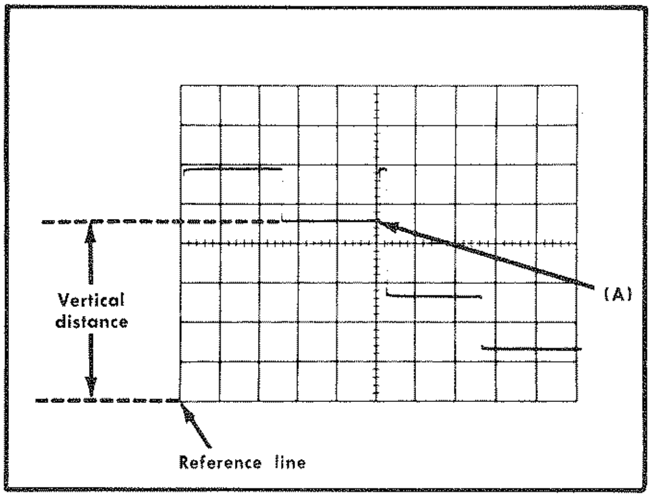

Fig. 1-4. Measuring instantaneous dc voltage with respect to a reference voltage.

5. Establish the polarity. The voltage is positive if the signal is applied to the + input connector and the waveform is above the reference line.

6. Multiply the distance measured in step 4 by the Volts/Div switch setting. Include the attenuation factor of the probe, if applicable (see the note following the Peak-to-Peak Voltage Measurement example).

EXAMPLE: Assume that the vertical distance measured is 4.6 divisions, the polarity is positive, and the Volts/Div switch setting is 2 V.

$$\text{Instantaneous Voltage} = \underset{\text{(divisions)}}{4.6} \times \underset{\text{(Volts/Div)}}{2} = \underset{\text{volts}}{+9.2}$$

Comparison Measurements

In some applications, it may be necessary to establish a set of deflection factors other than those indicated by the Volts/Div or Seconds /Div switches. This is useful for comparing signals to a reference voltage amplitude or period. To establish a new set of deflection factors based on a specific reference amplitude or period, proceed as follows:

Vertical Deflection Factor

1. Apply a reference signal of known amplitude to the vertical input connector. Using the Volts/Div switch and variable Volts/Div control, adjust the display for an exact number of divisions. Do not move the variable Volts/Div control after obtaining the desired deflection.

2. Divide the amplitude of the reference signal (volts) by the product of the deflection in divisions (established in step 1) and the Volts/Div switch setting. This is the Deflection Conversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal amplitude (volts)}}{\text{deflection (divisions)} \times \text{Volts/Div setting}}$$

3. To determine the peak-to-peak amplitude of a signal compared to a reference, disconnect the reference and apply the signal to the input connector.

4. Set the Volts/Div switch to a setting that provides sufficient deflection to make the measurement. Do not readjust the variable Volts/Div control.

5. To establish a Modified Deflection Factor at any setting of the Volts/Div switch, multiply the Volts/Div switch setting by the Deflection Conversion Factor established in step 2.

$$\text{Modified Deflection Factor} = \text{Volts/Div setting} \times \text{Deflection Conversion Factor}$$

6. Measure the vertical deflection in divisions and determine the amplitude by the following formula:

$$\text{Signal Amplitude} = \text{Modified Deflection Factor} \times \text{Deflection (divisions)}$$

EXAMPLE: Assume a reference signal amplitude of 30 volts, a Volts/Div switch setting of 5 V and a deflection of four divisions. Substituting these values in the Deflection Conversion Factor formula (step 2):

$$\frac{30\text{ V}}{(4)\ (5\text{ V})} = 1.5$$

Then, with a Volts/Div switch setting of 2 V, the Modified Deflection Factor (step 5) is:

$$(2\text{ V})\ (1.5) = 3\text{ volts/division}$$

To determine the peak-to-peak amplitude of an applied signal that produces a vertical deflection of five divisions with the above conditions, use the Signal Amplitude formula (step 6):

$$(3\ \text{V})\ (5) = 15\ \text{volts}$$

Sweep Rate

1. Apply a reference signal of known frequency to the vertical input connector. Using the Seconds/Div switch and variable Seconds/Div control, adjust the display so that one cycle of the signal covers an exact number of horizontal divisions. Do not change the variable Seconds/Div control after obtaining the desired deflection.

2. Divide the period of the reference signal (seconds) by the product of the horizontal deflection in divisions (established in step 1) and the setting of the Seconds/Div switch. This is the Deflection Conversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal period (seconds)}}{\text{horizontal deflection (divisions)} \times \text{Sec/Div switch setting}}$$

3. To determine the period of an unknown signal, disconnect the reference and apply the unknown signal.

4. Set the Seconds/Div switch to a setting that provides sufficient horizontal deflection to make an accurate measurement. Do not readjust the variable Seconds/Div control.

5. To establish a Modified Deflection Factor at any setting of the Seconds/Div switch, multiply the Seconds/Div switch setting by the Deflection Conversion Factor established in step 2.

$$\text{Modified Deflection Factor} = \text{Seconds/Div switch setting} \times \text{Deflection Conversion Factor}$$

6. Measure the horizontal deflection in divisions and determine the period by the following formula:

$$\text{Period} = \text{Modified Deflection Factor} \times \text{horizontal deflection (divisions)}$$

EXAMPLE: Assume a reference signal frequency of 455 hertz (period 2.2 milliseconds), a Seconds/Div switch setting of .2 ms, and a horizontal deflection of eight divisions. Substituting these values in the Deflection Conversion Factor formula (step 2):

$$\frac{2.2\ \text{ms}}{(8)\ (0.2\ \text{ms})} = 1.375$$

Then, with a Seconds/Div switch setting of 50 μs, the Modified Deflection Factor (step 5) is:

$$(50\ \mu\text{s})\ (1.375) = 68.75\ \text{microseconds/division}$$

To determine the time period of an applied signal which completes one cycle in seven horizontal divisions, use the Period formula (step 6):

$$(68.75\ \mu\text{s})\ (7) = 481\ \text{microseconds}$$

This product can be converted to frequency by taking the reciprocal of the period (see application of Determining Frequency).

Time Period Measurement

To measure the time (period) between two points on a waveform, use the following procedure:

1. Connect the signal to the vertical input connector, select either ac or dc input coupling, and set the Volts/Div switch to display about four divisions of the waveform.

2. Set the time-base triggering controls to obtain a stable display. Set the Seconds/Div switch to the fastest sweep rate that will permit displaying one cycle of the waveform in less than eight divisions (some non-linearity may occur in the first and last graticule divisions of display). Refer to Fig. 1-5.

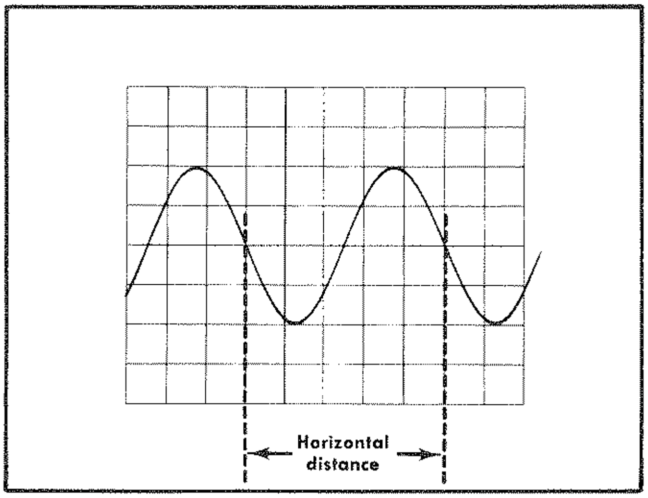

Fig. 1-5. Measuring time duration (period) between points on a waveform.

3. Adjust the vertical Position control to move the points between which the time measurement is made to the center horizontal line. Adjust the horizontal Position control to center the time-measurement points within the center eight divisions of the graticule.

4. Measure the horizontal distance between the time measurement points. Be sure the variable Seconds/Div control is in the Cal position.

5. Multiply the distance measured in step 4 by the setting of the Seconds/Div switch.

EXAMPLE: Assume that the horizontal distance between the time-measurement points is five divisions and the Seconds/Div switch is set to .1 ms. Using the formula:

$$\text{Period} = \begin{matrix}\text{horizontal} \\ \text{distance} \\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{Sec/Div} \\ \text{switch} \\ \text{setting}\end{matrix} = (5)\ (0.1\ \text{ms}) = 0.5\ \text{ms}$$

The period is 0.5 millisecond.

Determining Frequency

The time measurement technique can also be used to determine the frequency of a signal. The frequency of a periodically recurrent signal is the reciprocal of the time duration (period) of one cycle. Use the following procedure:

1. Measure the period of one cycle of the waveform as described in the previous application.

2. Take the reciprocal of the period to determine the frequency.

EXAMPLE: The frequency of the signal shown in Fig. 1-5, which has a period of 0.5 millisecond is:

$$\text{Frequency} = \frac{1}{\text{period}} = \frac{1}{0.5\ \text{ms}} = 2\ \text{kilohertz}$$

Risetime Measurement

Risetime measurements employ basically the same techniques as the time-period measurements. The main difference is the points between which the measurement is made. The following procedure gives the basic method of measuring risetime between the 10% and 90% points of the waveform.

1. Connect the signal to the input connector.

2. Set the Volts/Div switch and variable Volts/Div control to produce a display exactly five divisions in amplitude.

3. Center the display about the center horizontal line with the vertical Position control.

4. Set the time-base triggering controls to obtain a stable display. Set the Seconds/Div switch to the fastest sweep rate that will display less than eight divisions between the 10% and 90% points on the waveform (see Fig. 1-6).

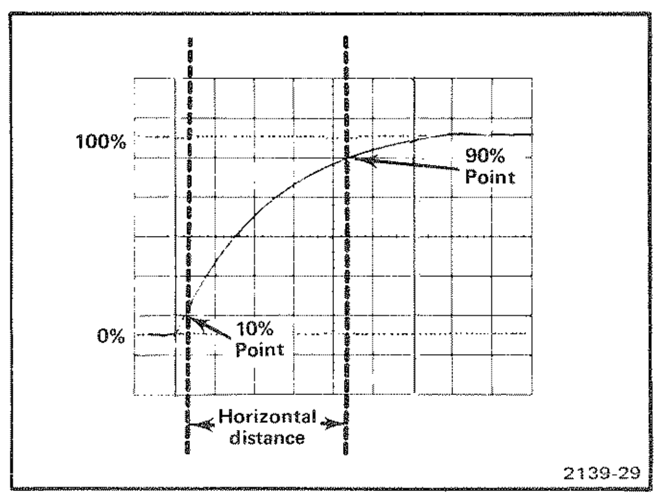

Fig. 1-6. Measuring risetime.

5. Adjust the horizontal Position control to move the 10% point of the waveform to the second vertical line of the graticule.

6. Measure the horizontal distance between the 10% and 90% points. Be sure the variable Seconds/Div control is in the Cal position.

7. Multiply the distance measured in step 6 by the setting of the Seconds/Div switch.

EXAMPLE: Assume that the horizontal distance between the 10% and 90% points is four divisions and the Seconds/Div switch is set to 1 μs.

Using the period formula to find risetime:

$$\text{Risetime period} = \begin{matrix}\text{horizontal}\\ \text{distance}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{Sec/Div}\\ \text{switch}\\ \text{setting}\end{matrix} = (4)\ (1\ \mu s) = 4\ \mu s$$

The risetime is 4 microseconds.

Time Difference Measurements

When used in conjunction with a calibrated time-base plug-in unit, the multi-trace feature of the oscilloscope permits measurement of time difference between two or more separate events. To measure time difference, use the following procedure:

1. Set the input coupling switches of the amplifier channels to either ac or dc.

2. Set the Display switch on the time-base unit to either Chop or Alt. In general, Chop is more suitable for low-frequency signals. More information on determining the mode is given under Vertical Display Mode in this section.

3. Set the vertical plug-in triggering switches to trigger the display on Channel 1 (or left plug-in) and Channel 2 (or center plug-in).

4. Connect the reference signal to the Channel 1 input connector and the comparison signal to the Channel 2 (or center plug-in) input connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have similar time-delay characteristics to connect the signal to the input connectors.

5. If the signals are of opposite polarity, invert the Channel 2 (or center plug-in) display. (Signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation.)

6. Set the Volts/Div switches to produce about four divisions of display waveform.

7. Set the time-base triggering controls for a stable display. Set the Seconds/Div switch for a sweep rate which shows three or more divisions between the measurement points, if possible.

8. Adjust the vertical Position controls to bring the measurement points to the center horizontal reference line.

9. Adjust the horizontal Position control so the Channel 1 (or left plug-in) waveform (reference) crosses the center horizontal line at a vertical graticule line.

10. Measure the horizontal distance between the two measurement points (see Fig. 1-7).

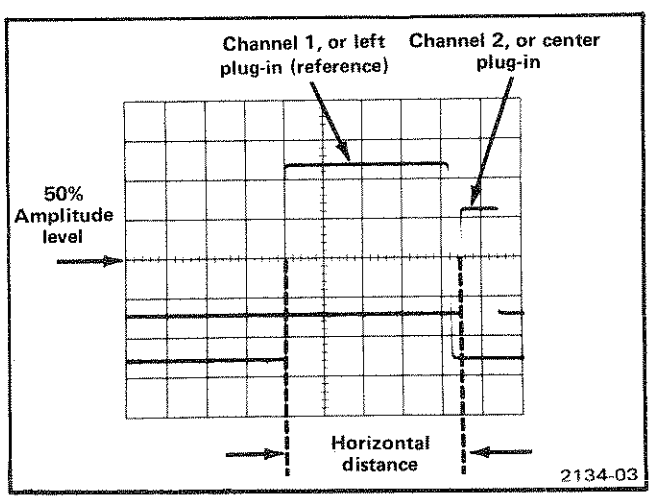

Fig. 1-7. Measuring time difference between two pulses.

11. Multiply the measured distance by the setting of the Seconds/Div switch.

EXAMPLE: Assume that the Seconds/Div switch is set to 50 μs and the horizontal distance between measurement points is four divisions. Using the formula:

$$\text{Time Delay} = \begin{matrix}\text{Sec/Div}\\ \text{switch}\\ \text{setting}\end{matrix} \times \begin{matrix}\text{horizontal}\\ \text{distance}\\ \text{(divisions)}\end{matrix} = (50\ \mu s)\ (4) = 200\ \mu s$$

The time delay is 200 microseconds.

Multi-trace Phase Difference Measurement

Phase comparison between two or more signals of the same frequency can be made using a dual-trace plug-in or two single-trace plug-ins. This method of phase difference measurement can be used up to the frequency limit of the vertical system. To make the comparison, use the following procedure:

1. Set the input coupling switches of the amplifier channels to either ac or dc.

2. Set the Display switch on the time-base unit to either Chop or Alt. In general, Chop is more suitable for low-frequency signals and the Alt position is more suitable for high-frequency signals. More information on determining the mode is given under Vertical Display Mode in this section.

3. Set the vertical plug-in triggering switches to trigger the display on Channel 1 (or left plug-in) and Channel 2 (or center plug-in).

4. Connect the reference signal to the Channel 1 input connector and comparison signal to the Channel 2 (or center plug-in) input connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have similar time-delay characteristics to connect the signals to the input connectors.

5. If the signals are of opposite polarity invert the Channel 2 (or center plug-in) display. (Signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation.)

6. Set the Volts/Div switches and the variable Volts/Div controls so the displays are equal and about five divisions in amplitude.

7. Set the time-base triggering controls to obtain a stable display. Set the Seconds/Div switch to a sweep rate which displays about one cycle of the waveform.

8. Move the waveforms to the center of the graticule with the vertical Position controls.

9. Turn the variable Seconds/Div control until one cycle of the reference signal (Channel 1, or left plug-in) occupies exactly eight divisions between the second and tenth vertical lines of the graticule (see Fig. 1-8). Each division of the graticule represents 45° of the cycle (360° ÷ 8 divisions = 45°/division). The sweep rate can be stated in terms of degrees as 45°/division.

10. Measure the horizontal difference between corresponding points on the waveforms.

11. Multiply the measured distance (in divisions) by 45°/division (sweep rate) to obtain the exact amount of phase difference.

EXAMPLE: Assume a horizontal difference of 0.6 division with a sweep rate of 45°/division as shown in Fig. 1-8. Use the formula:

$$\text{Phase Difference} = \begin{matrix}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{sweep rate}\\ \text{(degrees/}\\ \text{division)}\end{matrix} = (0.6)\ (45°) = 27°$$

The phase difference is 27°.

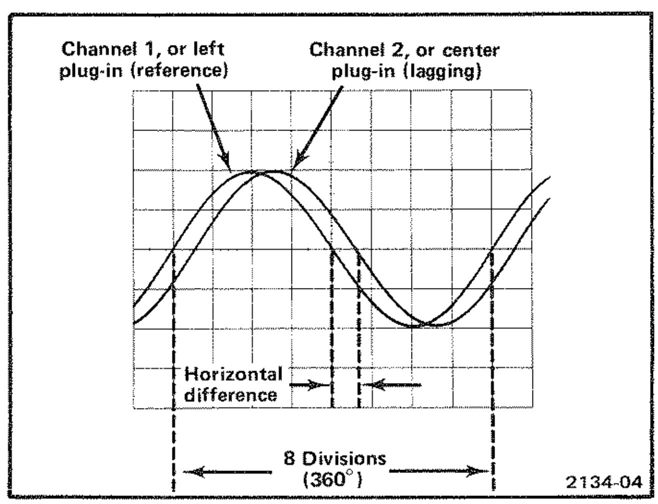

Fig. 1-8. Measuring phase difference.

High Resolution Phase Measurement

More accurate dual-trace phase measurements can be made by increasing the sweep rate (without changing the variable Seconds/Div control setting). One of the easiest ways to increase the sweep rate is with the Swp Mag (10X) button on the time-base unit.

EXAMPLE: If the sweep rate were increased 10 times with the magnifier, the magnifier sweep rate should be 45°/division ÷ 10 = 4.5°/division. Figure 1-9 shows the same signals as used in Figure 1-8, but with the Swp Mag button pushed in. With a horizontal difference of six divisions the phase difference is:

$$\text{Phase Difference} = \begin{matrix}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{magnified}\\ \text{sweep rate}\\ \text{(degrees/}\\ \text{division)}\end{matrix} = (6)\ (4.5°) = 27°$$

The phase difference is 27°.

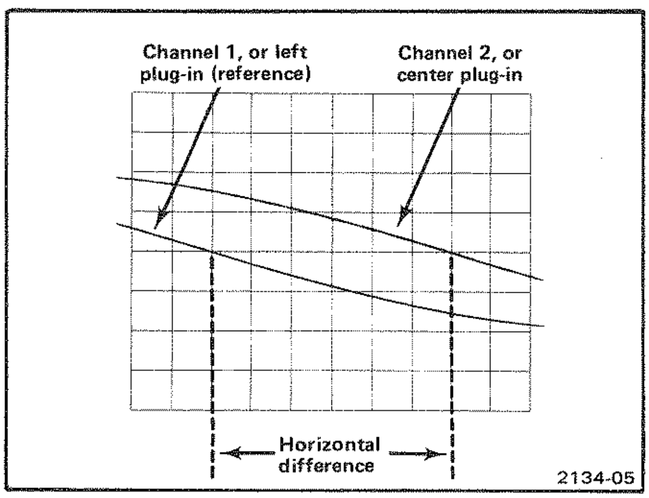

Fig. 1-9. High-resolution phase difference measurement with increased sweep rate.

X-Y Phase Measurements

The X-Y phase measurement method can also be used to measure the phase difference between two signals of the same frequency. The phase angle is determined from the Lissajous pattern as outlined in the following steps:

1. Insert an amplifier plug-in unit into one of the vertical plug-in compartments and an amplifier of the same type into the horizontal plug-in compartment.

2. Set each amplifier unit input coupling switch to dc, and set the position controls of the selected X and Y channels for a spot display at graticule center.

3. Connect low-frequency sine-wave signals of the same frequency to the selected X and Y inputs.

4. Advance the INTENSITY control until the display is at the desired viewing level. Set the amplifier deflection factors and variable Volts/Div controls for six divisions of vertical and horizontal deflection, and set the position controls to center the display on the graticule as shown in Fig. 1-10.

5. Measure and record the overall vertical deflection (A) and the opening of the Lissajous display (B), measuring vertically at the graticule horizontal center line (see Fig. 1-10).

6. Divide B by A to obtain the trigonometric sine of the phase angle difference between the two signals. Obtain the phase angle from a trigonometric table to determine the phase angle between the X and Y signals. If the display appears as a diagonal straight line, the two signals are either in phase (tilted upper right to lower left), or 180° out of phase (tilted upper left to lower right). If the display is a circle, the signals are 90° out of phase. Fig. 1-11 shows the Lissajous displays produced between 0° and 360°. Notice that above 180° phase shift, the resultant display is the same as at some lower angle.

EXAMPLE: Assume a display as shown in Fig. 1-10 where A is 6 divisions and B is 0.4 division.

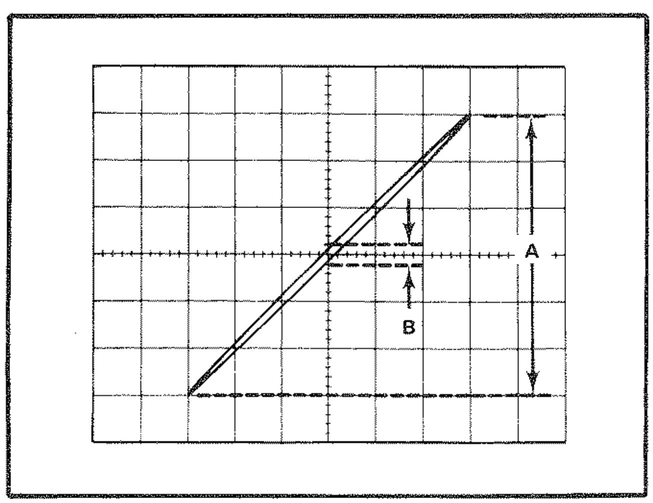

Fig. 1-10. Phase difference measurement from an X-Y display.

Using the formula:

$$\text{Sin } \Phi = \frac{B}{A} = \frac{0.4}{6} = 0.0667$$

From the trigonometric tables:

$$\Phi = \arcsin 0.0667 = 3.82°$$

The phase angle difference between the X and Y signals is 3.82°.

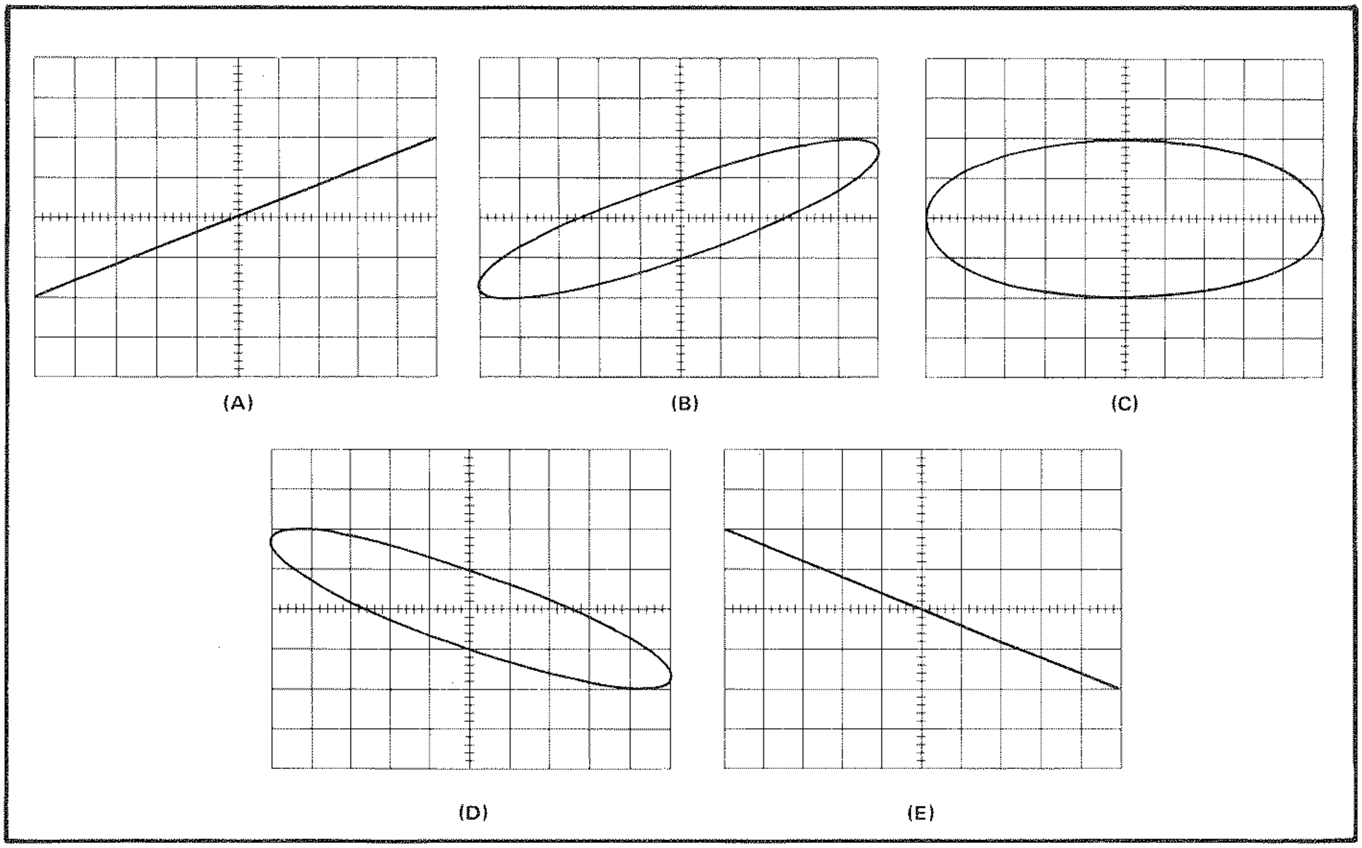

Fig. 1-11. Phase of a Lissajous display. (A) 0° or 360°, (B) 30° or 330°, (C) 90° or 270°, (D) 150° or 210°, and (E) 180°.

SPECIFICATION AND PERFORMANCE CHECK

SPECIFICATION

The following electrical characteristics are valid only if the instrument has been calibrated at an ambient temperature between +20° C and +30° C, the instrument is operating at an ambient temperature between 0° C and +50° C (unless otherwise noted), and each plug-in must be operating (fully installed) in a calibrated system.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the Performance Check in this manual. Items listed in the Supplemental Information column are not verified in this manual; they are either explanatory notes or performance characteristics for which no limits are specified.

ELECTRICAL CHARACTERISTICS

Table 2-1

VERTICAL AMPLIFIER

Characteristics	Performance Requirements	Supplemental Information
Input Signal Amplitude (Differential Input)		50 mV/displayed division.
Bandwidth	Dc to at least 2 MHz with a calibrated 5A18N.	
Channel Switching		
Chop Time Segment/Channel		Approximately 5 μs (≈3 μs displayed, ≈2 μs blanked).
Mainframe Compartment Chop Switching Sequence		Left, left, center, center...
Amplifier Channel Chop Switching Sequence		2 channel amplifier: Ch 1, Ch 2... 4 channel amplifier: Ch 1, Ch 2, off, off, Ch 3, Ch 4, off, off...
Alternate Frequency	Sweep rate (once each sweep).	
Mainframe Compartment Alternate Rate	One-half sweep rate (once every two sweeps).	
Amplifier Channel Alternate Rate	One-fourth sweep rate (once every four sweeps).	
Signal Outputs (Option 7)		
Left Out, Center Out Signals	Crt-related vertical signals	Derived from interface signal output pins
Sensitivity	0.5 V/crt div, ±3% into ⩾100 kΩ	
DC Offset		±500 mV max
Output Impedance	Approximately 1 kΩ	
Dynamic Range		±4 V max
Amplifier Bandwidth	⩾500 kHz up to ±2 V output into ⩽50 pF	
Common Mode Rejection Ratio		⩾28 dB at 1 kHz
Noise and Chop Breakthrough[a]	⩽100 mV at each output connector	

[a] If excessive noise and chop breakthrough occur, refer to Modifications To Pre-Option 7 Amplifier Plug-Ins in Section 4 Maintenance.

Table 2-2
HORIZONTAL AMPLIFIER

Characteristics	Performance Requirements	Supplemental Information
Input Signal Amplitude (Differential Input)		50 mV/displayed division.
Horizontal Centering		0.5 division or less.
Bandwidth	Dc to at least 2 MHz with a calibrated 5A18N.	
X-Y Phase Difference Between Vertical and Horizontal Compartments	1° or less to 100 kHz.	Checked with two plug-ins of the same type.
Signal Outputs (Option 7)		
Right Out Signal	Crt-related sweep signal	Derived from interface signal output pins
Sensitivity	0.5 V/crt div, ±3% into ⩾100 kΩ	
Polarity and Output Voltage	Positive-going ramp, ⩾5 V	DC offset provided by timebase position control
Output Impedance	Approximately 1 kΩ	
Gate Out Signal	Crt-related Z-axis signal	Selected by timebase
Output Levels	TTL compatible	Low: Sinking 1.6 mA, ⩽0.4 V High: Supplying 40 μA, ⩾2.4 V
Risetime		⩽1 μs into ⩽50 pF
Falltime		⩽200 ns into ⩽50 pF

Table 2-3
Z-AXIS AMPLIFIER

Characteristics	Performance Requirements	Supplemental Information
External Intensity Input		
Useful Input Voltage	+5 V will turn on display to a normal brightness level from an off level; −5 V will turn off display from a normal brightness level.	
Useable Frequency Range	Dc to 1 MHz.	
Input R and C		Approximately 10 kΩ, paralleled by approximately 40 pF.
Maximum Safe Input		±50 V (dc + peak ac).

Table 2-4
DISPLAY

Characteristics	Performance Requirements	Supplemental Information
Cathode-Ray Tube		
Deflection		Electrostatic.
Phosphor		P31 standard; P7 or P11 optional.

Table 2-4 (cont)
DISPLAY

Characteristics	Performance Requirements	Supplemental Information
Accelerating Voltage		3.5 kV.
Orthogonality		90°, within 1°.
Geometry		0.1 division or less.
Beam Finder		Limits display to within graticule area and intensifies display if brightness level is low.

Table 2-5
CALIBRATOR AND POWER INPUT

Characteristics	Performance Requirements	Supplemental Information
Calibrator Voltage		400 mV, within 1%.
Current		4 mA, within 1%.
Frequency		Twice the line frequency.
Power Input Line Voltage (RMS)		Nominal 100 V, 110 V, 120 V, 200 V, 220 V, 240 V ±10% (250 V maximum).
Fuse Data		1.6 A slow blow (120 V ac). 1 A slow blow (240 V ac).
Line Frequency		48 to 440 Hz.
Power Consumption		Typical: 53 W. Maximum: 75 W.
Insulation Voltage		1500 V (RMS) minimum at 50 to 60 Hz for 10 seconds duration minimum.
Ground Continuity (Between Safety Ground and Instrument)		Less than 0.1 Ω.

ENVIRONMENTAL CHARACTERISTICS

Table 2-6
ENVIRONMENTAL

Characteristics	Performance Requirements	Supplemental Information
Temperature Operating	0°C to +50°C.	
Storage	−40°C to +70°C.	
Altitude Operating	To 15,000 feet.	
Storage	To 50,000 feet.	
Vibration Operating and Non-Operating	With the instrument complete and operating, vibration frequency swept from 10 to 50 to 10 Hz at 1 minute per sweep. Vibrate 15 minutes in each of the three axes at 0.015" total displacement. Hold 3 minutes at any resonance, or if none, at 50 Hz. Total time, 54 minutes.	

Table 2-6 (cont)
ENVIRONMENTAL

Characteristics	Performance Requirements	Supplemental Information
Shock Operating and Non-Operating	30 g's, 1/2 sine, 11 ms duration, 2 shocks in each direction along 3 major axes for a total of 12 shocks.	
Transportation	Qualified under National Safe Transit Committee Test Procedure 1A, Category II.	

PHYSICAL CHARACTERISTICS

Table 2-7
PHYSICAL

Parameter	Bench Oscilloscope	Rack Oscilloscope
Overall Dimensions Height	12.0 in. (30.5 cm).	5.2 in. (13.2 cm).
Length	20.4 in. (51.8 cm).	20.4 in. (51.8 cm). Rack depth required: 19.0 in. (48.3 cm).
Width	8.4 in (21.4 cm).	19.0 in (48.3 cm).
Net Weight	Approximately 19.1 lbs. (8.7 kg).	Approximately 23.1 lbs. (10.5 kg).
Shipping Weight	Approximately 30.0 lbs. (13.6 kg).	Approximately 39.0 lbs. (17.7 kg).
Export Weight	Approximately 45.0 lbs. (20.4 kg).	Approximately 59.0 lbs. (26.8 kg).
Finish	Anodized aluminum panel and chassis. Blue-vinyl coated cabinet.	

POWER TO EXTERNAL EQUIPMENT

With the plug-in units removed from the oscilloscope, the unused power capability of the oscilloscope power supplies may be used to operate external electronic equipment. The recommended access to the power supplies is through the Interface circuit board. Special equipment is available from Tektronix, Inc. to facilitate connection to the individual power supply voltages. Order the equipment through your local Tektronix Field Office or representative.

Table 2-8 lists the maximum current draw and Interface pin assignment for only those power supply voltages recommended for operating external electronic equipment.

Table 2-8
POWER AVAILABLE TO EXTERNAL EQUIPMENT

Power Supply Voltage	Maximum Current/ Compartment	Maximum Total Current	Interface Pin No.
+200 V	10 mA	30 mA	A1
+30 V	80 mA	240 mA	A5
+5 V	130 mA	390 mA	B2
−30 V	80 mA	240 mA	B5

PERFORMANCE CHECK

Introduction

This procedure checks the oscilloscope for measurement accuracy against the tolerances listed as Performance Requirements that appear under Electrical Characteristics at the beginning of this section. If the instrument fails to meet the requirements given in this Performance Check, the Adjustment procedure (Section 3 in this manual) should be performed. The Performance Check can be used by an incoming inspection facility to determine acceptability of performance. It is not necessary to remove the instrument cabinet to perform this procedure, since all checks are made from the front panel.

The Electrical Characteristics in this section are valid only if the oscilloscope has been calibrated at an ambient temperature between +20° C to +30° C and is operating at an ambient temperature between 0° C to +50° C.

Tolerances that are specified in this Performance Check procedure apply to the instrument under test and do not include test equipment error. Limits and tolerances in this procedure are instrument performance requirements only if stated as such in the Performance Requirement column (under Electrical Characteristics). Information given in the Supplemental Information column is provided for user information only, and should not be interpreted as performance requirements.

PERFORMANCE CHECK INTERVAL

To ensure instrument accuracy, check the performance of the oscilloscope every 1000 hours of operation, or every 6 months if used infrequently.

TEST EQUIPMENT REQUIRED

The following test equipment, or equivalent, is required to perform a performance check of the oscilloscope. The test equipment performance requirements listed are the minimum required to verify the performance of the equipment under test. Substitute equipment must meet or exceed the stated requirements. All test equipment is assumed to be operating within tolerance.

SPECIAL TEST EQUIPMENT

Special test equipment is used where necessary to facilitate the procedure. Most of this equipment is available from Tektronix, Inc. and can be ordered through your local Tektronix Field Office or representative.

Table 2-9

LIST OF TEST EQUIPMENT REQUIREMENTS FOR PERFORMANCE CHECK

Description	Performance Requirements	Application	Example
Amplifier Plug-in unit[1]	Bandwidth, dc to 2 MHz; display modes, channel 1 and dual-trace; deflection factor, 5 mV to 5 V/div.	One required for all tests. Two required for steps 6, 7, 12.	a. TEKTRONIX 5A18N Dual-Trace Amplifier.
Time-base Plug-in unit	Sweep rate, at least 2 μs/div.	Steps 1 through 11, 13, 14.	a. TEKTRONIX 5B10N Time-Base.
Calibration generator	Amplitude calibration, 5 mV to 5V; accuracy, ±0.25% into 1 mΩ; output, square wave at approximately 1 kHz.	Steps 8, 10.	a. TEKTRONIX PG 506 Calibration Generator [2].
Sine-wave generator	Frequency, 50 kHz to 2 MHz; output amplitude, variable from 250 mV to 6 V into 50 Ω.	Steps 9, 11, 12, 13.	a. TEKTRONIX FG 503 Function Generator[2].

[1]**Two dual-trace amplifiers are required to check vertical alternate and chop operation. Two identical amplifiers are required to check x-y phase difference.**

[2]**Requires a TM 500-series power module.**

Table 2-9 (cont)

LIST OF TEST EQUIPMENT REQUIREMENTS FOR PERFORMANCE CHECK

Description	Performance Requirements	Application	Example
Coaxial cable	Impedance, 50 Ω; length, 42 inch; connectors, bnc.	Steps 8 through 13.	a. TEKTRONIX part 012-0057-01.
Coaxial cable	Impedance, 50 Ω, length, 18 inch; connectors, bnc.	Steps 12, 13.	a. TEKTRONIX part 012-0076-00.
1X passive probe	Compatible with 5A-series amplifiers used in the Oscilloscope.	Step 14.	a. TEKTRONIX P6101 Probe. b. TEKTRONIX P6062A Probe.
Termination	Impedance, 50 Ω; accuracy within 2%; connectors, bnc.	Steps 9, 11, 12.	a. TEKTRONIX part 011-0049-01.
Tee connector	Connectors, bnc.	Steps 12, 13.	a. TEKTRONIX part 103-0030-00.
Screwdriver	Length, 3-inch shaft; bit size, 3/32 inch.	Step 1.	a. Xcelite R3323.

PRELIMINARY PROCEDURE FOR PERFORMANCE CHECK

1. Ensure that all power switches are off.

2. Check the rear panel of the oscilloscope to ensure the indicated line voltage and the line voltage source are the same.

3. Ensure that all test equipment is suitably adapted to the line voltage to be applied.

4. If applicable, install the TM 500-series test equipment into the test equipment power module.

5. Install a dual-trace vertical amplifier unit into the left vertical compartment of the oscilloscope.

6. Install a time-base unit into the horizontal compartment of the oscilloscope.

7. Connect the equipment under test and the test equipment to a suitable line voltage source. Turn all equipment on and allow at least 20 minutes for the equipment to stabilize.

NOTE

Titles for external controls of the oscilloscope are capitalized in this procedure (e.g. INTENSITY, POWER).

INITIAL CONTROL SETTINGS

Set the following controls during warm-up time:

OSCILLOSCOPE

INTENSITY, FOCUS	Set for well-defined trace and normal brightness.

AMPLIFIER PLUG-IN

Display	On
Position	Centered
CH 1 Volts/Div	1
CH 1 Cal	Fully clockwise
CH 1 Input coupling	dc
Trigger	CH 1
Mode	CH 1

TIME BASE PLUG-IN

Display	Chop
Position	Centered
Seconds/Div	1 ms
Seconds/Div Cal	Fully clockwise
Swp Mag	Off
Triggering	+ Slope, Auto Trig, ac Couple
Triggering Source	Composite

PERFORMANCE CHECK PROCEDURE

1. Check Trace Alignment

a. Position the horizontal trace over the center horizontal graticule line.

b. Check—that the trace is parallel to the graticule line.

c. Adjust—the TRACE ROTATION control (rear-panel screwdriver adjustment) to align the trace horizontally.

2. Check Geometry

a. Press the POWER switch to turn off the oscilloscope.

b. Interchange the amplifier and time-base units in their respective compartments. Pull the POWER switch to on.

c. Position the vertical trace over the center vertical graticule line, extending vertically above and below the graticule area, and set the FOCUS and INTENSITY controls for a well-defined trace.

d. Check—that vertical bowing and tilt of the trace display is less than 0.1 division at the center line and when positioned horizontally across the entire graticule area.

e. Press the POWER switch to turn off the oscilloscope and interchange the amplifier and time-base units back to their usual compartments.

f. Pull the POWER switch to on.

3. Check Beam Finder

a. Set the INTENSITY control for a dim trace.

b. Press and hold the BEAM FINDER pushbutton in, then rotate the position control of the vertical amplifier and time-base units fully clockwise and counterclockwise.

c. Check—that the display is intensified, compressed, and remains within the graticule area.

d. Release the BEAM FINDER pushbutton and return the INTENSITY control to a normal setting.

4. Check Amplifier Alternate Operation

a. Push both CH 1 and CH 2 pushbuttons in and position the traces about two divisions apart.

b. Set the time-base unit Display pushbutton to Alternate.

c. Turn the time-base Seconds/Div switch throughout its range.

d. Check—for trace alternation at all sweep rates (except in amplifier positions). At faster sweep rates, alternation is not apparent; instead, the display appears as two traces on the screen.

e. Press the POWER switch to turn off the oscilloscope and change the amplifier from the vertical compartment to the center compartment.

f. Pull the POWER switch on and repeat parts c and d of this step.

5. Check Amplifier Chop Operation

a. Set the time-base unit Display pushbutton to Chop.

b. Turn the time-base Seconds/Div switch throughout its range.

c. Check—for a dual-trace display at all sweep rates (except in amplifier positions) without alternation.

d. Press the POWER switch to turn off the oscilloscope and change the amplifier from the center compartment to the left vertical compartment.

e. Pull the POWER switch to on and repeat parts b and c of this step.

6. Check Chop Operation Between Amplifiers

a. Press the POWER switch to turn off the oscilloscope. Install a second vertical dual-trace plug-in unit in the center plug-in compartment and set its controls for dual-trace operation. Pull the POWER switch to on.

b. Turn the time-base Seconds/Div switch throughout its range.

c. Check—for two traces for each amplifier (one for each channel) at all sweep rates.

NOTE

If a single-channel amplifier is used instead of the second dual-trace amplifier, the single-channel trace will appear once per sweep.

7. Check Alternate Operation Between Amplifiers

a. Set the time-base Display pushbutton to Alternate and the Seconds/Div switch to 50 ms.

b. Check—for two traces for the left amplifier (one for each channel), then two traces for the right amplifier, alternately between amplifier units.

NOTE

If a single-channel amplifier is used instead of a second dual-trace amplifier in the right vertical compartment, the single channel trace will appear twice for each alternation between amplifier units. To check alternate operation for the right vertical compartment, press the POWER switch to turn off the oscilloscope and interchange the two vertical amplifiers in their respective compartments. Pull the POWER switch to on and check for two traces from the dual-trace amplifier in the right vertical compartment.

c. Press the POWER switch to turn off the oscilloscope.

d. Remove the vertical amplifier from the center compartment. A dual-trace amplifier should remain installed in the left vertical compartment (install if necessary).

e. Pull the POWER switch to turn on the oscilloscope.

Set the equipment controls as follows:

AMPLIFIER PLUG-IN

Display	On
CH 1 Volts/Div	1
CH 1 Cal	Fully Clockwise
CH 1 Input Coupling	dc
Trigger	CH 1
Mode	CH 1

TIME BASE PLUG-IN

Seconds/Div	1 ms
Seconds/Div Cal	Fully clockwise
Swp Mag	Off
Triggering	+ Slope, Auto Trig, ac couple
Triggering Source	Composite

8. Check Vertical Gain

a. Connect a 5 volt, 1 kilohertz square wave signal of standardized amplitude from the calibration generator to the CH 1 amplifier input, using a 42-inch coaxial cable.

b. Position the resultant 5-division display to a convenient, centered location on the graticule. Set the INTENSITY and FOCUS controls for a well-defined display of normal brightness.

c. Check—the display for a vertical deflection of 5 divisions ±0.15 division (±3%).

d. Press the POWER switch to turn off the oscilloscope and remove the amplifier from the left vertical compartment and install it in the center compartment. Pull the POWER switch to on.

e. Check—the display for a vertical deflection of 5 divisions ±0.15 division (±3%).

f. Disconnect the coaxial cable between the amplifier and calibration generator.

9. Check Vertical Bandwidth

a. Connect the sine-wave generator to the amplifier input with a 42-inch coaxial cable and 50 ohm termination.

b. Adjust the sine-wave generator controls for a 6-division display at a frequency of 50 kHz. Center the display on the graticule.

c. Without changing the output amplitude, increase the sine-wave generator frequency until the displayed amplitude is reduced to 4.2 divisions.

d. Check—the generator for a reading of at least 2 MHz.

e. Press the POWER switch to turn off the oscilloscope and install the amplifier in the left vertical compartment. Pull the POWER switch to on.

f. Repeat parts b through d for the left vertical compartment.

g. Disconnect the coaxial cable and termination from the amplifier input connector.

10. Check Horizontal Gain

a. Press the POWER switch to turn off the oscilloscope and interchange the amplifier and the time-base units in their respective compartments. Pull the POWER switch to on.

b. Connect a 5 volt, 1 kilohertz square-wave signal of standardized amplitude from the calibration generator to the amplifier input connector, using a 42-inch coaxial cable.

c. Position the 5-division display between the second and seventh vertical graticule lines.

d. Check—the display for a horizontal deflection of 5 divisions ±0.15 division (±3%).

e. Disconnect the coaxial cable between the amplifier and the calibration generator.

11. Check Horizontal Bandwidth

a. Connect the sine-wave generator to the amplifier input, using a 42-inch coaxial cable and 50 ohm termination.

b. Adjust the sine-wave generator controls for a 6-division display at a frequency of 50 kHz. Position the display between the second and eighth vertical graticule lines.

c. Without changing the output amplitude, increase the sine-wave generator frequency until the displayed amplitude is reduced to 4.2 divisions.

d. Check—the generator for a reading of at least 2 MHz.

e. Disconnect the coaxial cable and termination from the amplifier input connector.

12. Check X-Y Phase Difference

a. Press the POWER switch to turn off the oscilloscope.

b. Remove the time-base unit from the vertical compartment and install the second amplifier unit in the left vertical compartment.

NOTE

Identical amplifier units should be installed in the oscilloscope.

c. Connect the sine-wave generator through a 42-inch coaxial cable, 50 ohm termination, and a tee connector, to an amplifier input. Connect an 18-inch coaxial cable from the tee connector to the other amplifier input.

d. Pull the oscilloscope POWER switch to on.

e. Set both amplifier units for a deflection factor of 1 volt/division and dc input coupling.

f. Set the sine-wave generator for a 100-kilohertz output.

g. Adjust the vertical and horizontal position controls to center the diagonal display, then adjust the sine-wave generator for a display amplitude of 6 divisions vertically and horizontally.

h. Check—the opening of the diagonal-loop display at the graticule center line is 0.07 division or less (measure horizontally). This indicates a phase difference of 1° or less between the vertical and horizontal systems.

13. Check Z Axis Amplifier

a. Press the POWER switch to turn off the oscilloscope.

b. Disconnect the coaxial cables, termination and tee connector between the amplfiers and sine-wave generator.

c. Remove the vertical amplifier from the horizontal compartment and install the time-base unit in that compartment. Pull the oscilloscope POWER switch to on.

d. Set the time-base unit for auto, internal triggering at a sweep rate of 20 μs/division and set the amplifier for a deflection factor of 2 V/division.

e. Connect a 50 kHz sine-wave signal from the sine-wave generator through a 42-inch coaxial cable and a tee connector to the amplifier input.

f. Set the amplifier and sine-wave generator controls to obtain a calibrated 10 volt reference display (5 divisions of display).

g. Set the oscilloscope INTENSITY control for a dim display.

h. Connect the signal from the output of the tee connector at the amplifier input, to the EXT INTENSITY INPUT connector on the front panel.

i. Check—the top of the waveform is intensified and the bottom portion is blanked out.

j. Temporarily disconnect the coaxial cable at only the EXT INTENSITY INPUT connector.

k. Set the time-base unit for a sweep rate of 2 μs/division, and increase the output frequency of the sine-wave generator to 1 MHz.

l. Reconnect the coaxial cable to the EXT INTENSITY INPUT connector.

m. Check—for a noticeable effect of intensification in the top portion of the displayed waveform and blanking in the bottom portion of the waveform.

n. Disconnect the coaxial cables and tee connector from the amplifier and oscilloscope.

14. Check Calibrator Signal

a. Connect the 1X probe to the CH 1 input of the amplifier. Connect the probe tip to the CALIBRATOR loop.

b. Set the amplifier CH 1 Volts/Div switch to .1, and set the time-base sweep rate to 2 ms/division.

c. Check—the display for a vertical deflection of approximately 4 divisions.

d. Check—the display for approximately 2.5 cycles in 10 divisions (based on a line frequency of 60 Hz).

e. Disconnect the 1X probe.

This completes the Performance Check of the oscilloscope. If the instrument has performed as given in this procedure, it is correctly calibrated and within specifications.