Instruction Manual

Tektronix

TAS 455 & TAS 465
Analog Oscilloscopes

070-8523-05

Warning
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to the Safety Summary prior to performing service.
WARRANTY

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of three (3) years from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be 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 connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THIS PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX’ RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.
Preface

This is the Instruction Manual for the TAS 455 and TAS 465 Analog Oscilloscopes. This manual provides you with both operation and module-level service information.

Use the Introduction section to learn what the TAS 455 and TAS 465 Analog Oscilloscopes can do and about the available options and accessories.

Use the Getting Started section to learn about applying power. This section also contains brief examples of how to use the controls.

Use the Operation section to learn about each of the front panel controls and how to perform certain tasks to help you understand typical steps involved to obtain stable, usable displays and take measurements.

Use the Specifications section as a reference for all nominal, warranted, and typical characteristics for the TAS 455 and TAS 465 Analog Oscilloscopes.

Use the Theory section to help you understand the operation of the oscilloscope to the block level.

Use the Performance Verification section to verify the functionality and warranted characteristics of the oscilloscope.

Use the Adjustment section to bring the TAS 455 and TAS 465 Analog Oscilloscopes into conformance with the warranted characteristics listed in the Specifications section. You should adjust the oscilloscope if indicated by the Performance Verification procedures.

Use the Maintenance section to learn how to perform general maintenance and troubleshoot your instrument to the module level. Procedures to replace mechanical parts and electrical modules are also located in this section.

Use the Replaceable Parts section for a list of the mechanical parts and modules.

Use the Appendices section to learn about each of the menus. The Appendices also contains a list of the controls affected when using the AUTOSET feature.
Related Manuals

Other documentation for the TAS 455 and TAS 465 Analog Oscilloscopes include:

- The *Reference* (Tektronix part number 070–8522–XX) gives you a quick overview of how to operate your TAS 400 Series Analog Oscilloscopes.

- The *Service manual* (Tektronix part number 070–8524–XX) provides extended service information not contained in the Instruction manual. Items included are a detailed Theory of Operation, Schematics, and a complete electrical and mechanical parts list.

- The *XYZs of Analog and Digital Oscilloscopes* (Tektronix part number 070–8690–XX) provides you with a basic understanding of oscilloscopes and their use.
Safety Summary

Please take a moment to review these safety precautions. They are provided for your protection and to prevent damage to the oscilloscope. This safety information applies to all operators and service personnel.

Symbols and Terms

These two terms appear in manuals:

- **CAUTION** statements identify conditions or practices that could result in damage to the equipment or other property.

- **WARNING** statements identify conditions or practices that could result in personal injury or loss of life.

These two terms appear on equipment:

- **CAUTION** indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

- **DANGER** indicates a personal injury hazard immediately accessible as one reads the marking.

This symbol appears in manuals:

![Static-Sensitive Devices](image)

These symbols appear on equipment:

- **DANGER** High Voltage
- **Protective ground (earth) terminal**
- **ATTENTION** Refer to manual
Specific Precautions

Observe all of the following precautions to ensure your personal safety and to prevent damage to either the TAS 455 and TAS 465 Analog Oscilloscopes or equipment connected to them.

Do Not Perform Service While Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections or components while power is on. Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

The TAS 455 and TAS 465 Analog Oscilloscopes are intended to operate from a power source that will not apply more than 250 V_{RMS} between the supply conductors or between either supply conductor and ground. A protective ground connection, through the grounding conductor in the power cord, is essential for safe system operation.

Grounding the Oscilloscope

The TAS 455 and TAS 465 Analog Oscilloscopes are grounded through the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle where earth ground has been verified by a qualified service person. Do this before making connections to the input or output terminals of the oscilloscope.

Without the protective ground connection, all parts of the TAS 455 and TAS 465 Analog Oscilloscopes are potential shock hazards. This includes knobs and controls that may appear to be insulators.

Use the Proper Power Cord

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified in the parts list for your product. It must be identical in type, voltage rating, and current rating.
Do Not Remove Covers or Panels

To avoid personal injury, do not operate the TAS 455 or TAS 465 without the panels or covers.

Do Not Operate in Explosive Atmospheres

The TAS 455 or TAS 465 provide no explosion protection from static discharges or arcing components. Do not operate the TAS 455 or TAS 465 in an atmosphere of explosive gasses.

Electric Overload

Never apply a voltage to a connector on the TAS 455 or TAS 465 that is outside the range specified for that connector.
Your Tektronix TAS 455 and TAS 465 Analog Oscilloscopes are superb tools for processing and displaying electrical signals. Their performance addresses the needs of both benchtop and portable applications with the following features:

- 60 MHz minimum bandwidth (TAS 455)
  100 MHz minimum bandwidth (TAS 465)

- Two-channel input

- Complete cursor measurement system
  - Voltage
  - Time
  - Frequency
- Delayed time base
- AUTOSET feature
- Front panel setup memory
- External trigger input
The features of the TAS 455 and TAS 465 Analog Oscilloscopes are briefly described here to help get you acquainted with the operating systems.

**User Interface**

This oscilloscope uses a combination of front-panel buttons, knobs, and on-screen menus to control its many functions. The front-panel controls are grouped according to function: vertical, horizontal, trigger, and special. Within each group, any function adjusted often, such as vertical positioning or the time base setting, is set directly by its own front-panel control.

**AUTOSET**

The AUTOSET button provides you with a usable, triggered display of a signal applied to an input channel. Many instrument controls and menus are set to a pre-defined state, providing you with a known starting point for your measurements. Page A-9 lists the actions taken by pressing the AUTOSET button.

**Menus**

Those functions for which control settings changed less often, such as vertical coupling and trigger mode, are set indirectly. That is, pressing a front-panel button, such as VERTICAL MENU, displays a menu of functions at the bottom of the screen related to that button. (For the button VERTICAL MENU, the menu displayed contains functions such as coupling and bandwidth.) The buttons below this main menu select a function, such as coupling and displays a sub menu of settings for that function, such as DC, AC, or GND, at the right side of the screen. The buttons to the right of the menu select a setting, such as DC.

**General Purpose Knob and TOGGLE**

Some menus assign the General Purpose Knob to a selected adjustment. The method employed is the same as for selecting a function, except the final selection in the side menu causes the General Purpose Knob to adjust some function, such as the position of measurement cursors on screen. Pressing the CLEAR MENU button clears the assignment of the General Purpose Knob except when assigned to adjust cursors or delay time.

The TOGGLE button works in conjunction with the General Purpose Knob when positioning cursors. Each press of the TOGGLE button switches which cursor is active, and therefore controlled by the General Purpose Knob.

**Save/Recall Setups**

You can store up to four complete front panel setups in memory. Once you complete a complex setup and then save it in one of the four memory locations, you can retrieve it at any time. Saved front panel settings do not include the assignment of the General Purpose Knob.
Vertical System

The vertical system provides two vertical channels with calibrated vertical scale factors from 2 mV to 5 V per division.

Both channels can be displayed, vertically positioned, bandwidth limited (to either Full or 20 MHz), inverted, and vertical coupling specified.

Besides the two channels, a math waveform is available for display. (A math waveform results when you add the two channels.)

Horizontal System

There are three horizontal display modes: main, delayed, and XY.

The main display is the standard horizontal display mode with calibrated sec/div scales.

The delayed display can be delayed by time with respect to the main trigger. The delayed display can also be set to display at the first valid trigger after the delay. The delayed display also has a calibrated sec/div scale.

XY mode is useful to measure the phase difference of two signals.

Trigger System

The triggering system comprises a complete set of features for triggering the horizontal system. You can configure trigger for source, slope, coupling, mode, and holdoff. Video triggers are available for triggering on video signals.

You can adjust the trigger level or automatically set it to 50% of the trigger signal with the press of a button.

Measurement Cursors

Once you have set up to take your measurements, the cursors can help you take those measurements quickly.

The TAS 455 and TAS 465 Oscilloscopes have two types of cursors for taking measurements on the displayed waveforms: delta (difference) and absolute. The General Purpose Knob controls the placement of the cursors. The TOGGLE button selects which cursor is active.

Delta voltage measures the voltage between the horizontal bar cursors. Delta time measures the time between vertical bar cursors. These are delta measurements; that is, measurements based on the difference between two cursors.

Absolute voltage measures the voltage position of a single horizontal bar cursor. The displayed voltage level readout is made with respect to the ground reference level of the channel.
The bar cursors remain displayed even if you change the function of the General Purpose Knob. This allows you to use them as reference points or markers to easily identify if measurement signals remain within the parameters set by the cursors. Remove the cursor display by turning the cursor measurement off.

Options

Several options are available for the TAS 455 and TAS 465 Analog Oscilloscopes. A description of each option follows.

Options A1—A5: International Power Cords

Besides the standard North American, 110 V, 60 Hz power cord, Tektronix ships any of five alternate power cord configurations. See Table 1-1.

<table>
<thead>
<tr>
<th>Option</th>
<th>Power Cord</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Universal European — 220 V, 50 Hz</td>
</tr>
<tr>
<td>A2</td>
<td>UK — 240 V, 50 Hz</td>
</tr>
<tr>
<td>A3</td>
<td>Australian — 240 V, 50 Hz</td>
</tr>
<tr>
<td>A4</td>
<td>North American — 240 V, 60 Hz</td>
</tr>
<tr>
<td>A5</td>
<td>Switzerland — 220 V, 50 Hz</td>
</tr>
</tbody>
</table>

Warranty-Plus Service Options

The following options add to the services available with the standard warranty. (The standard warranty appears following the title page in this manual.)

- **Option M2**: Tektronix provides five years of warranty/remedial service.
- **Option M3**: Tektronix provides five years of warranty/remedial service and four oscilloscope calibrations.
- **Option M8**: Tektronix provides four calibrations and four performance verifications, one of each in the second through the fifth years of service.

Option 3R: Rackmounted

With this option, Tektronix ships the oscilloscope with a rackmount kit, providing all the necessary hardware to adapt the oscilloscope for installation into a standard 19 inch instrument rack. Customers with instruments can order a rackmount kit (Tektronix part number 016—1166—00) for conversion with instructions.
Option 02: Front Cover and Pouch

With this option, Tektronix ships a protective front cover to prevent damage to the front panel of the oscilloscope while not in use. An attachable pouch (attaches to the instrument top) provides storage for the manuals and probes supplied with your oscilloscope plus other additional accessories you may want to keep with your oscilloscope.

Option 23: Additional Probes

With this option, Tektronix ships two P6129B 1X — 10X switchable passive probes in addition to the two standard-accessory P6109B probes normally shipped with the instrument.

Option 9C: Certificate of Calibration and Test Data Report

Tektronix ships a Certificate of Calibration that states this instrument meets or exceeds all warranted specifications and has been calibrated using standards and instruments whose accuracies are traceable to the National Institute of Standards and Technology, an accepted value of a natural physical constant or a ratio calibration technique. The calibration is in compliance with U.S. MIL-STD-45662A. This option also includes a test data report for the instrument.

Accessories

This section provides a list of both standard and optional accessories for the TAS 455 and TAS 465 Analog Oscilloscopes.

Standard Accessories

Table 1-2 lists the standard accessories included with the TAS 455 and TAS 465 Analog Oscilloscopes.

<table>
<thead>
<tr>
<th>Accessory</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction Manual</td>
<td>070-8523-XX</td>
</tr>
<tr>
<td>Reference</td>
<td>070-8522-XX</td>
</tr>
<tr>
<td>XYZs of Analog and Digital Oscilloscopes</td>
<td>070-8690-XX</td>
</tr>
<tr>
<td>U.S. Power Cord</td>
<td>161-0230-01</td>
</tr>
<tr>
<td>Fuse (250 V, 3 A Fast)</td>
<td>159-0277-00</td>
</tr>
<tr>
<td>Probes (quantity two), 10X Passive; 100 MHz</td>
<td>P6109B (single unit)</td>
</tr>
<tr>
<td>P6109B Probe Manual</td>
<td>070-7849-XX</td>
</tr>
</tbody>
</table>
### Optional Accessories

Table 1-3 lists a few of the optional accessories available for use with the TAS 455 and TAS 465 Analog Oscilloscopes.

<table>
<thead>
<tr>
<th>Accessory</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscilloscope Cart</td>
<td>K212</td>
</tr>
<tr>
<td>Rack Mount Kit (for field conversion)</td>
<td>016-1166-00</td>
</tr>
<tr>
<td>Service Manual</td>
<td>070-8524-XX</td>
</tr>
<tr>
<td>Accessory Pouch</td>
<td>016-1159-00</td>
</tr>
<tr>
<td>Fuse (250 V, 1.5 A Fast for Serial Number B020099 and below)</td>
<td>159-0311-00</td>
</tr>
<tr>
<td>Fuse (250 V, 3.15 A Fast)</td>
<td>159-0190-00</td>
</tr>
<tr>
<td>Front Cover</td>
<td>200-3232-00</td>
</tr>
<tr>
<td>Oscilloscope Camera</td>
<td>C-9 Option 06</td>
</tr>
<tr>
<td>Oscilloscope Camera Adapter</td>
<td>016-1154-00</td>
</tr>
<tr>
<td>Soft-sided Carrying Case</td>
<td>016-1158-00</td>
</tr>
<tr>
<td>Transit Case</td>
<td>016-1157-00</td>
</tr>
</tbody>
</table>

User manuals for the TAS 455 and TAS 465 Oscilloscopes and the XYZs of Analog and Digital Oscilloscopes are available in several languages. Table 1-4 provides a list of these manuals.

### Table 1-4: Available Languages

<table>
<thead>
<tr>
<th>Manual</th>
<th>Language</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAS 455 and TAS 465 Analog Oscilloscopes User Manual</td>
<td>French</td>
<td>070-8830-XX</td>
</tr>
<tr>
<td></td>
<td>Spanish</td>
<td>070-8828-XX</td>
</tr>
<tr>
<td></td>
<td>German</td>
<td>070-8829-XX</td>
</tr>
<tr>
<td>XYZs of Analog and Digital Oscilloscopes</td>
<td>French</td>
<td>070-8070-XX</td>
</tr>
<tr>
<td></td>
<td>Spanish</td>
<td>070-8071-XX</td>
</tr>
<tr>
<td></td>
<td>German</td>
<td>070-8071-XX</td>
</tr>
</tbody>
</table>
Accessory Probes

The following is a list of optional accessory probes to enhance the use of your oscilloscope:

- P6046 Active, differential probe, 100 MHz
- P6007 Passive, high voltage probe, 100X, 1500 VDC + Peak AC
- P6015A Passive high voltage probe, 1000X, 20 kVDC + Peak AC (40 kV peak for less than 100 ms)
- P6101B 1X, 15 MHz, Passive probe
- P6129B 1X — 10X switchable, 100 MHz, Passive probe
- P6408 20 MHz, 17 bit, Word Recognizer/Logic probe
- TVC 501 Time-to-Voltage Converter (time delay, pulse width, and period measurements)
- P6021 AC Current probe, 120 Hz to 60 MHz
- P6022 AC Current probe, 935 kHz to 120 MHz
- AM 503S — DC/AC Current Probe System, AC/DC (uses A6302 Current Probe)
Power On

Before you begin using the TAS 455 and TAS 465 Analog Oscilloscopes, ensure proper installation.

Installation

Perform this procedure to properly install and power on the TAS 455 and TAS 465 Analog Oscilloscopes.

1. Check that you have the proper electrical connections. The rear label lists power requirements for all possible voltage inputs.

2. For serial numbers B020099 and below, check that the Line Voltage Range switch (Figure 2-1) is at the proper setting for your power system. For serial numbers B020100 and above, no line voltage setting is required.

3. Check the fuse to ensure it is the proper type and rating (the rear panel provides you with this information). The TAS 455 and TAS 465 Analog Oscilloscopes are shipped with the UL approved fuse installed. Figure 2-2 illustrates how to open the fuse drawer.

4. Connect the proper power cord from the rear-panel power connector (Figure 2-1) to the power system.

![Figure 2-1: Rear Panel for B020099 and Below](image)

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2-1
5. Be sure you have the appropriate operating environment. Specifications for temperature, relative humidity, altitude, vibrations, and emissions are in Section 4, Specifications.

6. Leave space for cooling. Do this by verifying that the air intake and exhaust holes on the sides of the cabinet are free of any airflow obstructions. Leave at least 5.1 cm (2 in.) free on each side.

7. Press the POWER button to power on the oscilloscope.
Quick Start

This section helps you get acquainted with basic controls and operating systems of the TAS 455 and TAS 465 Analog Oscilloscopes once you have power applied. Review At a Glance in Section 3 if you want an overview of all controls and connectors.

Selecting and Deselecting Input Channels

The TAS 455 and TAS 465 Oscilloscopes have two input channels. You can display the channels separately or simultaneously. The following steps demonstrate how to select and deselect channels for display.

1. Power on the oscilloscope and wait for the self tests to complete.
2. Press the CH 1 button located on the front panel. The CH 1 indicator lights, channel 1 is displayed, and vertical controls and menus are assigned to channel 1.
3. Press the CH 2 button located on the front panel. The CH 2 indicator lights, channel 2 is displayed, and controls and menus are assigned to channel 2.
4. Press the CH 1 button, assigning control to channel 1.
5. Press the WAVEFORM OFF button, removing channel 1 from the display and leaving channel 2 displayed.

Using the Menus

The TAS 455 and TAS 465 Oscilloscopes use menus for many instrument settings. In the following steps, you will set only channel 1 on and turn the cursors on.

1. Press the WAVEFORM OFF button until only channel 1 is displayed.
2. Press the CURSOR menu button.
3. Set the delta volts (ΔVOLT) cursors on (using the following guide).
Quick Start

4. Now two horizontal bar cursors are displayed. The active (movable) one is a solid line and the inactive one is a dashed line. Use the General Purpose Knob to move the active cursor and use the TOGGLE button to select which cursor is active.

Connecting a Signal

The TAS 455 and TAS 465 Oscilloscopes accept signals through the front panel input connectors labeled CH 1 and CH 2. The probes you use for taking measurements should only be those supplied with the TAS 455 and TAS 465 Oscilloscopes. Connecting signals to the TAS 455 and TAS 465 Oscilloscopes is also possible with the use of 50 Ω coaxial cables.

Before using any probe to take measurements, compensate the probe to match the input channel. See Compensating the Probe on page 2-5.

Using AUTOSET

The AUTOSET feature of the TAS 455 and TAS 465 Oscilloscopes automatically sets most of the front panel controls.

1. Connect the probe compensation signal (from the PROBE COMP connector on the front panel) to either channel of the oscilloscope and display that channel (see Figure 2-5). Turn all other channels off.

2. Press the AUTOSET button on the front panel. Wait one to three seconds to allow the instrument to adjust all the control settings.

The instrument will trigger on the waveform, display at least one complete cycle, and center it horizontally on the CRT. The baseline of the waveform will be at the center horizontal graticule line. The intensity level is increased if set too low for a viewable display.

See Table A-2 on page A-9 for a complete list of AUTOSET default control settings.
Compensating the Probe

Passive probes require compensation to ensure maximum distortion-free input to the TAS 455 and TAS 465 Oscilloscopes. Before taking any measurements using a probe, first check the compensation of the probe and adjust it to match the channel inputs. The signal source for this check is the front-panel PROBE COMP signal (Figure 2-5).

1. Attach the probe to either the CH 1 or CH 2 input connectors along the lower right of the front panel.

2. Attach the probe tip to the PROBE COMP connector.

Figure 2-5: Connections for Compensating a Probe
Quick Start

3. Select the appropriate input channel, channel 1 or channel 2, by pressing the CH 1 or CH 2 front-panel button.

4. With the probe attached between an input channel and the probe compensation output of the oscilloscope, press the AUTOSET button on the front panel.

5. Set the vertical scale to 1 V using the VOLTS/DIV control.

6. Center the waveform vertically using the vertical POSITION control.

7. Set the horizontal scale to 200 µs using the SEC/DIV control.

8. Set the trigger coupling to Noise Reject (use the following guide).

9. Set the vertical bandwidth to Full (use the following guide).

10. Check that the displayed waveform is a square wave with flat tops and bottoms. See Figure 2-6 for illustrations indicating proper and improper probe compensation.
Quick Start

Probe Compensated Correctly

Probe Over Compensated

Probe Under Compensated

Figure 2-6: How Probe Compensation Affects Signals

11. Adjust the low frequency compensation adjustment, located in the probe body, for the best possible square wave. See Figure 2-7 for the location of the low frequency adjustment.

Figure 2-7: Location of Probe Head Adjustment
Adjusting Your Display Environment

You need to consider three oscilloscope operating systems to obtain the best possible display. AUTOSET adjusts many of these features for you with the press of a button.

**Vertical System**

You can change the vertical components of the displayed waveform by adjusting several features of the vertical operating system. Consider the following when setting up the vertical system for display:

- Vertical scale (volts/div)
- Input coupling
- Signal invert
- Input bandwidth

**Horizontal System**

You can change the horizontal components of the displayed waveform by adjusting several features of the horizontal operating system. Consider the following when setting up the horizontal system for display:

- Horizontal scale (sec/div)
- Magnification

**Trigger System**

You can modify the triggering system in a variety of ways to create the best possible triggered display, depending on the components of the input waveform. Consider the following when setting up the triggering system:

- Mode
- Source
- Coupling
- Slope
At a Glance

The TAS 455 and TAS 465 Oscilloscopes were designed for ease of use. To reduce the clutter of knobs and buttons on the front panel, many instrument control functions are now menu driven. The menus access instrument functions typically set once before taking measurements. The front panel controls access instrument functions you might need to adjust during measurements.

The menus are easy to use. For example, pressing the VERTICAL MENU button displays the menu choices for the vertical operating system.

This section of the manual illustrates each control and connector and contains a brief description of its use or function. Figure 3-1 shows the front panel of the TAS 465 Analog Oscilloscope.

Figure 3-1: The TAS 465 Analog Oscilloscope Front Panel
Power and Display Controls

The power and display controls allow you to cycle the power on and off and adjust the CRT display.

The TRACE ROTATION control is a screwdriver adjustment that aligns the CRT sweep to the horizontal graticule lines.

The power switch cycles the instrument power on and off. Front-panel settings existing prior to power off return at power on.

The INTENSITY control adjusts the brightness of the main sweep. The intensity ratio between the main sweep and delayed sweep is set in the Utility menu (see page A-7).

The SCALE ILLUM control adjusts the illumination level of the graticule lights.

The FOCUS control sharpens all displays.

The READOUT control adjusts the brightness of the readout displays (menus, readouts, and cursors).
Menu Select Buttons  Use the menu buttons to choose corresponding items from the menus when displayed.

The submenu buttons select items from a corresponding list on the display.

The CLEAR MENU button clears the displayed menus.

The main menu buttons select items from a corresponding list on the display.
Signal Inputs and Outputs

Use the input connectors to apply signals to the TAS 455 and TAS 465 Oscilloscopes. The outer contact rings on the **CH 1**, **CH 2**, and **EXT TRIG** connectors recognize attenuation factors of coded attenuator probes. A probe compensation signal and a chassis ground contact are also provided.

- **The PROBE COMP signal** provides a 5 V, 1 kHz square wave signal (into a 1 MΩ load) for compensating voltage probes. See page 2-5 for further information.

- **This connector provides contact with the chassis ground.**

- **The CH 1 input connector** connects signals to the input of the channel 1 vertical system.

- **A signal connected to the CH 1 input connector produces the horizontal deflection (X-axis) when horizontal mode XY is selected.**

- **The CH 2 input connector** connects signals to the input of the channel 2 vertical system.

- **A signal connected to the CH 2 input connector provides the vertical deflection (Y-axis) when horizontal mode XY is selected.**

- **The EXT TRIG input connector** allows the application of an external signal to use as the trigger source rather than a trigger signal generated from a vertical input channel. The input coupling is DC and the attenuator factor can be set to either 1 or ±10.

- **The EXT Z AXIS IN connector** allows the application of an external signal to modulate the display intensity.
Vertical Controls

Use the vertical controls to access the features of the vertical operating system.

The POSITION control vertically adjusts the position of the selected waveform display. Position the waveform created with the ADD function by positioning the added channels.

The VERTICAL MENU button displays the menu items for either the channel 1 or channel 2 vertical system. The menu displayed is dependent on the channel select buttons. See page 3-9 for menu choices.

The VOLTS/DIV control selects calibrated deflection factors for the channel 1 and channel 2 input channels.

The VOLTS/DIV control settings displayed in the CRT readout reflect the deflection factors. The volts/div readout reflects the deflection factor of coded probes.

The WAVEFORM OFF button removes the selected waveform from the display. The LED for that channel will be turned off. The channel label for that channel will be replaced with OFF. Turning the waveform off for one channel will automatically cause the oscilloscope to switch functions to a remaining channel. Channel 1 will remain selected when all others are turned off unless the ADD function is on.

The channel select buttons determine which channel is currently selected for control. A lighted LED next to the channel button indicates the selected channel. Multiple channels may be displayed but only one channel may be controlled at a time.

The ALT/CHOP ADD button displays the menu choices for multiple channel display and math operations. See page 3-9 for menu choices.
Horizontal Controls

Use the horizontal (sweep) controls to access the features of the horizontal system for both the main and delayed sweeps.

The horizontal POSITION control adjusts the horizontal position of the displayed waveforms.

The SEC/DIV control selects the horizontal deflection rate (sweep speed) for both the main sweep or the delayed sweep.

The calibrated main sweep speed is selectable from 0.5 s to 20 ns per division.

The calibrated delayed sweep speed is selectable from 5 ms to 20 ns per division.

The MAIN/Delay SELECT button assigns the horizontal controls to either the main or delayed sweep.

The HORIZONTAL MENU button displays menu choices for the horizontal operating system. See page 3-9 for menu choices.

The MAG button magnifies the main and delayed sweeps by a factor of 10. When on, the sec/div readouts reflect the correct sweep speeds and the $\times$ symbol appears next to the sec/div readouts.
Trigger Controls

The trigger controls provide access to the features of the trigger system for both the main and delayed sweeps.

The MAIN/Delay SELECT button assigns the trigger controls to either the main or delayed sweep.

The LEVEL control sets the amplitude level for the trigger circuitry. Its value is displayed in the readout. The sweep triggers when the amplitude level is reached. A trigger level indicator appears on the display while changing the level and disappears after about five seconds of no level changes.

The MAIN SWP TRIG'D indicator lights when the sweep is triggered.

The READY indicator lights when the single-sequence mode is ready to accept a triggering event.

The SET LEVEL TO 50% button automatically sets the trigger level to the mid point of the trigger source signal.

The TRIGGER MENU button displays menu choices for the trigger system. The TRIGGER MENU button displays menus for either the main sweep or the delayed sweep, depending on the selection of the MAIN/Delay SELECT button. See page 9-9 for menu choices.

The RESET S SEQ button enables the trigger circuit to receive another trigger event. RESET S SEQ functions only when the trigger mode is set to single sequence.
Miscellaneous Controls

The buttons described here either have a relationship with many instrument functions or perform specific tasks.

The TOGGLE button selects which cursor the General Purpose Knob controls.

The AUTOSET button sets the front-panel controls to obtain a usable display of an applied signal for all channels displayed.

The UTILITY button displays menus used to configure operating systems and perform calibration routines. See page 3-9 for menu choices.

The SAVE/RECALL SETUP button displays menus that allow four complete front-panel setups to be stored for later recall. See page 3-9 for menu choices.

The CURSOR button displays the measurement cursors. Use the General Purpose Knob to position the cursors. See page 3-9 for menu choices.

The General Purpose Knob is assigned to various operations, depending on the last applicable menu operation:

- Positioning cursors
- Adjusting time for delay events
- Variable volts/div and sec/div
- Delayed trace separation
- Calibration routines

If no menu is visible, the knob controls the last applicable menu selection.
Menu Map

Figure 3-2 is a complete map of the menus; it will help you locate menu driven functions and their available settings. Refer to Detailed Menu Descriptions, beginning on page A-1, for operating information about each menu.

Main Mode
Select LED on

- Auto
- Auto Level
- Normal
- Single Sequence
- Video Line
- Video Field
- odd even both

Trigger Menu
Button
- MODE
- SRC
- CPLG
- SLOPE
- HOLDOFF

- SELECT toggles between Main and Delay modes

Delay Mode
Select LED off

- Runs After
- Trig After
- Video Line

Trigger Menu
Button
- MODE
- SRC
- CPLG
- SLOPE

- DC
- Noise Reject
- HF Reject
- AC
- LF Reject

- Rising
- Falling

Select toggles between Main and Delay modes

Figure 3-2: Menu Map
**Readout Display**

The CRT displays information about instrument settings, menus, and measurement values. Figure 3-3 illustrates where on the CRT you can find the information. Figure 3-4 illustrates the types of indicators that appear on screen and what they mean. Figure 3-5 illustrates the waveform reference indicators and measurement cursors.

1**GPK** is the abbreviation for General Purpose Knob.

*Figure 3-3: Readout Display Map*
Figure 3-4: Readout Indicators
Figure 3-5: Waveform References
Using Basic Features

This section provides step-by-step instructions for using several basic features of the TAS 455 and TAS 465 Analog Oscilloscopes.

Displaying Repetitive Signals

Repetitive signals have a recurring pattern, where the amplitude and frequency do not change from one cycle to the next. The following steps describe how to display a repetitive signal, although pressing the AUOTSET button performs these tasks for you.

1. Adjust the vertical POSITION control to display the waveform at vertical center and the VOLTS/DIV control to provide the resolution desired.

2. Press the TRIGGER MENU button and set your triggering environment as desired from the menu choices.

3. Press the VERTICAL MENU button and set your vertical environment as desired from the menu choices.

4. Adjust the horizontal POSITION control to center the display horizontally and adjust the SEC/DIV control to display at least one complete cycle of the waveform.

Magnifying Your Signal

The MAG button horizontally magnifies the sweep by a factor of ten. This can be very useful in viewing a fast signal transition.

1. Connect the probe to the PROBE COMP output on the front panel and press AUTOSET.

2. Adjust the volts/div scale to obtain one complete cycle of the waveform for every horizontal division.

3. Press the MAG button, expanding the waveform horizontally by a factor of ten.

Take all measurements as usual, noting that the displayed readout for the sec/div scale has now increased by a factor of ten and the $\frac{1}{10}$ indicator appears next to the sec/div scale. Refer to Figure 3-6.
Displaying Video Signals

Video signals contain both horizontal and vertical sync pulses. The trigger system has modes to identify either of these pulses and produce a trigger.

1. Set the trigger mode to video line or video field (use the following guide).

2. Set the SRC to the appropriate trigger source.

3. Set the SLOPE to Falling for a standard composite video signal. Select Rising for inverted video signals.

4. Set the vertical and horizontal controls to produce the desired display. Figure 3-7 illustrates a typical triggered TV signal.
Using Single Sequence

The single sequence trigger mode allows one sweep of all displayed channels to occur for each trigger event. Another sweep cannot occur until the trigger circuit is re-armed.

Use single sequence mode to display and photograph either nonrepetitive signals or signals that cause unstable displays.

1. Set the vertical and horizontal controls as desired.

2. Press the TRIGGER MENU button to display the trigger menu choices and set the MODE to Single Sequence (use the following guide).

3. Set the readout and cursors display options by pressing the UTILITY button and selecting the appropriate choices with the menu select buttons. See page A-7 for a description of the utility menus.

4. Press the RESET S SEQ button, lighting the READY LED. The LED will remain lit until the instrument receives an appropriate trigger signal.

The MAIN SWP TRIG'D LED lights to indicate an adequate trigger signal is present for the main sweep.
Performing Waveform Math

The TAS 455 and TAS 465 Oscilloscopes provide a feature that allows you to add two separate signals, creating a third signal. With this feature you can see the results of adding two signals together or removing unwanted components of a signal. A $+$ symbol appears to the left of the channel 2 readout when add mode is on.

This procedure demonstrates how to use the add feature of the TAS 455 and TAS 465 Oscilloscopes by solving a common problem of having an AC line-frequency component mixed with another signal.

1. Using channel 1, obtain the signal containing the unwanted AC line-frequency component mixed with another signal.
2. Using channel 2, obtain the AC line-frequency component only.
3. Invert the channel 2 signal (use the following guide). The invert indicator \( \_ \) appears in the channel 2 readout display.
4. Set add mode to on (use the following guide).

The instrument displays a third waveform that shows the result of adding the two waveforms together. Figure 3-8 shows an example of subtracting (using invert) waveforms.

Vertical position of the added waveform is affected by the vertical position of the added channels.
Using the Delayed Sweep with Delayed Triggering

Delayed triggering allows you to set a time delay from the triggering event for the main sweep to start the delayed sweep. This enables you to effectively increase the resolution of a portion of the main sweep by displaying a segment of the main sweep using the delayed sweep.

1. Connect CH 1 to the PROBE COMP signal using the standard accessory probe.
2. Press the AUTOSET button.
3. Use the SEC/DIV control to set the sec/div scale to 2 ms.
4. Turn the delayed sweep on (use the following guide).
This extinguishes the LED for the MAIN/DELAY SELECT button, indicating that the trigger and horizontal controls are now assigned to the delayed sweep.

**NOTE**

_The intensity ratio between the two sweeps can be set to help differentiate between them. See the Utility functions on page A-7 to set this ratio._

5. Press the **UTILITY** button and select **CONFIG** from the main menu.

6. Select **MORE** until you can select the intensity level ratio for the delayed sweep (use the following guide).

7. Adjust the trace separation to vertically separate the main and delayed sweeps (use the following guide).
8. Set the trigger mode to runs after (use the following guide).

This causes the delayed sweep to start after the time delay setting regardless of a trigger.

9. Use the SEC/DIV control to set the delayed sec/div scale to 200 μs.

10. Adjust the delay time (move the intensified zone) using the General Purpose Knob. Use the following guide.

You now have a display that consists of the main sweep with an intensified portion and a delayed sweep of the intensified portion (see Figure 3-9).

**NOTE**

You cannot set the delayed sweep sec/div scale to a slower speed than the main sweep. When the delayed sweep scale matches the main sweep scale, further reduction of the delayed sweep scale also affects the main sweep scale. When the main sweep scale matches the delayed sweep scale, further increases of the main sweep scale also affects the delayed sweep scale.
Using Basic Features

**Figure 3-9: Using the Delayed Sweep**

11. Set the trigger mode to trig after, causing the delayed sweep to start after the delay setting and an appropriate trigger (use the following guide).

At this point, the two waveforms are still displayed, since an appropriate trigger signal is available. Adjusting the trigger LEVEL control out of the range of the waveform causes the delayed sweep to stop, since an appropriate trigger signal is no longer available.

**Using Dual Delay**

Dual delay displays two intensified zones on the main sweep, each defining the start point of a delayed sweep. This method more accurately measures time between two points on the main sweep than obtained with the measurement cursors.

1. Set the trigger mode to runs after (use the following guide).
2. Press the **UTILITY** button and select **CONFIG** from the main menu.

3. Select **MORE** until you can select **Dual Delay Enabled** (use the following guide).

4. Press the **CURSOR** button and set **TIME** to **On** (use the following guide).

   Notice that turning a measurement cursor on automatically turns a previously selected measurement cursor off.

5. Set the delay sec/div scale to 100 μs.

   You now have two intensified zones displayed on the main sweep.

6. Adjust the position of the intensified zones using the General Purpose Knob. Use the **TOGGLE** button to select which zone to move.
Notice that the delayed sweep now consists of two delayed sweeps, each representing one of the intensified zones. When the two delayed sweeps appear as one, the intensified zones are at exactly the same position of the cycle of the main sweep. Figure 3-10 shows the intensified portions on the main sweep and the delayed sweeps positioned together.

![Intensified Portions of the Main Sweep are the Delayed Sweeps](image)

Figure 3-10: Using Dual Delay

---

**Saving and Recalling Front Panel Setups**

The TAS 455 and TAS 465 Oscilloscopes provide four locations for you to store front-panel settings. This feature is very helpful when you have completed a complex front panel setup and you want to be able to recall the setup later.

**Saving a Setup**

Use this procedure to save a front-panel setup.

1. Press the **SAVE/RECALL SETUP** button to display the setup menu.
2. Select **SAVE** and memory location 1, placing the setup in memory location one (use the following guide).

**NOTE**

*Selecting a location previously used will replace the old settings with the new settings. Setup locations underscored contain a stored front-panel setup.*
Once you have saved a particular front-panel setup, you can change the settings as you wish, knowing that you can retrieve the original setup at any time.

**Recalling a Setup**

Use this procedure to recall a front-panel setup.

1. Press the SAVE/RECALL SETUP button to display the setup menu.
2. Select RECALL with the menu buttons.
3. Select the location from which you want to retrieve the front-panel settings (setup 1 through setup 4). Setup locations underscored contain a front-panel setup.

The oscilloscope returns the front-panel settings to those in the selected setup location.

**Erasing a Setup**

If you wish, you can erase any setup location.

1. Press the SAVE/RECALL SETUP button to display the setup menu.
2. Select ERASE with the menu buttons.
3. Select the location you wish to erase (setup 1 through setup 4). Setup locations underscored contain a front-panel setup.

The selected setup location is now empty.
Taking Measurements

This section provides procedures for taking several different types of measurements related to time and voltage. Since the cursor measurement system takes measurements easily and quickly, all measurements discussed in this section use the cursors.

Taking Time Related Measurements

You can take frequency, period, and time between event measurements with the cursor measurement system. The following procedures provide you with quick and easy methods to take these measurements.

Measuring the Frequency and Period

Measuring the frequency and period of a waveform are both time related measurements. You measure frequency in hertz (Hz) and period in seconds.

1. Obtain a stable display with at least one complete cycle of the waveform displayed.

2. Turn the $1/\Delta t$ cursors on to measure frequency (use the following guide).

3. Using the General Purpose Knob, move the active cursor along the waveform to a starting point for the measurement. A good place for this first cursor is midway on the rising portion of the waveform.

4. Press the TOGGLE button to activate the second cursor. Using the General Purpose Knob, move this second cursor to the same position on the waveform that is one complete cycle away. See Figure 3-11 for placement of cursors.

5. After you place the cursors, read the frequency of the waveform displayed in Hz on the CRT.
6. Change the displayed measurement from frequency to time by turning the \( \Delta \text{TIME} \) cursors on (use the following guide).

\[ \text{NOTE} \]

Do not move the placement of the cursors. Use the same waveform and cursor placement, as used in the frequency measurement, to measure the period.

7. Read the period of the waveform displayed in seconds on the CRT.

**Measuring Pulse Width**

You can measure a pulse width with the time measurement cursors.

1. Obtain a stable display with at least one complete cycle of the waveform displayed.

2. Turn the \( \Delta \text{TIME} \) cursors on (use the following guide).
3. Use the General Purpose Knob to move the active cursor along the waveform to a starting point for the measurement.

4. Press the TOGGLE button to activate the second cursor. Use the General Purpose Knob to move this second cursor to the place on the waveform where you want to measure time in relation to the first cursor.

Placing the cursors at the rising edge and the falling edge gives the pulse width measurement. See Figure 3-12 for placement of cursors.

5. The time (pulse width) in seconds appears on the CRT.

Figure 3-12: Taking Time Measurements

Taking Rise/Fall Time Measurements

Typically, you measure the rise and fall times between the 10% and 90% portions of the waveform. See Figure 3-13 to help take these measurements.

1. Obtain a stable display with at least one complete cycle of the waveform displayed.

2. Adjust the sec/div scale to display the rising or falling edge of the waveform.
3. Set the variable volts/div to on (use the following guide).

4. Adjust the volts/div scale, vertical position, and the General Purpose Knob (to adjust the variable gain) to obtain a centered six-division signal.

5. Set the time measurement cursors on (use the following guide).

6. Use the General Purpose Knob to move the active cursor to the point on the waveform where it crosses the 10% location of the waveform. This location is marked on the CRT graticule. See Figure 3-13 for placement of cursors.

Figure 3-13: Taking Rise/Fall Time Measurements
7. Press the **TOGGLE** button to activate the second cursor. Using the General Purpose Knob, move this second cursor to the 90% location of the waveform. This location is marked on the CRT graticule.

8. The rise time in seconds appears on the CRT.

---

**Taking Voltage Related Measurements**

You can take voltage measurements either as an absolute value or a differential (delta) value. Absolute voltage measurement is the voltage referenced to ground. Differential voltage measurement is the difference between the two cursors, typically referred to as the delta (Δ) value.

**Absolute Voltage Measurement**

The absolute volts measurement measures the DC value of a signal or a plain DC voltage. Only one cursor is active for this type of measurement.

1. Obtain a stable display.

2. Set vertical coupling to DC and adjust the volts/div scale and position to view the waveform.

3. Set the cursors to measure the absolute voltage (use the following guide).

4. Using the General Purpose Knob, move the cursor along the waveform to obtain the DC voltage level referenced to ground. See Figure 3-14 for placement of cursor.

5. The voltage appears on the CRT.
Taking Measurements

Voltage Cursor

Ground Reference

Figure 3-14: Taking an Absolute Voltage Measurement

Delta Voltage Measurement

The delta volts measurement measures the volts between the two horizontal cursors.

1. Obtain a stable display.

2. Set the cursors to measure delta volts (use the following guide).

3. Use the General Purpose Knob to move the first cursor along the waveform as a reference point for the measurement.

4. Press the TOGGLE button to activate the second cursor. Use the General Purpose Knob to move this second cursor along the waveform to the point where you want to make the measurement in reference to the placement of the first cursor. See Figure 3-15 for placement of cursors.

5. The delta voltage appears on the CRT.
Figure 3-15: Taking a Delta Voltage Measurement
Nominal Traits

This subsection contains a collection of tables that list the various nominal traits that describe the TAS 455 and TAS 465 Analog Oscilloscopes. Included are electrical and mechanical traits.

Nominal traits are described using simple statements of fact such as “Two, both identical” for the trait “Number of Input Channels,” rather than in terms of limits that are performance requirements.

Table 4-1: Nominal Traits — Vertical Deflection System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Input Channels</td>
<td>Two, both identical, called CH 1 and CH 2.</td>
</tr>
<tr>
<td>Input Coupling</td>
<td>DC, AC, or GND. GND input coupling disconnects the input connector from the attenuator and connects a ground reference to the input of the attenuator.</td>
</tr>
<tr>
<td>Sensitivity Range</td>
<td>2 mV/div to 5 V/div. The sensitivity ranges from 2 mV/div to 5 V/div in a 1–2–5 sequence.</td>
</tr>
<tr>
<td>Trace Separation Control Range</td>
<td>≥ ±4 divisions.</td>
</tr>
<tr>
<td>Bandwidth Selections</td>
<td>20 MHz and FULL, selected independently for each channel.</td>
</tr>
<tr>
<td>TAS 455 Rise Time</td>
<td>≤ 5.8 ns. Nominal rise times are calculated from the following formula:</td>
</tr>
<tr>
<td></td>
<td>[ \text{Rise Time (ns)} = \frac{350}{BW \text{ (MHz)}} ]</td>
</tr>
<tr>
<td>TAS 465 Rise Time</td>
<td>≤ 3.5 ns. Nominal rise times are calculated from the following formula:</td>
</tr>
<tr>
<td></td>
<td>[ \text{Rise Time (ns)} = \frac{350}{BW \text{ (MHz)}} ]</td>
</tr>
<tr>
<td>Vertical Position Range</td>
<td>≥ ±10 divisions from graticule center.</td>
</tr>
<tr>
<td>TekProbe Interface</td>
<td>Detects 1X, 10X, and 100X attenuator probes.</td>
</tr>
</tbody>
</table>

TAS 455 and TAS 465 Instruction Manual 4-1
Table 4-2: Nominal Traits — Time Base System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Seconds/Division Range</td>
<td>20 ns/div to 0.5 s/div. The seconds/division ranges from 20 ns/div to 0.5 s/div in a 1—2—5 sequence of settings. The X10 magnifier extends the maximum sweep speed to 2 ns/div.</td>
</tr>
<tr>
<td>Delayed Seconds/Division Range</td>
<td>20 ns/div to 5 ms/div. The seconds/division ranges from 20 ns/div to 5 ms/div in a 1—2—5 sequence of settings. The X10 magnifier extends the maximum sweep speed to 2 ns/div.</td>
</tr>
<tr>
<td>Sweep Length</td>
<td>&gt;10 divisions.</td>
</tr>
<tr>
<td>Delay Control Range</td>
<td>0.15 division to 10 times the Main seconds/division setting. The maximum value can not exceed the end of the Main sweep.</td>
</tr>
<tr>
<td>Delta Time Control Range</td>
<td>0 to 10 divisions to the right of setting of the delay control, but maximum value does not exceed end of the Main sweep.</td>
</tr>
</tbody>
</table>

Table 4-3: Nominal Traits — Triggering System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger Level or Threshold Ranges</td>
<td>The ranges are as follows:</td>
</tr>
<tr>
<td>Source</td>
<td>Range</td>
</tr>
<tr>
<td>Internal</td>
<td>±15 divisions from center of screen with ground at center graticule.</td>
</tr>
<tr>
<td>External 1X</td>
<td>±1.5 V.</td>
</tr>
<tr>
<td>External 10X</td>
<td>±15 V.</td>
</tr>
<tr>
<td>Line</td>
<td>±400 V.</td>
</tr>
</tbody>
</table>

Table 4-4: Nominal Traits — Video Triggering System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope Selection</td>
<td>Slope selection must match the polarity of the sync (i.e., for negative going sync, negative slope must be selected). A default slope selection for TV trigger modes can be entered in the scope configuration menu.</td>
</tr>
</tbody>
</table>
### Table 4-5: Nominal Traits — Cursors

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cursor Functions</td>
<td>ΔTime, 1/ΔTime, Absolute Volts, ΔVolts, Track Trig Level, Ground.</td>
</tr>
</tbody>
</table>

### Table 4-6: Nominal Traits — XY Operation

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity Range</td>
<td>Same as Vertical Deflection System. Volts/div variables in calibrated settings.</td>
</tr>
</tbody>
</table>

### Table 4-7: Nominal Traits — Setup Memory Characteristics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonvolatile Setup Memory</td>
<td>4 Setups.</td>
</tr>
</tbody>
</table>

### Table 4-8: Nominal Traits — Power Fuse (Serial Number B020099 and Below)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse Rating (Serial Number B020099 and Below)</td>
<td>Either of two fuses may be used. Fuse types are as follows:</td>
</tr>
<tr>
<td>Voltage Range</td>
<td>Fuse (250 V)  IEC 127 (5 × 20 mm)</td>
</tr>
<tr>
<td>UL 198.6 (5 × 20 mm)</td>
<td>Fuse (250 V)  IEC 127 (5 × 20 mm)</td>
</tr>
<tr>
<td>90 — 132 VAC</td>
<td>3 A Fast. 3.15 A Fast.</td>
</tr>
<tr>
<td>180 — 250 VAC</td>
<td>3 A Fast. 1.5 A Fast.</td>
</tr>
</tbody>
</table>

### Table 4-9: Nominal Traits — Power Fuse (Serial Number B020100 and Above)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse Rating (Serial Number B020100 and Above)</td>
<td>Either of two fuses may be used. Fuse types are as follows:</td>
</tr>
<tr>
<td>Voltage Range</td>
<td>Fuse (250 V)  IEC 127 (5 × 20 mm)</td>
</tr>
<tr>
<td>UL 198.6 (5 × 20 mm)</td>
<td>Fuse (250 V)  IEC 127 (5 × 20 mm)</td>
</tr>
<tr>
<td>90 — 250 VAC</td>
<td>3 A Fast. 3.15 A Fast.</td>
</tr>
</tbody>
</table>
### Table 4-10: Nominal Traits — Mechanical

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Weights that follow are nominal:</td>
</tr>
<tr>
<td></td>
<td>- 7.7 kg (17 lbs.), stand-alone instrument.</td>
</tr>
<tr>
<td></td>
<td>- 9.3 kg (20.5 lbs.), with front cover, accessories and accessories pouch installed.</td>
</tr>
<tr>
<td></td>
<td>- 13.6 kg (30 lbs.), when packaged for domestic shipment.</td>
</tr>
<tr>
<td>Overall Dimensions</td>
<td>Dimensions that follow are nominal:</td>
</tr>
<tr>
<td></td>
<td>Height:</td>
</tr>
<tr>
<td></td>
<td>- 191 mm (7.5 in.), when feet and accessories pouch are installed.</td>
</tr>
<tr>
<td></td>
<td>- 165 mm (6.5 in.), without the accessories pouch installed.</td>
</tr>
<tr>
<td></td>
<td>Width:</td>
</tr>
<tr>
<td></td>
<td>- 362 mm (14.25 in.), with handle.</td>
</tr>
<tr>
<td></td>
<td>Depth:</td>
</tr>
<tr>
<td></td>
<td>- 471 mm (18.55 in.), stand-alone instrument.</td>
</tr>
<tr>
<td></td>
<td>- 490 mm (19.28 in.), with optional front cover installed.</td>
</tr>
<tr>
<td></td>
<td>- 564 mm (22.20 in.), with fully handle extended.</td>
</tr>
<tr>
<td>Cooling Method</td>
<td>Forced-air circulation with no air filter.</td>
</tr>
<tr>
<td>Finish Type</td>
<td>Tektronix Blue textured paint finish on an aluminum cabinet.</td>
</tr>
<tr>
<td>Construction Material</td>
<td>Chassis parts constructed of aluminum alloy; front panel constructed of plastic laminate; circuit boards constructed of glass-laminate. Tektronix Blue textured paint finish on an aluminum cabinet. Plastic parts are polycarbonate.</td>
</tr>
<tr>
<td>Weight of rackmounted instrument and the rackmount conversion kit</td>
<td>Weights that follow are nominal:</td>
</tr>
<tr>
<td></td>
<td>- 4.5 kg (10 lbs.), for the rackmount conversion kit only; 7.9 kg (17.5 lbs.), when kit is packaged for domestic shipping.</td>
</tr>
<tr>
<td></td>
<td>- 7.3 kg (16 lbs.) plus weight of rackmount Parts, for the rackmounted instrument (option 3R).</td>
</tr>
<tr>
<td></td>
<td>- 15.4 kg (34 lbs.), when the rackmounted instrument is packaged for domestic shipment (no manuals tray).</td>
</tr>
<tr>
<td>Overall Dimensions of the rackmount instrument</td>
<td>Dimensions that follow are nominal:</td>
</tr>
<tr>
<td></td>
<td>- Height: 178 mm (7 in.).</td>
</tr>
<tr>
<td></td>
<td>- Width: 483 mm (19 in.).</td>
</tr>
<tr>
<td></td>
<td>- Depth: 472 mm (18.6 in.).</td>
</tr>
<tr>
<td></td>
<td>Including handles: 517 mm (20.35 in.).</td>
</tr>
</tbody>
</table>
Warranted Characteristics

This subsection lists the various warranted characteristics that describe the TAS 455 and TAS 465 Analog Oscilloscopes. Included are electrical and environmental characteristics.

Warranted characteristics are described in terms of quantifiable performance limits which are warranted. This subsection lists only warranted characteristics. A list of typical characteristics starts on page 4-13.

NOTE

In these tables, those warranted characteristics that are checked in the Performance Verification procedure, found in Section 6, appear in boldface type under the column Name.

Performance Conditions

The electrical characteristics found in these tables of warranted characteristics apply under the following conditions:

- The oscilloscope has been adjusted at an ambient temperature between +20° C and +30° C
- A warm-up period of at least 20 minutes has occurred
- The operating temperature is between −10° C and +55° C (unless otherwise noted)
- The Temperature Compensation Calibrations (signal path compensation) have been performed

Table 4-11: Warranted Characteristics — Vertical Deflection System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Impedance, DC Coupled</td>
<td>1 MΩ ±1% in parallel with 20 pF ±2.0 pF.</td>
</tr>
<tr>
<td>Variable Range</td>
<td>Increases deflection factor by ≥2.5:1.</td>
</tr>
<tr>
<td>DC Gain Accuracy</td>
<td>The limits are as follows:</td>
</tr>
<tr>
<td>Condition</td>
<td>Accuracy</td>
</tr>
<tr>
<td>+15° C to +35° C</td>
<td>±2.5% over the center 5 divisions after signal path compensation.</td>
</tr>
<tr>
<td>−10° C to +15° C and +35° C to +55° C</td>
<td>±3.5% over the center 5 divisions after signal path compensation.</td>
</tr>
</tbody>
</table>
### Warranted Characteristics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TAS 455 Bandwidth at the BNC input</strong> and probe tip, using the Standard-Accessory Probe</td>
<td>60 MHz.</td>
</tr>
<tr>
<td><strong>TAS 465 Bandwidth at the BNC input</strong></td>
<td>100 MHz.</td>
</tr>
<tr>
<td><strong>TAS 465 Bandwidth at the probe tip, using the Standard-Accessory Probe</strong></td>
<td>The limits are as follows:</td>
</tr>
<tr>
<td><strong>Condition</strong></td>
<td><strong>Bandwidth</strong></td>
</tr>
<tr>
<td>+15° C to +35° C</td>
<td>100 MHz.</td>
</tr>
<tr>
<td>−10° C to +15° C and +35° C to +55° C</td>
<td>90 MHz.</td>
</tr>
<tr>
<td><strong>Lower Frequency Limit, AC Coupled</strong></td>
<td>≤ 10 Hz with 1X probe. The AC Coupled Lower Frequency Limits are reduced by a factor of 10 when 10X, passive probes are used.</td>
</tr>
<tr>
<td><strong>TAS 455 Crosstalk (Channel Isolation)</strong></td>
<td>≥ 50 dB at 10 MHz, ≥ 35 dB at 60 MHz.</td>
</tr>
<tr>
<td><strong>TAS 465 Crosstalk (Channel Isolation)</strong></td>
<td>≥ 50 dB at 10 MHz, ≥ 35 dB at 100 MHz.</td>
</tr>
<tr>
<td><strong>Delay Between Channels, Full Bandwidth</strong></td>
<td>≤ 200 ps between channels 1 and 2 for equal volts/div and coupling settings.</td>
</tr>
<tr>
<td><strong>Common-mode Rejection Ratio (CMRR)</strong></td>
<td>≥ 10:1 at ≤ 50 MHz.</td>
</tr>
<tr>
<td><strong>Trace Shift</strong></td>
<td>The limits are as follows:</td>
</tr>
<tr>
<td><strong>Condition</strong></td>
<td><strong>Allowable Trace Shift</strong></td>
</tr>
<tr>
<td>Changing volts/div settings</td>
<td>≤ ±(0.1 division + 0.2 mV).</td>
</tr>
<tr>
<td>Selecting invert</td>
<td>≤ 0.5 division.</td>
</tr>
<tr>
<td>Changing from bandwidth limit to full bandwidth</td>
<td>≤ 0.1 division.</td>
</tr>
<tr>
<td><strong>Maximum Input Voltage</strong></td>
<td>±400 V (DC + peak AC); derate at 20 dB/decade from 100 kHz to 13 V at 3 MHz.</td>
</tr>
<tr>
<td><strong>Low Frequency Linearity</strong></td>
<td>Within ±5%.</td>
</tr>
</tbody>
</table>
### Table 4-12: Warranted Characteristics — Time Base System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time Base Accuracy, Magnify Off</strong></td>
<td>The limits are as follows:</td>
</tr>
<tr>
<td><strong>Conditions</strong></td>
<td><strong>Time Measurement Accuracy</strong></td>
</tr>
<tr>
<td>+15°C C to + 35°C</td>
<td>±2%.</td>
</tr>
<tr>
<td>−10°C C to + 15°C and +35°C C</td>
<td>±3%.</td>
</tr>
<tr>
<td><strong>Sweep accuracy applies over the center eight divisions. Excludes the greater of either the first ¼ division or 25 ns from the sweep start of the magnified sweep and anything beyond the 100th magnified division.</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **Time Base Accuracy, Magnify On**      | The limits are as follows:  

| **Conditions**                          | **Time Measurement Accuracy**                                                                                                                                                                                |
| −10°C C to + 55°C                       | Excluding 5 ns/div and 2 ns/div ±3%.                                                                                                                                                                          |
| +15°C C to + 35°C                       | 5 ns/div and 2 ns/div ±4%.                                                                                                                                                                                   |
| −10°C C to + 15°C and +35°C C           | 5 ns/div and 2 ns/div ±5%.                                                                                                                                                                                   |
| **Sweep accuracy applies over the center eight divisions. Excludes the greater of either the first ¼ division or 25 ns from the sweep start of the magnified sweep and anything beyond the 100th magnified division.** |                                                                                                                                                                                                              |
| **Horizontal Position Control Range**   | The position control is able to move the start of the sweep to the right of the center vertical graticule and able to move a time mark corresponding to the tenth division on an unmagnified sweep to the left of the graticule center. |
| **Variable Control Range**              | Continuously variable between calibrated seconds/division settings. Extends both the Main and Delayed sweep seconds/division settings by a factor of 2.5 times.                                                   |
| **Delay Accuracy, Main Sweep Trigger Point to Start of Delayed Sweep** | ±(0.5% of reading + 5% of 1 division of the Main sweep + 25 ns).                                                                                                                                              |
| **Delta Delay Accuracy**                | ±(0.5% of reading + 5% of 1 division of the Main sweep + 10 ns).                                                                                                                                              |
### Warranted Characteristics

#### Table 4-13: Warranted Characteristics — Triggering System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TAS 465 Edge-Type Trigger Sensitivity, DC Coupled</strong></td>
<td>The limits are as follows:</td>
</tr>
<tr>
<td>Trigger Source</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Internal, Any Channel</td>
<td>0.30 division from DC to 25 MHz, increasing to 1 div at 150 MHz.</td>
</tr>
<tr>
<td>External X1</td>
<td>35 mV from DC to 25 MHz, increasing to 100 mV at 150 MHz.</td>
</tr>
<tr>
<td>External X10</td>
<td>350 mV from DC to 25 MHz, increasing to 1 V at 150 MHz.</td>
</tr>
</tbody>
</table>

| **TAS 455 Edge-Type Trigger Sensitivity, DC Coupled** | The limits are as follows: |
| Trigger Source                                   | Sensitivity |
| Internal, Any Channel                            | 0.30 division from DC to 25 MHz, increasing to 1 div at 100 MHz. |
| External X1                                      | 35 mV from DC to 25 MHz, increasing to 100 mV at 100 MHz. |
| External X10                                     | 350 mV from DC to 25 MHz, increasing to 1 V at 100 MHz. |

| **Trigger Level or Threshold Accuracy** | The limits are as follows for signals having rise and fall times ≥ 20 ns: |
| Coupling                                       | Source       | Accuracy                |
| DC                                             | All except Line and External | ± (5% of reading + 0.4 division + 1 mV) |
|                                                | Internal (X1) | ± (5% of reading + 40 mV) |
|                                                | Internal (X10) | ± (5% of reading + 400 mV) |
| Noise Reject                                   | All except Line and External | ± (5% of reading + 1.1 division + 1 mV) |
|                                                | Internal (X1) | ± (5% of reading + 110 mV) |
|                                                | Internal (X10) | ± (5% of reading + 1.1 V) |
| HF Reject                                      | All except Line and External | ± (5% of reading + 0.35 division + 1 mV) |
|                                                | Internal (X1) | ± (5% of reading + 35 mV) |
|                                                | Internal (X10) | ± (5% of reading + 350 mV) |
### Table 4-13: Warranted Characteristics — Triggering System (Cont.)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Difference Between Ext Input and Any Channel</td>
<td>&lt;2 ns.</td>
</tr>
<tr>
<td>External Trigger Input Impedance</td>
<td>1 MΩ ±2% in parallel with 20 pF ±2.0 pF.</td>
</tr>
<tr>
<td>Maximum Input Voltage</td>
<td>±400 V (DC + peak AC); derate at 20 dB/decade from 100 kHz to 13 V at 3 MHz.</td>
</tr>
</tbody>
</table>

### Table 4-14: Warranted Characteristics — Video Triggering

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>0.75 divisions of composite sync will achieve a stable display.</td>
</tr>
<tr>
<td>60 Hz Rejection</td>
<td>Stable video trigger with up to 4 divisions of 60 Hz on the video signal.</td>
</tr>
<tr>
<td>Sync Offset</td>
<td>Stable video trigger if sync tip is ±15 divisions, referenced to input ground.</td>
</tr>
<tr>
<td>Sync Separation</td>
<td>Stable trigger on positive or negative composite horizontal sync (lines) video, for all 525/60 and 625/50 video systems which include: NTSC, PAL, and SECAM.</td>
</tr>
<tr>
<td>Field Interval</td>
<td>Stable trigger on vertical sync interval &gt;20 μs.</td>
</tr>
</tbody>
</table>

### Table 4-15: Warranted Characteristics — Cursors

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔTime Cursor to Signal Accuracy</td>
<td>Same as Time Base Accuracy + 0.1 division.</td>
</tr>
<tr>
<td>1/ΔTime Accuracy</td>
<td>Readouts calculated using ΔTime cursor difference.</td>
</tr>
<tr>
<td>Absolute Volts Accuracy</td>
<td>Accuracies are as follows:</td>
</tr>
<tr>
<td>Condition</td>
<td>Accuracy</td>
</tr>
<tr>
<td>−10° C to +30° C</td>
<td>±(1% of reading + 2% of one vertical division + HF display errors + 0.5 mV + trace shift errors).</td>
</tr>
<tr>
<td>+30° C to +55° C</td>
<td>±(1% of reading + 2% of one vertical division + HF display errors + 4 mV + trace shift errors).</td>
</tr>
<tr>
<td>ΔVolts Cursor to Signal Accuracy</td>
<td>±(1.6% of reading + 2% of one vertical division + HF display errors).</td>
</tr>
</tbody>
</table>
### Warranted Characteristics

#### Table 4-16: Warranted Characteristics — XY Operation

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XY Accuracy</td>
<td>±4%.</td>
</tr>
<tr>
<td>X Bandwidth</td>
<td>DC to at least 3 MHz.</td>
</tr>
<tr>
<td>Phase Difference Between X and Y Amplifiers</td>
<td>±3°, DC to 150 kHz.</td>
</tr>
</tbody>
</table>

#### Table 4-17: Warranted Characteristics — Power Requirements (Serial Number B020099 and Below)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Voltage and Frequency</td>
<td>90–132 VAC_{RMS} continuous range for 48 through 440 Hz.</td>
</tr>
<tr>
<td></td>
<td>160–250 VAC_{RMS} continuous range for 48 through 440 Hz.</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>≤ 85 watts (150 VA).</td>
</tr>
</tbody>
</table>

#### Table 4-18: Warranted Characteristics — Power Requirements (Serial Number B020100 and Above)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Voltage and Frequency</td>
<td>90–132 VAC_{RMS} continuous range for 48 through 440 Hz.</td>
</tr>
<tr>
<td></td>
<td>90–250 VAC_{RMS} continuous range for 48 through 63 Hz.</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>≤ 85 watts (150 VA).</td>
</tr>
</tbody>
</table>

#### Table 4-19: Warranted Characteristics — Environmental and Safety

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third Party Certifications</td>
<td>This product shall conform to and be certified where appropriate according to the following requirements:</td>
</tr>
<tr>
<td></td>
<td><strong>Certification</strong></td>
</tr>
<tr>
<td>Underwriter's Laboratories (UL)</td>
<td>Listed or Recognized Component, Electrical and Electronic Measuring and Testing Equipment UL 1244.</td>
</tr>
<tr>
<td>Canadian Standards CSA Association (CSA)</td>
<td>Category Certified Electronic Development and Test Equipment, CSA 22.2 no. 231.</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Temperature: Operating and Nonoperating</td>
<td>Operating: $-10^\circ$ C to $+55^\circ$ C. Nonoperating: $-51^\circ$ C to $+71^\circ$ C.</td>
</tr>
<tr>
<td>Humidity: Operating and Nonoperating</td>
<td>To 95% relative humidity at or below $+40^\circ$ C to 75% relative humidity from $+41^\circ$ C to $+55^\circ$ C. A more severe test than stated in MIL–T–28800E, para. 4.5.5.1.1.2.</td>
</tr>
<tr>
<td>Altitude: Operating and Nonoperating</td>
<td>Operating: To 4572 m (15,000 ft.). Nonoperating: To 12192 m (40,000 ft.).</td>
</tr>
<tr>
<td>Random Vibration: Nonoperating</td>
<td>2.46 g$_{\text{RMS}}$, from 5 to 500 Hz, 10 minutes each axis.</td>
</tr>
<tr>
<td>Random Vibration: Operating</td>
<td>0.31 g$_{\text{RMS}}$, from 5 to 500 Hz, 10 minutes each axis.</td>
</tr>
<tr>
<td>Emissions</td>
<td>The instrument meets or exceeds the EMC requirements of the following standards:</td>
</tr>
<tr>
<td></td>
<td>• VFG 243.</td>
</tr>
<tr>
<td>Electrostatic Discharge Susceptibility</td>
<td>IEC 801–2.</td>
</tr>
</tbody>
</table>
Typical Characteristics

This subsection contains tables that lists the various typical characteristics that describe the TAS 455 and TAS 465 Analog Oscilloscopes.

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

This subsection lists only typical characteristics. A list of warranted characteristics starts on page 4-5.

Table 4-20: Typical Characteristics — Vertical Deflection System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper-Frequency Limit, 20 MHz Bandwidth Limited</td>
<td>20 MHz.</td>
</tr>
<tr>
<td>Trace Shift Leakage</td>
<td>The typical amount of trace shift while changing the input coupling between GND and 1 MΩ DC is as follows:</td>
</tr>
<tr>
<td>Condition</td>
<td>Typical Trace Shift</td>
</tr>
<tr>
<td>−10°C to +35°C</td>
<td>&lt;0.5 mV</td>
</tr>
<tr>
<td>+35°C to +55°C</td>
<td>&lt;8 mV</td>
</tr>
<tr>
<td>Variable Volts/Div Offset</td>
<td>0.5 division trace shift while changing the variable volts/div setting.</td>
</tr>
<tr>
<td>Chop Mode Clock Rate</td>
<td>&gt;500 kHz, &lt;1 MHz. Chop mode is allowed from 0.5 s to 10 μs sec/div settings.</td>
</tr>
<tr>
<td>Noise (measured tangentially)</td>
<td>≤0.06 div at ≥ 10 mV/div (600 μV).</td>
</tr>
<tr>
<td></td>
<td>≤0.10 div at 5 mV/div (500 μV).</td>
</tr>
<tr>
<td></td>
<td>≤0.14 div at 2 mV/div (280 μV).</td>
</tr>
</tbody>
</table>

Table 4-21: Typical Characteristics — Time Base System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Base Linearity</td>
<td>±5%. Sweep linearity applies over the center eight divisions. Excludes the greater of either the first ¼ division or 25 ns from the sweep start of the magnified sweep and anything beyond the 100th magnified division.</td>
</tr>
<tr>
<td>Delay Jitter</td>
<td>≤ 1 part in 10,000 (20,000 for 1 ms and slower) + 2 ns, peak-to-peak during a two-second time interval. Exclude the first 0.15 divisions of the Main sweep.</td>
</tr>
</tbody>
</table>
### Table 4-22: Typical Characteristics — Triggering System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TAS 465 Edge-Type Trigger Sensitivity, Not DC Coupled</strong></td>
<td>The typical sensitivities are as follows:</td>
</tr>
<tr>
<td><strong>Trigger Source</strong></td>
<td><strong>Typical Signal Level for Stable Triggering</strong></td>
</tr>
<tr>
<td>Noise Reject</td>
<td>1.2 divisions from DC to 25 MHz, increasing to 2.2 divisions at 150 MHz. 0.5 division or less will not trigger.</td>
</tr>
<tr>
<td>HF REJ</td>
<td>0.30 division from DC to 10 kHz; attenuates signals above the upper −3 dB cut-off frequency of 50 kHz.</td>
</tr>
<tr>
<td>LF REJ</td>
<td>0.30 division from 100 kHz to 25 MHz, increasing to 1.0 division at 150 MHz; attenuates signals below the lower −3 dB cutoff frequency of 50 kHz.</td>
</tr>
<tr>
<td>AC</td>
<td>0.30 division from 350 Hz to 25 MHz, increasing to 1.0 division at 150 MHz; attenuates signals below the −3 dB cutoff frequency of 160 Hz.</td>
</tr>
</tbody>
</table>

Typical signal levels for External Triggering are derived by converting divisions to volts, where 1 division equals 100 mV of trigger signal level.

| **TAS 455 Edge-Type Trigger Sensitivity, Not DC Coupled**            | The typical sensitivities are as follows:                                   |
| **Trigger Source**                                                  | **Typical Signal Level for Stable Triggering**                             |
| Noise Reject                                                        | 1.2 divisions from DC to 25 MHz, increasing to 2.2 divisions at 100 MHz. 0.5 division or less will not trigger. |
| HF REJ                                                               | 0.30 division from DC to 10 kHz; attenuates signals above the upper −3 dB cut-off frequency of 50 kHz. |
| LF REJ                                                               | 0.30 division from 100 kHz to 25 MHz, increasing to 1.0 division at 100 MHz; attenuates signals below the lower −3 dB cutoff frequency of 50 kHz. |
| AC                                                                   | 0.30 division from 350 Hz to 25 MHz, increasing to 1.0 division at 100 MHz; attenuates signals below the −3 dB cutoff frequency of 160 Hz. |

Typical signal levels for External Triggering are derived by converting divisions to volts, where 1 division equals 100 mV of trigger signal level.
### Table 4-22: Typical Characteristics — Triggering System (Cont.)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest Frequency for Successful Operation of “Set Level to 50%” Function</td>
<td>50 Hz with 1 division.</td>
</tr>
<tr>
<td>Holdoff Control Range</td>
<td>Increases Main sweep holdoff time by a factor of 10.</td>
</tr>
</tbody>
</table>

### Table 4-23: Typical Characteristics — Video Triggering System

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Separation</td>
<td>Stable trigger on odd or even fields in interlaced video systems with line rates between 12 kHz and 17 kHz.</td>
</tr>
</tbody>
</table>

### Table 4-24: Typical Characteristics — Z-Axis

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>The sensitivity is as follows:</td>
</tr>
<tr>
<td>Condition</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>DC to 2 MHz</td>
<td>Positive voltage decreases intensity; +2 V blanks a maximum intensity trace.</td>
</tr>
<tr>
<td>2 MHz to 20 MHz</td>
<td>+2 V modulates a normal intensity trace. +2 V (DC to 20 MHz) blanks a 1 μA CRT beam.</td>
</tr>
<tr>
<td>Rise Time</td>
<td>&lt;15 ns.</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>10 kΩ ±10%.</td>
</tr>
<tr>
<td>Maximum Input Voltage</td>
<td>±25 V peak; 25 V&lt;sub&gt;pp&lt;/sub&gt; AC at 10 kHz or less.</td>
</tr>
</tbody>
</table>

### Table 4-25: Typical Characteristics — Probe Compensator

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe Compensator Output Voltage and Frequency</td>
<td>The limits are as follows:</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Limits</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>5 V (base-top) ±10% into a 1 MΩ load.</td>
</tr>
<tr>
<td>Frequency</td>
<td>1 kHz ±5%.</td>
</tr>
</tbody>
</table>
Table 4-26: Typical Characteristics — Setup Memory

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonvolatile Memory Retention Time</td>
<td>Internal batteries, installed at time of manufacture, have a life of ≥10 years when operated and/or stored at an ambient temperature from 0°C to +50°C. Retention time of the nonvolatile memories is equal to the remaining life of the batteries. Battery life can be reduced when the instrument is stored for extended time above +50°C. Retained data may be lost when stored for extended time below 0°C.</td>
</tr>
</tbody>
</table>
The following servicing instructions are for use only by qualified personnel. To avoid injury, do not perform any servicing other than that stated in the operating instructions unless you are qualified to do so. Refer to all Safety Summaries before performing any service.
Theory of Operation

This section describes the theory of operation of the Tektronix TAS 455 and TAS 465 Analog Oscilloscopes, using major circuit blocks.

This section has two main parts:

- **Service Strategy** describes the scope of the theory of operation with respect to the level of service supported by this manual.
- **Block Level Descriptions** describes circuit operation from a functional-circuit block perspective.

---

**Service Strategy**

This manual supports the maintenance and repair of the TAS 455 and TAS 465 Analog Oscilloscopes to the module level. Circuit descriptions and diagrams are provided to enable the user to isolate and replace a faulty module. If you require detailed component level documentation, please order the optional Service Manual listed in the Replaceable Parts section of this manual.

---

**Block Level Descriptions**

This overview describes the basic operation of each functional circuit block as shown in Figure 5-1.

**General**

The Tektronix TAS 455 and TAS 465 Analog Oscilloscopes are portable, two-channel instruments. Each channel provides a calibrated vertical scale factor.

**Input Signal Path**

A signal enters the oscilloscope through a probe connected to a BNC on the A1 Analog board.

**Attenuators** — Circuitry on the attenuator hybrid, including the vertical preamplifier IC, selects the input coupling, attenuation factor, variable gain, and the invert function. The processor system controls and calibrates the attenuators.

**Probe Coding Interface** — Probe coding interface signals pass through the A1 Analog board to the A5 CPU board and then to the A4 Front Panel board. The probe interface signals are digitized on the Front Panel board and communicated to the processor system.
External Trigger — A high impedance buffer is used to interface the external trigger signal to the analog acquisition hybrid.

A1 Analog Board — The input signals are routed to the highly integrated analog acquisition hybrid which does the analog processing required to provide vertical, horizontal, and z-axis signals to the A3 Display Driver board. Under control of the processor, the hybrid provides vertical signal processing, triggers, sweeps, sequencing logic, and intensity control.

A5 Processor System

The processor board is a microcontroller design. It consists of a microcontroller as the core of the circuit, operating at 16 MHz. The primary function of the processor is to receive input from the front panel, display the readout, and control the Analog board.

A3 Display Assembly

All information (waveforms, text, and cursors) is displayed by the A3 Display Driver board. It generates the high voltages necessary to drive the CRT. It also contains the vertical and horizontal amplifier circuitry.

A4 Front Panel

The processor system sends and receives information to and from the A4 Front Panel board. The Front Panel board reads the front-panel controls and changes in their settings are reported to the processor system. The Front Panel Processor turns the LEDs on and off, generates the probe compensation signal, and processes the probe coding interface signals.

Menu Switches — Front-panel menu switches are read by the Front Panel board and changes in menu selections are sent to the processor system.

Rear Panel

The External Z-Axis connector provides the ability to modulate the z-axis amplifier circuit on the A3 Display Driver board, thus modulating or blanking the intensity of the CRT display.
A63 Power Supply

The power supply is a switching power converter. It supplies power to all oscilloscope circuitry.

Two versions of power supplies were produced. The early version requires the operator to configure it to the incoming line voltage; the later version automatically adjusts to the incoming line voltage and has no external adjustments.

If an early model power supply is replaced with a later version, check with your local Tektronix representative about obtaining the necessary firmware upgrade.

The POWER switch, located on the front panel, controls all power to the oscilloscope including the power supply.

Fan

The fan provides forced air cooling for the oscilloscope. It connects to +12 V on the A63 Power Supply board.
Theory of Operation

Figure 5-1: Block Diagram (B020099 and Below)
Figure 5-1: Block Diagram (B020099 and Below) (Cont.)
Figure 5-2: Block Diagram (B020100 and Above)
Figure 5-2: Block Diagram (B020100 and Above) (Cont.)
General Instructions

This Performance Verification section is divided into two subsections, *Brief Performance Checks* and *Performance Tests*.

The *Brief Performance Checks* section contains procedures to verify the operation of the TAS 455 and TAS 465 Analog Oscilloscopes.

The *Performance Tests* section contains procedures to confirm the performance of the TAS 455 and TAS 465 Oscilloscopes to its warranted specifications.

If you are not familiar with operating this oscilloscope, read Section 2, *Getting Started* in this manual to acquaint you with the use of the front-panel controls and the menu system.

Figure 3-3 on page 3-10 provides a display map of the CRT to familiarize you with the readout locations for the TAS 455 and TAS 465 Oscilloscopes.

---

**Using the Brief Performance Checks Procedures**

The *Brief Performance Checks* contain three procedures: Power-On Self Tests, Functional Tests, and Temperature Compensation Calibrations. Completing these checks takes approximately one hour.

The *Self Tests* are performed each time the oscilloscope in powered on.

The *Functional Tests* use the probe compensation output on the front panel as a test-signal source for further verifying that the oscilloscope functions properly. A standard-accessory probe, included with this oscilloscope, is the only equipment required.

To rapidly confirm that this oscilloscope functions and was adjusted properly, perform the procedures in the *Functional Tests* section, which begin on page 6-3.

**Advantages:** These procedures are quick to do, require no external equipment or signal sources, and provide high confidence that the oscilloscope will perform properly. These procedures also provide hands-on experience to become familiar with the controls and menus.

The *Temperature Compensation Calibrations* allow you to adjust the display accuracy of the oscilloscope.

---

**Using the Performance Tests Procedures**

The *Performance Tests* confirm that the TAS 455 and TAS 465 Oscilloscopes perform as specified. The *Performance Tests* begin on page 6-13. Completing these tests takes approximately two hours and requires suitable test equipment. *(See Equipment Required on page 6-13.)*

**Advantages:** These procedures add direct checking of warranted specifications.
Conventions

The procedures in this section provide the following information:

- Title of test
- Equipment required (if applicable)
- Procedure

Where instructed to use a front-panel control or select from a menu, the name appears in boldface type. For example, “press VERTICAL MENU; then “set CPLG to DC.”

The symbol at the left is accompanied by information you must read to do the procedure properly.

These procedures make references to the graticule lines. For example, “position the cursor to the second vertical graticule line.” Figure 6-1 shows how to interpret the references.

![Graticule References](image)

**Figure 6-1: Graticule References**

These procedures may ask you to check for a stable display. A stable display is consistent. The display should not have its trigger point switching slopes (double trigger) nor should it “free-run.” The MAIN SWP TRIG'D LED should remain lit.
Brief Performance Checks

This section contains three brief procedures: two that verify the operation of the TAS 455 and TAS 465 Analog Oscilloscopes and one to perform a brief calibration to compensate for temperature variances.

The **Power-On Self Tests** use internal routines (performed at each power on) to confirm basic functionality and proper adjustment.

The **Functional Tests** further verify that the oscilloscope functions properly. These tests utilize the front panel **PROBE COMP** signal and a standard accessory probe.

The **Temperature Compensation Calibrations** use internal routines and actions from you to adjust the display accuracy of the oscilloscope. These adjustments are typically necessary only when the operating temperature and the last calibration temperature differs by more than 5° C. However, performing these compensations before making a critical measurement ensures optimum accuracy.

If any of these tests return a failed message or do not perform as stated, contact your local Tektronix service center or sales engineer for more information.

---

**Power-On Self Tests**

These tests verify that the internal power-on diagnostics passed by confirming no error messages are reported on-screen.

---

**Functional Tests**

The purpose of these procedures is to confirm that this oscilloscope functions properly. The only equipment required is a standard accessory probe.

These procedures verify function; that is, they verify that oscilloscope operates. They do not verify that it operates within limits.

STOP

Therefore, when the instructions in the functional tests that follow call for you to verify that a signal appears on screen “that is about five divisions in amplitude” or “has a period of about six horizontal divisions”, do not interpret the quantities given as limits. Operation within limits is checked in Performance Tests, which begin on page 6-13.

STOP

DO NOT make changes to the front-panel settings that are not called out in the procedures. Each verification procedure requires you to set the oscilloscope to certain default settings before verifying functions. If you make changes to these default settings, other than those called out in the procedure, you may obtain invalid results. In this case, begin the procedure again from step 1.
Functional Tests Prerequisites

1. Power on the oscilloscope and allow a 20 minute warm-up before performing this procedure; adjust the READOUT control to display the readout and the INTENSITY control to display waveforms.

2. Disable the dual delay with the following menu selections.
   a. Press the UTILITY button and select CONFIG from the main menu.
   b. Select MORE until you can select Dual Delay Disabled.

3. Press the ALT/CHOP, ADD button and set ADD to Off.

4. Install the probe on CH 1. Connect the probe tip to PROBE COMP on the front-panel; connect the probe ground to the ground barrel of an unused input BNC (see Figure 6-2).

Some functional checks require that you install the probe on connectors other than CH 1. All functional checks use the PROBE COMP on the front-panel as the signal source.

![Figure 6-2: Test Hookup for Functional Tests](image)

Verify the Probe Compensator Output

1. Press the WAVEFORM OFF button until the readout indicates that only channel 1 is selected.

2. Press the AUTOSET button.

3. Press the VERTICAL MENU button and set CPLG to DC.

4. Set the volts/div scale to 1 V and vertically center the display.

5. Set the sec/div scale to 500 µs.

6. Press the CURSOR button and set ΔVOLT to On.

7. Align the active cursor to the top of the signal using the General Purpose Knob.
8. Press the TOGGLE button and align the active cursor to the bottom of the signal using the General Purpose Knob.

9. Verify that the ΔVolts readout is about 5.2 V.

10. Set 1/ΔT to On.

11. Align the active cursor to a rising edge of the signal using the General Purpose Knob.

12. Press the TOGGLE button and align the active cursor to the next rising edge of the signal using the General Purpose Knob.

13. Verify that the 1/ΔT readout is about 1 kHz.

14. Set ΔTIME to On.

15. Verify that the ΔTime readout is about 1 ms.

Verify the Input Channels

1. Display the channel to be verified and turn all others off.

2. Install the probe on the channel to be verified.

3. Press the AUTOSET button.

4. Press the VERTICAL MENU button and set CPLG to DC.

5. Verify that the channel is operational, confirming the following statements are true.
   - The vertical scale readout is set to 2 V for the channel under test and a square wave signal about 2.6 divisions in amplitude is on-screen.
   - Pressing the SET LEVEL TO 50% button sets the trigger level readout to approximately 2.7 V.
   - The vertical POSITION control moves the signal up and down the screen when rotated. Return the bottom portion of the displayed waveform to the center horizontal graticule line.
   - Turning the VOLTS/DIV control counterclockwise and clockwise decreases and increases the amplitude of the waveform. Return the volts/div scale to 2 V.

6. Press the VERTICAL MENU button and select CPLG. Select the following coupling types and verify the display.
   - Select DC coupling and verify that the waveform amplitude is positive-going from the center horizontal graticule line.
   - Select AC coupling, press the SET LEVEL TO 50% button, and verify that the waveform is centered at about the center horizontal graticule line.
   - Select GND coupling and verify that a straight line is displayed (no waveform).
7. Return the coupling to DC and press the CLEAR MENU button.
8. Repeat this procedure until all input channels are verified.

**Verify the Alt/Chop and Add Functions**

1. Install the probe on CH 1.
2. Press the WAVEFORM OFF button until the readout indicates channel 1 is the only selected channel.
3. Press the AUTOSET button.
4. Press the CH 2 button and then position the channel 2 trace to the bottom horizontal graticule line.
5. Press the WAVEFORM OFF button, removing the channel 2 display.
6. Press the ALT/CHOP, ADD button and set ADD to On.
7. Verify that a second waveform of approximately 2.6 divisions amplitude has been added to the display.
8. Set DISP to Chop.
9. Set the sec/div scale to 100 ms.
10. Verify that the two waveforms are displayed simultaneously.
11. Set DISP to Alt.
12. Verify that the two waveforms are displayed alternately.
13. Set ADD to Off.
14. Press the CLEAR MENU button.

**Verify the Time Base**

1. Press the WAVEFORM OFF button until the readout indicates channel 1 is the only selected channel.
2. Install the probe on CH 1.
3. Press the AUTOSET button.
4. Verify that the main time base is operational, confirming the following statements are true.
   - One period of the square wave is about five horizontal divisions.
   - Rotate the SEC/DIV control clockwise and verify that the waveform expands (more horizontal divisions per period of waveform) and that counterclockwise rotation contracts it.
   - Set the sec/div scale to 1 ms and verify that approximately one period of waveform per horizontal division is displayed.
   - Rotate the horizontal POSITION control and verify that the waveform moves left and right on-screen.
   - Pressing the MAG button changes the sec/div scale from 1 ms to 100 μs and one period of the square wave is about ten horizontal divisions. Return to a non-magnified display by pressing the MAG button again.

5. Press the HORIZONTAL MENU button and set DELAY to On.
6. Set the delayed sec/div scale to 500 μs.
7. Press the TRIGGER MENU button and set MODE to Runs After.
8. Press the HORIZONTAL MENU button.
9. Select TRCSEP from the main menu and vertically position the delayed time base below the main time base using the General Purpose Knob.
10. Select DELAY from the main menu.
11. Verify that the delayed time base is operational, confirming the following statements are true.
    - The main sweep has an intensified zone of approximately 5.5 horizontal divisions. Adjust the INTENSITY level if necessary to view the entire intensified zone.
    - Rotating the General Purpose Knob clockwise moves the intensified zone to the right on-screen. Position the intensified portion to the center of the screen.
12. Adjust the delayed sec/div scale to 200 μs.
13. Set MAIN to Off and confirm that only the delayed sec/div scale is displayed and the period of the square-wave signal is about five horizontal divisions.
14. Set MAIN to On and DELAY to Off.

**Verify the Trigger System**

1. Press the WAVEFORM OFF button until the readout indicates channel 1 is the only selected channel.
2. Press the AUTOSET button.
3. Set the sec/div scale to 1 ms.

4. Press the TRIGGER MENU button and set MODE to Auto.

5. Verify that the main trigger is operational, confirming that the following statements are true.
   - Rotating the trigger LEVEL control changes the main trigger level readout.
   - Rotating the trigger LEVEL control through its range triggers and untriggers the display. Leave the signal untriggered.
   - Pressing the SET LEVEL TO 50% button triggers the signal and the trigger level readout indicates approximately 2.7 V.

6. Press the HORIZONTAL MENU button and set DELAY to On.

7. Set the delayed sec/div scale to 500 μs.

8. Verify that the delayed sweep is operational, confirming that an intensified zone appears on the main sweep.

9. Press the TRIGGER MENU button and set MODE to Trig After and SRC to Ch1.

10. Verify that the delayed trigger is operational, confirming that the following statements are true.
    - Rotating the trigger LEVEL control changes the delayed trigger level readout.
    - Rotating the trigger LEVEL control through its range triggers and untriggers (intensified zone displayed and not displayed) the delayed sweep. Leave the signal untriggered.
    - Pressing the SET LEVEL TO 50% button triggers the signal, the trigger level readout indicates approximately 2.7 V, and the intensified zone is displayed.

11. Press the HORIZONTAL MENU button and set DELAY to Off.

12. Set the sec/div scale to 50 ms.

13. Press the TRIGGER MENU button and set MODE to Single Sequence and confirm the following statements are true.
    - There is no waveform displayed.
    - Pressing the RESET S SEQ button causes one sweep of the waveform display to occur.

14. Set the sec/div scale to 1 ms.

15. Set MODE to Auto Level.

16. Disconnect the probe from the oscilloscope.
Verify the External Trigger

1. Press the TRIGGER MENU button; set MODE to Normal and SRC to EXT <1>. Confirm that no sweep is displayed.
2. Install the probe on the EXT TRIG connector. Connect the probe tip to PROBE COMP on the front-panel; connect the probe ground to the ground barrel of an unused input BNC.
3. Press the SET LEVEL TO 50% button.
4. Verify that the main sweep is triggered and a single trace is displayed.
5. Press the AUTOSET button.
6. Disconnect the probe from the oscilloscope.

Temperature Compensation Calibrations

The procedures that follow allow you to quickly compensate the calibration of the oscilloscope for any external temperature variations. This ensures the most accurate measurements. No test equipment is required to perform these procedures.

Optimum instrument performance depends on the recommended 20 minute minimum warm-up time prior to performing the following calibration routines. All calibration routines require a successful completion (no “failed” message).

The Temperature Compensation Calibrations affect the accuracy of the display system; therefore, they should only be performed by a qualified technician.

Horizontal Sweep Path

1. Press the AUTOSET button.
2. Press the UTILITY button and select CAL from the main menu.
3. Select Horizontal Sweep Path from the sub menu, initiating the routine.

The Horizontal Sweep Path routine takes about 20 seconds to complete its initial calibrations.

The following information (up to and including step 14) applies to Firmware versions prior to V2.10. For instruments with V2.10 and above, skip to step 15 on page 6-11.

Once the Horizontal Sweep Path routine is complete, two dots are displayed. The displayed dots are used for the next horizontal calibration steps.
NOTE

The following steps use both the General Purpose Knob and the TOGGLE button to make adjustments. The General Purpose Knob performs two functions: to adjust gain and centering. Pressing the TOGGLE button selects the function of the General Purpose Knob.

4. Use a combination of the TOGGLE button and the General Purpose Knob to position the two dots eight divisions apart, centered horizontally (see Figure 6-3).

![Diagram of Dots Eight Divisions Apart, Centered Horizontally]

Figure 6-3: Horizontal Adjustments (One)

5. Select Done when you have the appropriate display.

6. Again, use a combination of the TOGGLE button and the General Purpose Knob to position the two dots eight divisions apart, centered horizontally (see Figure 6-3).

7. Select Done when you have the appropriate display.

8. One dot is now displayed.

9. Use a combination of the TOGGLE button and the General Purpose Knob to horizontally center the single dot at the center of the screen (see Figure 6-4).

Continue to press the TOGGLE button and adjusting the dot to center screen with the General Purpose Knob until the dot stays horizontally centered while pressing the TOGGLE button.
Figure 6-4: Horizontal Adjustments (Two)

10. Select Done when you have the appropriate display.
11. Two vertical lines are now displayed.

Figure 6-5: Horizontal Adjustments (Three)

12. Use a combination of the TOGGLE button and the General Purpose Knob to position the two lines eight divisions apart, centered horizontally (see Figure 6-5).
13. Select Done when you have the appropriate display.
14. A pass or failed status appears on the screen.

The remaining step applies to all firmware versions.

15. Select Done to exit the routine, displaying a Calibration Finished message.
Vertical Signal Path

1. Press the AUTOSET button.

2. Press the UTILITY button and select CAL from the main menu.

3. Select Vertical Signal Path from the sub menu, initiating the routine.

4. Remove any input signals from the oscilloscope.

5. Select Done.

The Vertical Signal Path routine takes about one minute to complete. When finished, a pass or failed status will appear on the screen.

6. Press Done to exit the routine, displaying a Calibration Finished message.

7. Press the CLEAR MENU button.
Performance Tests

This subsection contains procedures to verify that the TAS 455 and TAS 465 Analog Oscilloscopes perform as warranted.

The procedures are arranged in three logical groupings: Vertical Checks, Horizontal Checks, and Trigger Checks. They check all the characteristics that are designated as checked in Section 4, Specifications. (The checked characteristics appear in **boldface** type under Warranted Characteristics in Section 4.)

These procedures extend the confidence level provided by the **Brief Performance Checks** in this section.

---

**Performance Tests Prerequisites**

The tests in this subsection comprise an extensive, valid confirmation of performance and functionality when the following requirements are met.

- The cabinet must be installed on the oscilloscope.
- The Power-On Self Tests show no failures.
- You must have completed the Temperature Compensation Calibrations, beginning on page 6-9.
- The oscilloscope must have an operating warm-up period of at least 20 minutes at an ambient temperature between $-10^\circ$ C and $+55^\circ$ C.
- Set the INTENSITY and READOUT controls for nominal viewing levels.
- Set the delayed sweep intensity to Intensity Delay > Main in the Utility Configure menu.

**Related Information** — Read General Instructions that start on page 6-1. If you are not familiar with operating this oscilloscope, read Section 2, Getting Started, before performing these procedures.

---

**Equipment Required**

These procedures use external, traceable signal sources to directly check warranted characteristics. Table 6-1 lists the required test equipment.
### Table 6-1: Test Equipment

<table>
<thead>
<tr>
<th>Item Number and Description</th>
<th>Minimum Requirements</th>
<th>Example</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Attenuator, 5X³</td>
<td>Ratio: 5X; Impedance 50 Ω; Connectors: female BNC input, male BNC output</td>
<td>Tektronix part number 011-0060-02</td>
<td>Signal attenuation</td>
</tr>
<tr>
<td>2 Attenuator, 10X</td>
<td>Ratio: 10X; Impedance 50 Ω; Connectors: female BNC input, male BNC output</td>
<td>Tektronix part number 011-0059-02</td>
<td>Signal attenuation</td>
</tr>
<tr>
<td>3 Termination, 50 Ω (two required)</td>
<td>Impedance 50 Ω; Connectors: female BNC input, male BNC output</td>
<td>Tektronix part number 011-0049-01</td>
<td>Signal interconnection</td>
</tr>
<tr>
<td>4 Termination, 75 Ω</td>
<td>Impedance 75 Ω; Connectors: female BNC input, male BNC output</td>
<td>Tektronix part number 011-0102-01</td>
<td>Signal interconnection, video</td>
</tr>
<tr>
<td>5 Cable, Precision Coaxial</td>
<td>50 Ω, 36 in, male-to-male BNC connectors</td>
<td>Tektronix part number 012-0482-00</td>
<td>Signal interconnection</td>
</tr>
<tr>
<td>6 Cable, Coaxial</td>
<td>75 Ω, 36 in, male-to-male BNC connectors</td>
<td>Tektronix part number 012-1338-00</td>
<td>Signal interconnection, video</td>
</tr>
<tr>
<td>7 Coupler, Dual-Input</td>
<td>Female-BNC-to-dual-male-BNC</td>
<td>Tektronix part number 067-0525-02</td>
<td>Signal interconnection</td>
</tr>
<tr>
<td>8 Generator, Level Sine Wave</td>
<td>200 kHz to 250 MHz; Variable amplitude from 5 mV to 4 V_{p-p} into 50 Ω</td>
<td>TEKTRONIX SG 503 Leveled Sine Wave Generator¹</td>
<td>Trigger and bandwidth checks</td>
</tr>
<tr>
<td>9 Generator, Time Mark</td>
<td>Variable marker frequency from 10 ms to 10 ns; accuracy within 2 ppm</td>
<td>TEKTRONIX TG 501A Time Mark Generator¹</td>
<td>Timing accuracy checks</td>
</tr>
<tr>
<td>10 Generator, Pulse</td>
<td>High Amplitude pulse with variable amplitude of 60 V to 100 V</td>
<td>TEKTRONIX PG 506A Calibration Generator¹,²</td>
<td>Gain accuracy checks</td>
</tr>
<tr>
<td>11 Generator, DC Calibration</td>
<td>DC voltage levels from 100 mV to 10 V</td>
<td>TEKTRONIX PG 506A Calibration Generator¹,²</td>
<td>Gain accuracy checks</td>
</tr>
<tr>
<td>12 Probe, 10X, included with this instrument</td>
<td>Standard accessory probe</td>
<td>TEKTRONIX P6109B</td>
<td>Signal interconnection</td>
</tr>
<tr>
<td>Item Number and Description</td>
<td>Minimum Requirements</td>
<td>Example</td>
<td>Purpose</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------</td>
<td>------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>13 Generator, Video Signal</td>
<td>Provides NTSC compatible outputs</td>
<td>TEKTRONIX TSG 100</td>
<td>Video trigger check</td>
</tr>
<tr>
<td>14 Multimeter, Digital</td>
<td>DC voltage to 10 V</td>
<td>TEKTRONIX DM 2510</td>
<td>Power Supply Adjustment (B020100 and above)</td>
</tr>
<tr>
<td>15 Adjustment Tool(^3)</td>
<td>0.1 inch hex on both ends</td>
<td>GC Electronics #8806</td>
<td>Internal adjustments</td>
</tr>
</tbody>
</table>

\(^1\) Requires a TM 500 or TM 5000 Series Power Module Mainframe.
\(^2\) The PG 506A must have the internal Square-Wave/DC switch repositioned depending on the requirements of the procedure.
\(^3\) This item is used only when performing the Adjustment Procedures.
Vertical System Checks

These procedures check those characteristics that relate to the vertical system and are listed as checked under *Warranted Characteristics* in Section 4, *Specifications*.

**Check DC Gain and Voltage Measurement Accuracy**

**Equipment Required:** One pulse generator (item 10) and one precision coaxial cable (item 5).

1. Display the channel to be verified, turning all others off.
2. Press the AUTOSET button.
3. Set the sec/div scale to 500 μs.
4. Press the TRIGGER MENU button and set CPLG to Noise Reject.
5. Press the CURSOR button and set ΔVolt to On.
6. Press the VERTICAL MENU button and make the following selections:
   - Set CPLG to DC
   - Set BW to 20 MHz
7. Set the volts/div scale to 2 mV.
8. Position the trace three divisions below the center horizontal graticule line.
9. Connect the standard amplitude output of the pulse generator to the input of the channel to be verified as shown in Figure 6-6.

![Pulse Generator](image)

**Figure 6-6: Gain and Voltage Test Setup**

10. Set the pulse generator for 10 mV amplitude output.
11. Use the General Purpose Knob and TOGGLE button to precisely align the cursors to the signal peaks.
12. Check the Displayed Signal Accuracy and Volts Readout Accuracy while setting the Volts/Div Scale and the Input Amplitude given in Table 6-2.
Table 6-2: DC Gain and Delta Volts Accuracy

<table>
<thead>
<tr>
<th>Volts/Div Scale</th>
<th>Input Amplitude</th>
<th>Displayed Signal Accuracy</th>
<th>Delta Volts Readout Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mV</td>
<td>10 mV</td>
<td>4.87 to 5.13 div</td>
<td>9.80 mV to 10.2 mV</td>
</tr>
<tr>
<td>5 mV</td>
<td>20 mV</td>
<td>3.9 to 4.1 div</td>
<td>19.6 mV to 20.4 mV</td>
</tr>
<tr>
<td>10 mV</td>
<td>50 mV</td>
<td>4.87 to 5.13 div</td>
<td>49.0 mV to 51.0 mV</td>
</tr>
<tr>
<td>20 mV</td>
<td>0.1 V</td>
<td>4.87 to 5.13 div</td>
<td>98.0 mV to 102 mV</td>
</tr>
<tr>
<td>50 mV</td>
<td>0.2 V</td>
<td>3.9 to 4.1 div</td>
<td>196 mV to 204 mV</td>
</tr>
<tr>
<td>100 mV</td>
<td>0.5 V</td>
<td>4.87 to 5.13 div</td>
<td>490 mV to 510 mV</td>
</tr>
<tr>
<td>1 V</td>
<td>5 V</td>
<td>4.87 to 5.13 div</td>
<td>4.90 V to 5.10 V</td>
</tr>
</tbody>
</table>

13. Return the volts/div scale to 2 mV and set the pulse generator for 10 mV amplitude output.

14. Press the VERTICAL MENU button and set VAR to On.

15. Check that rotating the General Purpose Knob counterclockwise reduces the displayed signal amplitude to two divisions or less. Set VAR to Off.

16. Disconnect the test setup from the oscilloscope.

17. Repeat this procedure until you have verified all input channels.

18. Press the CURSOR button and set ΔVolt to Off.

Check Trigger Level Accuracy

Equipment Required: One DC calibration generator (item 11) and one precision coaxial cable (item 5).

1. Display channel 1, turning all others off.

2. Press the AUTOSET button.

3. Set the sec/div scale to 500 μs.

4. Press the TRIGGER MENU button and make the following selections:
   - Set CPLG to DC
   - Set SLOPE to Rising

5. Press the VERTICAL MENU button and make the following selections:
   - Set CPLG to DC
   - Set BW to 20 MHz

6. Set the volts/div scale to 50 mV.

7. Position the trace three divisions below the center horizontal graticule line.
8. Connect the DC calibration generator to the CH 1 input as shown in Figure 6-7.

![DC Calibration Generator](image)

Figure 6-7: Trigger Level Test Setup

9. Set the DC calibration generator for a 200 mV output.
10. Press the **SET LEVEL TO 50%** button.
11. Check that the Trigger Level Accuracy readout is in the range of 169 mV to 231 mV.
12. Press the **TRIGGER MENU** button and set **SLOPE** to **Falling**.
13. Press the **SET LEVEL TO 50%** button.
14. Check that the Trigger Level Accuracy readout is in the range of 169 mV to 231 mV.
15. Press the **MAIN/DELAY SELECT** button, displaying the delay trigger menu.
16. Set **MODE** to **Runs After** and **SRC** to **Ch1**.
17. Press the **SET LEVEL TO 50%** button.
18. Check that the Trigger Level Accuracy readout is in the range of 169 mV to 231 mV.
19. Disconnect the test setup from the oscilloscope.
20. Press the **MAIN/DELAY SELECT** button and set **SLOPE** to **Rising**.
21. Press the **HORIZONTAL MENU** button and set **DELAY** to **Off**.

**Check DC Coupling Bandwidth**

**Equipment Required:** One leveled sine wave generator (item 8), one precision coaxial cable (item 5), and one 50 Ω termination (item 3).

1. Display the channel to be verified, turning all others off.
2. Connect the output of the sine wave generator to the channel to be verified as shown in Figure 6-8.
3. Press the **AUTOSET** button.
4. Set the volts/div scale to 2 mV.
5. Set the sec/div scale to 200 μs.
6. Set the sine wave generator for a 50 kHz reference frequency and adjust the amplitude for a six division display.
7. Press the **TRIGGER MENU** button and set CPLG to **Noise Reject**.
8. Use the following substeps (a to c) and the settings and limits given in Table 6-3 to confirm the bandwidth of the input channels.
   a. Set the volts/div scale as indicated.
   b. Set the signal generator for the specified amplitude at the reference frequency.
   c. While confirming the Display Amplitude remains greater than the minimum number of divisions, increase the signal generator frequency to 60 MHz or 100 MHz, depending on the instrument model.

### Table 6-3: DC Coupled Bandwidth

<table>
<thead>
<tr>
<th>Volts/Div Scale</th>
<th>50 kHz Reference Amplitude</th>
<th>Display Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>TAS 455</strong> To 60 MHz</td>
</tr>
<tr>
<td>2 mV</td>
<td>6 division</td>
<td>≥ 4.2 division</td>
</tr>
<tr>
<td>5 mV</td>
<td>6 division</td>
<td>≥ 4.2 division</td>
</tr>
<tr>
<td>10 mV</td>
<td>6 division</td>
<td>≥ 4.2 division</td>
</tr>
<tr>
<td>20 mV</td>
<td>6 division</td>
<td>≥ 4.2 division</td>
</tr>
<tr>
<td>50 mV</td>
<td>6 division</td>
<td>≥ 4.2 division</td>
</tr>
<tr>
<td>100 mV</td>
<td>6 division</td>
<td>≥ 4.2 division</td>
</tr>
<tr>
<td>1 V</td>
<td>5 division</td>
<td>≥ 3.5 division</td>
</tr>
</tbody>
</table>
9. Disconnect the test setup from the oscilloscope.
10. Repeat this procedure until all input channels are verified.

**Check X-Axis Gain**

**Equipment Required:** One pulse generator (item 10) and one precision coaxial cable (item 5).

1. Display channel 1, turning all others off.
2. Connect the output of the pulse generator to the **CH 1** input as shown Figure 6-9.

![Pulse Generator and Oscilloscope Diagram]

**Figure 6-9: X-Axis Gain Test Setup**

3. Set the output of the pulse calibration generator for 50 mV.
4. Press the **AUTOSET** button.
5. Set the volts/div scale to 10 mV.
6. Center the display using the vertical **POSITION** control.
7. Press the **HORIZONTAL MENU** button and set **XY** to **On**.
8. Check that the amplitude of the X-axis signal is 4.8 to 5.2 divisions.
9. Set **XY** to **Off**.
10. Disconnect the test setup from the oscilloscope.

---

**Horizontal System Checks**

These procedures check those characteristics that relate to the horizontal system and are listed as checked under **Warranted Characteristics** in Section 4, **Specifications**.

**Check Time Base and Time Cursor Accuracy**

**Equipment Required:** One time marker generator (item 9), one precision coaxial cable (item 5), and one 50 Ω termination (item 3).

1. Display channel 1, turning all others off.
2. Connect the output of the time marker generator to the **CH 1** input as shown in Figure 6-10.

![Time Mark Generator](image)

**Figure 6-10: Timing Test Setup**

3. Set the output of the generator for 20 ns markers.
4. Press the **AUTOSET** button.
5. Set the sec/div scale to 20 ns.
6. Set the volts/div scale to 500 mV.
7. Center the time mark display vertically.
8. Press the **CURSOR** button and set **TIME** to **On**.
9. Position the rising edge of the second time mark to the second vertical graticule line.
10. Align the active cursor to the second time mark at the point the rising edge intersects the center horizontal graticule line using the General Purpose Knob.
11. Press the **TOGGLE** button and align the second cursor to the tenth time mark at the point the rising edge intersects the center horizontal graticule line using the General Purpose Knob.
12. Check that the Time-mark to Graticule Accuracy and the Time Cursor Readout Accuracy over the center eight divisions are within the limits shown for each Sec/Div Scale listed in Table 6-4.

<p>| Table 6-4: Time Base and Cursor Accuracies (Mag Off) |
|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th><strong>Sec/Div Scale (Mag Off)</strong></th>
<th><strong>Time Mark Setting</strong></th>
<th><strong>Over Center 8 Divisions</strong></th>
<th><strong>2nd and 10th Time Marks</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>20 ns</td>
<td>20 ns</td>
<td>±0.16 division</td>
<td>157 ns to 163 ns</td>
</tr>
<tr>
<td>50 ns</td>
<td>50 ns</td>
<td>±0.16 division</td>
<td>392 ns to 408 ns</td>
</tr>
<tr>
<td>100 ns</td>
<td>0.1 μs</td>
<td>±0.16 division</td>
<td>784 ns to 816 ns</td>
</tr>
</tbody>
</table>
### Table 6-4: Time Base and Cursor Accuracies (Mag Off) (Cont.)

<table>
<thead>
<tr>
<th>Sec/Div Scale (Mag Off)</th>
<th>Time Mark Setting</th>
<th>Over Center 8 Divisions</th>
<th>2nd and 10th Time Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 ns</td>
<td>0.2 µs</td>
<td>±0.16 division</td>
<td>1.57 µs to 1.63 µs</td>
</tr>
<tr>
<td>500 ns</td>
<td>0.5 µs</td>
<td>±0.16 division</td>
<td>3.92 µs to 4.08 µs</td>
</tr>
<tr>
<td>1 µs</td>
<td>1 µs</td>
<td>±0.16 division</td>
<td>7.84 µs to 8.16 µs</td>
</tr>
<tr>
<td>2 µs</td>
<td>2 µs</td>
<td>±0.16 division</td>
<td>15.7 µs to 16.3 µs</td>
</tr>
<tr>
<td>5 µs</td>
<td>5 µs</td>
<td>±0.16 division</td>
<td>39.2 µs to 40.8 µs</td>
</tr>
<tr>
<td>10 µs</td>
<td>10 µs</td>
<td>±0.16 division</td>
<td>78.4 µs to 81.6 µs</td>
</tr>
<tr>
<td>20 µs</td>
<td>20 µs</td>
<td>±0.16 division</td>
<td>157 µs to 163 µs</td>
</tr>
<tr>
<td>50 µs</td>
<td>50 µs</td>
<td>±0.16 division</td>
<td>392 µs to 408 µs</td>
</tr>
<tr>
<td>100 µs</td>
<td>0.1 ms</td>
<td>±0.16 division</td>
<td>784 µs to 816 µs</td>
</tr>
<tr>
<td>200 µs</td>
<td>0.2 ms</td>
<td>±0.16 division</td>
<td>1.57 ms to 1.63 ms</td>
</tr>
<tr>
<td>500 µs</td>
<td>0.5 ms</td>
<td>±0.16 division</td>
<td>3.92 ms to 4.08 ms</td>
</tr>
<tr>
<td>1 ms</td>
<td>1 ms</td>
<td>±0.16 division</td>
<td>7.84 ms to 8.16 ms</td>
</tr>
<tr>
<td>2 ms</td>
<td>2 ms</td>
<td>±0.16 division</td>
<td>15.7 ms to 16.3 ms</td>
</tr>
<tr>
<td>5 ms</td>
<td>5 ms</td>
<td>±0.16 division</td>
<td>39.2 ms to 40.8 ms</td>
</tr>
</tbody>
</table>

13. Set ∆TIME to Off.

14. Set the time mark generator to 20 ns.

15. Set the main sec/div scale to 20 ns.

16. Press the HORIZONTAL MENU button and set DELAY to On and MAIN to Off.

17. Set the delayed sec/div scale to 20 ns.

18. Set the delay time to 3 ns using the General Purpose Knob.

19. Position the edge of the second time mark to the second vertical graticule line.

20. Check that the Time Mark to Graticule Accuracy over the center eight divisions are within the limits shown for each sec/div scale listed in Table 6-4 (disregard the Time Cursor Readout Accuracy column).

21. Set MAIN to On.

22. Set the main sec/div scale to 20 ns.

23. Set MAIN to Off.
24. Press the MAG button, turning magnification on.

25. Set the time mark generator for 5 ns markers.

26. Set the volts/div scale to 200 mV.

27. Check that the timing accuracies at the beginning, middle, and end of sweep over the center eight divisions are within the limits shown for each of the sec/div scales given in Table 6-5. Exclude the first and last five divisions of the magnified sweep for accuracy measurements.

<table>
<thead>
<tr>
<th>Sec/Div Scale (Mag On)</th>
<th>Time Marker Setting</th>
<th>Time Mark to Graticule Over Center 8 Divisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ns</td>
<td>5 ns(^1)</td>
<td>±0.32 division(^2)</td>
</tr>
<tr>
<td>5 ns</td>
<td>5 ns(^1)</td>
<td>±0.32 division</td>
</tr>
<tr>
<td>10 ns</td>
<td>10 ns</td>
<td>±0.24 division</td>
</tr>
<tr>
<td>100 ns</td>
<td>0.1 μs</td>
<td>±0.24 division</td>
</tr>
<tr>
<td>100 μs</td>
<td>0.1 ms</td>
<td>±0.24 division</td>
</tr>
</tbody>
</table>

\(^1\) Change the volts/div scale as necessary to maintain vertical amplitude.

\(^2\) At this setting, two cycles of the signal are displayed for every five horizontal divisions.

28. Set MAIN to On and DELAY to Off.

29. Set the sec/div scale to 2 ns.

30. Set the time mark generator for 5 ns markers.

31. Check that the timing accuracies at the beginning, middle, and end of sweep over the center eight divisions are within the limits shown for each Sec/Div Scale given in Table 6-5. Exclude the first and last five divisions of the magnified sweep for accuracy measurements.

32. Press the MAG button, turning magnification off.

**Check Dual Delay Accuracy**

**Equipment Required:** One time marker generator (item 9), one precision coaxial cable (item 5), and one 50 Ω termination (item 3).

1. Display channel 1, turning all others off.

2. Connect the output of the time marker generator to the CH 1 input as shown in Figure 6-11.
3. Set the output of the time marker generator for 0.5 ms markers.

4. Press the AUTOSET button.

5. Set the sec/div scale to 500 μs.

6. Set the volts/div scale to 500 mV.

7. Position the time marker display to the upper half of the graticule and align the first time marker to the second vertical graticule line.

8. Press the TRIGGER MENU button and then the MAIN/DELAY SELECT button.

9. Set MODE to Runs After.

10. Set the delayed sec/div scale to 50 μs.

11. Press HORIZONTAL MENU.

12. Select TRCSEP and position the delayed time marker display to the lower half of the graticule using the General Purpose Knob.

13. Select DELAY.

14. Using the General Purpose Knob, position the intensified zone on the main sweep to the second time marker; then, slightly adjust the General Purpose Knob until the delayed sweep time marker is at the graticule center.

15. Press the UTILITY button and select CONFIG from the main menu.

16. Select MORE until you can select Dual Delay Enabled from the sub menu.

17. Press the CURSOR button and set ΔTIME to On.

18. Using the General Purpose Knob, position the second intensified zone on the main sweep to the third time marker; then, slightly adjust the General Purpose Knob to superimpose the delayed sweep time markers at the graticule center. Press the TOGGLE button to assign the General Purpose Knob to the second intensified zone if necessary.

19. Check the Dual Delay Accuracy Reading for each time marker pair listed in Table 6-6.
Table 6-6: 500 μs Dual Delay Accuracy

<table>
<thead>
<tr>
<th>Time Markers Intensified</th>
<th>Dual Delay Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second and third</td>
<td>473 μs to 527 μs</td>
</tr>
<tr>
<td>Second and fourth</td>
<td>970 μs to 1.03 ms</td>
</tr>
<tr>
<td>Second and sixth</td>
<td>1.97 ms to 2.03 ms</td>
</tr>
<tr>
<td>Second and tenth</td>
<td>3.96 ms to 4.04 ms</td>
</tr>
</tbody>
</table>

20. Press the MAIN/DELAY SELECT button and set the main sec/div scale to 200 ns.

21. Press the MAIN/DELAY SELECT button and set the delayed sec/div scale to 20 ns.

22. Set the time mark generator for 0.2 μs markers.

23. Using the General Purpose Knob, position the second intensified zone on the main sweep to the tenth time marker; then, slightly adjust the General Purpose Knob to superimpose the delayed sweep time markers at the graticule center.

24. Check the dual delay accuracy (ΔTime) reading is in the range of 1.58 μs to 1.62 μs.

25. Press the CURSOR button and set ΔTIME to Off.

26. Press the UTILITY button and select Dual Delay Disabled.

27. Press the HORIZONTAL MENU button and set DELAY to Off

28. Disconnect the test setup from the oscilloscope.

---

Trigger System Checks

These procedures check those characteristics that relate to the trigger system and are listed as checked under Warranted Characteristics in Section 4, Specifications.

Check Trigger Sensitivity

Equipment Required: One sine wave generator (item 8), one 10X attenuator (item 2), one precision coaxial cable (item 5), one dual-input coupler (item 7), and two 50 Ω terminations (item 3).

Low Frequency — The following steps check trigger sensitivity at 25 MHz.

1. Display channel 1, turning all others off.

2. Connect the output of the sine wave generator to the CH 1 and EXT TRIG inputs as shown in Figure 6-12.
3. Set the frequency of the sine wave generator to 25 MHz.

4. Press the **AUTOSET** button.

5. Set the volts/div scale to 50 mV.

6. Set the sec/div scale to 100 ns.

7. Press the **VERTICAL MENU** button and set **CPLG** to **DC**

8. Press the **TRIGGER MENU** button and make the following selections from the main trigger menu:
   - Set **MODE** to **Auto**
   - Set **SRC** to **Ch1**
   - Set **CPLG** to **DC**
   - Set **SLOPE** to **Rising**

9. Press the **MAIN/DELAY SELECT** button and make the following selections from the delay trigger menu:
   - Set **MODE** to **Runs After**
   - Set **SRC** to **Ch1**
   - Set **CPLG** to **DC**
   - Set **SLOPE** to **Rising**

10. Set the delayed sec/div scale to 50 ns.

11. Press the **HORIZONTAL MENU** button and select **DELAY**.

12. Set the delay time to 15 ns using the General Purpose Knob.

13. Set **DELAY** to **Off**.

14. Adjust the sine wave generator amplitude for a three division display.

15. Add a 10X attenuator to the test setup as shown in Figure 6-13.
16. Press the **SET LEVEL TO 50%** button and confirm a stable display.
17. Press the **TRIGGER MENU** button and set **SLOPE** to **Falling**.
18. Press the **SET LEVEL TO 50%** button and confirm a stable display.
19. Press the **HORIZONTAL MENU** button and set **DELAY** to **On**.
20. Select **TRCSEP** and position the delayed sweep below the main sweep using the General Purpose Knob.
21. Press the **TRIGGER MENU** button and set **MODE** to **Trig After**.
22. Press the **SET LEVEL TO 50%** button and confirm a stable delayed sweep display.
23. Set **SLOPE** to **Falling**.
24. Press the **SET LEVEL TO 50%** button and confirm a stable delayed sweep display.
25. Press the **HORIZONTAL MENU** button and set **DELAY** to **Off**.
26. Set the volts/div scale to 10 mV.
27. Set the sine wave generator to 50 kHz.
28. Set the sec/div scale to 50 μs.
29. Adjust the sine wave generator amplitude for a 3.5 division display.
30. Set the sine wave generator frequency to 25 MHz.
31. Set the main sec/div scale to 100 ns.
32. Press the **TRIGGER MENU** button and set **SRC** to **EXT <1>**.
33. Press the **SET LEVEL TO 50%** button and confirm a stable display.
**High Frequency** — The following steps check trigger sensitivity at 100 MHz (TAS 455) or 150 MHz (TAS 465).

1. Remove the 10X attenuator from the test setup. Reconnect as shown in Figure 6-14.

2. Set the volts/div scale to 1 V.

3. Adjust the sine wave generator amplitude for a one division display at 25 MHz.

4. Set the sine wave generator frequency as follows:
   - TAS 455 — 100 MHz
   - TAS 465 — 150 MHz

5. Press the **MAG** button.

6. Set **SRC** to **EXT <10>**.

7. Press the **SET LEVEL TO 50%** button and confirm a stable display.

8. Add a 10X attenuator to the test setup as shown in Figure 6-15.

---

**Figure 6-14: Trigger Sensitivity Test Setup (Three)**

**Figure 6-15: Trigger Sensitivity Test Setup (Four)**
9. Set the volts/div scale to 50 mV.
10. Adjust the sine wave generator amplitude for a one division display.
11. Set SRC to Ch1.
12. Press the SET LEVEL TO 50% button and confirm a stable display.
13. Set SLOPE to Rising.
14. Press the SET LEVEL TO 50% button and confirm a stable display.
15. Press the MAIN/DELAY SELECT button (selecting delay).
16. Press the SET LEVEL TO 50% button and confirm a stable delayed sweep display (see the following note).

NOTE

A slight adjustment of the delay time may be necessary to obtain a stable delayed sweep display. Press the Horizontal Menu button and adjust the delay time using the General Purpose Knob. Press the Trigger Menu button after confirming a stable display.

17. Set SLOPE to Rising.
18. Press the SET LEVEL TO 50% button and confirm a stable delayed sweep display.

NOTE

A slight adjustment of the delay time may be necessary to obtain a stable delayed sweep display. Press the Horizontal Menu button and adjust the delay time using the General Purpose Knob.

19. Press the HORIZONTAL MENU button and set DELAY to Off.
20. Disconnect the test setup from the oscilloscope.

Video Trigger — The following steps check the video trigger sensitivity.

Equipment Required: One NTSC Television signal generator (item 13), one 75 Ω termination (item 4), and one 75 Ω coaxial cable (item 6).

1. Display channel 1, turning all others off.
2. Connect the composite sync output of the television signal generator to the CH 1 input as shown in Figure 6-16.
3. Press the AUTOSET button.
4. Set the volts/div scale to 200 mV.
5. Set the sec/div scale to 100 µs.
6. Press the UTILITY button and select CONFIG.
7. Select MORE until you can select Video Sync Negative from the sub menu.
8. Press the TRIGGER MENU button and make the following selections:
   - Set MODE to Video Field <odd>
   - Set SLOPE to Falling
9. Confirm a stable display of the video field.
10. Set MODE to Video Field <even>.
11. Confirm a stable display of the video field.
12. Disconnect the test setup from the oscilloscope.
Adjustment Procedures

This section contains information needed to adjust the TAS 455 and TAS 465 Analog Oscilloscopes.

**Description** — The Adjustment Procedures are divided into two parts:

- General information about adjusting the oscilloscope
- Written procedures for oscilloscope calibration

**Purpose** — Use this procedure to return the oscilloscope to conformance with its Warranted Characteristics as listed in Section 4, Specifications. It also optimizes the performance of the oscilloscope.

This procedure is not required to verify the oscilloscope conforms with its warranted characteristics. Performance verification procedures are found in Section 6, Performance Verification.

**Adjustment Interval** — As a general rule, perform these adjustments after every 2,000 hours of operation or once a year if used infrequently.

---

**Requirements for Performance**

Before you perform this procedure, you need to address the following requirements.

**Personnel**

This procedure is only to be performed by trained service technicians.

**Access to Adjustments**

The cabinet must be removed to perform the adjustment procedure. Refer to the Maintenance section for procedures to remove the cabinet. The adjustment procedures make references to adjustments located on internal circuit boards. Figure 7-1 shows the location of each board with adjustments. The end of this section contains figures that show the location of each adjustment for each circuit board.

**Warm-Up Period**

This oscilloscope requires a 20 minute warm-up period in a 20°C to 30°C environment before performing this adjustment procedure. Adjustments performed before the operating temperature has stabilized may cause errors in performance.
Equipment Required

These procedures use external, traceable signal sources to calibrate the TAS 455 and TAS 465 Oscilloscopes. Table 6-1 on page 6-14 lists all the test equipment required for these procedures.

Performing the Adjustment Procedures

The following topics cover what is required to adjust the oscilloscope. Also, the performance of individual adjustments is discussed.

The Factory Horizontal Cal and Factory Vertical Cal calibration routines are selected from the Utility menu of the oscilloscope. These routines use both front-panel controls and external standards you provide in response to instructions displayed on the CRT readout.
Complete Adjustment

A complete adjustment consists of a sequence of individual calibration steps performed in the order shown:
1. Power Supply Adjustment (Serial Number B020100 and Above)
2. CRT Adjustment
3. Low Frequency Output Compensation
4. Factory Horizontal Cal
5. Factory Vertical Cal
6. High Frequency Step Response Adjustment
7. Attenuator Compensation
8. Vertical Gain Adjustment

Partial Adjustment

The Adjustment Procedures allow you to make individual adjustments of the steps outlined above; however, usually all adjustment steps are made. Read the information under Adjustment Dependencies that follows before performing an individual adjustment.

Adjustment Dependencies

Some adjustments depend on the successful prior completion of other adjustments. Generally, the procedures should be performed in the order shown under Complete Adjustment. Some adjustments do not depend on completion of other adjustments. Table 7-1 lists the adjustments and their dependencies.

Table 7-1: Adjustments and Dependencies

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>Prior Completion Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply (B020100 and above)</td>
<td>None</td>
</tr>
<tr>
<td>CRT Adjustment</td>
<td>Power Supply (B020100 and above)</td>
</tr>
<tr>
<td>Low Frequency Output Compensation</td>
<td>Power Supply (B020100 and above)</td>
</tr>
<tr>
<td>Factory Horizontal Cal</td>
<td>CRT Adjustment</td>
</tr>
<tr>
<td>Factory Vertical Cal</td>
<td>Low Frequency Output Compensation and Factory Horizontal Cal</td>
</tr>
<tr>
<td>High Frequency Step Response</td>
<td>Factory Vertical Cal</td>
</tr>
<tr>
<td>Attenuator Compensation</td>
<td>Low Frequency Output Compensation</td>
</tr>
</tbody>
</table>
Table 7-1: Adjustments and Dependencies (Cont.)

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>Prior Completion Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Gain Adjustment</td>
<td>Low Frequency Output Compensation, Factory Vertical Cal, and Attenuator Compensation</td>
</tr>
</tbody>
</table>

Adjustment Instructions

The following instructions will guide you through each of the adjustments outlined in Complete Adjustments. Each adjustment section lists all necessary equipment required to perform the adjustments.

Power Supply Adjustment (Serial Number B020100 and Above)

Equipment Required: One digital multimeter (item 14) and one adjustment tool (item 15).

Adjustment Locations: This procedure requires adjustment to the Power Supply board. See Figure 7-16 on page 7-21 for the location of the adjustment.

1. Connect the digital voltmeter low lead to chassis ground and connect the volts lead to the $-8.6$ V supply (WS5-2) on the CPU board.
2. Measure the $-8.6$ V supply. If the supply measures from $-8.56$ V to $-8.64$ V, the supply is adjusted properly and you may disconnect the voltmeter.
3. If the power supply is not within the limits specified in step 2, adjust the $-8.6$ V ADJ potentiometer (R43) for a voltmeter reading of $-8.60$ V.
4. Disconnect the voltmeter from the instrument.

CRT Adjustments

Equipment Required: One time marker generator (item 9), one precision coaxial cable (item 5), and one 50 Ω termination (item 3).

Adjustment Locations: This procedure requires adjustments to the Display Driver board. See Figure 7-14 on page 7-19 for the location of the adjustments.

1. Disconnect all signal inputs from the oscilloscope.
2. Display channel 1, turning all others off.
3. Press the AUTOSET button.
4. Set the volts/div scale to 50 mV.
5. Set the sec/div scale to 2 μs.
6. Press the **VERTICAL MENU** button and make the following selections from the menu:
   - Set **CPLG** to **GND**
   - Set **BW** to **20 MHz**

7. Position the channel 1 trace to the center horizontal graticule line and adjust the **FOCUS** control for a well-defined display.

8. Adjust the **TRACE ROTATION** control (screw-driver adjustment) to align the trace with the center horizontal graticule line.

9. Press the **HORIZONTAL MENU** button and set **XY** to **On**.

10. Set the **INTENSITY** control fully counterclockwise (off).

11. Adjust R321 on the Display Driver board until the dot is visible, then re-adjust R321 until the dot just extinguishes.

12. Set **XY** to **Off**.

13. Connect the output of the time mark generator to the **CH 1** input as shown in Figure 7-2.

![Time Mark Generator](Image)

**Figure 7-2: CRT Adjustments Calibration Setup**

14. Set the time mark generator for 1 μs markers.

15. Set the **INTENSITY** control to view the display.

16. Press the **VERTICAL MENU** button and set **CPLG** to **DC**

17. Press the **SET LEVEL TO 50%** button.

18. Adjust the **FOCUS** and R322 on the Display Driver board for the best focus of the time mark display and readout display.

19. Set the vertical **POSITION** control counterclockwise, moving the baseline of the time mark display down off the graticule area.

20. Set the **READOUT INTENSITY** control fully counterclockwise (off).

21. Adjust R323 on the Display Driver for the best geometry (minimum bowing) of the time mark display across the entire graticule area.
22. Set the **READOUT INTENSITY** control to view the readout.

23. Disconnect the calibration setup from the oscilloscope.

**Low Frequency Output Compensation**

**Equipment Required:** One pulse generator (item 10), one precision coaxial cable (item 5), one 50 Ω termination (item 3), and one dual-input coupler (item 7).

**Adjustment Locations:** This procedure requires adjustments to the Display Driver board. See Figure 7-14 on page 7-19 for the location of the adjustments.

1. Display channel 1, turning all others off.
2. Press the **AUTOSET** button.
3. Set the volts/div scale to 50 mV.
4. Set the sec/div scale to 1 ms.
5. Press the **ALT/CHOP ADD** button and set **DISP** to **Alt**.
6. Press the **VERTICAL MENU** button and set **CPLG** to **AC**.
7. Connect the positive fast rise pulse output of the pulse generator to the **CH 1** and **CH 2** input connectors as shown in Figure 7-3.

![Diagram of Pulse Generator and Oscilloscope]

**Figure 7-3: Low Frequency Output Compensation Calibration Setup**

8. Set the pulse generator for fast rise period of 1 ms and a 4 division display.
9. Press the **SET LEVEL TO 50%** button.
10. Press the **CURSOR** button and set **VOLT** to **On**.
11. Set the cursors 5 divisions apart using the General Purpose Knob and the **TOGGLE** button.
12. Set the volts/div scale to 20 mV.
13. Press the CH 2 button.
14. Set the channel 2 volts/div scale to 20 mV.
15. Press the VERTICAL MENU button and make the following selections from the menu (channel 2):
   - Set CPLG to GND
   - Set VAR to Off
   - Set INV to Off
   - Set BW to Full
16. Position the channel 2 trace to the center vertical graticule line.
17. Set CPLG to AC.
18. Adjust R111 located on the Display Driver board for minimum vertical movement of the readout (over the entire graticule area).
19. Disconnect the test setup from the oscilloscope.

**Factory Horizontal Cal**

**Equipment Required:** One time mark generator (item 9), one precision coaxial cable (item 5), and one 50 Ω termination (item 3).

**Prerequisites:** CRT adjustment procedure.

**NOTE**

To enable factory calibration on oscilloscopes with firmware version 2.10 or above, remove jumper J205 (CAL – DIS) on the CPU board. (See Figure 7-17 on page 7-22 for the location of J205.) If you do not remove this jumper, the message “See manual to enable Factory Cal” appears when you select the factory calibration routine.

Firmware versions below 2.10 do not have the calibration lockout feature and the factory calibration routine can still execute with J205 installed.

1. Disconnect all signal inputs from the oscilloscope.
2. Press the UTILITY button to display the Utility menu.
To avoid replacing the calibration constants with erroneous values, be sure to complete all steps of this procedure after initiating the calibration routine.

3. Select **CAL** from the main menu.

4. Select **Factory Horizontal Cal** to initiate the calibration routine.
   
   This routine takes about 20 seconds to complete its initial calibrations. Once complete, 2 dots are displayed and the message "**Toggle to set 8div about center**" appears. The displayed dots are used for the next horizontal calibration steps.

**NOTE**

The following steps use both the General Purpose Knob and the **TOGGLE** button to make adjustments. The General Purpose Knob performs two functions: to adjust horizontal gain and centering. The **TOGGLE** button selects the function of the General Purpose Knob.

5. Use a combination of the **TOGGLE** button and the General Purpose Knob to position the dots 8 divisions apart, centered horizontally (see Figure 7-4).

6. Select **Done** when you have the appropriate display.

![Diagram of Dots Eight Divisions Apart, Centered Horizontally]

**Figure 7-4: Horizontal Adjustments (One)**

7. Again, use a combination of the **TOGGLE** button and the General Purpose Knob to position the dots 8 divisions apart, centered horizontally (see Figure 7-4).
8. Select **Done** when you have the appropriate display.

9. One dot is displayed.

10. Use a combination of the TOGGLE button and the General Purpose Knob to center the single dot at the center of the screen (see Figure 7-5).

![Diagram of a display with a centered dot and TOGGLE button label](image)

**Figure 7-5: Horizontal Adjustments (Two)**

11. Continue to press the TOGGLE button and adjusting the dot to center screen with the General Purpose Knob until the dot stays centered while pressing the TOGGLE button.

12. Select **Done** when you have the appropriate display.

13. Two vertical cursor lines are displayed.

14. Use a combination of the TOGGLE button and the General Purpose Knob to position the vertical lines 8 divisions apart, centered horizontally (see Figure 7-6).

![Diagram of a display with vertical lines and TOGGLE button label](image)

**Figure 7-6: Horizontal Adjustments (Three)**
15. Select **Done** with the menu button when you have the appropriate display.

**NOTE**

At this time, the calibration routine can be terminated by selecting **Abort** instead of **Done**. The abort option appears through the remainder of this Factory Horizontal Cal routine.

16. Select **Done** to continue or **Abort** to terminate the calibration routine.

17. Connect the output of the time mark generator to the **CH 1** input as shown in Figure 7-7.

![Time Mark Generator](image)

*Figure 7-7: Horizontal Output Calibration Setup*

18. Set the time mark generator for 5 ns markers.

19. Select **Done** when completed.

20. Adjust the 5 ns main sweep accuracy by performing these substeps.
   a. Using the General Purpose Knob, adjust the display for 1 time marker per division over the center 8 divisions.
   b. Select **Done** when adjusted.

21. Adjust the 5 ns delay sweep accuracy by performing these substeps.
   a. Using the General Purpose Knob, adjust the display for 1 time marker per division over the center 8 divisions.
   b. Select **Done** when adjusted.

22. Adjust the 2 ns main sweep accuracy by performing these substeps.
   a. Using the General Purpose Knob, adjust the display for 2 time markers per 5 divisions over the center 8 divisions.
   b. Select **Done** when adjusted.

23. Adjust the 2 ns delay sweep accuracy by performing these substeps.
a. Using the General Purpose Knob, adjust the display for 2 time markers per 5 divisions over the center 8 divisions.

b. Select **Done** when adjusted; a **Cal Passed** message appears.

24. Select **Done** to exit the routine.

25. Disconnect the test setup from the oscilloscope.

26. If you do not intend to proceed with Factory Vertical CAL, replace J205 (CAL—DIS) to lock out the calibration routine. (This jumper only works with firmware version 2.10 and above.)

---

**CAUTION**

*To prevent accidental loss of calibration, be sure the calibration lockout jumper (J205) is in place. If J205 is not in place, erroneous calibration constants can result if the calibration routine is accidentally invoked and not properly completed.*

---

**Factory Vertical Cal**

**Equipment Required**: One DC calibration generator (item 11), one precision coaxial cable (item 5), and one dual-input coupler (item 7).

**Prerequisites**: Low Frequency Output Compensation adjustment and Self Cal Horizontal adjustment procedures.

---

**NOTE**

*To enable factory calibration on oscilloscopes with firmware version 2.10 or above, remove jumper J205 (CAL—DIS) on the CPU board. (See Figure 7-17 on page 7-22 for the location of J205.) If you do not remove this jumper, the message “See manual to enable Factory Cal” appears when you select the factory calibration routine.*

*Firmware versions below 2.10 do not have the calibration lockout feature and the factory calibration routine can still execute with J205 installed.*

---

1. Press the **UTILITY** button.
To avoid replacing the calibration constants with erroneous values, be sure to complete all steps of this procedure after initiating the calibration routine.

2. Select **CAL** from the main menu.
3. Select **Factory Vertical Cal** to initiate the calibration routine.

The calibration routine displays user prompts on-screen throughout this procedure.

**NOTE**

At this time, the calibration routine can be terminated by selecting **Abort**. The abort option appears through the remainder of this Factory Vertical Cal routine.

4. Set the DC calibration generator for 10 VDC output and connect to the **CH 1** and **CH 2** inputs as shown in Figure 7-8.

![DC Calibration Generator](image)

**Figure 7-8: Factory Vertical Calibration Setup**

5. Select **Done** when completed.
6. Set the DC calibration generator for 1 VDC output.
7. Select **Done** when completed.
8. Set the DC calibration generator for 100 mVDC output.
9. Select **Done** when completed.
10. Disconnect the test setup.
11. Select **Done** when completed.

This portion of the routine takes about one minute to complete.
12. Connect the DC calibration generator to the **EXT TRIG** input as shown in Figure 7-9.

![DC Calibration Generator](image)

**Figure 7-9: External Trigger Calibration Setup**

13. Set the DC calibration generator for 500 mVDC output.

14. Select **Done** when completed.

15. Set the DC calibration generator for 5 VDC output.

16. Select **Done** when completed.

**NOTE**

The following steps use both the General Purpose Knob and the **TOGGLE** button to make adjustments. The General Purpose Knob performs two functions: adjust horizontal gain and centering. The **TOGGLE** button selects the function of the General Purpose Knob.

17. Use a combination of the **TOGGLE** button and the General Purpose Knob to position the dots 6 divisions apart, centered horizontally (see Figure 7-10).

![Dots Six Divisions Apart, Centered Horizontally](image)

**Figure 7-10: Vertical Adjustments**
18. Select **Done** when you have the appropriate display.

19. Adjust R112 (vertical gain) and R154 (vertical centering) on the Display Driver board, setting the horizontal cursors 6 divisions apart, centered vertically (see Figure 7-11).

![Figure 7-11: Adjusting Vertical Gain and Centering](image)

20. Select **Done** when you have completed the adjustments.

21. Select **Done** again to exit the routine.

22. Replace J205 (CAL-DIS) to lock out the calibration routine. (This jumper only works with firmware version 2.10 and above.)

**CAUTION**

*To prevent accidental loss of calibration, be sure the calibration lockout jumper (J205) is in place. If J205 is not in place, erroneous calibration constants can result if the calibration routine is accidentally invoked and not properly completed.*

### High Frequency Step Response

**Equipment Required:** One pulse generator (item 10), one precision coaxial cable (item 5), one 5X attenuator (item 1), and one 50 Ω termination (item 3).

**Adjustment Locations:** This procedure requires adjustments to the Display Driver board. See Figure 7-14 on page 7-19 for the location of the adjustments.

**Prerequisites:** Factory Vertical Cal adjustment procedure.

1. Display channel 1, turning all others off.
2. Connect the positive fast rise pulse output of the pulse generator to the CH 1 input as shown in Figure 7-12.

![Figure 7-12: High Frequency Step Response Test Setup](image)

3. Set the pulse generator fast rise period to 1 μs and pulse amplitude to mid-range.
4. Press the AUTOSET button.
5. Set the volts/div scale to 10 mV.
6. Set the sec/div scale to 200 ns.
7. Press the VERTICAL MENU button and set CPLG to DC.
8. Adjust the vertical POSITION control and the generator pulse amplitude to obtain a 5 division, vertically centered, display.
10. Set the sec/div scale to 20 ns.
11. Adjust R140 and C121 on the Display Driver board for minimum signal aberrations of the pulse front corner.

**NOTE**

Some interaction of the adjustments made in steps 9 and 11 may occur. For optimum oscilloscope performance, these steps should be rechecked after making adjustments.

12. Disconnect the calibration setup from the oscilloscope.
Attenuator Compensation

**Equipment Required:** One pulse generator (item 10), one precision coaxial cable (item 5), one 50 Ω termination (item 3), and one dual-input coupler (item 7).

**Adjustment Locations:** This procedure requires adjustments to the Analog board. See Figure 7-15 on page 7-20 for the location of the adjustments.

**Prerequisites:** Low Frequency Output Compensation adjustment procedure.

1. Display channel 1, turning all others off.

2. Connect the high amplitude output of the pulse generator to the **CH 1** and **CH 2** inputs as shown in the following test setup diagram.

![Pulse Generator Diagram](image)

Figure 7-13: Attenuator Compensation Test Setup

3. Set the pulse generator high amplitude period to 1 ms.

4. Press the **AUTOSET** button.

5. Press the **VERTICAL MENU** button and set **CPLG** to **DC**.

6. Set the volts/div scale to 200 mV.

7. Set the sec/div scale to 200 μs.

8. Using the vertical **POSITION** control and the generator pulse amplitude, obtain a 5 division, vertically centered display of channel 1.

9. Set the volts/div scale to 100 mV.

10. Press the **CH 2** button.

11. Press the **VERTICAL MENU** button and make the following selections from the menu:
- Set **CPLG** to **DC**
- Set **VAR** to **Off**
Set INV to Off

Set BW to Full

Set the volts/div scale to 100 mV

Position the channel 2 display approximately 0.5 divisions below the channel 1 display

12. Press the CH 1 button.

13. Adjust Ch 1 10X on the Analog board for the flattest response of the most positive portion of the channel 1 waveform.

14. Set the channel 1 volts/div scale to 1 V.

15. Press the CH 2 button.

16. Adjust Ch 2 10X adjustment on the Analog board for the flattest response of the most positive portion of the channel 2 waveform.

17. Set the channel 2 volts/div scale to 1 V.

18. Set the pulse generator amplitude to maximum.

19. Adjust Ch 2 100X on the Analog board for the flattest response of the channel 2 waveform.

20. Adjust Ch 1 100X on the Analog board for the flattest response of the channel 1 waveform.

21. Disconnect the test setup from the oscilloscope.

Vertical Gain Adjust (Cabinet On)

Equipment Required: None.

Adjustment Locations: This procedure requires adjustments to the Display Driver board. See Figure 7-14 on page 7-19 for the location of the adjustments.

Prerequisites: Low Frequency Output Compensation, Factory Vertical Cal, and Attenuator Compensation adjustment procedures.

1. Slide the cabinet on the instrument and allow a 20-minute warm-up.

2. Press the CURSOR button and set ΔVOLT to On.

3. Set the volts/div scale to 1 V.

4. Position the cursors 6 divisions apart, centered vertically and check that the ΔVolts readout is between 5.96 V and 6.04 V.

NOTE

If the readout in step 4 is within the limits given, stop here. The calibration is complete.

If the readout is outside the limits, continue with this procedure.
5. Adjust the cursors until the ΔVolts readout is 6 V.

6. Note the cursor display error (are the cursors more or less than six divisions apart).

7. Slide the cabinet off the instrument and adjust R112 on the Display Driver board to compensate for the display error noted in step 6.

   For example, if you noted in step 6 that the ΔVolts readout at 6 V, the cursor display equaled 6.2 divisions. Compensate by adjusting the cursor display to 5.8 divisions with R112.

8. Slide the cabinet on the instrument and repeat this procedure until the cursor display matches the ΔVolts readout.

**Adjustment Complete**

The adjustment procedure is complete. Install the cabinet and rear cover.
Figure 7-14: Display Driver Board Adjustment Locations
Figure 7-15: Analog Board Adjustment Locations
Figure 7-16: Power Supply Adjustment Location (B020100 and Above)
Figure 7-17: Location of J205 (CAL–DIS) on the CPU Board
Maintenance Information

This section contains the information needed to do periodic maintenance and make basic repairs to the TAS 455 and TAS 465 Analog Oscilloscopes.

- **Maintenance Information** — This subsection. It includes this introduction, servicing information, plus general information on preventing damage to internal modules when doing maintenance.

- **Inspection and Cleaning** — Information and procedures for inspecting the oscilloscope and cleaning its external and internal modules.

- **Removal and Installation Procedures** — Procedures for removing and installing the modules, circuit boards, and mechanical parts.

- **Troubleshooting Aids** — Procedures that help isolate problems to a module.

---

**Before Servicing**

This manual is for servicing of the TAS 455 and TAS 465 Analog Oscilloscopes. To prevent injury to yourself or damage to the oscilloscope, do the following before you attempt service.

- Be sure you are a qualified service person.
- Read the *Safety Summary* found at the beginning of this manual.

When using this manual for servicing, be sure to heed all warnings, cautions, and notes.

---

**Tektronix Service**

Tektronix provides service to cover repair under warranty as well as other services that may provide a cost-effective answer to your service needs.

Whether providing warranty repair service or any of the other services listed below, Tektronix service technicians, trained on Tektronix products, are best equipped to service your TAS 455 and TAS 465 Analog Oscilloscopes. Tektronix technicians are apprised of the latest information on improvements to the product as well as the latest new options.

**Warranty Service**

Tektronix warrants this product for three years from date of purchase, excluding probes for which the warranty is one year. (The warranty appears on the back of the title page in this manual.) Tektronix technicians provide warranty service at most Tektronix service locations worldwide. Your Tektronix product catalog lists all service locations worldwide.
Repair or Calibration Service
Tektronix offers several types of service contracts that you may purchase to tailor repair and/or calibration of your TAS 455 and TAS 465 Analog Oscilloscopes to fit your requirements.

Self Service
This manual contains all the information needed for periodic maintenance and repair of the TAS 455 and TAS 465 Analog Oscilloscopes.

For periodic maintenance, use these sections:
- Performance verification procedures
- Calibration procedures

For instrument repair, use these sections:
- Troubleshooting aids to help isolate problems to a module
- Disassembly procedures
- Parts lists

Replace failed modules with fully tested modules obtained from the factory.

For information, contact your local Tektronix service center or sales engineer on any repair services.

Preventing ESD
When performing any service which requires internal access to the oscilloscope, adhere to the following precautions to avoid damaging internal modules and their components due to electrostatic discharge (ESD).

CAUTION
Static discharge can damage any semiconductor component in this oscilloscope.

1. Minimize handling of static-sensitive modules.
2. Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these modules. All service must be done at a static-free work station.
3. Do not remove the oscilloscope cabinet unless you have met precaution number 2, above. Consider all internal modules static-sensitive.
4. Remove anything capable of generating or holding a static charge from the work station surface.
5. Do not slide the modules over any surface.
6. Do not use high-velocity compressed air when cleaning dust from modules.

Susceptibility to ESD

Table 8-1 lists the relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Table 8-1: Relative Susceptibility to Static-Discharge Damage

<table>
<thead>
<tr>
<th>Semiconductor Classes</th>
<th>Relative Susceptibility Levels¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS or CMOS microcircuits or discrete circuits, or linear</td>
<td>1</td>
</tr>
<tr>
<td>microcircuits with MOS inputs (most sensitive)</td>
<td></td>
</tr>
<tr>
<td>ECL</td>
<td>2</td>
</tr>
<tr>
<td>Schottky signal diodes</td>
<td>3</td>
</tr>
<tr>
<td>Schottky TTL</td>
<td>4</td>
</tr>
<tr>
<td>High-frequency bipolar transistors</td>
<td>5</td>
</tr>
<tr>
<td>JFET</td>
<td>6</td>
</tr>
<tr>
<td>Linear microcircuits</td>
<td>7</td>
</tr>
<tr>
<td>Low-power Schottky TTL</td>
<td>8</td>
</tr>
<tr>
<td>TTL (least sensitive)</td>
<td>9</td>
</tr>
</tbody>
</table>

¹Voltage equivalent for levels (voltage discharged from a 100 pF capacitor through resistance of 100 ohms):

- 1 = 100 to 500 V
- 2 = 200 to 500 V
- 3 = 250 V
- 4 = 500 V
- 5 = 400 to 600 V
- 6 = 600 to 800 V
- 7 = 400 to 1000 V (est.)
- 8 = 900 V
- 9 = 1200 V
Inspection and Cleaning

*Inspection and Cleaning* describes how to inspect and clean the TAS 455 and TAS 465 Analog Oscilloscopes. Inspection and cleaning are preventive maintenance. Preventive maintenance, when done regularly, may prevent oscilloscope malfunction and enhance its reliability.

Preventive maintenance consists of visually inspecting and cleaning the oscilloscope and using general care when operating it.

How often to do maintenance depends on the severity of the environment in which you use the oscilloscope. A proper time to perform preventive maintenance is just before oscilloscope adjustment.

---

**General Care**

The cabinet helps keep dust out of the oscilloscope and it is a major component of its cooling system. It should normally be in place when operating the oscilloscope. The oscilloscope front cover protects the front panel and display from dust and damage. Install it when storing or transporting the oscilloscope.

---

**Inspection and Cleaning Procedures**

Inspect and clean the oscilloscope as often as operating conditions require. The collection of dirt on components inside can cause them to overheat and breakdown. (Dirt acts as an insulating blanket, preventing efficient heat dissipation.) Dirt also provides an electrical conduction path that could cause an oscilloscope failure, especially under high-humidity conditions.

---

**CAUTION**

Avoid the use of chemical cleaning agents that might damage the plastics used in this oscilloscope. Use a 75% isopropyl alcohol solution as a cleaner and rinse with deionized water. Use only deionized water when cleaning the menu buttons or front-panel buttons. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

Avoid the use of high pressure compressed air when cleaning dust from the interior of this instrument. (High pressure air can cause ESD.) Instead, use low pressure compressed air (about 9 psi).
Inspection and Cleaning

Inspection — Exterior

Inspect the outside of the oscilloscope for damage, wear, and missing parts. Use Table 8-2 as a guide. Oscilloscopes that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Repair defects that could cause personal injury or lead to further damage to the oscilloscope immediately.

<table>
<thead>
<tr>
<th>Item</th>
<th>Inspect For</th>
<th>Repair Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabinet, front panel, and cover</td>
<td>Cracks, scratches, deformations, damaged hardware or gaskets.</td>
<td>Replace defective module.</td>
</tr>
<tr>
<td>Front-panel knobs</td>
<td>Missing, damaged, or loose knobs.</td>
<td>Repair or replace missing or defective knobs.</td>
</tr>
<tr>
<td>Connectors</td>
<td>Broken shells, cracked insulation, and deformed contacts. Dirt in connectors.</td>
<td>Replace defective modules. Clear or wash out dirt.</td>
</tr>
<tr>
<td>Carrying handle and cabinet feet</td>
<td>Correct operation.</td>
<td>Repair or replace defective module.</td>
</tr>
<tr>
<td>Accessories</td>
<td>Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors.</td>
<td>Replace damaged or missing items.</td>
</tr>
</tbody>
</table>

Cleaning Procedure — Exterior

1. Remove loose dust on the outside of the oscilloscope with a lint free cloth.

2. Remove remaining dirt with a lint free cloth dampened in a general purpose detergent-and-water solution. Do not use abrasive cleaners.

\[\text{CAUTION}\]

To prevent getting moisture inside the oscilloscope during external cleaning, use only enough liquid to dampen the cloth or applicator.

3. Clean the CRT screen with a lint-free cloth dampened with either a 75% isopropyl alcohol solution or, preferably, a gentle, general purpose detergent-and-water solution.

\[\text{NOTE}\]

If the CRT Implosion Shield needs further cleansing, refer to the procedure on page 8-7.
Cleaning Procedure — Interior

If, after doing steps 1 and 2, a module is clean upon inspection, skip the remaining steps.

1. Blow off dust with dry, low-pressure, deionized air (approximately 9 psi).

2. Remove any remaining dust with a lint free cloth dampened in isopropyl alcohol (75% solution) and rinse with a warm deionized water. (A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.)

3. If steps 1 and 2 do not remove all the dust or dirt, the oscilloscope may be spray washed using a solution of 75% isopropyl alcohol by doing steps 4 through 8.

4. Gain access to the parts to be cleaned by removing easily accessible shields and panels (see Removal and Installation Procedures).

5. Spray wash dirty parts with the isopropyl alcohol solution and wait 60 seconds for the majority of the alcohol to evaporate.

6. Use hot (+50°C to +60°C) deionized water to thoroughly rinse them.

7. Dry all parts with low-pressure, deionized air.

8. Dry all components and assemblies in an oven or drying compartment using low-temperature (+50°C to +60°C) circulating air.

Cleaning the CRT Implosion Shield

This procedure describes how to clean both sides of the CRT Implosion Shield, thus requiring its removal. Perform this procedure only if cleaning the backside of the Implosion Shield is necessary.

1. Remove the Implosion Shield as described in Removal and Replacement beginning on page 8-26.

2. Clean the shield with a lint free cloth dampened in a general purpose detergent-and-water solution. Do not use abrasive cleaners.

3. Remove any static charge that may have accumulated by holding the shield in a deionized air flow.

4. Install the shield as described in Removal and Replacement beginning on page 8-26.
Inspection and Cleaning
Removal and Installation Procedures

This subsection contains procedures for removal and installation of all replaceable mechanical and electrical modules. Replaceable mechanical and electrical modules are listed in the Replaceable Parts section of this manual.

Preparation — Please Read

**WARNING**

Before doing this or any other procedure in this manual, read the Safety Summary found at the beginning of this manual. Also, to prevent possible injury to service personnel or damage to oscilloscope components, read Safety Summary in the front matter, and Preventing ESD in this section.

This subsection contains the following:
- This preparatory information that you need to properly do the procedures that follow.
- A list of equipment required to remove and disassemble all modules.
- Procedures for removal and reinstallation of the electrical and mechanical modules.
- Three module locator diagrams for finding all the modules in this oscilloscope. (See Figures 8-2, 8-3, and 8-4.)

**WARNING**

Before doing any procedure in this subsection, disconnect the power cord from the line voltage source. Failure to do so could cause serious injury or death.

Cable Removal

Cables are partially or completely removed in the course of removing a board or module they plug into.
General Instructions

READ THESE GENERAL INSTRUCTIONS BEFORE REMOVING A MODULE.

First read over the Summary of Procedures that follows to understand how the procedures are grouped. Then read Equipment Required for a list of the tools needed to remove and install modules in this oscilloscope.

Procedures refer to the “front,” “rear,” “top,” etc. of the oscilloscope. Figure 8-1 illustrates these references.

Figure 8-1: Oscilloscope Orientation

Summary of Procedures

The procedures are described in the order in which they appear in this section. In addition, you can look up any procedure for removal and reinstallation of any module in the Table of Contents of this manual.
**Equipment Required** — Table 8-3 lists the tools required to completely disassemble the oscilloscope into its modules.

All the tools are standard tools readily available from tool suppliers.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Screwdriver handle</td>
<td>Accepts Torx®-driver bits.</td>
</tr>
<tr>
<td>2</td>
<td>T-15 Torx tip</td>
<td>Torx®-driver bit for T-15 size screw heads.</td>
</tr>
<tr>
<td>3</td>
<td>T-20 Torx tip</td>
<td>Torx®-driver bit for T-20 size screw heads. Used only for removal of the cabinet handle.</td>
</tr>
<tr>
<td>4</td>
<td>Nut driver, 5/16 inch</td>
<td>Used for removing the CRT earth ground cable.</td>
</tr>
<tr>
<td>5</td>
<td>Angle-tip tweezers</td>
<td>Used for knob and shaft removal.</td>
</tr>
<tr>
<td>6</td>
<td>Flat-bladed spudger</td>
<td>A non-metallic probe-like tool with a flat bladed tip. Used to remove the front-panel trim and front module.</td>
</tr>
<tr>
<td>7</td>
<td>Slip-Jaw Pliers</td>
<td>Used for removing the front feet from the cabinet.</td>
</tr>
</tbody>
</table>
Figure 8-2: Cabinet and Front-Panel Mounted Modules
Figure 8-3: Internal Modules
Line Cord and Line Fuse

The following procedures describe how to remove and install the line cord and line fuse located on the back side of the oscilloscope.

**WARNING**

Unplug the line cord from the line voltage power source before continuing. Failure to do so can cause injury or death.

Prepare the oscilloscope by positioning the bottom side down on the work surface and facing the back side toward you. Refer to Figure 8-5.

**Line Cord**

1. Unplug the line cord from the power source.
2. Unplug the other end of the line cord from the back of the oscilloscope.
3. Grasp the end of the line cord and retaining clamp and rotate them 90 degrees counterclockwise (Figure 8-5).
4. Pull the line cord and clamp away from the back of the oscilloscope.
5. Perform this procedure in reverse order to install the power cord on the oscilloscope.

**Line Fuse**

1. Unplug the line cord from the power source.
2. Pull out the fuse holder drawer and remove the fuse (Figure 8-5).
3. Perform this procedure in reverse order to install the fuse.

![Line Fuse and Line Cord Removal](image)

**Figure 8-5: Line Fuse and Line Cord Removal**

---

**Front-Panel Knobs and Shafts**

Use the following procedures to remove and install front-panel knobs and shafts.

Prepare the oscilloscope by setting it bottom side down on the work surface and facing the front side toward you.

**Removing Front-Panel Knobs and Shafts**

1. Remove any knob by pulling it straight out from the front panel slightly. This will create some clearance between the base of the knob and the front panel to create some clearance between the base of the knob and the front panel.

2. Insert the tweezers between the knob and front panel and use them to remove the knob and attaching shaft (see Figure 8-6).
3. Pull the shaft out of the knob to separate the two pieces.

**Installing Front-Panel Knobs and Shafts**

1. Align the inside of the knob to the end of the shaft and push it in until it snaps.
2. Insert the shaft of the assembly into the proper hole on the front panel and push it in until it stops.
3. Lightly push in the knob and rotate it until the shaft slips into place.
4. Push the knob all the way in to seat the assembly.

*Figure 8-6: Knob and Shaft Removal*
Feet, Rear Cover, and Cabinet

Before removing the rear cover or cabinet, install the optional front cover on the front panel of the oscilloscope (if available) and then position the oscilloscope as indicated in Figure 8-7.

*Figure 8-7: Rear Cover, Cabinet, and Feet Removal*
Rear Cover
1. Position the oscilloscope as indicated in Figure 8-7.
2. Use the screwdriver to remove the four T-15 Torx screws that secure the rear cover to the oscilloscope.
3. Lift off the rear cover. Do these steps in reverse order to install the rear cover.

Cabinet
1. Remove the rear cover.
2. Remove the single T-15 Torx screw on the left side of the oscilloscope.
3. Grasp the two handle hubs and pull them outward as if to rotate the handle.
4. While holding the handle hubs out, lift the cabinet up and slide it off the oscilloscope. Take care not to bind or snag the cabinet on the internal cabling as you remove it.

Replacing the Front Feet
If you are replacing a front foot, use a pair of slip-jaw pliers to firmly grip the foot, then pull with a turning motion to remove. Do this step in reverse order to replace the foot.

Front-Panel Trim, Menu and Power Buttons, EMI Gasket
Use the following procedures to remove and install front-panel trim, buttons, and EMI gaskets.

Additional procedures required — These procedures require that the following procedures be performed first:
- Rear Cover Removal
- Cabinet Removal

Removing the Front Trim
1. Slide a flat-bladed spudger between the chassis and the plastic front trim, near one of the four flex locks. See Figure 8-8.
2. Gently pry the front trim up and slightly forward to disengage the flex lock. Do this until all four flex locks are disengaged.
3. Pull the front trim forward and off the instrument.
Menu Buttons and Elastomer

1. Lay the front trim on a flat surface.
2. Gently remove menu button elastomer. Avoid touching the electrical contacts.
3. Remove the menu button(s).
4. Install menu buttons by placing a menu button in each menu button location.
5. Place the menu button elastomer over the menu buttons, ensuring that all standoffs protrude through the elastomer. Avoid touching the electrical contacts.

Power Button Replacement

1. With the front trim removed, grasp the power button and pull straight out from the chassis.
2. Install the power button by pushing the button onto the power button shaft until it locks into place.

Installing the Front Trim

1. If the menu buttons were removed, insert each button to its hole in the trim ring and install the menu button elastomer.
2. Align the front trim to the front of the instrument, without engaging any of the four flex locks.
3. Position the power button in line with the front-panel power button opening.
4. Slide the front trim onto the instrument, ensuring that all four flex locks engage.
5. If installing a new front trim, apply the appropriate front trim label.
Installing the EMI Gaskets

The EMI gaskets were added to improve the performance of the oscilloscope. You may add them to your oscilloscope if they were not installed originally.

1. If you are servicing the front EMI gaskets, discard the old ones.

2. Without installing the EMI gaskets, align the trim ring to the front of the chassis and push it on to seat. Be sure that both pairs of flex locks, one pair each at the inside top and bottom of the trim ring, snap over the edge of the chassis.

3. Lay the oscilloscope so its front cover is on the work surface.

4. Align an EMI gasket so it lies between any pair of adjacent flex locks along the groove between the cabinet and the trim ring.

5. Using a flat-bladed spudger, push the EMI gasket until it is firmly seated at the bottom of the groove (see Figure 8-9). It should not overlap either flex lock.

6. Repeat the process just described to install the remaining three gaskets.
A62 Front Panel Module Removal

The following procedure describes how to remove the A62 Front Panel module.

**Additional procedures required** — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front-Panel Trim Ring

1. Set the oscilloscope so its bottom is down on the work surface and its front is facing you.

2. Insert a flat-bladed screwdriver into the slot at the front-right of the chassis. Push inwards to release the snap lock at the right side. (See Figure 8-10.)
3. Pull the Front Panel module slightly away from the front of the chassis until you can reach the interconnect cables at the rear of the module.

4. Unplug the following cables from their jacks on the Front Panel module:
   - The Display Control-to-front-panel cable at J84
   - The menu flex circuit-to-front panel at J40
   - The CPU-to-front-panel cable at J30

5. Lift the Front Panel module out from the chassis.

![Front Panel Assembly](image)

**Figure 8-10: A62 Front Panel Module Removal**

---

**Menu Flex Circuit Replacement**

**STOP** Perform this procedure only if replacing a failed or damaged menu flex circuit with a fresh unit from the factory. (Removal of the circuit is likely to destroy it.)

**Additional procedures required** — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal
- A62 Front Panel Module Removal
1. Pull the flex circuit away from the front of the main chassis. (It is held on by its sticky backing.) See Figure 8-11.

2. Wipe the front of the chassis using isopropyl alcohol and a clean, lint-free cloth. Let dry. (Some adhesive from the flex circuit you removed will be left on the front of the chassis. This is normal.)

Figure 8-11: Menu Flex Circuit Board Removal

3. Find the score line in the adhesive backing and peel the backing off of the menu flex circuit.

**NOTE**

*DO NOT touch the contacts on the menu flex circuit with your bare fingers. You should wear clean cloth gloves that are free of lint when installing the menu flex circuit on the front chassis.*

4. Carefully align the three holes on the menu flex circuit to the locator studs on the front of the main chassis. When the alignment is correct, press the flex circuit against the chassis so it adheres to the chassis.
Removal and Installation Procedures

5. Clean the surface of the menu flex circuit just installed using isopropyl alcohol and a clean, lint-free cloth.

6. Repeat all procedures performed in reverse order to reassemble the instrument.

A1 Analog Board

The following procedure describes how to remove the A1 Analog board.

Additional procedures required — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal

1. Set the oscilloscope so its top side is down on the work surface and its front is facing you.

2. Disconnect the delay line from its holder and at connector J68 on the Analog board.

3. Disconnect the cables at connectors J50 and J67 on the Analog board.

4. Disconnect the cable to the rear panel Z-axis connector.

5. Using Figure 8-12 as a guide, remove the four T-15 Torx® screws securing the attenuator assembly to the front of the chassis. Next remove the four T-15 Torx® screws securing the attenuator board to the chassis.

6. Lift the attenuator assembly away from the oscilloscope to complete its removal.
Display Driver Board
(A3)

Remove and replace the Display Driver board as follows:

1. Remove the plastic high voltage cover from the rear of the Display Driver board (A3). Refer to Figure 8-13.

2. Disconnect the delay line from its holder and at connector J69 on the Display Driver board.

3. Disconnect the cables from J70, J71, J72, J73, J74, J75, and J80 on the Display Driver board.


5. Remove the four T-15 Torx screws used to attach the Display Driver board to the chassis.
6. Remove the Display Driver board from the chassis, but leave the clear plastic sheet in place.

7. Replace the Display Driver board by performing the reverse of the procedure described in steps 1 through 5.

---

**CRT Implosion Shield**

The procedures that follow describe how to remove and install the CRT Implosion Shield. The method to accomplish this is different depending on the serial number of your instrument. Choose the correct procedure for your instrument by comparing your instrument serial number to those listed.

**Current Method**—The following procedures describe the removal of the CRT Implosion Shield for the instrument models described in the following note.

**NOTE**

*TAS 455 — SN: B011876 and Above*
*TAS 465 — SN: B011640 and Above*
Additional procedures required — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal

1. From the front of the Implosion Shield, slip the spudger into the slot provided on the side of the CRT Front Bracket. See Figure 8-14.
2. Carefully pry the Implosion Shield up and out of the CRT Front Bracket guides.
3. Re-install the Implosion Shield by placing the left side of the shield into the CRT Front Bracket guides. If installing a new Implosion Shield, remove the clear protective covers.
4. Snap the right side of the Implosion shield into the CRT Front Bracket snaps.
5. Install all previously removed components.

Figure 8-14: CRT Implosion Shield Removal
**Removal and Installation Procedures**

**Early Method**—The following procedures describe the removal of the CRT Implosion Shield for the instrument models described in the following note.

**NOTE**

*TAS 455 — SN: B011875 and Below
TAS 465 — SN: B011639 and Below*

**Additional procedures required** — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal
- A3 Display Driver Board
- CRT

1. From the front of the Implosion Shield, push the top of the shield until it pops out of the back side of the CRT Front Bracket.
2. Re-install the CRT Implosion shield by snapping the shield into the rear of the CRT Front Bracket. If installing a new Implosion Shield, remove the clear protective covers.
3. Install all previously removed components.

---

**CRT**

The procedures that follow describe how to remove and install the CRT. Refer to Figure 8-16 for this procedure.

**Additional procedures required** — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal
- A3 Display Driver Board

**CRT Removal**

1. Set the oscilloscope so its bottom is down on the work surface, with its front facing you.
WARNING

Breaking a CRT causes it to implode, scattering glass fragments with high velocity and possibly injuring you. Wear protective clothing and safety glasses (preferably a full-face shield). Avoiding striking the CRT with or against any object.

Store the CRT with its display face down in a protected location, placing it on a soft, nonabrasive surface to prevent scratching the face plate.

2. Unplug the the 2-wide red/black cable from the A2 Display Control board.

WARNING

High voltage is present on the anode lead. Do not touch the end of the anode lead until it has been fully discharged to ground.

3. Disconnect the red CRT anode lead from the A63 Power Supply module and immediately discharge to chassis ground.

4. Using a 5/16 inch nut driver, remove the nut securing the ground wire at the rear of the CRT.

5. From the bottom of the chassis, unsnap the Rear CRT Bracket from the chassis. See Figure 8-15.

![Figure 8-15: CRT Rear Bracket and Ground Clip](diagram)

---

TAS 455 and TAS 465 Instruction Manual 8-29
6. Lift the rear of the CRT until it is above the chassis. Then pull the CRT away from the CRT Front Bracket.

STOP

Stop here if you are removing the CRT assembly to gain access to other portions of the instrument. If you are installing a new CRT or hardware attached to the CRT, continue with this procedure.

7. Slide the Rear CRT Bracket from the CRT. The Spring Ground Clip will slide out also.

8. Remove the CRT Socket with its cover from the rear pin connector of the CRT.

9. Disconnect the vertical and horizontal control wires from the side of the CRT. Note the proper location of both sets of wires for reinstallation.

10. Slide the CRT shield and its front support off the CRT.

11. Store the CRT in a safe location.

**CRT Installation**

1. Slide the CRT shield and its front support onto the CRT as far forward as possible.

2. Align the holes in the shield so that the vertical and horizontal control pins on the side of the CRT are accessible.

3. Align the slot in the CRT Socket to the key on the CRT pin connector and slide the Socket onto the pins.

4. Slip the CRT socket wires through the Rear CRT Bracket and slide the bracket onto the rear of the CRT.

5. Ensure that the Rear CRT Bracket is properly aligned with the slots provided in the CRT Shield.

6. Slide the Spring Ground Clip into the slot provided in the Rear CRT Bracket.

7. Connect the vertical and horizontal control wires to the side CRT pins.

8. Guide the front of the CRT into the CRT Front Bracket. Ensure that the four CRT Cushions are in their proper place in each corner of the Bracket.

9. Lower the rear of the CRT into the chassis and press down on the CRT Rear Bracket until it snaps into the chassis.

10. Route the vertical and horizontal control cables to the bottom of the chassis.

11. Connect the red anode lead to its connector from the A63 Power Supply module.

12. Plug the red/black cable to the A2 Display Control board.

13. Install all previously removed components.
CRT Light Guide

The procedures that follow describe how to remove and install the CRT Light Guide. Refer to Figure 8-16 for this procedure.

Additional procedures required — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal
Removal and Installation Procedures

- A3 Display Driver Board
- CRT
  1. Lift the light guide off the light bulbs on the A2 Display Control board.
  2. Re-install the light guide by sliding the guide over the light bulbs on the A2 Display Control board.

**NOTE**

*To properly guide the light to the CRT, the beveled edge of the light guide must be facing up, toward the CRT.*

3. Install all previously removed components.

---

**CRT Front Bracket**

The procedures that follow describe how to remove and install the CRT Front Bracket. Refer to Figure 8-16 for this procedure.

**Additional procedures required** — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
- Front Trim Removal
- A3 Display Driver Board
- CRT
  1. Remove the four screws securing the CRT front bracket to the chassis.
  2. Lift the CRT front bracket out from inside the chassis.
  3. Re-install the CRT front bracket by sliding the bracket into the chassis and secure it with the four mounting screws.
  4. Install all previously removed components.

---

**A2 Display Control Board**

The procedures that follow describe how to remove and install the CRT Front Bracket.

**Additional procedures required** — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal
Removal and Installation Procedures

- Front Trim Removal
- A3 Display Driver Board
- CRT
  1. Unplug the cables from connectors J80, J82, and J84 on the A2 Display Control board.
  2. Lift the A2 Display Control board up toward the top of the chassis, sliding the board out of the board retainers.
  3. Re-install the A2 Display Control board by sliding the board into the board retainers.
  4. Re-install all cables at connectors J80, J82, and J84.
  5. Install all previously removed components.

A63 Power Supply Module

The procedures that follow describe how to remove and install the Power Supply module.

Additional procedures required — This procedure requires that the following procedures be performed first:
- Rear Cover Removal
- Cabinet Removal

Power Supply Removal

1. Set the oscilloscope so its top is down on the work surface.

2. Disconnect the power button shaft from the power switch on the Power Supply module. See Figure 8-17.

![Power Button Shaft](image)

Figure 8-17: Power Button Shaft Disconnect

3. Unplug the cables going to the A3 Display Driver board at J70 and J71.

4. Set the oscilloscope so its bottom down on the work surface.

5. Unplug the cable going to the A5 CPU board at J55.

6. Unplug the two-wide cable from the fan.
Removal and Installation Procedures

7. Unplug the red CRT anode lead from the power supply connector.

8. Remove the two screws securing the Power Supply module to the chassis.

9. Lift the Power Supply module out of the chassis to complete its removal.

10. Slide the Power Supply module into the chassis, noting that the tab at the bottom of the Power Supply module slides into the slot at the bottom of the chassis.

Power Supply Installation

1. Reconnect all cables and wires disconnected during the removal procedure.

2. Re-install all components removed.

![Power Supply Diagram](image-url)

**Figure 8-18: Power Supply Removal**
Fan and Fan Mount

The procedures that follow describe how to remove and install the Fan and Fan Mount.

Additional procedures required — This procedure requires that the following procedures be performed first:

- Rear Cover Removal
- Cabinet Removal

Fan and Fan Mount Removal

1. Set the oscilloscope so its bottom is down.
2. Unplug the fan power cable from the A63 Power Supply module.
3. Rotate the oscilloscope so the side that houses the fan mount is facing upwards.
4. Depress the two flex locks to release them (see Figure 8-19).
5. While holding the flex locks released, slide the fan mount so its four retainer lugs slide from their small retainer holes in the chassis into their large release holes.
6. Move the fan mount inward so its retainer lugs are out of the large retainer holes and lift the fan mount and fan out of the chassis.
Figure 8-19: Fan and Fan Mount Removal

DO NOT remove the fan from the fan mount unless servicing a broken fan or fan mount or removing the mount for cleaning.

7. Release the two flex locks securing the top of the fan to the fan mount, and then lift the fan out from the mount.

Fan and Fan Mount Installation

1. If the fan was removed from the fan mount, press the fan into the fan mount until the four retainer clips snap into place, securing the fan.

2. Install the fan assembly so that the retainer lugs on the mount are positioned in the large holes of the chassis; then, slide the fan assembly until the lugs slip into the small holes and the two flex locks snap into place.

3. Reconnect the fan's power cable.

4. Re-install all removed components.
Troubleshooting

This subsection contains information and procedures designed to help you isolate problems to a faulty module in the oscilloscope. If a module needs to be removed for repair or replacement, follow the Removal and Installation Procedures located in this section.

**Troubleshooting Procedure**

If the oscilloscope does not perform correctly, note each symptom or failure. Next, refer to the Symptom Matrix Table (Table 8-5). Locate the symptoms that most closely resemble the symptoms you noted. If there are multiple symptoms, use a process of elimination to reduce the number of possible faulty modules. Identify possible faulty modules, then perform the troubleshooting procedure/s indicated.

The cabinet must be removed to gain access to the modules for measuring signals and voltages. Refer to the Removal and Installation Procedures beginning on page 8-9 for instructions to remove the cabinet.

**Equipment**

Table 8-4 list the equipment is required to perform the troubleshooting procedures.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Oscilloscope</td>
<td>Tektronix TAS 465</td>
</tr>
<tr>
<td>Digital Multimeter (DMM)</td>
<td>Tektronix DM250</td>
</tr>
<tr>
<td>High Voltage Probe</td>
<td>Fluke Model 80K-40</td>
</tr>
</tbody>
</table>

**CAUTION**

*High voltages are present when the cabinet is removed. Do not remove the high voltage shield from the A3 Display Driver board unless it is necessary to measure the high voltage. Do not perform this procedure without the presence of another person who is capable of providing aid.*
Troubleshooting

Symptom Matrix

The Symptom Matrix (Table 8-5) is an aid in determining which modules to troubleshoot. There is no separate troubleshooting procedure for the power supply, since each module troubleshooting procedure includes checks of the power supply. The CRT is checked in the display control and display driver troubleshooting procedures.

The ● indicates the troubleshooting procedure most likely to locate the failed module. The ○ indicates additional troubleshooting procedures that may help locate the failed module.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Processor</th>
<th>Analog</th>
<th>Display Driver</th>
<th>Front Panel</th>
<th>Display Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No display at all</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Traces or readout, but not both</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Abnormal readout</td>
<td>●</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal traces</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal traces and readout</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power-on diagnostics indicates a failure</td>
<td>●</td>
<td>●</td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Self-calibration does not pass</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volts/Div and Sec/Div controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One control works but not both</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neither control works</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No control of Volts/Div or vertical position of a single channel</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No control of Volts/Div or vertical position of any channels</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity Control Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No control of readout and trace intensity</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of readout or trace intensity but not both</td>
<td>●</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No control of focus</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Unable to focus properly</td>
<td>●</td>
<td>○</td>
<td></td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>No control of trace rotation</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No control of scale illumination</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptom</td>
<td>Processor</td>
<td>Analog</td>
<td>Display Driver</td>
<td>Front Panel</td>
<td>Display Control</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----------</td>
<td>--------</td>
<td>----------------</td>
<td>-------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Trigger level, vertical position, and horizontal position</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The trace position controls nor the Trigger Level control works</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Some of these controls work but not all</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probe Scale (X10) Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volts/Div readout does not change with a X10 probe on any channel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Front Panel Control Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front panel controls do not work but readout display works</td>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Front panel controls do not work and the readout display is abnormal</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRT Bezel buttons do not work but other buttons and knobs work</td>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Front panel LED Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No LED’s momentarily light at power-on but readout is okay</td>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>No LED’s momentarily light at power-on and abnormal readout</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some LED’s momentarily light at power-on, but not all do</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>No trigger on line source</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Troubleshooting

This procedure assumes that there is front panel control and readout on the CRT.

Measure the power supply voltages at J55 on the A5 CPU board:
- Pin 1: -5.2V
- Pin 2: +5.2V
- Pin 3: Ground
- Pin 4: -8.6V
- Pin 5: +8.6V

Are the voltages approximately the same as the nominal values?

Turn the power off. Remove the cable to J55 on the A5 CPU board and check pins 1, 2, 4, and 5 for shorts to ground (pin 3).

Measure the signal on U217 pin 26 on the A5 CPU board with the test oscilloscope.

Is the signal amplitude approximately 5V and the period 60 nS?

Disconnect the cable at J30 on the A4 Front Panel board and check the pins again for shorts.

Are any of the pins shorted?

Is the line fuse resistance less than 10 Ω?

Replace the line fuse.

Does the line fuse blow when the POWER button is pressed?

Replace the A83 Power Supply module.

Perform the A4 Front Panel board troubleshooting procedure.

A5 CPU board.

Replace the A5 CPU board.

Does the signal trigger the oscilloscope when the knob is turned?

Figure 8-20: A5 CPU Board Troubleshooting Procedure
This procedure assumes that there is front panel control.

Measure the power supply voltages on J67 on the A1 Analog board.
- Pin 12: +1.5V
- Pin 10: +5.6V
- Pin 9: -8.6V
- Pin 6: +5.2V
- Pin 1: -5.2V

Are the voltages approximately the same as the nominal values?

- Yes
  - Press the CH1 button and rotate the VOLTS/DIV knob several times in each direction. Repeat for remaining channel(s). Listen for clicks between some of the voltage ranges.

  Were clicks heard for each channel?
  - Yes: Go to Part Two
  - No: Turn the power off. Remove the cable at J67 on the A1 Analog board and check pins 12, 10, 9, 6, and 1 for shorts to ground.

  Are any of the pins shorted?
  - Yes: Replace the A1 Analog board.
  - No: Perform the A3 Display Driver Board Troubleshooting Procedure.

Have you performed both the A5 CPU Board and the A62 Front Panel module Troubleshooting Procedures?

- Yes: Replace the A1 Analog board.
- No: Perform both to isolate the problem.
Troubleshooting

Put the oscilloscope in XY mode. Select CH2 and turn the readout intensity to minimum. Measure the voltage across the delay line (J88) with a DMM.

Does the voltage vary between 100 mV to -100 mV as the vertical position knob is rotated?

Yes

Select CH1 and measure the voltage across pins 16 and 17 of J67 with a DMM or oscilloscope.

Yes

Does the voltage change as the vertical position knob is rotated?

Yes

Rotate the Intensity knob and measure the voltage at pin 19 of J67 with a DMM or oscilloscope.

Yes

Does the voltage vary as the position knob is moved?

Yes

Perform the A5 CPU Board Troubleshooting Procedure.

No

Is the A5 CPU board okay?

Yes

Replace the A5 CPU board.

No

Replace the A1 Analog board.

No

Replace the A5 CPU board.

Yes

Replace the A1 Analog board.

Done.

Note: In XY mode, a single dot should appear near the center of the CRT. Reduce the intensity until the spot is dim, so that the CRT phosphor will not be damaged.

Figure 8-21: A1 Analog Board Troubleshooting Procedure (Cont.)
This procedure assumes that there is front panel control.

Measure the power supply voltages on the A3 Display Driver board.

W66:
Pin 12  +15V
Pin 10  +8.6V
Pin 9   −8.6V
Pin 6   +5.2V
Pin 1   −5.2V

J70:
Pin 10  +60V
Pin 11  +130V
Pin 13  200V (AC)

Are the voltages approximately the same as their nominal values?

Yes → Measure voltage on pin 1 of J71 with a high-voltage probe and a DMM.

No → Turn the power off. Disconnect the cables at W66 and J70 on the A1 Analog board. Check the pins listed above for shorts to ground.

Was the voltage approximately −2 kV?

Yes → Go to Part Two

No → Replace the A3 Display Driver board.

Are any of the pins shorted?

Yes → Replace the A3 Display Driver board.

No → Turn the power off and remove the power cord. Remove the fuse from the fuse holder. Measure the fuse resistance with a DMM.

Is the line fuse resistance less than 10 Ω?

Yes → Replace the line fuse.

No → Does the line fuse blow when the POWER button is pressed?

Yes → Replace the A3 Display Power Supply module.

No → Replace the line fuse.

Figure 8-22: A3 Display Driver Board Troubleshooting Procedure
Troubleshooting

Part Two

Put the oscilloscope in XY mode. Turn the readout intensity all the way down. Select CH2 and vary the vertical position knob while measuring the voltage across J75 pins 3 and 1 (W76 and W75 on TAS 485) with a DMM or oscilloscope. Note: In XY mode, a single dot should appear near the center of the CRT. Reduce the intensity until the spot is dim so that the CRT phosphor will not be damaged.

Does the voltage vary as the position knob is moved? No

Yes

Press the CH1 button and rotate the vertical position knob while measuring the voltage across the pins 16 and 17 of J67 with a DMM or oscilloscope.

Does the voltage vary as the position knob is moved? No

Yes

Are traces and readout visible on the CRT? No

Yes

Can the trace and readout be focused with the focus thumbwheel? No

Yes

Done.

Have you performed the A1 Analog Board Troubleshooting Procedure? No

Yes

Perform the A1 Analog Board Troubleshooting Procedure.

Replace the A3 Display Driver board.

Perform the A2 Display Control Board Troubleshooting Procedure.

Does the voltage vary as the position knob is moved? No

Yes

Replace the CRT.

Figure 8-22: A3 Display Driver Board Troubleshooting Procedure (Cont.)
This procedure checks the A62 Front Panel module. Since the front panel is difficult to probe while installed, measurements are taken on J30 of the processor module.

Measure the power supply voltages on J30 of the A5 CPU board.
Pin 10 = -5.2V
Pin 1  = +5.2V

Are the voltages approximately the same as the nominal values?

Yes

With an oscilloscope, measure the signals on pins 5 and 6 of J30. Turn knobs and press buttons while watching the signals for small changes in shape.

Does the signal change shape with front panel changes?

Yes

Connect a X10 probe to the CH 1 input connector while watching the Volts/Div readout on the CRT.
Did the Volts/Div readout change?

Yes

Done.

No

Replace the A62 Front Panel module.

No

Turn the power off. Disconnect the cable from the A62 Front Panel module to the A5 CPU board. Check pins 1 and 10 for shorts to ground.

Are any of the pins shorted?

Yes

Replace the A62 Front Panel module.

No

Perform the A5 CPU Board Troubleshooting Procedure.

Any of the pins shorted?

Yes

Disconnect the front panel cable to J84 on the display control module and check the J30 pins 1 and 10 again for shorts to ground.

Are any of the pins shorted?

Yes

Replace the A3 Display Driver board.

No

Replace the A62 Front Panel module.

Did the voltage change from about 4.8V to about 5.2V?

Yes

Replace the A1 Analog board.

No

Replace the A62 Front Panel module.

Figure 8-23: A62 Front Panel module Troubleshooting Procedure
Troubleshooting

This procedure checks the A2 Display Control board.

Turn the Scale Illumination control while watching the CRT.

Does the scale illumination change? No

Disconnect the cable to J90 on the A2 Display Control board.

Is the voltage on pin 12, W66 on the A3 Display Driver board approximately +15V? No

Replace the A63 Power Supply module.

Yes

Replace the A2 Display Control board.

Measure the voltage on the center pin of each of the control potentiometers. Check for the voltages below while rotating the controls.

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<tr>
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<th>Focus</th>
<th>Intensity</th>
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<td>0 to -5.2V</td>
<td>0 to +5.2V</td>
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Do the voltages vary approximately within their range? No

Disconnect the cable to J84. Perform the front panel troubleshooting procedure to check the supply voltages.

Are the front panel voltages approximately their nominal value? No

Perform the A62 Front Panel Module Troubleshooting Procedure.

Yes

Replace the A2 Display Control board.

Yes

Adjust the Trace Rotation while watching the CRT display.

Disconnected the cable to J82 on the A2 Display Control board. Measure the voltage on pin 1 while varying the Trace Rotation.

Does the CRT display rotate with adjustment? No

Replace the A2 Display Control board.

Does the voltage on pin 1 vary from approximately +5.2V to -5.2V? No

Replace the CRT.

Yes

Replace the A2 Display Control board.

Figure 8-24: A2 Display Control Board Troubleshooting Procedure
Repackaging Information

If you ship the TAS 455 or TAS 465, pack it in the original shipping carton and packing material. If the original packing material is not available, package the instrument as follows:

1. Obtain a corrugated cardboard shipping carton with inside dimensions at least 15 cm (6 in) taller, wider, and deeper than the TAS 455 or TAS 465. The shipping carton must be constructed of cardboard with 170 kg (375 pound) test strength.

2. If you are shipping the TAS 455 or TAS 465 to a Tektronix field office for repair, attach a tag to the oscilloscope showing the instrument owner and address, the name of the person to contact about the instrument, the instrument type, and the serial number.

3. Wrap the oscilloscope with polyethylene sheeting or equivalent material to protect the finish.

4. Cushion the oscilloscope in the shipping carton by tightly packing dunnage or urethane foam on all sides between the carton and the oscilloscope. Allow 7.5 cm (3 in) on all sides, top, and bottom.

5. Seal the shipping carton with shipping tape or an industrial stapler.
Replaceable Parts

This section contains a module level list of the replaceable parts for the TAS 455 and TAS 465 Oscilloscopes. Use this list to identify and order replacement parts.

Parts Ordering Information

Replacement parts are available from or through your local Tektronix, Inc. service center or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest circuit improvements. Therefore, when ordering parts, it is important to include the following information in your order:

- part number
- instrument type or model number
- instrument serial number
- instrument modification number, if applicable

If a part you order has been replaced with a different or improved part, your local Tektronix service center or representative will contact you concerning any change in the part number.

Change information, if any, is located at the rear of this manual.

Instrument Repair

If your TAS 455 and TAS 465 Oscilloscopes appears to have an electrical failure during or after the warranty period, contact your local Tektronix service center or representative or call 1-800-TEKWIDE, extension 6630.

A Service manual is also available for the TAS 455 and TAS 465 Analog Oscilloscopes, part number 070–8524–XX. The service manual contains a complete electrical and mechanical parts list for the TAS 455 and TAS 465 Oscilloscopes.
Using the Replaceable Parts List

The tabular information in the Replaceable Parts List is arranged for quick retrieval. Understanding the structure and features of the list will help you find all the information you need for ordering replacement parts.

**Item Names**

In the Replaceable Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, U.S. Federal Cataloging Handbook H6-1 can be used where possible.

**Indentation System**

This parts list is indented to show the relationship between items. The following example is of the indentation system used in the Description column:

```
1  2  3  4  5              Name & Description
Assembly and/or Component
Attaching parts for Assembly and/or Component
(END ATTACHING PARTS)
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
(END ATTACHING PARTS)
Parts of Detail Part
Attaching parts for Parts of Detail Part
(END ATTACHING PARTS)
```

Attaching parts always appear at the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. Attaching parts must be purchased separately, unless otherwise specified.

**Abbreviations**

Abbreviations conform to American National Standards Institute (ANSI) standard Y1.1
## CROSS INDEX – MFR. CODE NUMBER TO MANUFACTURER

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Figure 9-4: Circuit Boards
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**STANDARD ACCESSORIES**

**OPTIONAL ACCESSORIES**

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Appendix A: Detailed Menu Descriptions

This section contains detailed information of the TAS 455 and TAS 465 Oscilloscopes menu functions.

Vertical System Menus

The VERTICAL MENU button displays the menu items for either channel 1 or channel 2 vertical operating system. The menu displayed is dependent on the channel select buttons. Each menu and its choices are discussed here.

- **CPLG** — Selects the method to couple input signals to the attenuators of the selected input channel.
  - **DC** — DC coupling passes all components of the signal to the input channel. The $D_C$ indicator appears to the right of the associated volts/div readout.
  - **AC** — AC coupling blocks the DC component of the input signal. The $A_C$ indicator appears to the right of the associated volts/div readout.
  - **GND** — Disconnects the input signal and grounds the input of the associated vertical attenuator to provide a zero (ground) reference voltage display; it does not ground the front panel input connector. The $\rightarrow$ indicator appears to the right of the associated volts/div readout.

- **VAR** — When on, the VOLTS/DIV control operates in an uncalibrated or variable mode and the $>$ symbol appears to the left of the readout.

Variable gain increases the vertical deflection of the selected channel by a factor of at least 2.5 times. Use the General Purpose Knob to change the gain by a factor of up to 2.5 times the current volts/div scale.

- **INV** — When on, the instrument inverts the channel input signal and the $\downarrow$ indicator appears to the right of the channel indicator.

- **BW** — Provides a selection to enable the full bandwidth of the vertical and trigger systems or limit them.
  - **20 MHz** — Selecting 20 MHz limits the bandwidth of the vertical deflection system and trigger system to 20 MHz. The $B_W$ indicator appears in the readout when the bandwidth limit is in effect.
  - **Full** — Selecting Full enables the entire bandwidth of the oscilloscope.
ALT/CHOP, ADD — Pressing the **ALT/CHOP ADD** button displays the menu choices for display modes and math operations.

- **ADD** — When on, the instrument displays a third signal that is the sum of the channel 1 and channel 2 input signals. The + indicator appears when add mode is on.

- **DISP** — The display selection allows you to choose how to display multiple channels.
  - **Alt** — When in alternate mode, the instrument displays the selected channels in sequence (alternating at the end of each sweep).
  - **Chop** — When in chop mode, the display chops between selected input channels at a rate of about 550 kHz.

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**Horizontal System Menus**

The **HORIZONTAL MENU** button displays the following menu choices for the horizontal operating system.

- **MAIN** — Selects the main sweep horizontal deflection mode. The **SEC/DIV** control determines the sweep speed scale, which appears on the CRT readout. The main sweep can be displayed exclusively or with delay.

- **DELAY** — Selects the delayed sweep horizontal deflection mode. The **SEC/DIV** control determines the delayed sweep speed scale, which appears on the CRT readout. The delayed sweep can be displayed exclusively or with main.

In **Runs After** mode, the start of the delayed sweep (or the arming of the delayed trigger in any trigger mode) is delayed by the time you set with the General Purpose Knob. The delayed sec/div scale and the delay time position setting appear in the CRT readout. The > indicator appears in front of the delay time position readout if the delayed trigger mode is not **Runs After**.

- **XY** — Selects XY mode. The **CH 1** input signal produces the horizontal (X-axis) deflection. The **CH 2** or the added channel are sources for providing the vertical (Y-axis) deflection.

Use the channel 1 **POSITION** control to horizontally position an XY display. Use the channel 2 **POSITION** control for vertical positioning.

- **VAR** — When on, the **SEC/DIV** control is uncalibrated and provides variable, uncalibrated sweep speeds to at least 2.5 times slower than the calibrated sec/div scales. Use the General Purpose Knob to change the variable sweep speeds.

The > indicator appears to the left of the sec/div readout to show that the horizontal scale is uncalibrated.

- **TRCSEP** — Trace separation assigns the General Purpose Knob to adjust the vertical separation between the main and delayed sweeps.
Trigger System Menus

The TRIGGER MENU button displays menu choices for the trigger operating system. This section discusses each menu and its choices. Menus for either the main or delayed sweeps are dependent on the selection of the MAIN/DELAY SELECT button.

Main Trigger Menu

- **MODE** — Selects the type of trigger used to initiate a sweep.
  - **Auto** — The main sweep will trigger when you set the trigger level within the peak-to-peak limits of an adequate trigger signal. The main sweep will free-run if the trigger is lost, such as if the signal amplitude is too low or the frequency is less than 10 Hz.
  - **Auto Level** — Automatically sets the trigger level to midtrace.
    
    If the instrument loses the trigger, it will reset the auto-level range. The main sweep will free-run if the trigger is lost, such as if the signal amplitude is too low or the frequency is less than 10 Hz.
  - **Normal** — The main sweep will trigger when you set the trigger level within the peak-to-peak limits of an adequate trigger signal. The main sweep will not run if there is no adequate trigger signal.
  - **Single Sequence** — Single sequence sets the main sweep to complete one sweep when the instrument receives an adequate trigger. Once triggered, the MAIN SWP TRIG'D indicator lights and remains lit until the instrument completes all displays. Pressing the RESET S SEQ button arms the main sweep, lights the READY indicator, and the trigger circuit waits for the next trigger signal.
    
    You can set the readout and cursors to turn on briefly at the start of the sequence (useful when using a camera), or remain on by changing the instrument configuration from the UTILITY menu (see page A-7).
  - **Video Line** — The main sweep triggers at the beginning of each horizontal sync pulse (every line) of a composite video signal. The SLOPE polarity must match the Video Sync Polarity (see page A-7) to obtain video line triggering. Inverted video uses positive trigger slope. Normal video uses negative trigger slope.
Appendix A: Detailed Menu Descriptions

- **Video Field** — The main sweep triggers at the beginning of each vertical sync pulse (every field) of a composite video signal. The SLOPE polarity must match the Video Sync Polarity (see page A-7) to obtain video field triggering.

  - **odd** — The main sweep triggers at the beginning of the vertical sync pulse of field one in a standard interlaced video signal.
  
  - **even** — The main sweep triggers at the beginning of the vertical sync pulse of field two in a standard interlaced video signal.
  
  - **both** — The main sweep triggers at the beginning of the vertical sync pulse of either field one or field two in a standard interlaced video signal.

- **SRC** — Selects the source of the trigger signal to initiate the main sweep.

  - **Priority Vert** — The instrument obtains the trigger signal from the highest priority active channel. See Table A-1 to determine the trigger source.

  - **CH1** — The signal applied to the CH 1 input connector is the source of the trigger signal.

  - **CH2** — The signal applied to the CH 2 input connector is the source of the trigger signal.

  - **Add** — The instrument obtains the trigger signal from the signal created when adding input channels together.

  - **Line** — The instrument obtains the triggering signal from the AC power source.

  - **Ext 1 10** — The instrument obtains the trigger signal the signal applied to the EXT TRIG input connector. Selecting 10 attenuates the signal by a factor of 10. Selecting 1 provides no signal attenuation.

<table>
<thead>
<tr>
<th>Channel Conditions</th>
<th>Selected Trigger Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 1</td>
<td>CH 2</td>
</tr>
<tr>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>Off</td>
<td>On</td>
</tr>
<tr>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>Off</td>
<td>On</td>
</tr>
<tr>
<td>Off</td>
<td>Off</td>
</tr>
</tbody>
</table>
Appendix A: Detailed Menu Descriptions

- **CPLG** — Coupling selects the components of the trigger signal applied to the trigger circuitry.

- **DC** — Couples DC and all frequency components of a triggering signal to the trigger circuitry.

- **Noise Reject** — Noise reject couples all frequency components of the trigger signal to the trigger circuitry but increases the peak-to-peak signal amplitude required to trigger the sweep.

- **HF Reject** — High frequency reject attenuates the frequency components of the trigger signal that are above 50 kHz, reducing high-frequency interference.

- **AC** — Blocks the DC component of the trigger signal and attenuates trigger signal frequency components below 160 Hz.

- **LF Reject** — Low frequency reject blocks the DC component of the trigger signal and attenuates the frequency components of the trigger signal that are below 50 kHz, reducing low-frequency interference.

- **SLOPE** — Selects the slope of the trigger source signal that triggers the sweep.

- **Rising** — The rising edge (positive going) of the input signal triggers the sweep.

- **Falling** — The falling edge (negative going) of the input signal triggers the sweep.

- **HOLDOFF** — When on, holdoff adds additional time between the end of the sweep and the arming of the trigger circuit. The holdoff time is adjustable from a preset minimum value to 10 times the minimum value. The General Purpose Knob adjusts the holdoff time.

**Delayed Trigger Menu**

- **MODE** — Selects the operating mode of the delayed trigger system.

- **Runs After** — Starts the delayed sweep immediately after the delay time requirement is satisfied, selected by the General Purpose Knob.

- **Trig After** — The delayed sweep triggers when the instrument receives an adequate trigger signal after the delay time condition has been met. When there is no trigger signal, there is no delayed sweep trace.

- **Video Line (from main trigger)** — Starts the delayed sweep at the beginning of a video signal line received after the delay time condition has been met.

Slope polarity defaults to the main trigger slope. The slope polarity must match the **Video Sync Polarity** (see page A-7) to obtain correct triggering on the horizontal sync pulse.
Appendix A: Detailed Menu Descriptions

- **SRC** — Selects the source of the trigger signal to initiate the delayed sweep.
  - **Ch1** — The signal applied to the CH 1 input connector is the source of the trigger signal.
  - **Ch2** — The signal applied to the CH 2 input connector is the source of the trigger signal.
  - **Add** — The trigger signal is the signal created when adding input channels together.
  - **Line** — The triggering signal is the AC power source.

- **CPLG** — Coupling selects the components of the trigger signal applied to the trigger circuitry.
  - **DC** — Couples DC and all frequency components of a triggering signal to the trigger circuitry.
  - **Noise Reject** — Noise reject couples all frequency components of the trigger signal to the trigger circuitry but increases the peak-to-peak signal amplitude required to trigger the sweep.
  - **HF Reject** — High frequency reject attenuates the high-frequency components of the trigger signal that are above 50 kHz, reducing high-frequency interference.
  - **AC** — Blocks the DC component of the trigger signal and attenuates trigger signal frequency components below 160 Hz.
  - **LF Reject** — Low frequency reject blocks the DC component of the trigger signal and attenuates the low-frequency components of the trigger signal that are below 50 kHz, reducing low-frequency interference.

- **SLOPE** — Selects the slope of the trigger source signal that triggers the sweep.
  - **Rising** — The sweep triggers on the rising (positive going) edge of the input signal.
  - **Falling** — The sweep triggers on the falling (negative going) edge of the input signal.

---

**Cursor Menus**

The **CURSOR** button displays the cursors on the waveform. Use the General Purpose Knob to move the cursors. The **TOGGLE** button switches cursor control from active cursor to inactive.

- **AVOLTS** — Displays the delta voltage (difference) between the two horizontal cursors.
- **ABS V** — Displays the absolute voltage level of the horizontal cursor (referenced to ground).
Appendix A: Detailed Menu Descriptions

- **ΔT** — Displays the delta time (measured in seconds) between the two vertical cursors.
- **1/ΔT** — Displays the frequency (measured in Hertz) between the two vertical cursors.

Save and Recall Menus

The **SAVE/RECALL SETUP** button displays menus that allow you to store four complete front-panel setups for later recall. You can select save and recall functions by pressing the menu-item select buttons. Setup locations are underlined on the CRT if they contain a stored setup.

- **RECALL** — Pressing the **RECALL** menu button recalls the front-panel settings previously saved in one of the four memory locations.
  - **1 through 4** — These are the memory locations to retrieve a front-panel setting.

- **SAVE** — Pressing the **SAVE** menu button will save the front-panel setup to one of four memory locations.
  - **1 through 4** — These are the memory locations to save a front-panel setting.

- **ERASE** — Pressing the **ERASE** menu button will erase the memory of one of the four memory locations.
  - **1 through 4** — These are the memory locations that can be erased.

Utility Menus

The **UTILITY** button displays menus used to configure certain aspects of the oscilloscope operating system and perform calibration routines.

- **CONFIG** — Use the configuration menu to define operating conditions seldom changed once set.
  - **Intensity Delay = Main** — Both the main and the delayed sweeps have the same intensity level.
  - **Intensity Delay > Main** — The intensity of the delayed sweep is greater than that of the main sweep.
  - **Intensity Delay >> Main** — The intensity of the delayed sweep is much greater than that of the main sweep.
  - **Video Sync Positive** — When using a video trigger mode, the trigger system triggers on the positive slope of the video signal (horizontal sync pulses on the top of the video signal).
  - **Video Sync Negative** — When using a video trigger mode, the trigger system triggers on the negative slope of the video signal (horizontal sync pulses on the bottom of the video signal).
  - **Video Sync = Main Trigger Slope** — Sets the slope of the trigger source for video signals to match the main trigger slope selection.
Appendix A: Detailed Menu Descriptions

- **Dual Delay Disabled** — Provides one intensified delayed event.
- **Dual Delay Enabled** — Provides two intensified delayed events when time measurement cursors are on and both the main and delayed sweeps are on.
- **SSeq Readout Continuous** — The readout remains on when the trigger mode is set to single sequence.
- **SSeq Readout Flash** — The readout is flashed on at the end of the display sequence when the trigger mode is set to single sequence.
- **CAL** — This selection displays calibration routines.
  - **Horizontal Sweep Path** — Initiates the temperature compensation calibration procedure for the horizontal system.
  - **Vertical Signal Path** — Initiates the temperature compensation calibration procedure for the vertical system.
  - **Factory Horizontal Cal** — Initiates the horizontal calibration procedure.
  - **Factory Vertical Cal** — Initiates the vertical calibration procedure.
- **ID** — Displays the software version on-screen.
Appendix B: Autoset Control Settings

Using the Autoset Feature

The **AUTOSET** feature of the TAS 455 and TAS 465 Oscilloscopes automatically sets most of the front panel controls. Table A-2 lists the instrument control settings obtained when using **AUTOSET**.

<table>
<thead>
<tr>
<th>Front Panel Control</th>
<th>AUTOSET Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td></td>
</tr>
<tr>
<td>Magnification</td>
<td>X1.</td>
</tr>
<tr>
<td>Position</td>
<td>Midrange.</td>
</tr>
<tr>
<td>Main Sweep</td>
<td>On.</td>
</tr>
<tr>
<td>Delay Sweep</td>
<td>Off.</td>
</tr>
<tr>
<td>XY</td>
<td>Off.</td>
</tr>
<tr>
<td>Main Sec/Div Scale(^1)</td>
<td>At least one complete cycle of the signal is displayed (no slower than 20 ms/div).</td>
</tr>
<tr>
<td>Variable</td>
<td>Off.</td>
</tr>
<tr>
<td>Trigger</td>
<td></td>
</tr>
<tr>
<td>Main Mode</td>
<td>Auto Level.</td>
</tr>
<tr>
<td>Main Source</td>
<td>Priority Vert.</td>
</tr>
<tr>
<td>Main Coupling</td>
<td>Noise Reject if the volts/div scale is set to 2 mV or 5 mV, otherwise DC.</td>
</tr>
<tr>
<td>Main Level</td>
<td>Midway between the peaks of the signal.</td>
</tr>
<tr>
<td>Holdoff</td>
<td>Off (min).</td>
</tr>
<tr>
<td>Vertical</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>Full.</td>
</tr>
<tr>
<td>Add</td>
<td>Off.</td>
</tr>
<tr>
<td>Display Mode</td>
<td>Chop if the main sec/div scale is 0.1 ms/div or slower; alternate if 50 μs/div or faster.</td>
</tr>
<tr>
<td>Invert</td>
<td>Off.</td>
</tr>
<tr>
<td>Position (both channels displayed)(^2)</td>
<td></td>
</tr>
<tr>
<td>CH 1</td>
<td>If selected, the ground level is aligned with third graticule line (± 0.2 div) from the top; otherwise no action.</td>
</tr>
<tr>
<td>CH 2</td>
<td>If selected, the ground level is aligned with seventh graticule line (± 0.2 div) from the top; otherwise no action.</td>
</tr>
<tr>
<td>Front Panel Control</td>
<td>AUTOSET Action</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Position (single channel displayed) 2</td>
<td>The ground level is aligned with the center horizontal graticule line.</td>
</tr>
<tr>
<td>CH 1 or CH 2</td>
<td></td>
</tr>
<tr>
<td>Volts/Div Scale (displayed channels)</td>
<td>The lowest value for which all waveform values are within approximately ± 2 divisions of ground.</td>
</tr>
<tr>
<td>Coupling (displayed channels)</td>
<td>DC, if coupling set to GND or DC; otherwise AC.</td>
</tr>
<tr>
<td>Variable Mode</td>
<td>Off.</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Menu Selection</td>
<td>Menus are turned off.</td>
</tr>
<tr>
<td>Intensity</td>
<td>40% of maximum intensity if current intensity is less than 28% from the counter clockwise stop; otherwise as adjusted by user.</td>
</tr>
</tbody>
</table>

1 Uncertain settings may occur when using AUTOSET on signals with periods of less than 20 ms (50Hz).

2 Uncertain settings may occur when using AUTOSET on signals with large DC offsets relative to the pk-to-pk voltage when vertical coupling is set to DC.
Glossary

AC coupling
A type of signal transmission that blocks the DC component of a signal but uses the dynamic (AC) component. Useful for observing an AC signal that is normally riding on a DC signal.

Accuracy
The closeness of the indicated value to the true value.

Active cursor
The cursor that moves when you turn the General Purpose Knob. It is represented in the display by a solid line.

Amplitude
The high waveform value less the low waveform value.

Area
Measurement of the waveform area taken over the entire waveform or the gated region. Expressed in volt-seconds. Area above ground is positive; area below ground is negative.

Attenuation
The degree the amplitude of a signal is reduced when it passes through an attenuating device such as a probe or attenuator. That is, the ratio of the input measure to the output measure. For example, a 10X probe will attenuate, or reduce, the input voltage of a signal by a factor of 10.

Automatic trigger mode
A trigger mode that causes the oscilloscope to automatically display a sweep if triggerable events are not detected within a specified time period.

Autoset
A function of the oscilloscope that automatically produces a stable waveform of usable size. Autoset sets up front-panel controls based on the characteristics of the active waveform.

Bandwidth
The highest frequency signal the oscilloscope can accurately display with no more than $-3 \text{dB} (\times .707)$ attenuation of the original (reference) signal.

Channel
An input used for coupling signals to oscilloscope.

Coupling
The association of two or more circuits or systems in such a way that power or information can be transferred from one to the other. You can couple the input signal to the trigger and vertical systems several different ways.
Glossary

Cursors
Paired markers that you can use to make measurements between two waveform locations. The oscilloscope displays the values (expressed in volts or time) of the position of the active cursor and the distance between the two cursors.

Cycle area
A measurement of waveform area taken over one cycle. Expressed in volt-seconds. Area above ground is positive; area below ground is negative.

Cycle RMS
The true root mean square voltage over one cycle.

DC coupling
A mode that passes both AC and DC signal components to the circuit. Available for both the trigger system and the vertical system.

Delay measurement
A measurement of the time between the middle reference crossings of two different waveforms.

Delay time
The time between the trigger event and the display of data.

Display system
The part of the oscilloscope that shows waveforms, measurements, menu items, status, and other parameters.

Edge Trigger
Triggering occurs when the oscilloscope detects the source passing through a specified voltage level in a specified direction (the trigger slope).

Fall time
A measurement of the time it takes for trailing edge of a pulse to fall from a high-ref value (typically 90%) to a low-ref value (typically 10%) of its amplitude.

Frequency
A timing measurement that is the reciprocal of the period. Measured in Hertz (Hz) where 1 Hz = 1 cycle per second.

General purpose knob
A front-panel knob used for multiple tasks such as cursor placement or changing the value of the assigned parameter.

Graticule
A grid on the display screen that creates the horizontal and vertical axes. You can use it to visually measure waveform parameters.

Ground (GND) coupling
Coupling option that disconnects the input signal from the vertical system.
Holdoff, trigger
A specified amount of time after a trigger signal that elapses before the trigger circuit will accept another trigger signal to help ensure a stable display.

Horizontal bar cursors
The two horizontal bars that you position to measure the voltage parameters of a waveform. The oscilloscope displays the value of the active (moveable) cursor with respect to ground and the voltage value between the bars.

Intensity
Display brightness.

Main menu
A group of related controls for a major oscilloscope function that the oscilloscope displays across the bottom of the screen.

Main menu buttons
Bezel buttons under the main menu display. They allow you to select items in the main menu.

Maximum
Amplitude (voltage) measurement of the maximum amplitude. Typically the most positive peak voltage.

Mean
Amplitude (voltage) measurement of the arithmetic mean over the entire waveform.

Minimum
Amplitude (voltage) measurement of the minimum amplitude. Typically the most negative peak voltage.

Negative duty cycle
A timing measurement representing the ratio of the negative pulse width to the signal period, expressed as a percentage.

Normal trigger mode
A mode on which the oscilloscope does not display a waveform unless a valid trigger event occurs.

Oscilloscope
An instrument for making a graph of two factors. These are typically voltage versus time.

Peak-to-Peak
Amplitude (voltage) measurement of the absolute difference between the maximum and minimum amplitude.

Period
A timing measurement of the time covered by one complete signal cycle. It is the reciprocal of frequency and is measured in seconds.
Phase
A timing measurement between two waveforms of the amount one leads or lags the other in time. Phase is expressed in degrees, where 360° comprise one complete cycle of one of the waveforms. Waveforms measured should be of the same frequency or one waveform should be a harmonic of the other.

Positive duty cycle
A timing measurement of the ratio of the positive pulse width to the signal period, expressed as a percentage.

Positive width
A timing measurement of the distance (time) between two amplitude points — rising-edge and falling-edge on a positive pulse.

Probe
An oscilloscope input device.

Probe compensation
Adjustment that improves low-frequency response of a probe.

Reference memory
Memory in an oscilloscope used to store settings. The data is saved even when the oscilloscope is turned off or unplugged.

Rise time
The time it takes for a leading edge of a pulse to rise from the minimum value (typically 10%) to the maximum value (typically 90%) of its amplitude.

RMS
Amplitude (voltage) measurement of the true root mean square voltage.

Selected waveform
The waveform on which all measurements are performed, and which is affected by vertical position and scale adjustments. The light next to one of the channel selector buttons indicates the current selected waveform.

Side menu
Menu that appears to the right of the display. These selections expand on main menu selections.

Side menu buttons
Bezel buttons to the right of the side menu display. They allow you to select items in the side menu.

Slope
The direction at a point on a waveform. You can calculate the direction by computing the sign of the ratio of change in the vertical quantity (Y) to the change in the horizontal quantity. The two values are rising and falling.

Sweep speed
See time base.
**Time base**
The parameters that let you define the timing of the sweep, expressed as seconds per division.

**Toggle button**
A button that changes which of two displayed cursors is active.

**Trigger**
An event that marks time zero in the waveform record. It results in acquisition and display of the waveform.

**Trigger level**
The vertical level the trigger signal must cross to generate a trigger.

**Vertical bar cursors**
The two vertical bars you position to measure the time parameter of a waveform record. The oscilloscope displays the value of the active (moveable) cursor with respect to trigger and the time value between the bars.

**Waveform**
The shape or form (visible representation) of a signal.

**XY format**
A display format that compares the voltage level of two waveforms. It is useful for studying phase relationships between two waveforms.

**YT format**
The conventional oscilloscope display format. It shows the voltage of a waveform (on the vertical axis) as it varies over time (on the horizontal axis).
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