

Keysight Infiniium 9000 Series Oscilloscopes

Service Guide

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NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to **www.keysight.com**.



Infiniium 9000 Series Oscilloscopes

The Keysight Technologies Infiniium 9000 Oscilloscope at a Glance

Ease of use with high performance

The Keysight Technologies Infiniium oscilloscopes combine unprecedented ease-of-use with high-performance digitizing oscilloscope functionality to simplify your design and analysis measurement tasks.

- Traditional oscilloscope front-panel interface provides direct access to the controls needed for most troubleshooting tasks.
- Graphical user interface with menus, windows, dialog boxes, and toolbars provides easy access to dozens of configuration and analysis tools, ensuring you can set up and make the most complex measurements.
- Models with bandwidths from 250 MHz to 4 GHz.

Display shows waveforms and graphical user interface

- Graphical interface allows direct interaction with waveforms, including drag-and-drop positioning and instant waveform zoom.
- Touchscreen display allows oscilloscope operation without an external pointing device.
- Waveforms displayed in color, making correlation easy.
- Current configuration parameters displayed near the waveform display and are color-coded to make identification easy.
- Graphical interface menus and toolbars simplify complex measurement setups.

Horizontal controls set sweep speed and position

- Main sweep speeds from 5 ps/div to 20 s/div.
- Intensified waveforms on main sweep window make it easy to see what will appear in the zoom window.

Acquisition and general controls start and stop the scope and do basic setup

- Run and stop controls for continuous or single acquisitions.
- Clear display before one or more acquisitions.
- Default setup and Autoscale set initial configuration.

Hard disk drive and USB 2.0 port for saving and restoring setups and measurement results

- Store measurement displays for inclusion in reports and test setup guides.
- Store oscilloscope setups to repeat tests another time.
- Hard disk stores oscilloscope operating system.

Trigger setup controls set mode and basic parameters

- Select Edge, Glitch, or Advanced Modes.
- Choose input source and slope.
- Use graphical user interface to simplify configuration of pattern, state, delay, and violation trigger modes.

Vertical controls set attenuation and position

- Input attenuation adjustable from 1 mV/div to 1 V/div.
- Color-coded knobs make it easy to find the controls that affect each waveform.

Marker and quick measurements help measure waveform parameters

- Waveform markers A and B to check voltage or Δ -time at any point on the displayed waveform.

Service Policy

The service policy of this instrument requires replacing defective assemblies. Some assemblies can be replaced on an exchange basis.

In This Service Guide

This book provides the service documentation for the Keysight Technologies 9000 Series oscilloscopes. It is divided into eight chapters.

Chapter 1, "General Information," provides information about which oscilloscopes are covered by this manual, environmental requirements, and oscilloscope dimensions.

Chapter 2, "Calibration," explains how and when you should run the user calibration procedure.

Chapter 3, "Testing Performance," provides information about testing the oscilloscope to verify that it performs according to specifications.

Chapter 4, "Troubleshooting," provides information about how to identify defective assemblies.

Chapter 5, "Replacing Assemblies," gives the procedures and techniques for replacing defective parts.

Chapter 6, "Replaceable Parts," includes a list of exchange assemblies and other replaceable parts, part ordering information, and shipping information.

Chapter 7, "Theory of Operation," briefly describes the internal operation of the oscilloscope.

At the back of the book you will find safety notices.

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Instruments covered by this service guide

Oscilloscopes manufactured after the date this manual was released may be different from those described in this manual. The release date of this manual is shown on the title page. This manual will be revised when necessary.

If you have an oscilloscope that was manufactured after the release of this manual, please check the Keysight Technologies website at www.keysight.com to see whether a newer version of this manual is available.

The following 9000 Series oscilloscopes are covered in this guide.

Oscilloscopes Covered by this Service Guide

Model	Bandwidth
DSO/MS09064A	600 MHz
DSO/MS09104A	1 GHz
DSO/MS09254A	2.5 GHz
DSO/MS09404A	4 GHz
DSO9024H	250 MHz
DSO9054H	500 MHz
DSO9104H	1 GHz
DSO9204H	2 GHz

The oscilloscope can be identified by the product number on the front or rear panel. DSO9024H, DSO9054H, DSO9104H, and DSO9204H models have up to 12 bits of resolution.

Accessories supplied

The following accessories are supplied.

- Mouse
- Stylus
- Keyboard
- Accessory Pouch
- Front panel Cover
- Localized Power Cord
- N2873A 10:1 Divider Passive Probe (one per scope channel)
- Channel Flying Lead Set Logic Probe, MSO Cable, and Calibration Fixture (MSO models only)
- Keysight I/O Libraries Suite 15.0

Specifications and Characteristics

For complete specifications and characteristics, direct your web browser to www.keysight.com and perform a search for the oscilloscope's model number. Then select "Data Sheets" from the Library.

Specifications that are pertinent to each test are given in the "Testing Performance" chapter.

Specifications are valid after a 30-minute warm-up period, and within $\pm 5^{\circ}\text{C}$ from the temperature at which the last self-calibration was performed.

Environmental Conditions

Overvoltage Category

This product is intended to be powered by MAINS that comply to Overvoltage Category II, which is typical of cord-and-plug connected equipment.

Pollution Degree

The 9000 Series oscilloscope may be operated in environments of Pollution Degree 2 (or Pollution Degree 1).

Pollution Degree Definitions

Pollution Degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence. Example: A clean room or climate controlled office environment.

Pollution Degree 2. Normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation may occur. Example: General indoor environment.

Pollution Degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is expected. Example: Sheltered outdoor environment.

Measurement Category



Measurement Category

The 9000 Series oscilloscope is intended to be used for measurements in Measurement Category I.

Measurement Category Definitions

Measurement Category I is for measurements performed on circuits not directly connected to MAINS. Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS derived circuits. In the latter case, transient stresses are variable; for that reason, the transient withstand capability of the equipment is made known to the user.

Measurement Category II is for measurements performed on circuits directly connected to the low voltage installation. Examples are measurements on household appliances, portable tools and similar equipment.

Measurement Category III is for measurements performed in the building installation. Examples are measurements on distribution boards, circuit-breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use and some other equipment, for example, stationary motors with permanent connection to the fixed installation.

Measurement Category IV is for measurements performed at the source of the low-voltage installation. Examples are electricity meters and measurements on primary overcurrent protection devices and ripple control units.

Transient Withstand Capability

The maximum transient withstand capability of this instrument is not specified. Do not apply more than 5 volts rms at the oscilloscope's vertical input BNC connectors.

Setting Up the Oscilloscope

For detailed information on setting up the 9000 Series oscilloscope, refer to the *Infiniium 9000 Series Oscilloscope User's Guide*.

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To run the self calibration

Let the Oscilloscope Warm Up Before Adjusting

Warm up the oscilloscope for 30 minutes before starting calibration procedure. Failure to allow warm up may result in inaccurate calibration.

The self calibration uses signals generated in the oscilloscope to calibrate channel sensitivity, offsets, and trigger parameters. You should run the self calibration

- yearly, or according to your periodic needs,
- when you replace the acquisition assembly or acquisition hybrids,
- when you replace the hard drive or any other assembly,
- when the oscilloscope's operating temperature (after the 30 minute warm-up period) is more than ± 5 °C different from that of the last calibration.

Equipment Required

Equipment	Critical Specifications	Keysight Part Number
50 Ω BNC Cable	50 Ω characteristic impedance BNC cable	
10 MHz Signal Source (required for time scale calibration)	Frequency accuracy better than 0.4 ppm	Keysight 53131A with Opt. 010
MSO calibration fixture that ships with the oscilloscope (MSO models only)		
MSO cable that ships with the oscilloscope (MSO models only)		Keysight 54904-61615

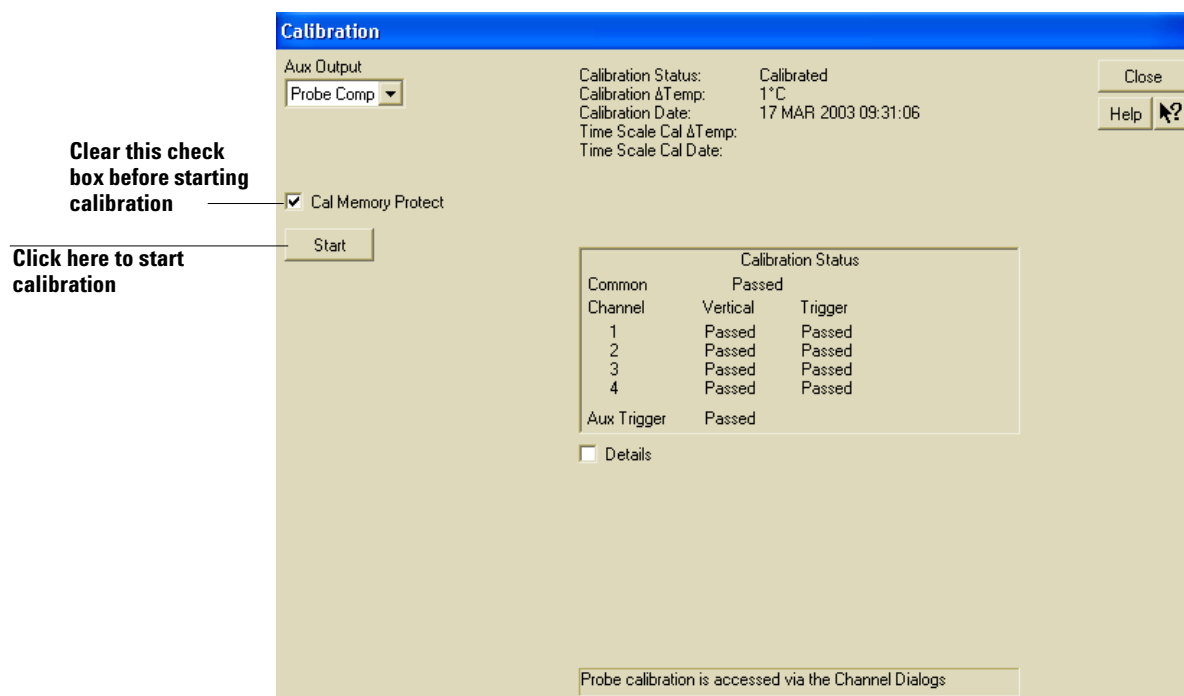
Self calibration

Calibration time

It will take approximately 1 hour to run the self calibration on the oscilloscope, including the time required to change cables from channel to channel.

- 1 Let the oscilloscope warm up before running the self calibration.
The self calibration should only be done after the oscilloscope has run for 30 minutes at ambient temperature with the cover installed. Calibration of an oscilloscope that has not warmed up may result in an inaccurate calibration.
- 2 Pull down the Utilities menu and select Calibration.
- 3 Click the check box to clear the Cal Memory Protect condition.
You cannot run self calibration if this box is checked. See Figure 1.

Figure 1



4 Click Start, then follow the instructions on the screen.

The routine will ask you to do the following things in sequence:

- a** Decide if you want to perform the Time Scale Calibration. Your choices are:
 - **Standard Calibration** - Time scale calibration will not be performed. Time scale calibration factors from the previous time scale calibration will be used and the 10 MHz reference signal will not be required. The remaining calibration procedure will continue.
 - **Standard Calibration and Time Scale Calibration** - Performs the time scale calibration. This option requires you to connect a 10 MHz reference signal to channel 1 that meets the following specifications. Failure to use a reference signal that meets this specification will result in an inaccurate calibration.
 - Frequency: 10 MHz ± 0.4 ppm = 10 MHz ± 4 Hz
 - Amplitude: 0.2 V_{peak-to-peak} to 5.0 V_{peak-to-peak}
 - Wave shape: Sine or Square
 - **Standard Calibration and Reset Time Scale Calibration** - Factory time scale calibration factors will be used. The 10 MHz reference signal will not be required. The remaining calibration procedure will continue.
- b** Disconnect everything from all inputs and Aux Out.
- c** Connect the 50 Ω BNC cable from Aux Out to channel 1.
- d** Connect the 50 Ω BNC cable from Aux Out to each of the channel inputs as requested.
- e** Follow the directions for calibrating the digital channels (MSO models only).
- f** A Passed/Failed indication is displayed for each calibration section. If any section fails, check the calibration cables and run the oscilloscope Self Test in the Utilities menu. Page 87 also has a little section on what to do if a self cal fails in terms of replacing assemblies.

5 After the calibration procedure is completed, click Close.

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This section documents performance test procedures. Performance verification for the products covered by this manual consists of three main steps:

- Performing the internal product self-tests to ensure that the measurement system is functioning properly
- Calibrating the product
- Testing the product to ensure that it is performing to specification

Performance Test Interval

The procedures in this section may be performed for incoming inspection and should be performed periodically to verify that the oscilloscope is operating within specification. The recommended test interval is once per year or after 2000 hours of operation. Performance should also be tested after repairs or major upgrades.

Performance Test Record

A test record form is provided at the end of this section. This record lists performance tests, test limits and provides space to record test results.

Test Order

The tests in this section may be performed in any order desired. However, it is recommended to conduct the tests in the order presented in this manual as this represents an incremental approach to performance verification. This may be useful if you are attempting to troubleshoot a suspected problem.

Test Equipment

Lists of equipment needed to conduct each test are provided for each test procedure. The procedures are written to minimize the number and types of test equipment and accessories required. The test equipment in these lists are ones that are currently available for sale by Keysight at the time of writing this document. In some cases, the test procedures use features specific to the test equipment in the recommended equipment list. However, with some modification to the test procedures, equipment, cables and accessories that satisfy the critical specifications in these lists may be substituted for the recommended models with some modification to the test procedures.

Contact Keysight Technologies for more information about the Keysight products in these lists.

Performing Self-Test and Calibration

- 1** Warm up the oscilloscope for at least 30 minutes.
- 2** Perform self tests.
 - a** Pull down the Utilities menu and select Self Test.
 - b** Select Scope Self Test from the Self Test list.
 - c** Click Start Test to start the self test procedure.

If any of the self tests fail, ensure that the failure is diagnosed and repaired before calibrating and testing performance.
- 3** Perform calibration. See “To run the self calibration” on page 14.

Vertical Performance Verification

This section contains the following vertical performance verification:

- Impedance Test
- Offset Accuracy Test
- DC Gain Accuracy Test
- Analog Bandwidth Test
- Time Scale Accuracy (TSA)

To test input impedance

This test checks the input impedance of the vertical inputs. A four-wire measurement is used to accurately measure the 50 Ω and 1 M Ω inputs.

Specification: 1 M Ω \pm 1% and 50 Ω \pm 2.5%

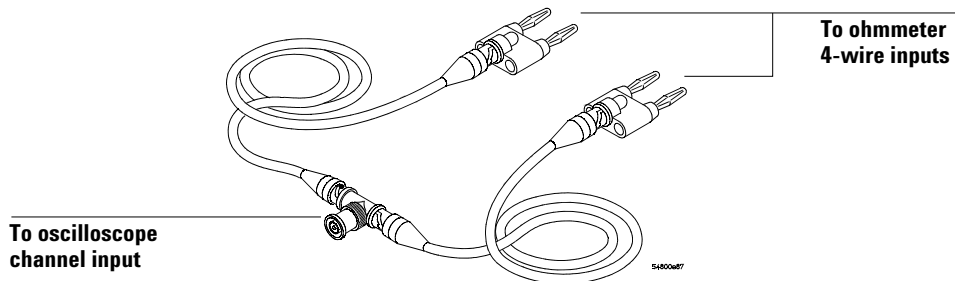
Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Digital Multimeter	Measure resistance (4-wire) at better than \pm 0.1% accuracy	Keysight 34401A
Cables (2)	BNC	Keysight 10503A
Adapter	BNC Tee (m)(f)(f)	Keysight 1250-0781
Adapters (2)	BNC (f) to dual banana (m)	Keysight 1251-2277

Procedure

- 1 Set up the multimeter to make a four-wire resistance measurement.
- 2 Assemble the test cables.
 - a Use the two BNC-to-banana adapters to connect one end of each BNC cable to the four-wire resistance connections on the multimeter.
 - b Connect the free ends of the cables to the BNC tee as shown here.

Input Resistance Equipment Setup



- 3 Connect the male end of the BNC tee to the channel 1 input of the oscilloscope.
- 4 Press **[Default Setup]** to set the oscilloscope to default conditions. Then set the scale for Channel 1 to 5 mV/div.
- 5 Open the Channel Setup dialog box for Channel 1 (Setup > Channel 1) to set the channel input resistance to 50 Ω and verify a resistance reading of 50 Ω \pm 1.25 Ω .
- 6 Record the readings in the Performance Test Record at the end of this chapter (Impedance Test table).
- 7 Repeat steps 5 and 6 for the remaining 50 Ω vertical scale settings in the Impedance Test table.
- 8 Repeat steps 3 through 7 on the remaining channels of the oscilloscope.
- 9 Repeat steps 3 through 8 using an input resistance of 1 M Ω instead of 50 Ω and verify resistance readings of 1 M Ω \pm 10 k Ω .

Offset Accuracy Test

CAUTION

Ensure that the input voltage to the oscilloscope never exceeds ± 5 V.

Let the oscilloscope warm up before testing

The oscilloscope and other equipment under test must be warmed up (with the oscilloscope application running) for at least 30 minutes prior to the start of any performance test.

Specifications

Offset Accuracy	$\pm(1.25\%$ of channel offset + 1% of full scale + 1 mV)
50 Ohm Input Impedance: Full scale is defined as 8 vertical divisions. Magnification is used below 10 mV/div. Below 10 mV full scale is defined as 80 mV. The major scale settings are 5 mV, 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV and 1 V.	
1 MOhm Input Impedance: Full scale is defined as 8 vertical divisions. The major scale settings are 5 mV, 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, and 5 V.	

Equipment Required

Description	Critical Specifications	Recommended Model/ Part Numbers
Digital Multimeter	DC voltage measurement accuracy better than $\pm 0.1\%$ of reading	Keysight 34401A or Keysight 3458A
Cable Assembly (2 required)	50 Ω characteristic impedance, BNC (m) connectors	Keysight 8120-1840
DC Power Supply	100V	Keysight 6614C
Adapter	BNC Tee (m)(f)(f)	Keysight 1250-0781
2 Adapters	2 BNC (f) to dual banana	Keysight 1251-2277

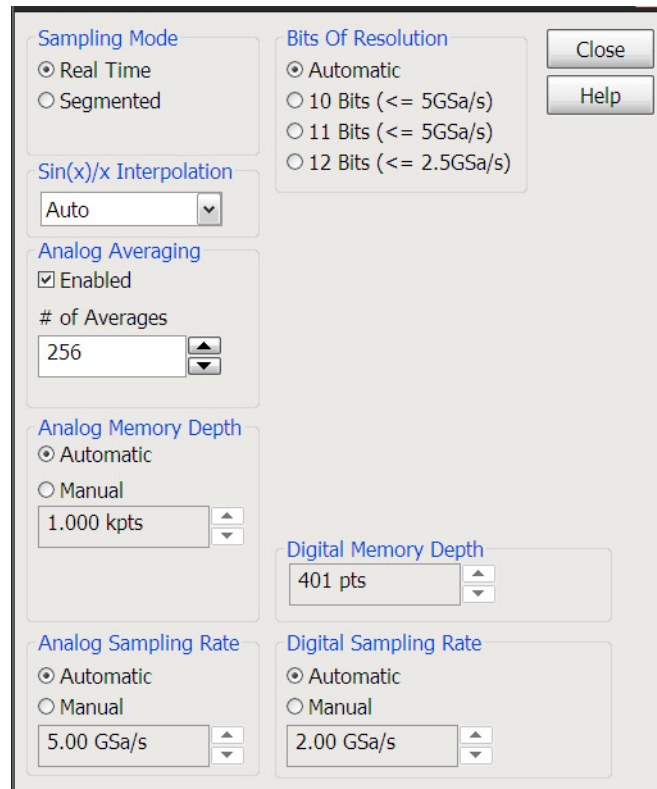
The offset accuracy specification consists of two terms: offset gain and zero error. The offset gain characteristic is $\pm 1.25\%$ of channel offset and the zero error characteristic is $\pm 1\%$ of full scale. The offset accuracy test procedure tests the zero error and offset accuracy.

Procedure

Zero Error Test

- 1 Disconnect all cables from the scope channel inputs.
- 2 Press [Default Setup], then configure the scope as follows:
 - a Pull down the Setup menu and select Acquisition.

- b When the Acquisition Setup window appears, enable averaging and set the # of averages to 256 as shown below.



- 3 Configure the scope to measure Average voltage on channel 1 as follows:
a Change the vertical scale of channel 1 to 5 mV/div.
b Click the V avg measurement on the left side of the screen.

V avg
measurement



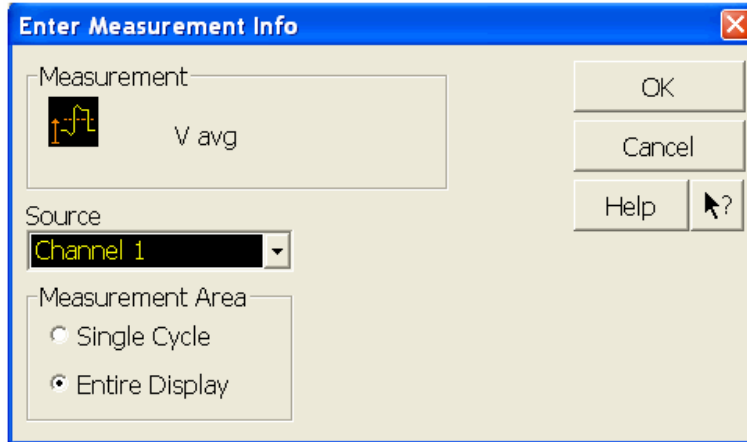
Chapter 3: Testing Performance

Offset Accuracy Test

- c When the Enter Measurement Info window appears, ensure that the V avg function is set up as follows and then click OK:

Source = Channel 1

Measurement Area = Entire Display



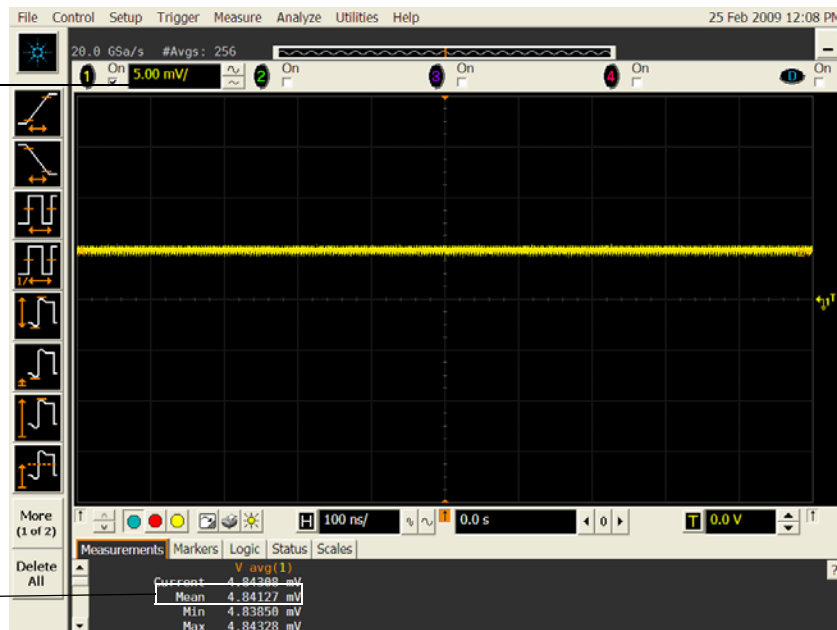
- 4 Press **[Clear Display]** on the scope and wait for the #Aves value (top left corner of screen) to return to 256. Record the scope's mean V avg reading in the $V_{\text{zero-error}}$ column (Offset Accuracy Test tables - both the 50 Ω table and 1 M Ω table) of the Performance Test Record at the end of this chapter.

Notes

- For all scope readings in this procedure, use the mean value in the Measurements display area at the bottom of the screen.
- If a question mark appears in front of any of the values at the bottom of the screen, press **[Clear Display]** on the scope, wait for the #Aves value to return to 256 and then record the scope reading. The question mark indicates that the oscilloscope could not make a reliable measurement. Therefore, any results that contain a question mark should be considered suspect and you should follow the directions above.

Vertical scale control for step 5

Record the mean reading

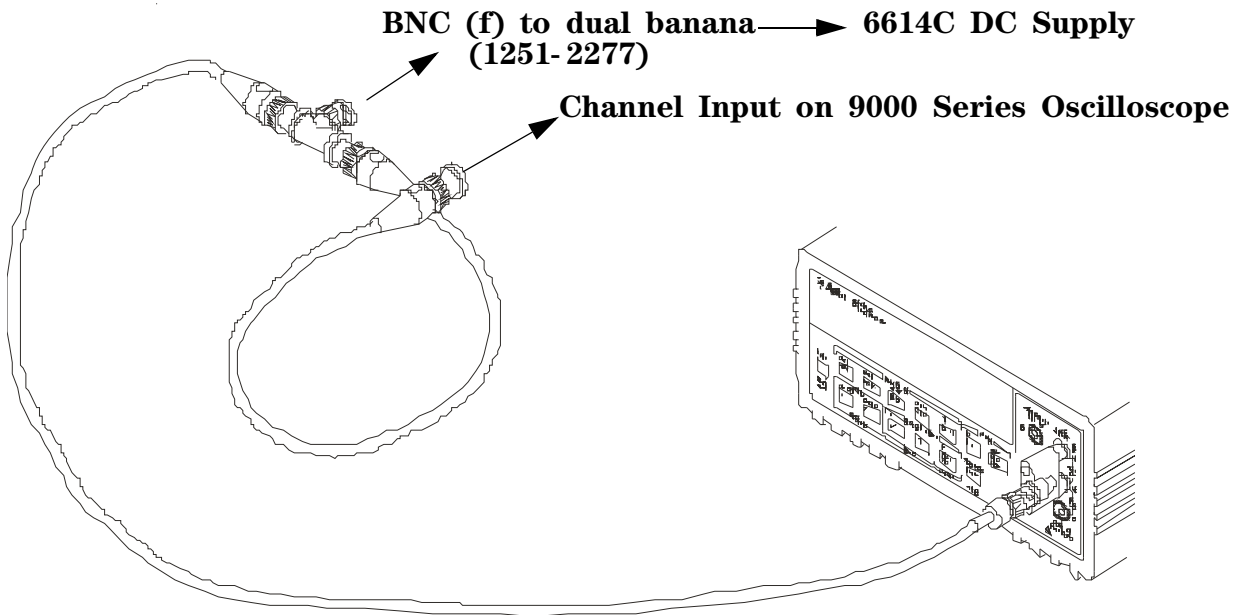


- 5 Change the vertical scale of channel 1 to 10 mV/div, press **[Clear Display]**, wait for the #Avgs value (top left corner of screen) to return to 256 and then record the scope V avg reading in the $V_{\text{zero-error}}$ column (Offset Accuracy Test tables - both the 50 Ω table and 1 M Ω table) in the Performance Test Record section at the end of this chapter.
- 6 Repeat step 5 for the remaining vertical scale settings for channel 1 in the Offset Accuracy Test tables in the Performance Test Record section.
- 7 Press **[Default Setup]**, then turn off channel 1 and turn channel 2 display on.
- 8 Configure the scope to measure V avg on Channel 2 as follows:
 - a Pull down the Setup menu and select Acquisition. When the Acquisition Setup window appears, enable averaging and set the # of averages to 256.
 - b Change the vertical scale of channel 2 to 5 mV/div.
 - c Click the V avg measurement icon on the left side of the screen.
 - d When the Enter Measurement Info window appears, ensure that the Vavg function is set up as follows and then click OK:
Source = Channel 2
Measurement area = Entire Display
- 9 Press **[Clear Display]** on the scope, wait for the #Avgs value to return to 256, and then record the scope's mean V avg reading in the $V_{\text{zero-error}}$ column (Offset Accuracy Test tables - both the 50 Ω table and 1 M Ω table) in the Performance Test Record section at the end of this chapter.
- 10 Repeat step 9 for the remaining vertical scale settings for channel 2 in the Offset Accuracy Test table of the Performance Test Record.
- 11 Repeat steps 7 through 10 for channels 3 and 4.
- 12 Ensure that each $V_{\text{zero-error}}$ is less than the corresponding $V_{\text{zero-error}}$ Limit entry in the Offset Accuracy Test table.

Offset Accuracy Test

13 Make the connections to scope channel 1 as shown below.

Connections



Notes:

- Where it is used, it is important to connect the BNC Tee adapter directly to the scope channel input to minimize ground potential differences and to ensure that the DMM measures the input voltage to the scope channel as accurately as possible. Differences in ground potential can be a significant source of measurement error, particularly at high scope sensitivities.
- It also helps to reduce ground potential differences if the scope and DMM are connected to the same AC supply circuit.
- A fairly large number of averages are used in the scope measurements of this section to reduce measurement noise and to reduce the measurement error due to resolution.

14 Set up the DMM to perform DC voltage measurements.

15 Configure the scope to measure V avg on Channel 1 as follows:

- a** Press **[Default Setup]**.
- b** Pull down the Setup menu and select Acquisition. When the Acquisition Setup window appears, enable averaging and set the # of averages to 256.
- c** Change the vertical scale of channel 1 to 5 mV/div.
- d** Click the V avg measurement icon on the left side of the screen.
- e** When the Enter Measurement Info window appears, ensure that the V avg function is set up as follows and then click OK:
Source = Channel 1
Measurement area = Entire Display

- 16 Set the channel 1 offset value to 60.0 mV and the impedance to 50 Ω (or to an offset of 2 V and the impedance to 1 M Ω if this is your second pass through this test and you are using the 1 M Ω input impedance version) by:
 - a Pull down the Setup menu and select Channel 1 or click the Channel 1 setup icon.
 - b Click the Offset control arrows to change the offset value or click on the offset value and enter 60.0 mV in the dialog box (or 2 V for the 1 M Ω impedance version).
 - c Select the 50 Ω button in the Impedance section of the Channel 1 Setup dialog box.

Channel 1
setup icon



- 17 Set the DC supply voltage (External Supply Setting) to +60.0 mV (or +2 V for the 1 M Ω version of this test).
- 18 Press [Clear Display] on the scope, wait for the #Aves value (top left corner of screen) to return to 256, and then record the DMM voltage reading as V_{DMM+} and the scope Vavg reading as V_{Scope+} in the Offset Accuracy Test section of the Performance Test Record (either the 50 Ω or the 1 M Ω version depending on which version of the test you are on). Fill in the V_{error+} column by using the following equation:

$$V_{error+} = V_{DMM+} - V_{scope+}$$

V_{error+} must be within the limits specified by the corresponding Offset Accuracy Limit listed in the table.

Chapter 3: Testing Performance

Offset Accuracy Test

- 19 Change the channel 1 offset value to -60.0 mV (or -2 V for the 1 M Ω version of this test).
- 20 Set the DC supply voltage to -60.0 mV (or -2 V for the 1 M Ω version of this test).
- 21 Press [**Clear Display**] on the scope, wait for the #Avgs value (top left corner of screen) to return to 256 and then record the DMM voltage reading as V_{DMM-} and the scope Vavg reading as V_{Scope-} in the Offset Accuracy Test section of the Performance Test Record (either the 50 Ω or 1 M Ω version of the table depending on which version of the test you are using). Fill in the V_{error-} column by using the following equation:

$$V_{error-} = V_{DMM-} - V_{scope-}$$

V_{error-} must be within the limits specified by the corresponding Offset Accuracy Limit listed in the table.

- 22 Repeat steps 15 to 20 for the remaining channel 1 vertical scale settings in the Offset Accuracy Test section of the Performance Test Record (either the 50 Ω or 1 M Ω version of the table depending on which version of the test you are performing). For each measurement, set both the DC supply voltage (External Supply Setting) and the Channel offset voltage to the positive External Supply Setting value and then to the negative External Supply Setting value in the "External Supply Setting" column of the Offset Accuracy Test section in the Performance Test Record for each of the vertical scale settings.
- 23 Move the Tee connector to the next channel input and repeat steps 15 to 22 for the channels 2 to 4.
- 24 Repeat steps 12 through 22 for the 1 M Ω channel input impedance setting. This means you should follow the directions exactly as stated except in step 15(c) you will select the 1 M Ω button instead of the 50 Ω one and all values will be entered in the Offset Accuracy Test (1 M Ω) section of the Performance Test Record rather than the Offset Accuracy Test (50 Ω) section. You will also want to be sure to use the external supply settings and offset values from the 1 M Ω version of the Offset Accuracy Test table as they are different than the 50 Ω version.

DC Gain Accuracy Test

CAUTION

Ensure that the input voltage to the oscilloscope never exceeds ± 5 V.

Let the oscilloscope warm up before testing

The oscilloscope under test and other test equipment must be warmed up (with the oscilloscope application running) for at least 30 minutes prior to the start of any performance test.

Specifications

DC Gain Accuracy	$\pm 2\%$ of full scale at full resolution channel scale (± 5 °C from calibration temperature)
<p>50 Ω Input Impedance: Full scale is defined as 8 vertical divisions. Magnification is used below 10 mV/div. Below 10 mV full scale is defined as 80 mV. The major scale settings are 5 mV, 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV and 1 V.</p> <p>1 MOhm Input Impedance: Full scale is defined as 8 vertical divisions. The major scale settings are 5 mV, 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, and 5 V.</p>	

Equipment Required

Description	Critical Specifications	Recommended Model/Part Numbers
Digital Multimeter	DC voltage measurement accuracy better than $\pm 0.1\%$ of reading	Keysight 34401A or Keysight 3458A
Cable Assembly (2 required)	50 Ω characteristic impedance, BNC (m) connectors	Keysight 8120-1840
DC Power Supply	100 V	Keysight 6614C
Adapter	BNC Tee (m)(f)(f)	Keysight 1250-0781
2 Adapters	2 BNC (f) to dual banana	Keysight 1251-2277

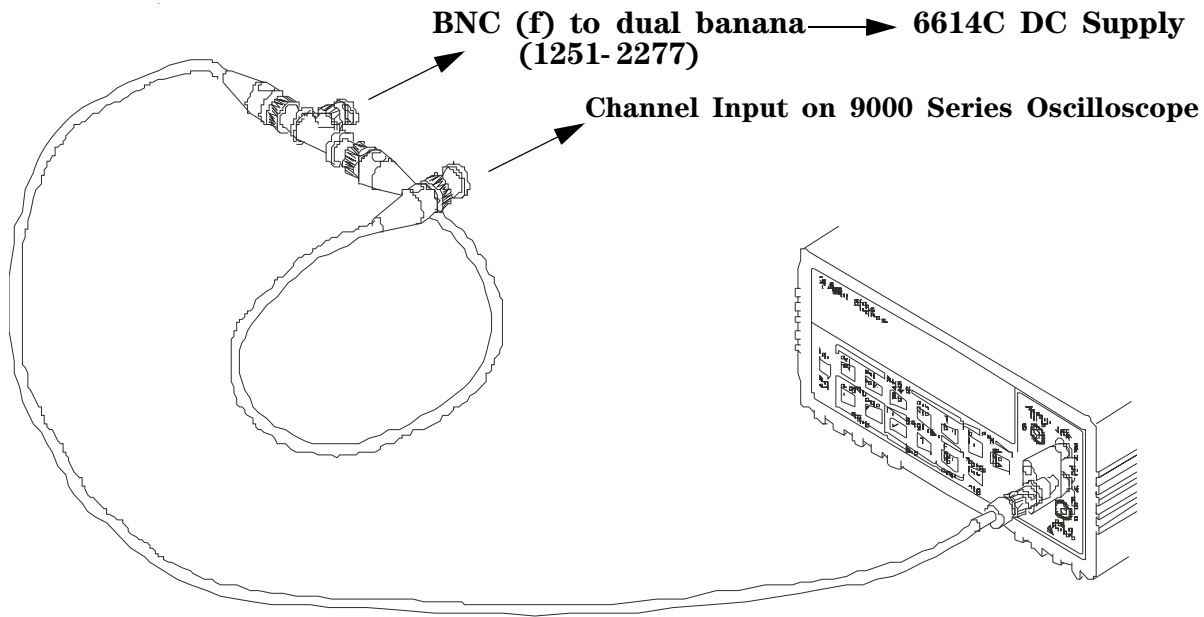
Chapter 3: Testing Performance

DC Gain Accuracy Test

Procedure

- 1 Make the connections to scope channel 1 as shown below.

Connections

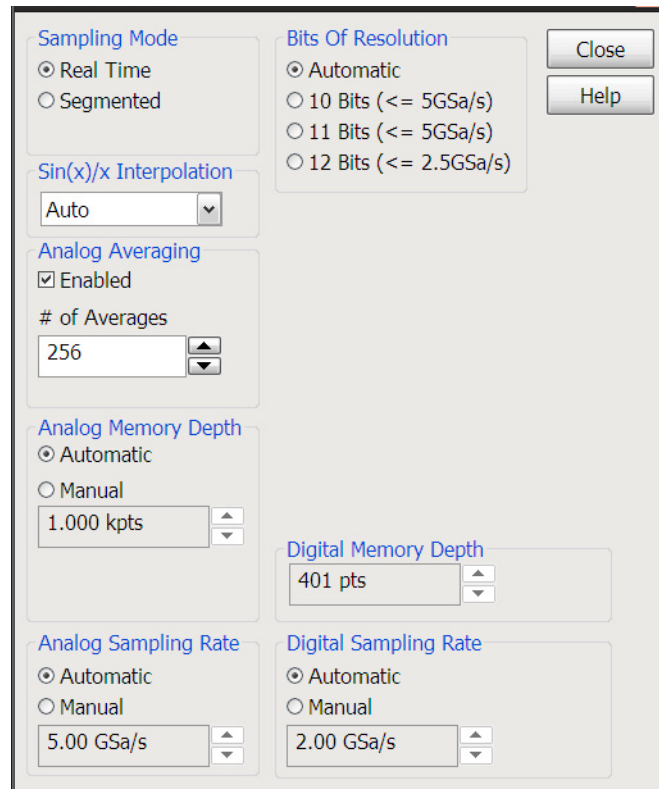


Notes:

- Where it is used, it is important to connect the BNC Tee adapter directly to the scope channel input to minimize ground potential differences and to ensure that the DMM measures the input voltage to the scope channel as accurately as possible. Differences in ground potential can be a significant source of measurement error, particularly at low voltage per division settings.
- It also helps to reduce ground potential differences if the scope and DMM are connected to the same AC supply circuit.
- A fairly large number of averages are used in the scope measurements of this section to reduce measurement noise and to reduce the measurement error due to resolution.

- 2 Press [**Default Setup**], then configure the scope as follows:
 - a Pull down the Setup menu and select Acquisition.

- b When the Acquisition Setup window appears, enable averaging and set the # of averages to 256 as shown below.



- 3 Set the DC Supply voltage (External Supply Setting) to +15 mV as follows:
4 Set the channel 1 vertical scale value to 5 mV/div and set the input impedance to 50 Ω .
a Pull down the Setup menu and select Channel 1 or click the Channel 1 setup icon.
b Change the vertical scale of channel 1 to 5 mV/div.
c Select the 50 Ω button from the Impedance section of this dialog box.
d Select the Vavg measurement as shown below.

V avg
measurement



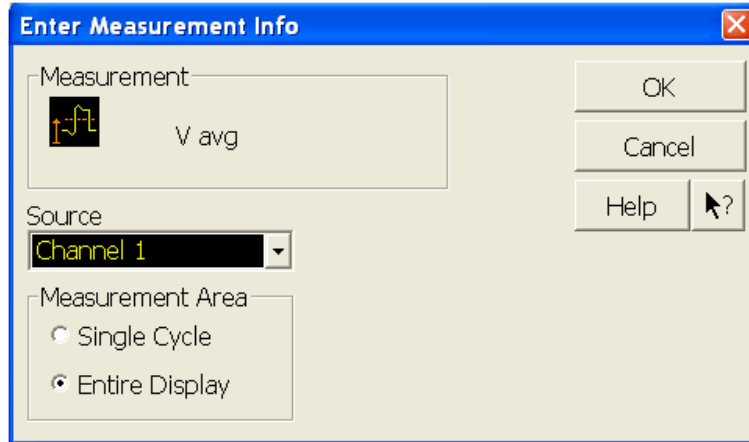
Chapter 3: Testing Performance

DC Gain Accuracy Test

- e When the Enter Measurement Info window appears, ensure that the V avg function is set up as follows and then click OK:

Source = Channel 1

Measurement Area = Entire Display

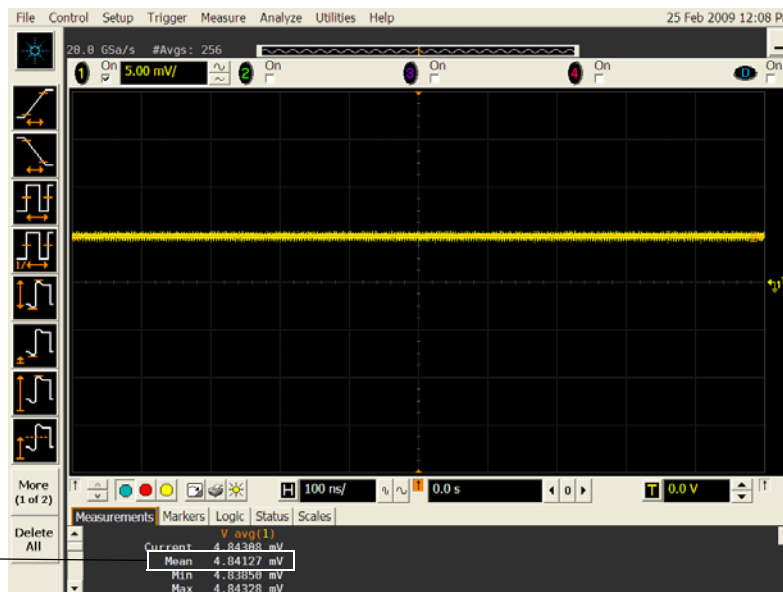


- 5 Press **[Clear Display]** on the scope, wait for the #Avgs value (top left corner of screen) to return to 256 and then record the scope's mean V avg reading in the Vscope+ column in the Offset Accuracy Test (50 Ω) section of the Performance Test Record.

Notes

- For all scope readings in this procedure, use the mean value in the Measurements display area at the bottom of the screen.
- If a question mark appears in front of any of the values at the bottom of the screen, press **[Clear Display]** on the scope, wait for the #Avgs value to return to 256 and then record the scope reading. The question mark indicates that the oscilloscope could not make a reliable measurement. Therefore, any results that contain a question mark should be considered suspect and you should follow the directions above.

Record the mean reading



- 6 Change the DC Supply voltage to -15 mV.

- 7 Press **[Clear Display]** on the scope, wait for the #Avgs value to return to 256 and then record the DMM voltage reading (Vdmm- column) and the scope V avg reading (Vscope-column) in the DC Gain Test (50 Ω) section of the Performance Test Record.
- 8 Repeat step 7 for the remaining vertical sensitivities for channel 1 shown in the DC Gain Test (50 Ω) section of the Performance Test Record.
- 9 Press **[Default Setup]**, then turn off channel 1 and turn channel 2 display on.
- 10 Set the DC Supply voltage (External Supply Setting) to +15 mV.
- 11 Configure the scope to measure V avg on Channel 2.
 - a Pull down the Setup menu and select Acquisition. When the Acquisition Setup window appears, enable averaging and set the # of averages to 256.
 - b Change the vertical scale of channel 2 to 5 mV/div.
 - c Click the V avg measurement icon on the left side of the screen.
 - d When the Enter Measurement Info window appears, ensure that the Vavg function is set up as follows and then click OK:
Source = Channel 2
Measurement area = Entire Display
- 12 Press **[Clear Display]** on the scope, wait for the #Avgs value to return to 256 and then record the DMM voltage reading (Vdmm+) and the scope V avg reading (Vscope+) in the DC Gain Test (50 Ω) section of the Performance Test Record.
- 13 Repeat step 12 for the remaining vertical scale settings for channel 2 in the DC Gain Test (50 Ω) section of the Performance Test Record.
- 14 Repeat steps 9 through 13 for channels 3 and 4.
- 15 Repeat steps 1 through 14 using 1 M Ω for the scope input impedance rather than 50 Ω . The steps should be followed exactly except in step 4(c), you should select the 1 M Ω button from the Impedance section of the Channel 1 Setup dialog box rather than 50 Ω and all values should be entered in the DC Gain Test (1 M Ω) section rather than the DC Gain Test (50 Ω) section.

Chapter 3: Testing Performance
DC Gain Accuracy Test

- 16** Calculate the offset gains for the 50 Ω test and the 1 M Ω test using the following expression and record this value in the DC Gain Test section of the Performance Test Record.

For the 50 Ω input impedance version of this test at the 5 mV/div scale setting, use the following equation:

$$DCGainError = \frac{\Delta V_{out}}{\Delta V_{in}} = \left(\frac{V_{scope+} - V_{scope-}}{V_{DMM+} - V_{DMM-}} - 1 \right) 0.375$$

All vertical scale settings used for the 1 M Ω test (including the 5 mV/div setting) and all 50 Ω test vertical scale settings used except for the 5 mV/div setting should then use the following equation:

$$DCGainError = \frac{\Delta V_{out}}{\Delta V_{in}} = \left(\frac{V_{scope+} - V_{scope-}}{V_{DMM+} - V_{DMM-}} - 1 \right) 0.75$$

Analog Bandwidth - Maximum Frequency Check

CAUTION

Ensure that the input voltage to the oscilloscope never exceeds ± 5 V.

Let the oscilloscope warm up before testing

The oscilloscope under test and other test equipment must be warmed up (with the oscilloscope application running) for at least 30 minutes prior to the start of any performance test.

Specification

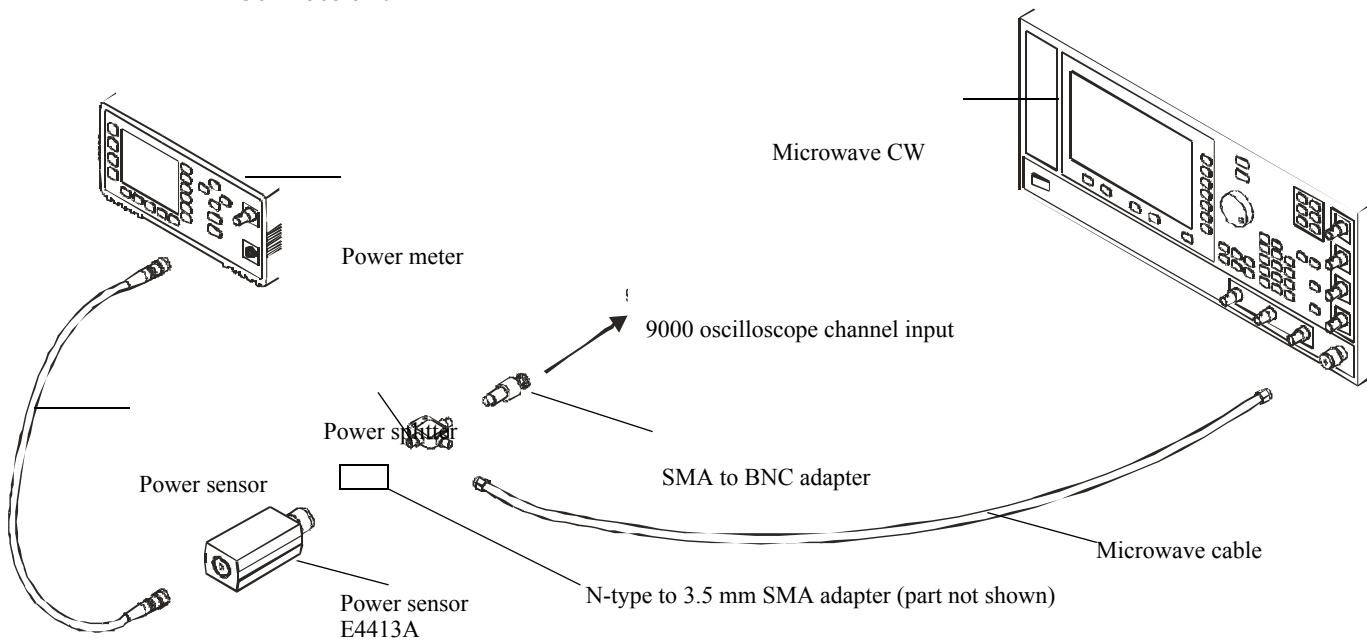
Analog Bandwidth (-3 dB)	
DSO/MS09404A	4 GHz
DSO/MS09254A	2.5 GHz
DSO/MS09104A	1 GHz
DSO/MS09064A	600 MHz

Analog Bandwidth (-4 dB)	
DSO9204H	2 GHz
DSO9104H	1 GHz
DSO9054H	500 MHz
DSO9024H	250 MHz

Equipment Required

Description	Critical Specifications	Recommended Model/ Part Numbers
Microwave CW Generator	Maximum Frequency ≥ 14 GHz Power range: -20 dBm to +16 dBm into 50Ω Output resistance = 50Ω	Keysight E8257D with Opt 520
Power Splitter	2 Resistor Power Splitter (f) Max Frequency ≥ 18 GHz	Keysight 11667B
Power Meter	Keysight E-series with power sensor compatibility	Keysight E4418B or E4419B
Power Sensor	Maximum Frequency ≥ 14 GHz Power range: -24 dBm to +16 dBm	Keysight E4413A
Microwave Cable	50Ω Characteristic Impedance 3.5 mm (m) to 3.5 mm (m) SMA connectors Max Frequency ≥ 18 GHz	Keysight 8120-4948
N-Type to SMA Adapter	N-type to 3.5 mm (m) SMA	Keysight 1250-1750
SMA to BNC Adapter	SMA (m) to Precision BNC (No Substitute)	Keysight 1250-1200

Connections



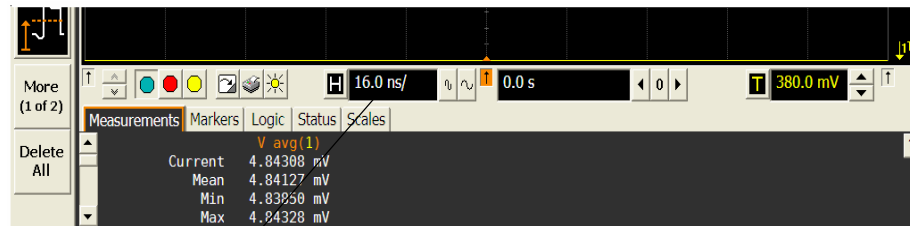
Notes

- Connect output 1 of the 11667B splitter to the scope Channel n input directly using the 1250-1200 adapter, without any additional cabling or adapters.
- Connect output 2 of the 11667B power splitter to the power sensor using the 1250-1750 N-type to 3.5mm adapter, without any additional cabling or adapters.
- Minimize the use of other adapters.
- Ensure that SMA and 3.5 mm connectors are tightened properly:
 8 in-lbs (90 N-cm) for 3.5 mm
 5 in-lbs (56 N-cm) for SMA

Procedure

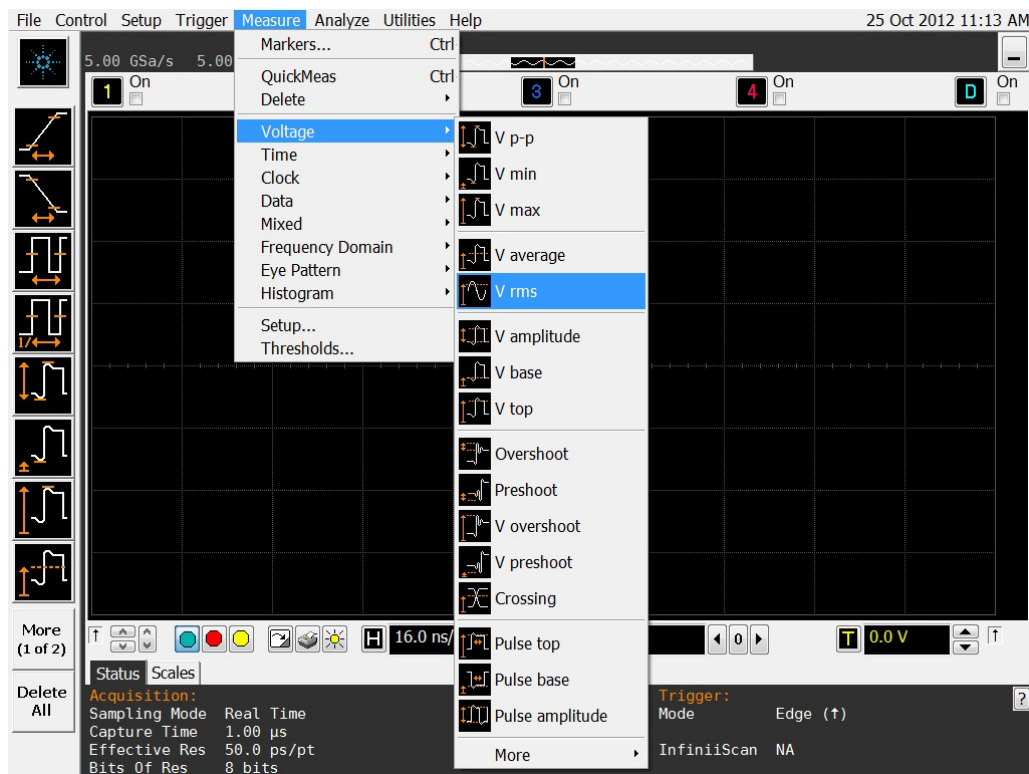
- 1 Preset the power meter.
- 2 Ensure that the power sensor is disconnected from any source and zero the meter.
- 3 Connect the power sensor to the power meter's Power Ref connector and calibrate the meter.
- 4 Make the connections to scope channel 1 as shown in the connection diagram above.
- 5 Set up the Power Meter to display measurements in units of Watts.
- 6 Press [**Default Setup**], then configure the scope as follows:
 - a Ensure Channel 1 is displayed and all other channels are turned off.
 - b Set the vertical scale of channel 1 to 5 mV/div.
 - c Set the input impedance to 50 Ohms (Setup > Channel dialog box).

- d Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).



Click here and enter 16E-9

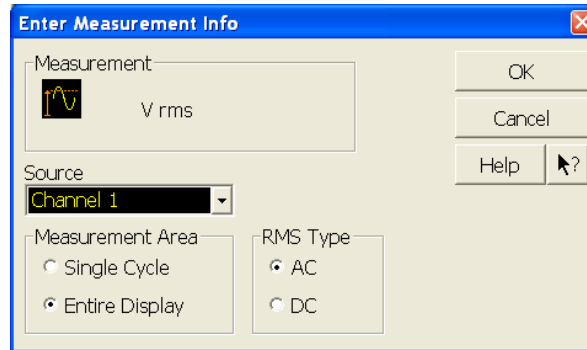
- e Pull down the Setup menu, select Acquisition, and set up the acquisition parameters as follows:
 Sin(x)/x Interpolation filter = Auto
 Analog Averaging = Enabled with # of Averages set to 16 samples
 Analog Memory Depth = Automatic
 Analog Sampling rate = Maximum (check the Manual button, click the field displaying the value, and then click the Max button in the dialog box that appears)
- f Pull down the Measure menu, select Voltage, and then select V rms.



Chapter 3: Testing Performance

Analog Bandwidth - Maximum Frequency Check

- g When the RMS voltage measurement setup window appears, configure this measurement as follows:
- Source = Channel 1
 - Measurement Area = Entire Display
 - RMS Type = AC



- 7 Set the generator to apply a 50 MHz sine wave with a peak-to-peak amplitude of about 4 divisions.
- Use the following table to determine the approximate required signal amplitude.
The amplitude values in the table below are not absolutely required. If your generator is unable to produce the recommended amplitude, then set the generator to the highest value that does not produce a vertically clipped signal on the scope.

Table 3-1. Nominal Generator Amplitude Settings

Scope Vertical Scale Setting	Generator Signal Amplitude (Vp-p)	Generator Signal Amplitude (dBm)
5 mV/div	0.02	-30
10 mV/div	0.04	-24
20 mV/div	0.08	-18
50 mV/div	0.20	-10
100 mV/div	0.40	-4
200 mV/div	0.80	+2
500 mV/div	2.0	+10
1 V/div	4.0	+16

- 8 Measure the input power to the scope channel and convert this measurement to Volts RMS using the expression:

$$V_{in} = \sqrt{P_{meas} \times 50\Omega}$$

For example, if the power meter reading is 4.0 μ W, then $V_{in} = (4.0 \times 10^{-6} \times 50\Omega)^{1/2} = 14.1$ mVrms.

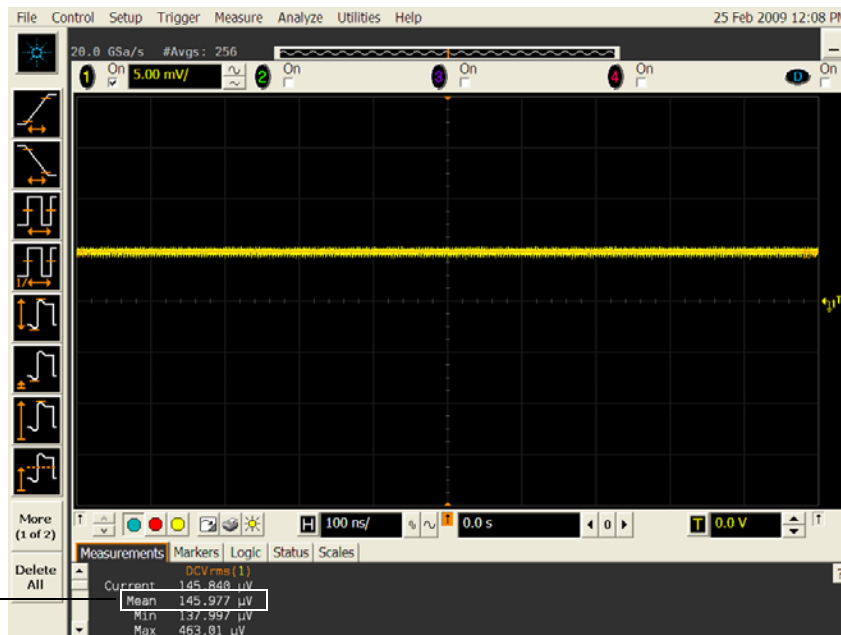
Record the RMS voltage in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record (in the V_{in} @ 50 MHz column).

- 9 Press **[Clear Display]** on the scope and record the scope V_{rms} reading in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record (V_{out} @ 50 MHz). For all scope readings in this procedure, use the mean value in the Measurements display area at the bottom of the screen.

Notes

- For all scope readings in this procedure, use the mean value in the Measurements display area at the bottom of the screen.
- If a question mark appears in front of any value at the bottom of the screen, press **[Clear Display]** on the scope, wait for the #Aves value to return to 16, and then record the scope reading.

Record the
mean reading



- 10 Calculate the reference gain as follows:

$$Gain_{50 \text{ MHz}} = \frac{V_{out @ 50 \text{ MHz}}}{V_{in @ 50 \text{ MHz}}}$$

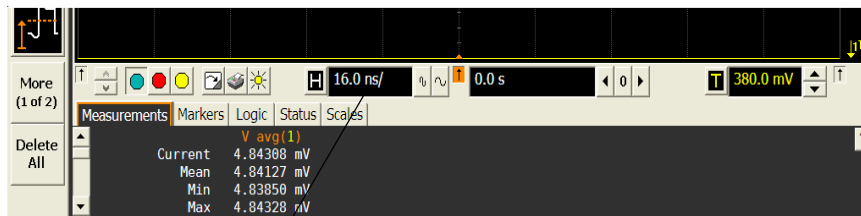
Record this value in the Calculated Gain @50 MHz column in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record.

Chapter 3: Testing Performance
Analog Bandwidth - Maximum Frequency Check

- 11 Change the generator frequency to the maximum value for the model being tested as shown in the table below. It is not necessary to adjust the signal amplitude at this point in the procedure.

Setting	Model						
	DSO9404A MSO9404 A	DSO9254A MSO9254 A	DSO9204 H	DSO9104A MSO9104A DSO9104H	DSO9064A MSO9064 A	DSO9054H	DSO9024H
Maximum Frequency	4 GHz	2.5 GHz	2 GHz	1 GHz	600 MHz	500 MHz	250 MHz
Scope Time Base Setting	200 ps/div	320 ps/div	400 ps/div	800 ps/div	1.3 ns/div	1.6 ns/div	3.2 ns/div

- 12 Change the scope time base to the value for the model under test in the table above.



Click here and enter time base value from table

- 13 Measure the input power to the scope channel at the maximum frequency and convert this measurement to Volts RMS using the expression:

$$V_{in} = \sqrt{P_{meas} \times 50\Omega}$$

For example, if the power meter reading is 4.0 μ W, then $V_{in} = (4.0 \times 10^{-6} \times 50\Omega)^{1/2} = 14.1$ mVrms.

Record the RMS voltage in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record (V_{in} @ Max Freq).

- 14 Press **[Clear Display]** on the scope and record the scope V_{rms} reading in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record (V_{out} @ Max Freq).
 15 Calculate the gain at the maximum frequency using the expression:

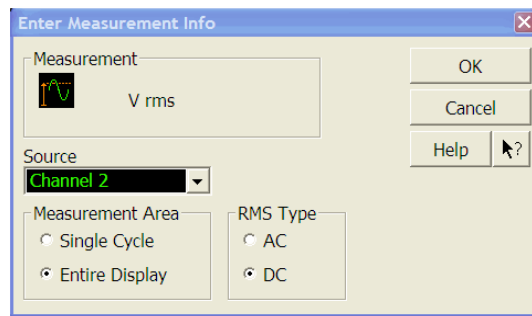
$$Gain_{Max\ Freq} = 20 \log_{10} \left[\frac{(V_{out\ Max\ Freq}) / (V_{in\ Max\ Freq})}{Gain_{50\ MHz}} \right]$$

For example, if (V_{out} @ Max Frequency) = 13.825 mV, (V_{in} @ Max Frequency) = 13.461 mV and Gain @ 50MHz = 1.0023, then:

$$Gain_{Max\ Freq} = 20 \log_{10} \left[\frac{13.825\ mV / 13.461\ mV}{1.0023} \right] = 0.212\ dB$$

Record this value in the Calculated Gain @Max Freq column in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record. To pass this test, this value must be greater than -3.0 dB for DSO/MSO9064A, DSO/MSO9104A, DSO/MSO9254A, and DSO/MSO9404A models, and greater than -4 dB for DSO9024H, DSO9054H, DSO9104H, and DSO9204H models.

- 16 Change the scope setup as follows:
 - a Change the channel vertical scale to 10 mV/div.
 - b Reset the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
- 17 Change the generator output as follows:
 - a Reset the generator frequency to 50 MHz.
 - b Change the amplitude to the value suggested for this scale setting in Table 3-1.
- 18 Repeat steps 8, 9, and 10 to measure the reference gain at 50 MHz for this scale.
- 19 Repeat steps 11, 12, 13, and 14 to measure the gain at maximum frequency for this scale.
- 20 Repeat steps 15 to 19 to complete measuring gains for remaining scale settings for channel 1 in the Analog Bandwidth - Maximum Frequency Check section of the Performance Test Record.
- 21 Move the splitter to channel 2 and change the scope configuration as follows:
 - Ensure Channel 2 is displayed and all other channels are turned off.
 - Set the vertical scale of channel 2 to 5 mV/div.
 - Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
 - Right click on the V rms measurement at the bottom of the screen. When the RMS voltage measurement setup window appears, change the source from Channel 1 to Channel 2.



- 22 Repeat steps 7 to 20 to complete measuring gains for channel 2.
- 23 Move the splitter to channel 3 and change the scope configuration as follows:
 - a Ensure Channel 3 is displayed and all other channels are turned off.
 - b Set the vertical scale of channel 3 to 5 mV/div.
 - c Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
 - d Click on the V rms measurement at the bottom of the screen and select Customize. When the V rms setup window appears, change the source from Channel 2 to Channel 3.
- 24 Repeat steps 7 to 20 to complete measuring gains for channel 3.
- 25 Move the splitter to channel 4 and change the scope configuration as follows:
 - a Ensure Channel 4 is displayed and all other channels are turned off.
 - b Set the vertical scale of channel 4 to 5 mV/div.
 - c Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
 - d Click on the V rms measurement at the bottom of the screen. When the V rms setup window appears, change the source from Channel 3 to Channel 4.
- 26 Repeat steps 7 to 20 to complete measuring gains for channel 4.

Time Scale Accuracy (TSA)

This procedure verifies the maximum TSA specification for the oscilloscope.

Description

TSA refers to the absolute accuracy of oscilloscope's time scale. Because TSA depends directly on frequency of a crystal oscillator, it is comprised of two components: an initial accuracy component and an aging component. The initial accuracy component applies to the oscilloscope's accuracy immediately after a calibration, whether performed at the factory, by a customer, or by a Keysight service center. The aging component scales linearly from the time since the last factory calibration and adds to the initial accuracy component.

Specifications

TSA is published as a warranted specification, expressed by the following formula. The aging component is specified by the crystal manufacturer while the initial accuracy component represents our best estimate of the final value, which will be determined from subsequent characterization of a large sample of production units.

$$\text{TSA} = \pm(0.4 + 0.5(\text{Years Since Factory Calibration})) \text{ ppm peak}$$

To see the number of years since factory calibration, open the oscilloscope application and navigate to Utilities -> Calibration in the top menu bar. Inside this dialog box will be a line specifying the Time Scale Cal Date. This is the date of the last factory calibration.

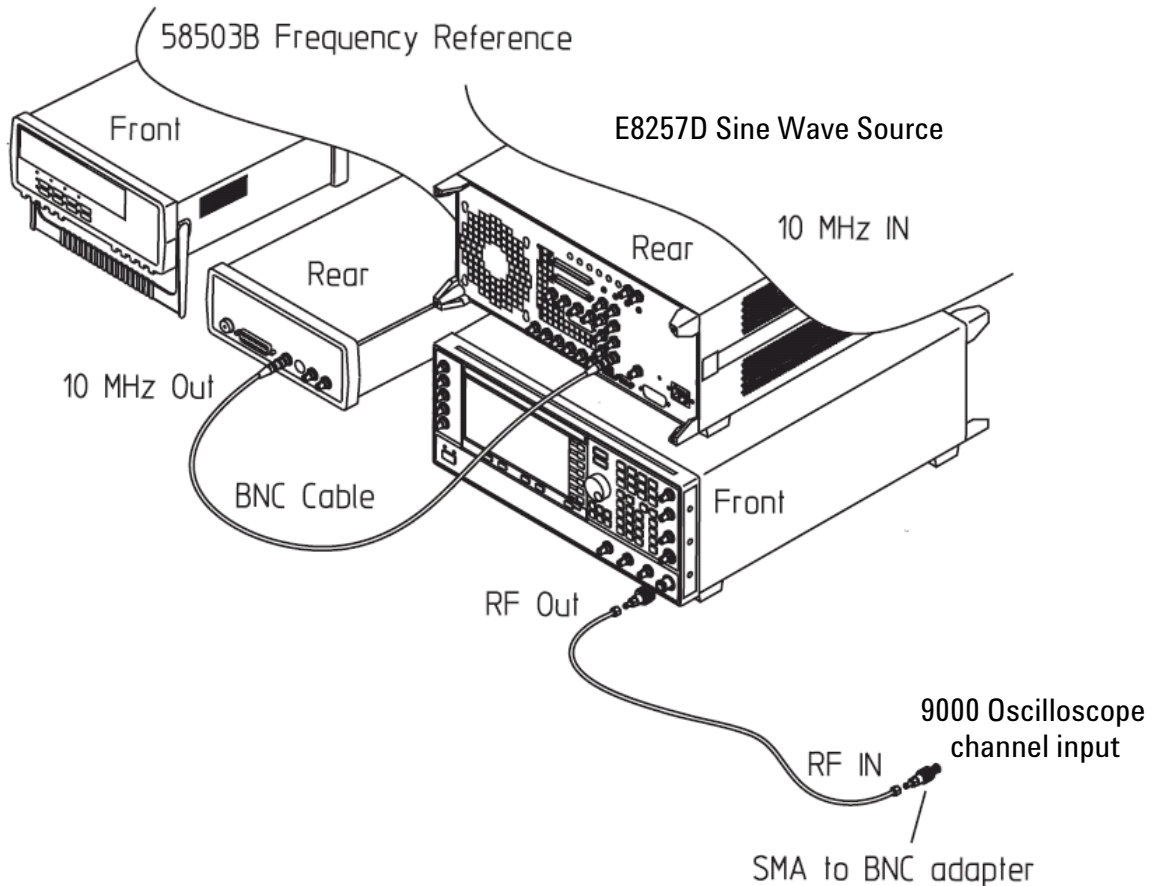
Note that TSA is specified with respect to an absolute standard and therefore its measurement results must be compared against test limits that account for the uncertainties in its measurement results. The total measurement uncertainty of the following test procedure is 0.1 ppm. It is the sum of 0.01 ppm for the test signal's absolute frequency accuracy, 0.04 ppm for the voltage noise and phase noise of the oscilloscope's digitized waveforms, and 0.05 ppm for the residual settling time of the crystal oscillator after the specified 30 minute warm-up time. Therefore, all measurement results need to be better than the specified values by a test margin of at least 0.1 ppm in order to guarantee compliance to the specification.

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Synthesized sine wave source	Output Frequency: ≥ 10 MHz Output Amplitude: 0 dBm Frequency Resolution: 0.1 Hz	Keysight E8257D PSG
10 MHz frequency reference	Output Frequency: 10 MHz Output Amplitude: 0 dBm Absolute Freq. Error: $< \pm 0.01$ ppm	Symmetricon 58503B
SMA cable	50 ohm characteristic impedance SMA (m) connectors Max Frequency: ≥ 50 MHz	Keysight 8120-4948
RF cable	50 ohm characteristic impedance BNC (m) connectors Max Frequency: ≥ 50 MHz	Keysight 8120-1840
Adapters, assorted	3.5 mm (f) to Precision BNC (m)	Keysight 54855-67604

Connections

Connect the equipment as shown in the following figure.



Procedure, 9000A Series

- 1 Configure the sine wave source to output a 0 dBm (600 mVpp) sine wave into 50 ohms with a frequency of 10.00002000 MHz.
- 2 Adjust source amplitude such that displayed sine wave is 600 mVpp.
- 3 Press **[Default Setup]** on the oscilloscope.
- 4 Set channel 1's vertical scale to 100 mV/div.
- 5 Set the oscilloscope sample rate to 100 kSa/s. (The resulting measurement will be aliased.)
- 6 Set the scope's horizontal scale to 20 ms/div.
- 7 Set the measurement thresholds for all waveforms to a fixed voltage level of 0 V and ± 20 mV hysteresis.
- 8 Enable a frequency measurement on channel 1.
- 9 On the oscilloscope, press **Stop**.
- 10 Press **Clear Display**.
- 11 Press **Run**, wait until 10 acquisitions have accumulated, and then press **Stop**.
- 12 Convert the average frequency value to time scale error by subtracting 20 Hz and dividing by 10 Hz/ppm.
- 13 Record the time scale error value as well as the time since the previous calibration (in years).
- 14 Calculate the specification for Time Scale Accuracy based on the oscilloscope's age using

Chapter 3: Testing Performance Time Scale Accuracy (TSA)

the following formula:

$$\text{TSA} = \pm(0.4 + 0.5(\text{Years Since Factory Calibration})) \text{ ppm peak}$$

- 15 Compare the measured time scale error to the TSA specification. Note that the measurement result should exceed the specified accuracy by at least 0.1 ppm to guarantee compliance to the specification.
- 16 Record the results in the Performance Test Record.

Procedure, 9000H Series

- 1 Set up the signal generator.
 - a Set the output to 10 MHz, approximately 1 V_{pp} sine wave.
- 2 Connect the output of the signal generator to oscilloscope channel 1 using the BNC cable.
- 3 Set up the oscilloscope:
 - a Press [**AutoScale**].
 - b Set the oscilloscope Channel 1 vertical scale to 200 mv/div.
 - c Set the oscilloscope horizontal scale to 5 ns/div.
 - d Adjust the intensity to get a sharp, clear trace.
 - e Adjust the oscilloscope's trigger level so that the rising edge of the waveform at the center of the screen is located where the center horizontal and vertical grid lines cross (center screen).
 - f Ensure the horizontal position control is set to 0.0 seconds.
- 4 Make the measurement:
 - a Set horizontal position control to +1 ms (rotate control CCW).
 - b Record the number of nanoseconds from where the rising edge crosses the center horizontal grid line to the center vertical grid line. The number of nanoseconds is equivalent to the time base error in ppm.
$$\text{TSA} = \pm(0.4 + 0.5(\text{Years Since Factory Calibration})) \text{ ppm peak}$$
 - c Record the result and compare it to the limits in the Performance Test Record.

Performance Test Record

Keysight Technologies

Keysight 9000 Series Oscilloscopes

Model Number _____

Tested by _____

Serial Number _____

Work Order No. _____

Recommended Test Interval - 1 Year/2000 hours

Date _____

Recommended next test date _____

Ambient temperature _____

Impedance Test

Input Resistance	Vertical Scale	Channel 1	Channel 2	Channel 3	Channel 4	Limits
50 Ω	0.005 V/div					48.75 Ω to 51.25 Ω
50 Ω	0.01V/div					48.75 Ω to 51.25 Ω
50 Ω	0.02 V/div					48.75 Ω to 51.25 Ω
50 Ω	0.05 V/div					48.75 Ω to 51.25 Ω
50 Ω	0.1 V/div					48.75 Ω to 51.25 Ω
50 Ω	0.2 V/div					48.75 Ω to 51.25 Ω
50 Ω	0.5 V/div					48.75 Ω to 51.25 Ω
50 Ω	1 V/div					48.75 Ω to 51.25 Ω
1 M Ω	0.005 V/div					990 k Ω to 1.010 M Ω
1 M Ω	0.01V/div					990 k Ω to 1.010 M Ω
1 M Ω	0.02 V/div					990 k Ω to 1.010 M Ω
1 M Ω	0.05 V/div					990 k Ω to 1.010 M Ω
1 M Ω	0.1 V/div					990 k Ω to 1.010 M Ω
1 M Ω	0.2 V/div					990 k Ω to 1.010 M Ω
1 M Ω	0.5 V/div					990 k Ω to 1.010 M Ω
1 M Ω	1 V/div					990 k Ω to 1.010 M Ω
1 M Ω	2 V/div					990 k Ω to 1.010 M Ω
1 M Ω	5 V/div					990 k Ω to 1.010 M Ω

Chapter 3: Testing Performance
Performance Test Record

Offset Accuracy Test (50 Ω)

Vertical Scale	External Supply Setting	V _{DMM+}	V _{scope+}	V _{error+}	V _{DMM-}	V _{Scope-}	V _{error-}	Offset Accuracy Limit (\pm)	V _{zero-error}	V _{zero-error} Limit (\pm)
Channel 1										
0.005 V/div	± 60 mV							2.55 mV		1.8 mV
0.01V/div	± 120 mV							3.30 mV		1.8 mV
0.02 V/div	± 240 mV							5.60 mV		2.6 mV
0.05 V/div	± 600 mV							12.50 mV		5.0 mV
0.1 V/div	± 1.2 V							24.00 mV		9.0 mV
0.2 V/div	± 2.4 V							47.00 mV		17.0 mV
0.5 V/div	± 4.0 V							91.00 mV		41.0 mV
1 V/div	± 4.0 V							131.00 mV		81.0 mV
Channel 2										
0.005 V/div	± 60 mV							2.55 mV		1.8 mV
0.01V/div	± 120 mV							3.30 mV		1.8 mV
0.02 V/div	± 240 mV							5.60 mV		2.6 mV
0.05 V/div	± 600 mV							12.50 mV		5.0 mV
0.1 V/div	± 1.2 V							24.00 mV		9.0 mV
0.2 V/div	± 2.4 V							47.00 mV		17.0 mV
0.5 V/div	± 4.0 V							91.00 mV		41.0 mV
1 V/div	± 4.0 V							131.00 mV		81.0 mV
Channel 3										
0.005 V/div	± 60 mV							2.55 mV		1.8 mV
0.01V/div	± 120 mV							3.30 mV		1.8 mV
0.02 V/div	± 240 mV							5.60 mV		2.6 mV
0.05 V/div	± 600 mV							12.50 mV		5.0 mV
0.1 V/div	± 1.2 V							24.00 mV		9.0 mV
0.2 V/div	± 2.4 V							47.00 mV		17.0 mV
0.5 V/div	± 4.0 V							91.00 mV		41.0 mV
1 V/div	± 4.0 V							131.00 mV		81.0 mV
Channel 4										
0.005 V/div	± 60 mV							2.55 mV		1.8 mV
0.01V/div	± 120 mV							3.30 mV		1.8 mV
0.02 V/div	± 240 mV							5.60 mV		2.6 mV
0.05 V/div	± 600 mV							12.50 mV		5.0 mV
0.1 V/div	± 1.2 V							24.00 mV		9.0 mV
0.2 V/div	± 2.4 V							47.00 mV		17.0 mV
0.5 V/div	± 4.0 V							91.00 mV		41.0 mV
1 V/div	± 4.0 V							131.00 mV		81.0 mV

Offset Accuracy Test (1 M Ω)

Vertical Scale	External Supply Setting	V _{DMM+}	V _{scope+}	V _{error+}	V _{DMM-}	V _{Scope-}	V _{error-}	Offset Accuracy Limit (\pm)	V _{zero-error}	V _{zero-error} Limit (\pm)
Channel 1										
0.005 V/div	± 2 V							26.4 mV		1.4 mV
0.01V/div	± 5 V							64.3 mV		1.8 mV
0.02 V/div	± 10 V							127.6 mV		2.6 mV
0.05 V/div	± 10 V							130.0 mV		5.0 mV
0.1 V/div	± 20 V							259.0 mV		9.0 mV
0.2 V/div	± 20 V							267.0 mV		17.0 mV
0.5 V/div	± 20 V							291.0 mV		41.0 mV
1 V/div	± 100 V							1.33 V		81.0 mV
2 V/div	± 100 V							1.41 V		161 mV
5 V/div	± 100 V							1.65 V		401 mV
Channel 2										
0.005 V/div	± 2 V							26.4 mV		1.4 mV
0.01V/div	± 5 V							64.3 mV		1.8 mV
0.02 V/div	± 10 V							127.6 mV		2.6 mV
0.05 V/div	± 10 V							130.0 mV		5.0 mV
0.1 V/div	± 20 V							259.0 mV		9.0 mV
0.2 V/div	± 20 V							267.0 mV		17.0 mV
0.5 V/div	± 20 V							291.0 mV		41.0 mV
1 V/div	± 100 V							1.33 V		81.0 mV
2 V/div	± 100 V							1.41 V		161 mV
5 V/div	± 100 V							1.65 V		401 mV
Channel 3										
0.005 V/div	± 2 V							26.4 mV		1.4 mV
0.01V/div	± 5 V							64.3 mV		1.8 mV
0.02 V/div	± 10 V							127.6 mV		2.6 mV
0.05 V/div	± 10 V							130.0 mV		5.0 mV
0.1 V/div	± 20 V							259.0 mV		9.0 mV
0.2 V/div	± 20 V							267.0 mV		17.0 mV
0.5 V/div	± 20 V							291.0 mV		41.0 mV
1 V/div	± 100 V							1.33 V		81.0 mV
2 V/div	± 100 V							1.41 V		161 mV
5 V/div	± 100 V							1.65 V		401 mV
Channel 4										
0.005 V/div	± 2 V							26.4 mV		1.4 mV
0.01V/div	± 5 V							64.3 mV		1.8 mV
0.02 V/div	± 10 V							127.6 mV		2.6 mV
0.05 V/div	± 10 V							130.0 mV		5.0 mV
0.1 V/div	± 20 V							259.0 mV		9.0 mV
0.2 V/div	± 20 V							267.0 mV		17.0 mV
0.5 V/div	± 20 V							291.0 mV		41.0 mV
1 V/div	± 100 V							1.33 V		81.0 mV
2 V/div	± 100 V							1.41 V		161 mV
5 V/div	± 100 V							1.65 V		401 mV

Chapter 3: Testing Performance
Performance Test Record

DC Gain Test (50 Ω)

Vertical Scale	External Supply Setting	V _{DMM+}	V _{DMM-}	V _{Scope+}	V _{Scope-}	Calculated DC Gain Error	DC Gain Error Test Limits
Channel 1							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
Channel 2							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
Channel 3							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
Channel 4							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %

DC Gain Test (1 M Ω)

Vertical Scale	External Supply Setting	V _{DMM+}	V _{DMM-}	V _{Scope+}	V _{Scope-}	Calculated DC Gain Error	DC Gain Error Test Limits
Channel 1							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
2 V/div	±6.0 V						±2 %
5 V/div	±15.0 V						±2 %
Channel 2							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
2 V/div	±6.0 V						±2 %
5 V/div	±15.0 V						±2 %
Channel 3							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
2 V/div	±6.0 V						±2 %
5 V/div	±15.0 V						±2 %
Channel 4							
5 mV/div	±15 mV						±2 %
10 mV/div	±30 mV						±2 %
20 mV/div	±60 mV						±2 %
50 mV/div	±150 mV						±2 %
100 mV/div	±300 mV						±2 %
200 mV/div	±600 mV						±2 %
500 mV/div	±1.5 V						±2 %
1 V/div	±3.0 V						±2 %
2 V/div	±6.0 V						±2 %
5 V/div	±15.0 V						±2 %

Chapter 3: Testing Performance

Performance Test Record

Analog Bandwidth - Maximum Frequency Check

Max frequency: DSO/MS09404A = 4 GHz, DSO/MS09254A = 2.5 GHz, DSO/MS09104A = 1 GHz, DSO/MS09064A = 600 MHz, DSO9024H = 250 MHz,

DSO9054H = 500 MHz, DSO9104H = 1 GHz, DSO9204H = 2 GHz

Vertical Scale	Measurement					
	Vin @ 50 MHz	Vout @ 50 MHz *	Calculated Gain @ 50 MHz	Vin @ Max Freq	Vout @ Max Freq	Calculated Gain @ Max Freq *
Channel 1						
5 mV/div						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						
Channel 2						
5 mV/div						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						
Channel 3						
5 mV/div						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						
Channel 4						
5 mV/div						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						

* Test limit for DSO/MS09404A, DSO/MS09254A, DSO/MS09064A, and DSO/MS09104A = greater than -3 dB

Test limit for DSO9024H, DSO9054H, DSO9104H, and DSO9204H = greater than -4 dB

Test	Limits	Results		
Time Scale Accuracy	Limit Limit is based on years since oscilloscope's last calibration $TSA = \pm(0.4 + 0.5(\text{Years Since Calibration})) \text{ ppm}$	Calculated TSA Spec	Measured time scale error	Pass/Fail
		_____	_____	_____

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Troubleshooting

The service strategy for troubleshooting Keysight Technologies 9000 Series oscilloscopes is to isolate problems to a faulty assembly, then use the disassembly and assembly procedures in the “Replacing Assemblies” chapter to replace the defective assembly.

Safety

Read the Safety Notices at the back of this manual before servicing the oscilloscope. Before performing any procedure, review it for cautions and warnings.

WARNING

SHOCK HAZARD!

Maintenance should be performed by trained service personnel aware of the hazards involved (for example, moving parts, fire and electric shock). Lack of training and awareness of the hazards could result in electrical shock or other injury. When maintenance can be performed without power applied, the power cord should be removed from the oscilloscope.

WARNING

INJURY CAN RESULT!

Use caution when working around the cooling fans with the cover removed from the oscilloscope. The cooling fan blades are exposed on one side and can be hazardous. If the procedure allows, replace the cover over the chassis (without screwing it back in place) before turning the oscilloscope on. If the procedure requires you to have the cover off, be careful not to contact these fan blades with any part of your body.

CAUTION

AVOID ESD DAMAGE TO COMPONENTS! ELECTROSTATIC DISCHARGE (ESD) can damage electronic components. Use proper ESD precautions when doing any of the procedures in this chapter. Failure to follow proper ESD procedures may cause immediate failure or latent damage. Latent damage may result in equipment failure after a period of time. As a minimum, place the oscilloscope on a properly grounded ESD mat and wear a properly grounded ESD strap.

Tools Required

You will need basic electronic troubleshooting tools, including a digital multimeter and a 100 MHz (or faster) oscilloscope.

If you need to remove and replace assemblies, see chapter 5, “Replacing Assemblies”

Default Setup

A Default Setup is provided to return the oscilloscope to a known state. You can use the default setup to undo previous setups so they do not interfere with the current measurement. Use the default setup when a procedure requires it. Press **[Default Setup]** on the front panel to set the oscilloscope to the default state.

To troubleshoot the oscilloscope

The primary procedural tool in this section is the Primary Trouble Isolation section. This section refers to sections in this chapter where the procedures are described in detail.

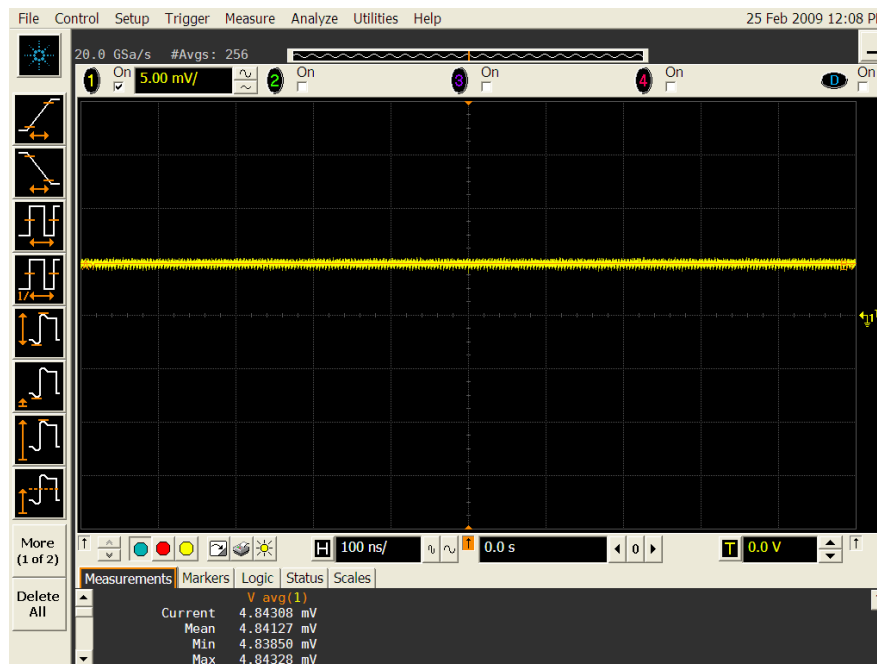
If you are unfamiliar with this oscilloscope, start with the Primary Trouble Isolation section.

Primary Trouble Isolation

A Perform power-up.

Connect the oscilloscope power cord and press the power button in the lower left corner of the front panel. If the oscilloscope is working properly, it will take several minutes to start up, and the graticule will appear on the screen. The exact appearance may look slightly different than shown in Figure 2, depending on the setup selected before the oscilloscope was turned off.

Figure 2



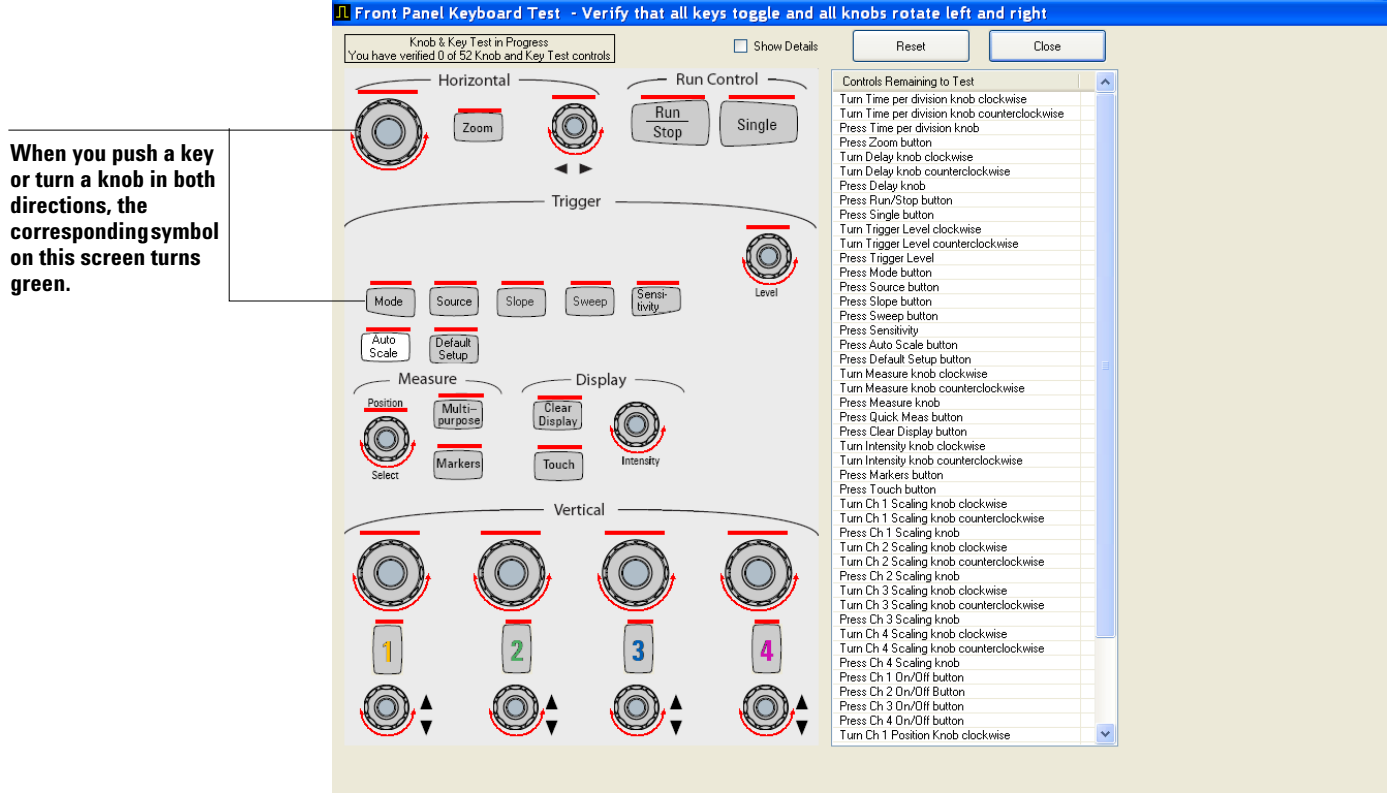
- 2 If the oscilloscope shuts down without you pressing the front panel power button, unplug the AC power cord from the rear of the instrument and wait 20 to 30 seconds. Then plug the AC power cord back into the oscilloscope and press the front panel power button (or you can perform a hard shutdown by holding the power button down for 5-6 second so the power turns off and then pressing the power button again to restart the oscilloscope). If it shuts down again, look through the rear fan slots to see the upper right corner of the acquisition board (as viewed from the rear of the oscilloscope). A series of LEDs is located in this corner of the acquisition board. Refer to the Power Supply Trouble Isolation section (page 60) of this chapter for more information on decoding these LEDs.

Figure 3



- 3 Once the oscilloscope will remain powered up, run the oscilloscope self-tests.
 - 1 Select Self Test from the Utilities menu (these are discussed in detail starting on page 73).
 - 2 Select Scope Self Tests from the Self Test drop down list box.
 - 3 Click the Start Test button and follow the instructions on the screen.If any of the self tests fail, go to the Acquisition Trouble Isolation troubleshooting flowchart later in this chapter for further troubleshooting. Otherwise, go to step D.
- 4 Check the front panel response by running the Keyboard and LED self tests. Use this procedure to verify correct keyboard operation.
 - 1 Select Self Test from the Utilities menu.
 - 2 Select Keyboard Test from the Self Test drop down list box, then click Start.A new window appears with a symbolic representation of the keyboard. See Figure 4.

Figure 4



Knob and Key Self Test Screen

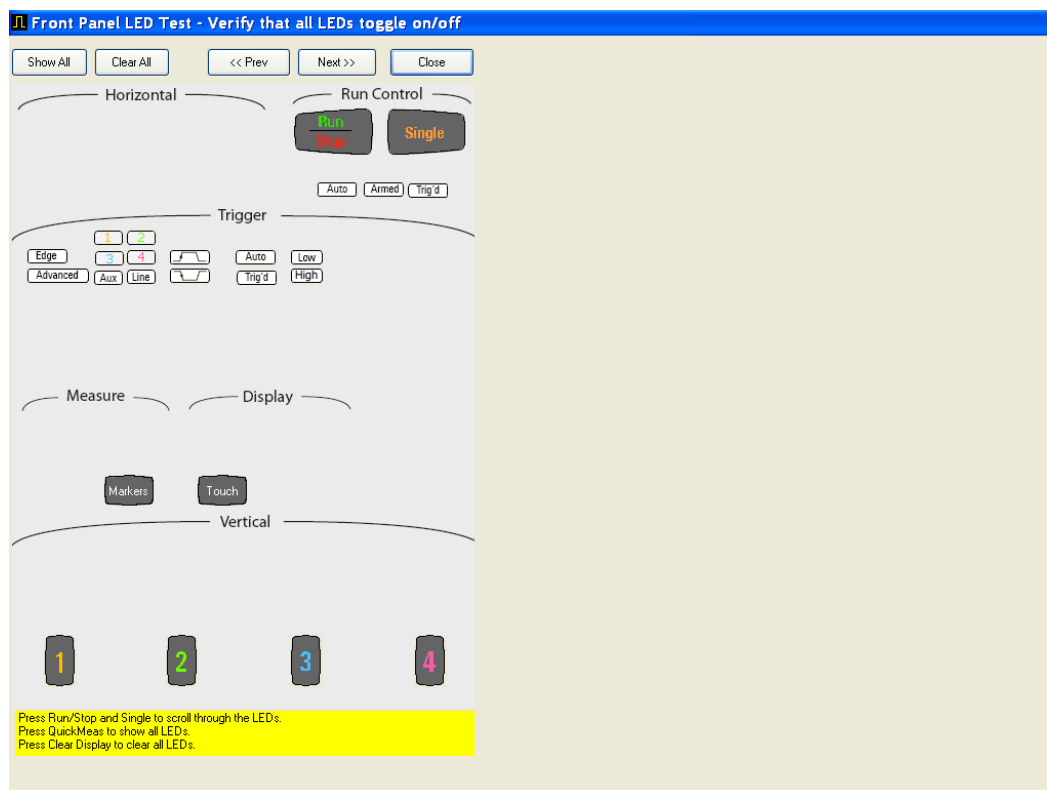
- 3 Press each key on the keyboard until you have pressed all keys.
- 4 When you press a key/knob, the bar above the corresponding key/knob symbol on the display should change from red to green.
- 5 Turn each knob in both directions until you have turned all knobs.
- 6 When you turn a knob in one direction, half the rotation arrow under the corresponding knob symbol should turn green. When you then turn the knob in the other direction, the entire rotation arrow under the knob symbol should turn green.
- 7 When you are finished, click **Close**.
- 8 If any of the knobs or keys do not work, go to “Keyboard Trouble Isolation Procedure” later in this chapter.

Use the following procedure to test the front-panel LED (light-emitting diode) indicators.

- 1 Select Self Test from the Utilities menu.
- 2 Select LED Test from the Self Test drop-down list box, then click Start Test.

The LED test screen appears, which shows a symbolic representation of all front panel LED indicators. See Figure 5.

Figure 5



LED Test Screen

- 3 Repeatedly push the Single button on the front panel to step through and highlight each LED symbol in the test screen. You can also step through the LEDs by clicking the [Prev] or [Next] buttons on the display screen. Verify that the corresponding LEDs on the front panel are the only ones illuminated. Additionally, pressing the [Multi Purpose] button on the front panel will illuminate all the LEDs while pressing the [Clear Display] button on the front panel will turn off all the LEDs.
 - 4 When you are finished, click Close.
 - 5 If any of the LEDs do not work, go to “To check the LEDs” later in this chapter.
 - 6 If both tests pass, go to step E.
- 5 Self Calibration
- 1 Complete a self calibration by following the procedures in chapter 4.
 - 2 If the calibration test fails, replace the acquisition board.
- 6 The system is operational. Performance test the oscilloscope using the procedures in chapter 4 of this service manual.

Power Supply Trouble Isolation

WARNING

SHOCK HAZARD!

Only trained service personnel who are aware of the hazards involved should perform the maintenance. Read the safety summary at the back of this book before proceeding. Failure to observe safety precautions may result in electric shock.

For information on how to replace assemblies, see "Replacing Assemblies," beginning on page 81.

These trouble isolation instructions help isolate the problem to the assembly level when the power system is not operating. Because of advanced power system protection features, the problem may not be with the supply itself and, therefore, you will need to use the LEDs located in the upper right corner of the acquisition board to determine the fault. These LEDs can be seen by looking through the rear fan slots in the upper right corner as viewed from the rear of the oscilloscope. After a shutdown occurs, keep the power cord plugged in so the LEDs remain illuminated. Once you have noted the LED pattern, you can unplug the instrument.



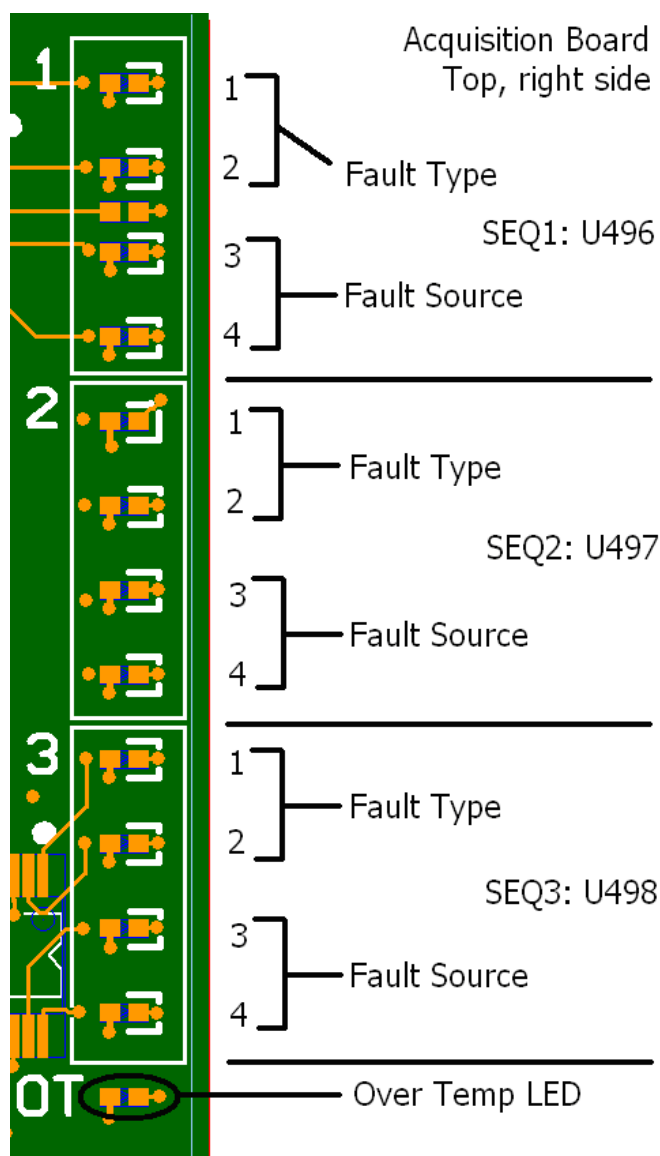
Look through these slots and the fans located behind them to see the upper right corner of the acquisition board

If the oscilloscope still will not power on after you have followed the required steps below, refer to the Motherboard Verification section in this chapter for additional diagnosis suggestions.

How to Use the Power Fault LEDs

The previous page showed where to look through the rear fan slots to see the upper right corner of the acquisition board. A series of 13 LEDs is separated into three sections of four LEDs each, with the Over Temperature LED by itself at the bottom (as shown in Figure 6).

Figure 6



By looking at the pattern of LEDs illuminated after a power failure, you can determine the cause of the fault. However, in most cases, only assembly level repair is required which greatly simplifies decoding these LEDs. An in-depth discussion of this LEDs will first be presented so you understand how they operate and then the assembly level repair procedures will be discussed.

The LEDs must be interpreted in groups of four (as shown in the layout above) with the upper two LEDs in each group indicating the type of failure and the lower two LEDs indicating the source of the failure.

Chapter 4: Troubleshooting

How to Use the Power Fault LEDs

If a shutdown occurs, use the following table to decode the upper two LEDs (LEDs 1 and 2) in each group. Remember these are the LEDs that specify the type of failure that occurred. The fault types are described below the table.

Fault Type	LED1	LED2
Sequence	On	On
Reset	On	Off
Command	Off	On
External	Off	Off

The following table then shows how to decode the bottom two LEDs in each group (LEDs 3 and 4). Remember that these LEDs specify the source of the failure.

Fault Source	LED3	LED4
1	On	On
2	On	Off
3	Off	On
4	Off	Off

The fault source refers to the input channel of the corresponding sequencer. Below is a listing of the inputs for each sequencer.

Sequencer 1

Input	Supply
1	+12V Bulk
2	+5 V
3	+3.3 V
4	+2.5 V

Sequencer 2

Input	Supply
1	+1.8V
2	+2.25 V
3	+1.6 V
4	+1.2 V

Sequencer 3

Input	Supply
1	-12V Bulk
2	-6 V
3	-5.2 V
4	-3.8 V

When a fault occurs on a given sequencer, it notifies the other two using the Fault signal. The other two sequencers report this as an External Fault as well. For example, if the first sequencer has an over-voltage on Channel 1, it will report an External Fault with Channel 1 as the source. The other two sequencers will report it as an External Fault with the source as Channel 4. Similarly, if the first sequencer has an under-voltage failure on +12V, it will report a Reset Fault on Channel 1 and the other two sequencers will report External Faults on Channel 4. As you can see, any fault on one of the sequencers always reports an External Fault on Channel 4 on the other two sequencers. Look for the fault that is not an External Fault on Channel 4 as the cause of the shutdown. If all three sequencers report an External Fault on channel 4, it will take some work to determine the real source. It could be on any of the Channel 4 sources (+2.5V, +1.2V, -3.8V), an over-temperature fault (look for the over-temperature LED to light), or an FPGA issued fault.

Sequence Fault: A Sequence Fault happens when a supply does not come up in time during a power-on sequence.

Reset Fault: A Reset Fault happens if the oscilloscope shuts down during the monitor phase because a supply went under voltage. This is probably due to the supply failing to an off state or the load becoming too much for the supply.

Command Fault: A Command Fault happens when the ON sequence to one of the sequencers goes HIGH to initiate a turn-on, but then goes LOW before the turn-on sequencing finishes. Similarly, if the ON signal goes HIGH during sequencing off, a Command Fault occurs. This kind of fault indicates something is going wrong with the ON signal. Since the second two sequencers are fed by 7 other sequencers, this will most likely happen on the first sequencer. The ON signal is driven by the minimum on-time limiter. There could be a problem here as well.

External Fault: An External Fault can be caused by several failures. If a supply goes over-voltage, an external fault is issued. If the over-temperature sensor or FPGA issues a fault, it will be displayed as an external fault on channel 4. This presents an ambiguous case as an External Fault on channel four could occur for multiple reasons. To help determine the cause, the over-temperature LED will light during an over-temperature fault. However, this LED does not latch to failure. Once the oscilloscope cools to below the over-temperature condition, the LED will turn off. The main reason for an over-temperature fault is a stopped fan or blocked air inlet. Check for these and power the oscilloscope back up. If it continues to shut down, it could be a bad over-temperature sensor or comparator circuit.

Assembly Level Repair

Please read the paragraph directly below as it discusses that a fault on one sequencer causes LEDs corresponding to other sequencers to illuminate. This is important to understand before proceeding so you know which LED is actually the root of the problem.

When a fault occurs on a given sequencer, it notifies the other two using the Fault signal. The other two sequencers report this as an External Fault as well. For example, if the first sequencer has an over-voltage on Channel 1, it will report an External Fault with Channel 1 as the source. The other two sequencers will report it as an External Fault with the source as Channel 4. Similarly, if the first sequencer has an under-voltage failure on +12V, it will report a Reset Fault on Channel 1 and the other two sequencers will report External Faults on Channel 4. As you can see, any fault on one of the sequencers always reports an External Fault on Channel 4 on the other two sequencers. Look for the fault that is not an External Fault on Channel 4 as the cause of the shutdown. If all three sequencers report an External Fault on channel 4, it will take some work to determine the real source. It could be on any of the Channel 4 sources (+2.5V, +1.2V, -3.8V), an over-temperature fault (look for the over-temperature LED to light), or an FPGA issued fault.

Sequencer 1 Group Faults:

If the fault occurs in the first group of LEDs (Sequencer 1) then the problem is with the 12 V bulk power supply, the power cables, or the acquisition board. You should check the power cables first, then the bulk power supply, and finally the acquisition board. Reinstall any power supplies, cables, or acquisition boards that turned out not to be the problem.

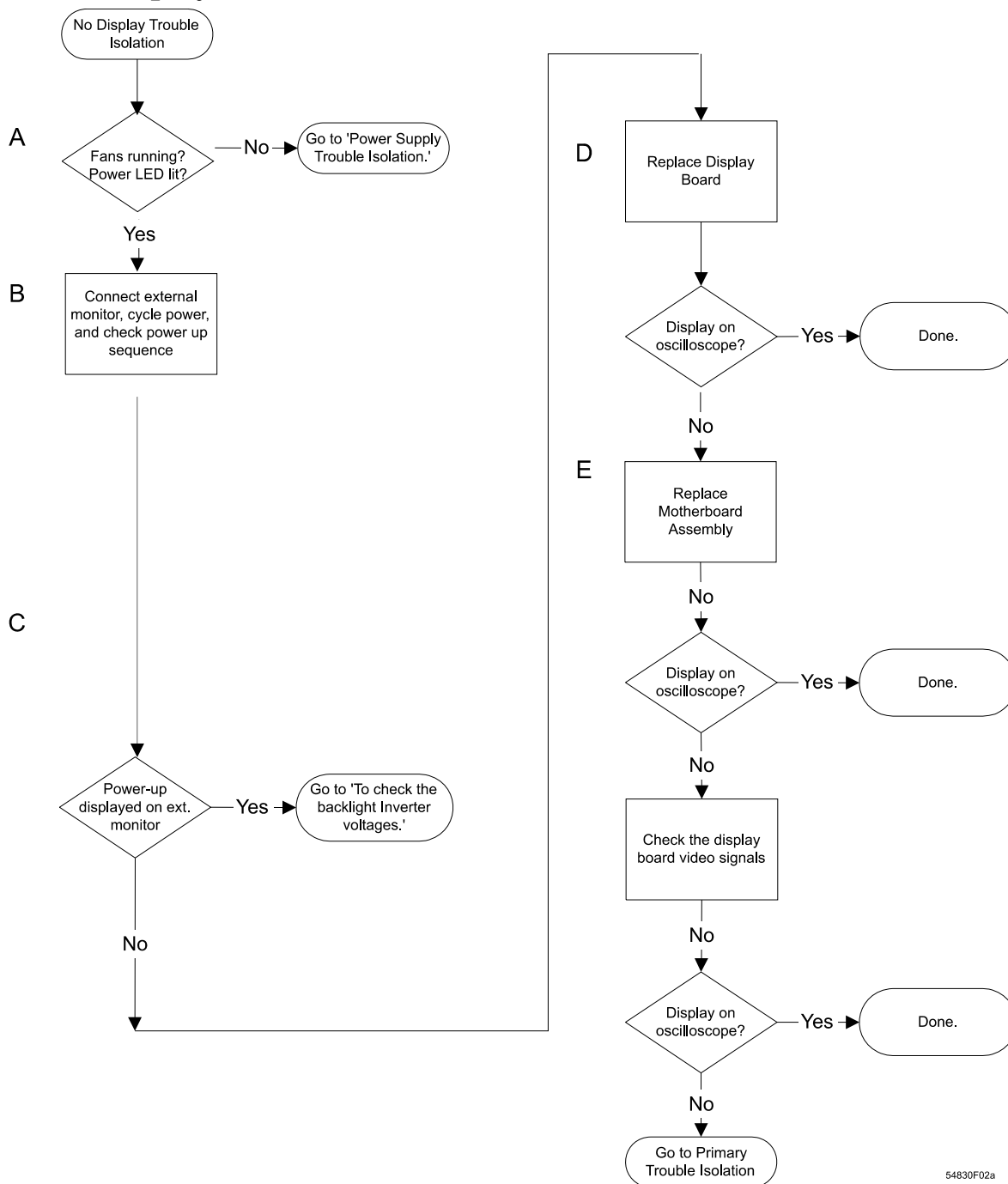
Sequencer 2 or 3 Groups Faults:

If the fault occurs in any of the other groupings (Sequencer 2 or 3) then the problem is most likely the acquisition board. If replacing the acquisition board does not fix the fault then the power cables may be causing the problem.

Over Temp LED Fault:

If the Over Temp LED is illuminated then first make sure that nothing is blocking the air flow. There cannot be anything underneath the oscilloscope (such as a piece of paper) that will block the vents nor can the oscilloscope rest on anything except a hard, flat surface. Also, there needs to be proper clearance in the rear of the oscilloscope. If the clearance is adequate then investigate the fans. If one or more are not turning then there is either a problem with the fan(s) or the fan cables.

Display Trouble Isolation

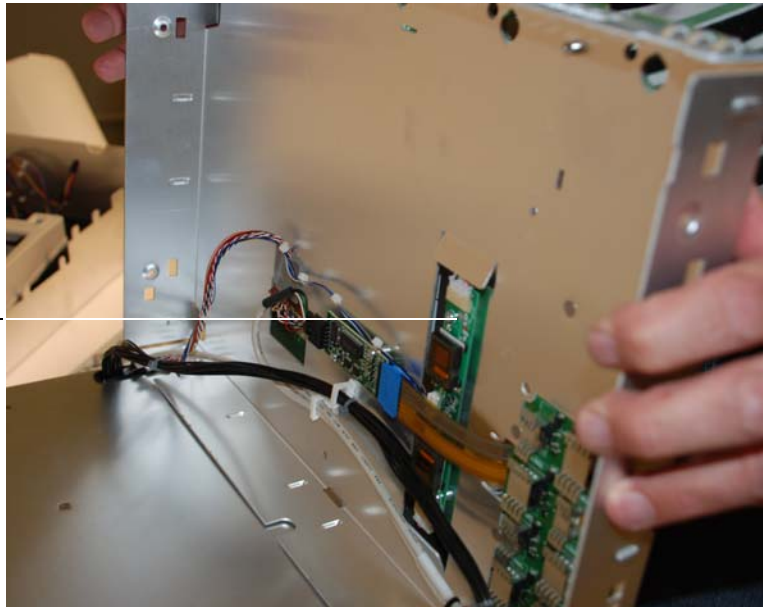


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To check the backlight inverter voltages

The backlight inverter board is accessed by opening the front chassis as described in the “Replacing Assemblies” chapter. Below is a picture showing what the inverter board looks like (this picture is of the back of the front chassis - the display is on the other side of this piece).

This is the backlight inverter board



- There is an input connector at one side of the board.
- There are two output connectors on the other end of the board, that power the two backlights which are inserted into the flat panel display.

The output voltage is approximately 300-450 V_{rms}, 40 kHz (measured differentially between the two wires) when the backlight is illuminated. The voltage is approximately 1 kV before the backlight tube is illuminated. A red LED on the backlight inverter board illuminates when the output voltage is present.

When the backlight goes off (when the oscilloscope’s operating system switches to screen saver mode) the voltage on pins 1 and 2 (with respect to ground) slowly decays to 0 V. The outputs are controlled by the input. Notice that input pin 5 goes low to enable the output voltage. These pins can be reached at J1 on the display board MP12.

Table 4-1

Backlight Inverter Board Input Voltages

Input Pin #	7	6	5	4	3	2	1
Backlight OFF	0 V	0 V	0 V	0 V	0 V	0 V	0 V
Backlight ON	5 V	0 V	2.5 V	0 V	0 V	12 V	12 V

To check the display board video signals

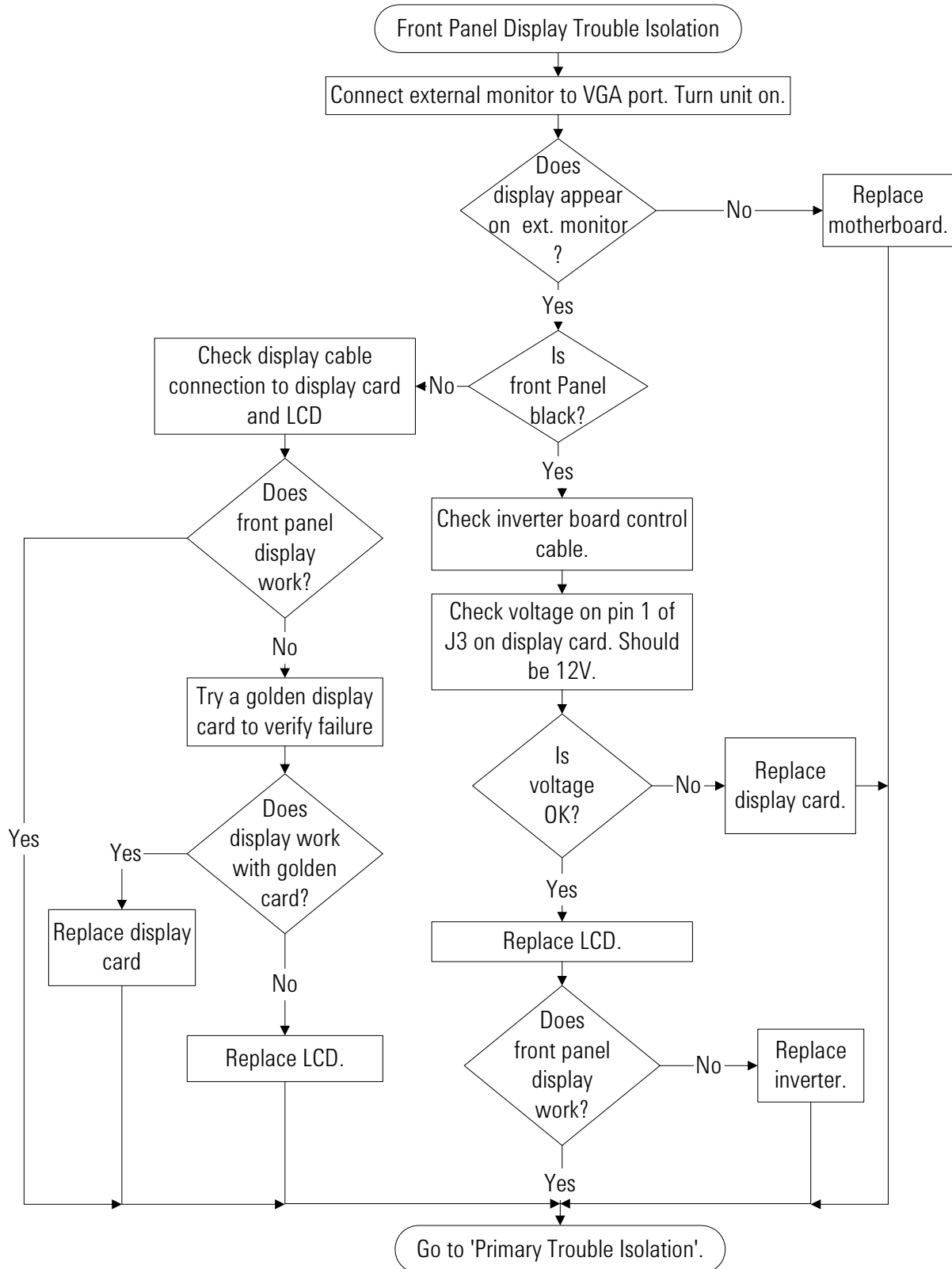
The video signals are checked on the 32-pin connector on the display board. You can use an oscilloscope with a bandwidth of at least 100 MHz to verify the signals. Even-numbered pins are closest to the PC board. If the signals are not present, suspect the display card. If the signals are present and the backlights are on, suspect the flat-panel display as the problem. Note that CLK, A0, A1, A2, and A3 are Low Voltage Differential Signals (LVDS).

Table 4-2

Video Signals

Pin Number	Signal	Pin Number	Signal
1	NC	26	NC
2	CLK-	27	NC
3	CLK (LVDS pair) +	28	NC
4	GROUND	29	NC
5	A3-	30	NC
6	A3+ (LVDS pair)	31	NC
7	GROUND	32	NC
8	A2-		
9	A2+ (LVDS pair)		
10	GROUND		
11	A1-		
12	A1+ (LVDS pair)		
13	GROUND		
14	A0-		
15	A0+ (LVDS pair)		
16	NC		
17	NC		
18	NC		
19	NC		
20	NC		
21	GROUND		
22	GROUND		
23	+3.3 V		
24	+3.3 V		
25	+3.3 V		

Front Panel Display Trouble Isolation



WARNING

SHOCK HAZARD!

The backlight inverter assembly, which is mounted at the front corner of the oscilloscope near the flat-panel display, operates at 1.65 kV at turn on. DO NOT handle this assembly while it is in operation. An LED on the inverter board illuminates to indicate the presence of high voltage.

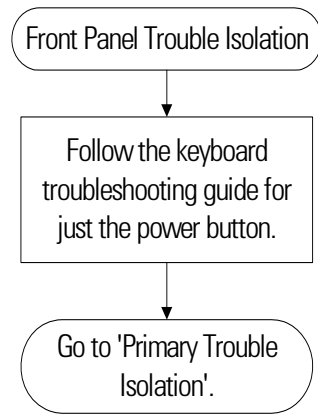
WARNING

INJURY CAN RESULT!

Once the cover is removed, the fan blades are exposed both inside and outside the chassis. Disconnect the power cable before working around the fans. Use extreme caution in working with the oscilloscope when the cover is removed. If the procedure allows, replace the cover over the chassis (without screwing it back in place) before turning the oscilloscope on. If the procedure requires you to have the cover off, be careful not to contact these fan blades with any part of your body.

For information on how to replace the display parts, see "Replacing Assemblies," beginning on page 81.

Front Panel Trouble Isolation



Motherboard Verification

If you have been through the Power Supply Trouble Isolation section of this chapter and the oscilloscope still does not stay powered up, the problem may be with the motherboard.

To set up the BIOS

If the BIOS settings become corrupt, the Infiniium oscilloscope PC motherboard will not recognize the hard drive and the oscilloscope may not start up. To configure the motherboard BIOS parameters to the default settings, follow these steps:

- 1** Connect the power cable to the Infiniium oscilloscope.
- 2** Connect the external keyboard to the rear panel.
- 3** Press **[Delete]** when the following prompt appears on the bottom of the screen:

Press TAB to Show POST screen, DEL to enter SETUP, F12 to select boot device.

If the prompt does not appear, or the oscilloscope does not appear to be functioning, check the ribbon cable connectors. Otherwise, continue with the next step.

- 4** Go to **Load 15" LCD Defaults** and press **[Enter]** for optimized values, or go to **Load 8.4" LCD Defaults** and press **[Enter]** for fail-safe values. Select **Y** to load the defaults, then press **[Enter]**.
- 5** Go to the **Save and Exit Setup** option and press **[Enter]** to save and exit the setup. Select **Y** to save and exit, then press **[Enter]**.

Acquisition Board Trouble Isolation - Scope Self Tests

If an acquisition board has been removed by a prior procedure, reinstall it.

Power up the oscilloscope and then go under Utilities > Self Test. Select the Scope Self Test option from the Self Test pull-down menu and then press the Start Test button. If one of these tests fails and mentions what channel the failure occurred on, replace the acquisition board.

If the error message does not mention a channel, then refer to the discussions below for the test that failed to see what the test is testing.

Scope Self Tests

Vertical Test Group

- **Front End DAC Linearity Test** - This test verifies the linearity of each channel's front end DAC. If the test finds a problem, it will report a failure for the DAC on the associated channel.
- **Front End DAC MaxMin Test** - This test measures the minimum and maximum output voltage values of each channel's front end DAC. If the test measures any values that are out of the range of expected values, it will report a failure for the DAC on the associated channel.
- **Otter Register** - This test verifies that all of the Otter preamp registers can be correctly written to and read from. If this test reads any registers whose values are not equal to what they were written to, it will report a failure for the preamp on the associated channel.
- **Overload** - This test simulates an overload condition on each channel and verifies that when such a condition exists it immediately generates an interrupt to the host processor. If such a condition is not detected properly, the test will report a failure for the associated channel.

Trigger Test Group

- **Trigger Lvl DAC Test** - This test has not been implemented yet and currently does nothing.

Timebase Test Group

- **Timebase Interpolator Test** - This test validates the timebase interpolator hardware by verifying that it is able to produce unique values for different trigger settings. If this test fails, there *may* be a problem with the timebase interpolator IC. However, this test has many other hardware dependencies so a failure from this test cannot necessarily be associated with any specific hardware failure. Try replacing the acquisition board and see if the test will then pass.

ADC Test Group

- **ADC Register Test** - This test verifies that all of the ADC registers can be correctly written to and read from. If the test reads any registers whose values are not equal to what they were written to, it will report a failure for the ADC on the associated channel.
- **ADC Voltage Test Points Test** - This test verifies that voltages measured from 32 test

Chapter 4: Troubleshooting

Acquisition Board Trouble Isolation - Scope Self Tests

points within the ADC are within their expected range. If any test point is found to be outside of its expected range, a failure is reported for the ADC containing the associated test point.

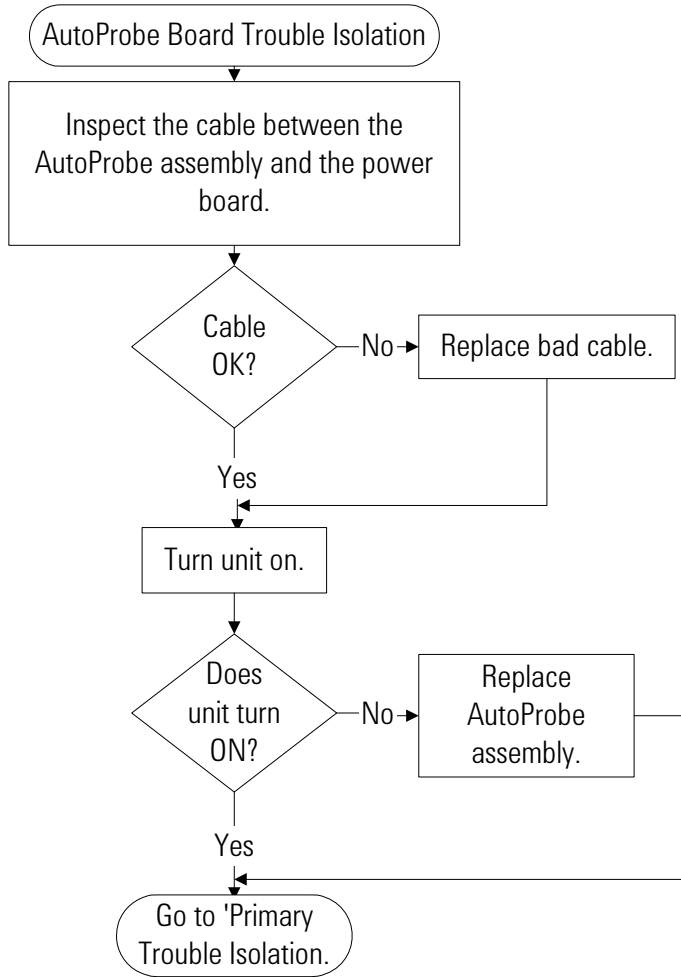
Acquisition Memory Test Group

- MBIST - This test checks the embedded memory in each memory controller ASIC for errors. If the errors can be corrected using the redundancy present in the IC, the software will perform the necessary correction.
- Register Test - This test verifies that all of the memory controller ASIC registers can be correctly written to and read from. If the test reads any registers whose values are not equal to what they were written to, it will report a failure for the Hedwig with the associated error.

Misc. Scope Test Group

- Temp Sensor Test - This test verifies that all of the temperature sensors in the oscilloscope are reading values within the expected range. Temperature sensors exist for each of the memory controller ICs, each of the ADC ICs, and each of the front end ICs. If any temperature sensor measure a temperature that is outside of the expected operating range, a failure will be reported for the IC associated with that temperature sensor.
- Acq Flash RAM Test - This test checks the flash RAM located on the acquisition board for errors. If any errors are found, a failure is reported for the particular flash RAM that was found to be bad.

AutoProbe Board Trouble Isolation



Keyboard Trouble Isolation Procedure

Use this procedure only if you encounter key failures in the keyboard self test procedure. If any knobs fail, replace the keyboard assembly.

- 1 Disconnect the power cord and remove the cover.
- 2 Remove the front panel assembly.
See chapter 6 for instructions.
- 3 Remove the keyboard assembly from the front panel assembly. Partially re-assemble the front panel assembly, including the flat-panel display and lens, but omitting the keyboard. Re-attach the partial assembly to the chassis.

Be sure to reconnect the display video cable and the backlight inverter cables. See chapter 6 for instructions on removing and disassembling the front panel.

- 4 Separate the elastomeric keypads from the keyboard assembly.

CAUTION

CONTAMINATION CAN CAUSE INTERMITTENT OPERATION!

Be careful not to contaminate the key side of the PC board or the keypads. Dust and fingerprints on these parts may cause intermittent key operation.

- 5 Set the keyboard assembly on an antistatic electrical insulated surface.
- 6 Connect the keyboard cable to the scope interface board in the chassis.
You may need to set the chassis on its side to allow proper routing of the cables without straining them.
- 7 Reconnect the power cable and apply power.
- 8 Enable the graphical interface, then start the keyboard test as described in the Primary Trouble Isolation section of this chapter.
- 9 Carefully short the PC board trace with a paper clip or screwdriver at each non-operating key (as determined by keyboard test), and look for an appropriate response on the display.
 - If the display responds as though a key were pressed, replace the elastomeric keypad.
 - If the display does not respond as though a key were pressed, replace the keyboard.
- 10 Re-assemble the oscilloscope.

To check the LEDs

If any of the LEDs are not working on the front panel, the first step is to trouble shoot the acquisition assembly to make sure it is working. If it is working then replace the keyboard assembly and see if the LEDs will illuminate. If the LEDs will not illuminate, the last step is to reload the oscilloscope software.

When reassembling the oscilloscope all boards that were replaced, but turned out not to be causing the problem should be reinstalled in the oscilloscope.

Before You Contact Keysight

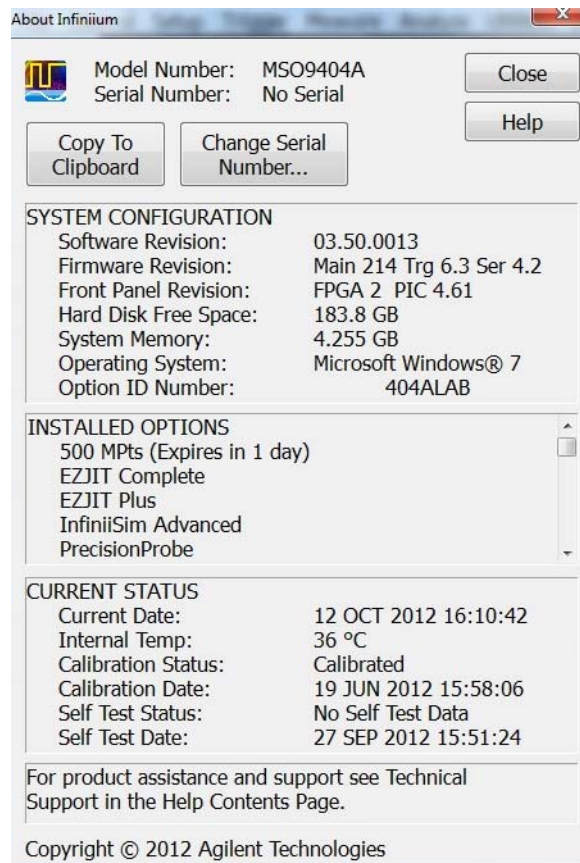
If you have read this Troubleshooting chapter and have unresolved questions about troubleshooting the oscilloscope, be ready to provide system information such as the current software version and installed options. This information will be useful when you contact Keysight Technologies.

To find and save system information, follow these steps:

- 1 Select **Help > About Infiniium**.

A dialog box similar to the one in figure 7 appears.

Figure 7



- 2 Click **Copy to Clipboard**.
- 3 Bring up a text editor, such as Notepad, and paste the copied information into the editor.
- 4 Save the text editor file.

To check probe power outputs

Probe power outputs are on the front panel, surrounding each BNC input.

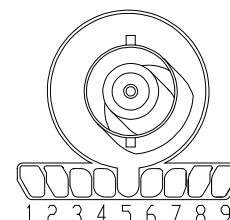
Use the table and figure to the right to check the power output at the connectors.

The +12 V and –12 V supplies come from ripple regulator on the power board, and the +3 V and –3 V supplies are developed in three-terminal regulators on the probe power and control assembly.

Measure the voltages with respect to the ground terminal on the front panel, located near the Aux Out BNC.

Do not attempt to measure voltages at pins 3 through 7.

Pin	Supply
1	+3V
2	–3V
3	Offset
4	Data
5 & ring	Probe ID
6	Clk
7	R _p
8	–12 V
9	+12 V



Any failure may be a problem with the probe power and control assembly, the AutoProbe flex cable, the probe power and control cable, or the power board.

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Replacing Assemblies

Replacing Assemblies

Use the procedures in this chapter when removing and replacing assemblies and parts in the Keysight Technologies Infiniium 9000 Series oscilloscopes.

In general, the procedures that follow are placed in the order to be used to remove a particular assembly. The procedures listed first are for assemblies that must be removed first. However, the one caveat to this is that the front panel assemblies can be replaced without having to open the rear of the instrument and vice versa.

The graphics in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

ESD Precautions

When using any of the procedures in this chapter you must use proper ESD precautions. As a minimum you must place the oscilloscope on a properly grounded ESD mat and wear a properly grounded ESD wrist strap.

CAUTION

AVOID DAMAGE TO THE OSCILLOSCOPE!

Failure to implement proper antistatic measures may result in damage to the oscilloscope.

Tools Required

The following tools are required for these procedures.

- Torx drivers: T6, T10, T20
- Flathead screwdriver

CAUTION

REMOVE POWER BEFORE REMOVING OR REPLACING ASSEMBLIES!

Do not remove or replace any circuit board assemblies in this oscilloscope while power is applied. The assemblies contain components which may be damaged if the assembly is removed or replaced while power is connected to the oscilloscope.

WARNING

SHOCK HAZARD!

To avoid electrical shock, adhere closely to the following procedures. Also, after disconnecting the power cable, wait at least three minutes for the capacitors on the power supply to discharge before servicing this oscilloscope. Hazardous voltages exist on the inverter for the display monitor.

WARNING

SHOCK HAZARD!

Read the Safety information at the back of this guide before performing the following procedures. Failure to observe safety precautions may result in electrical shock.

WARNING

INJURY CAN RESULT!

Use caution when the oscilloscope fan blades are exposed as they can cause injury.

To return the oscilloscope to Keysight Technologies for service

Before shipping the oscilloscope to Keysight Technologies, contact your nearest Keysight Technologies oscilloscope Support Center (or Keysight Technologies Service Center if outside the United States) for additional details.

- 1** Write the following information on a tag and attach it to the oscilloscope.
 - Name and address of owner
 - Oscilloscope model numbers
 - Oscilloscope serial numbers
 - Description of the service required or failure indications
- 2** Remove all accessories from the oscilloscope.

Accessories include all cables. Do not include accessories unless they are associated with the failure symptoms.
- 3** Protect the oscilloscope by wrapping it in plastic or heavy paper.
- 4** Pack the oscilloscope in foam or other shock absorbing material and place it in a strong shipping container.

You can use the original shipping materials or order materials from a Keysight Technologies Sales Office. If neither are available, place 8 to 10 cm (3 to 4 inches) of shock-absorbing material around the oscilloscope and place it in a box that does not allow movement during shipping.
- 5** Seal the shipping container securely.
- 6** Mark the shipping container as **FRAGILE**.

In any correspondence, refer to oscilloscope by model number and full serial number.

To remove and replace the handle and rear cover

Use this procedure to remove and replace the handle and rear cover. When necessary, refer to other removal procedures. The pictures in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

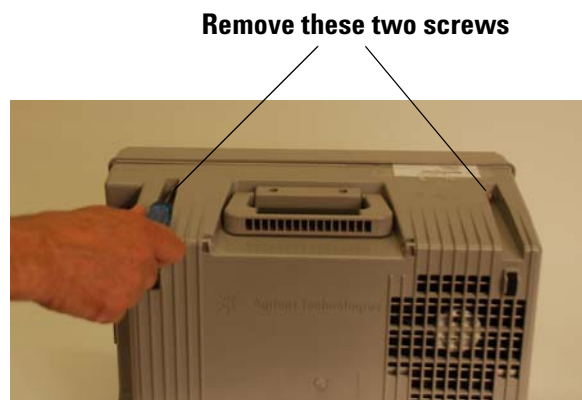
- 1 Disconnect the power cable.
- 2 Disconnect all oscilloscope probes and BNC input cables from the front panel.
- 3 Disconnect any other cables, such as mouse, keyboard, printer, USB, or LAN cables.
- 4 Remove the accessory pouch from the rear of the oscilloscope if it is attached.
- 5 Remove the two Torx T20 screws securing the handle on the top of the oscilloscope.
WARNING: Keep track of which screws go with the handle because when you go to reattach it, using different screws could result in a safety hazard.

Figure 8



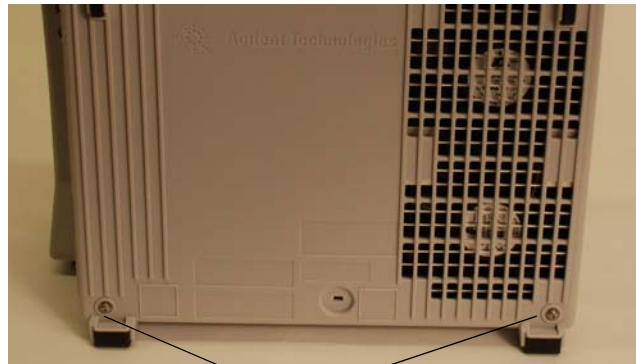
- 6 Remove the two Torx T15 screws from the upper rear cover of the instrument as shown below (Note: handle should already be removed unlike in the picture.)

Figure 9



- 7** Remove the two Torx T15 screws located on the bottom rear cover of the oscilloscope (see Figure 10 and Figure 11).

Figure 10



Remove these two screws

Figure 11



Chapter 5: Replacing Assemblies
To remove and replace the handle and rear cover

- 8 Put the oscilloscope on its face (be sure the front cover is on so the display does not get damaged) and then lift up on the rear cover to remove it from the chassis as shown in Figure 12.

Figure 12



- 9 To replace the rear cover and handle, reverse the above procedure.

CAUTION

PROPERLY TIGHTEN HANDLE AND SCREWS!

Tighten the handle screws to 21 in-lbs and the four rear cover screws to 18 in-lbs.

To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

- 1 Disconnect the power cable and remove the handle and rear cover as described above in the section on removing the handle and rear cover.
- 2 Position the oscilloscope upright and disengage the series of tabs around the outside of the front bezel as shown in Figure 13.
- 3 With the tabs disengaged, pull the front bezel off as shown in Figure 14.

Figure 13

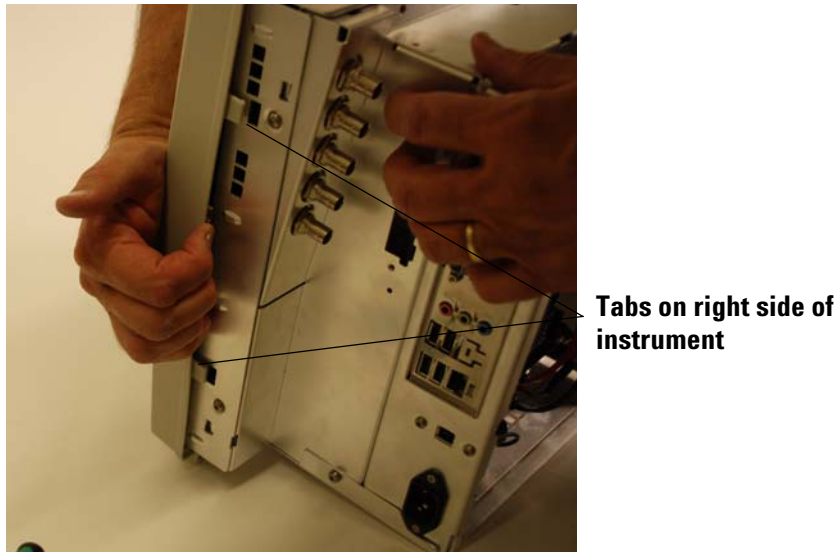


Figure 14



Chapter 5: Replacing Assemblies

To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

- 4 Pull up on each of the front panel knobs to remove them from the front panel keyboard as shown in Figure 15.

Figure 15



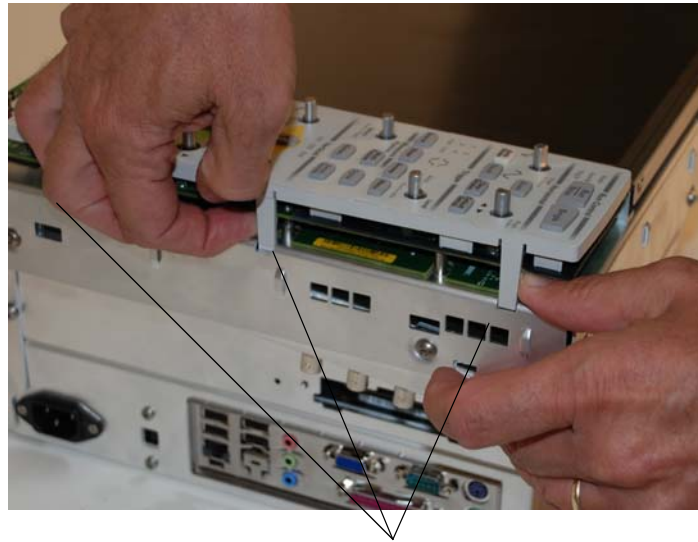
- 5 Remove the T10 screw from the bottom of the front panel keyboard near the front panel USB ports as shown in Figure 16. When you are putting this screw back in during reassembly, tighten to 5 in-lbs.

Figure 16



To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

- 6 Disengage the three tabs located on the outside edge of the plastic piece covering the front panel keyboard as shown in Figure 17.

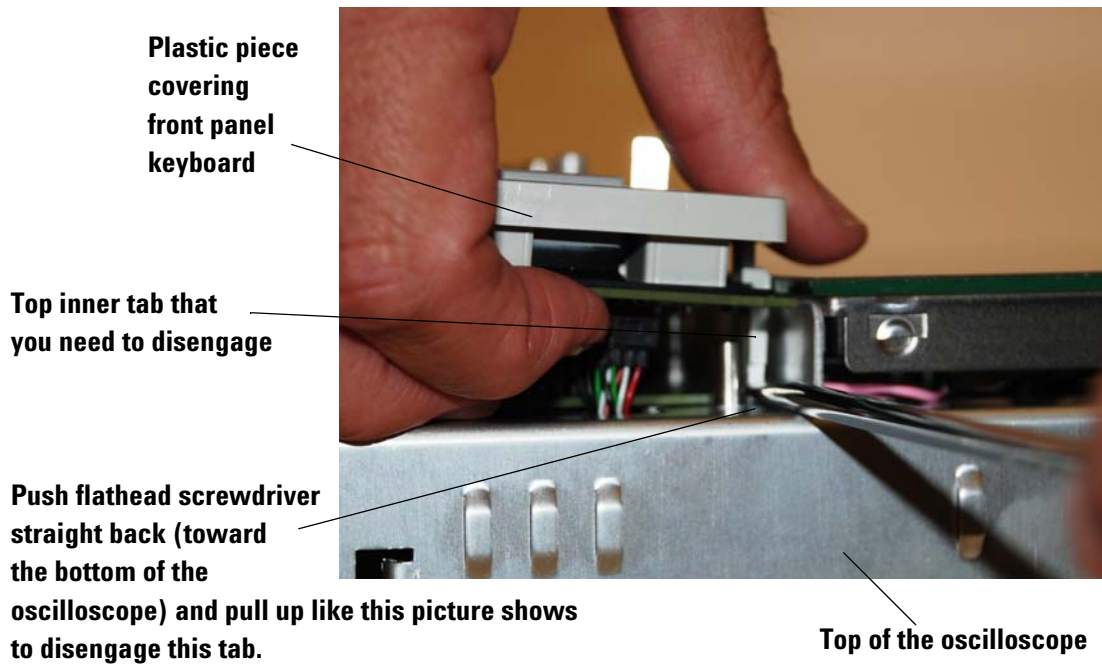
Figure 17**Disengage three tabs**

- 7 There are two tabs on the edge closest to the touch screen that need to be disengaged. To disengage the one near the top of the oscilloscope, look down the edge from the top and press in on the tab (meaning press straight towards the bottom of the oscilloscope) with a flathead screwdriver while pulling up on the plastic keyboard cover / keyboard. The plastic piece and keyboard will not come all the way off because you need to repeat this procedure for the bottom tab (look along the inner edge from the bottom, push in on the bottom tab (meaning push towards the top of the oscilloscope), and then pull up on the plastic keyboard cover / front panel keyboard). Figure 18 shows a picture of performing this procedure on the upper tab.

Chapter 5: Replacing Assemblies

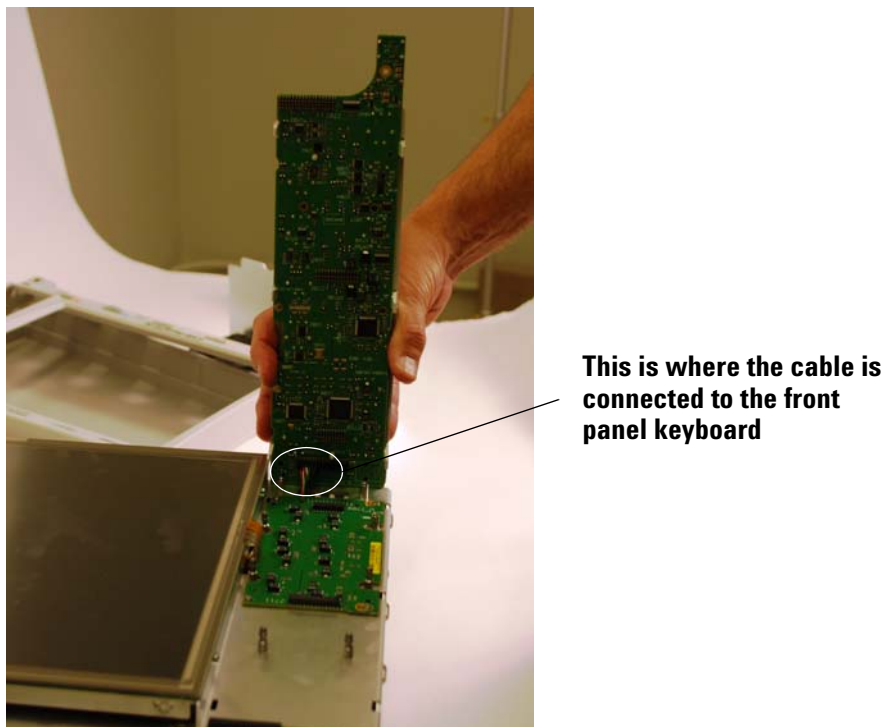
To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

Figure 18



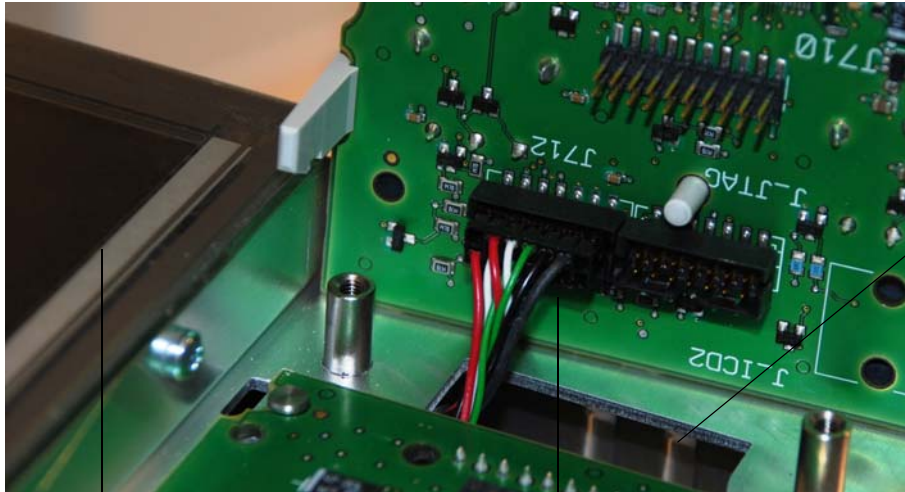
- 8 Once the two inner tabs and three outer tabs have been disengaged, pull the plastic cover / front panel keyboard up from the bottom, tilting it towards the top because there is a cable connected to the top of the front panel keyboard (see Figure 19).

Figure 19



To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

- 9 Disconnect the cable connected to the front panel keyboard. Please note that there are two similar connections right next to each other. When you reconnect this cable, it goes in the connection closest to the touch screen (see Figure 20).

Figure 20

Touch screen

Cable plugs into the connection closest to the touch screen

Be sure that this cable does not fall through this opening. When you reattach the cable to the front panel keyboard, you will need it to be accessible. If it does fall through the opening then either use tweezers to get it or open up the front chassis as described in Step 15.

- 10 The next step is to remove the front panel keyboard from the plastic covering. There are a series of six tabs around the outside edge holding the plastic covering to the keyboard. Disengage all of these and then separate the two pieces as shown in Figure 21 and Figure 22.

Chapter 5: Replacing Assemblies

To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

Figure 21

These are two of the tabs

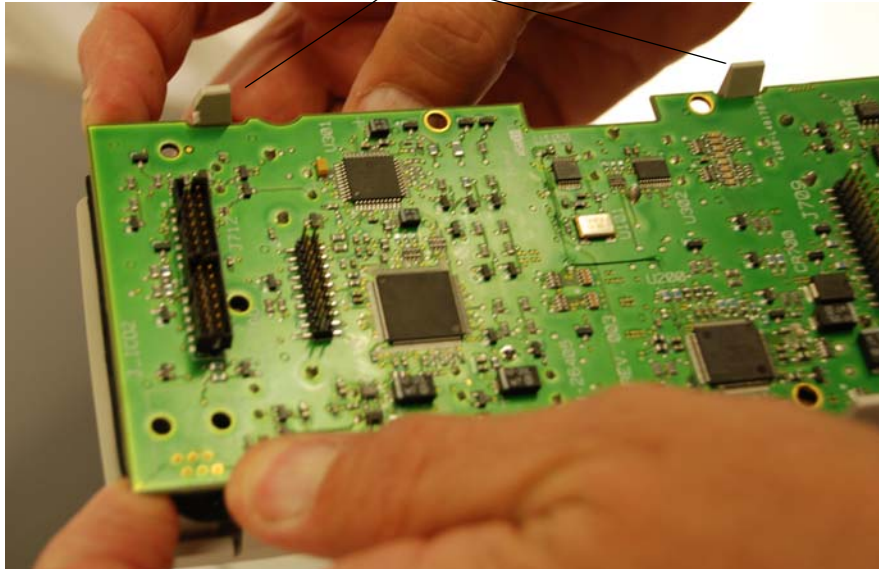
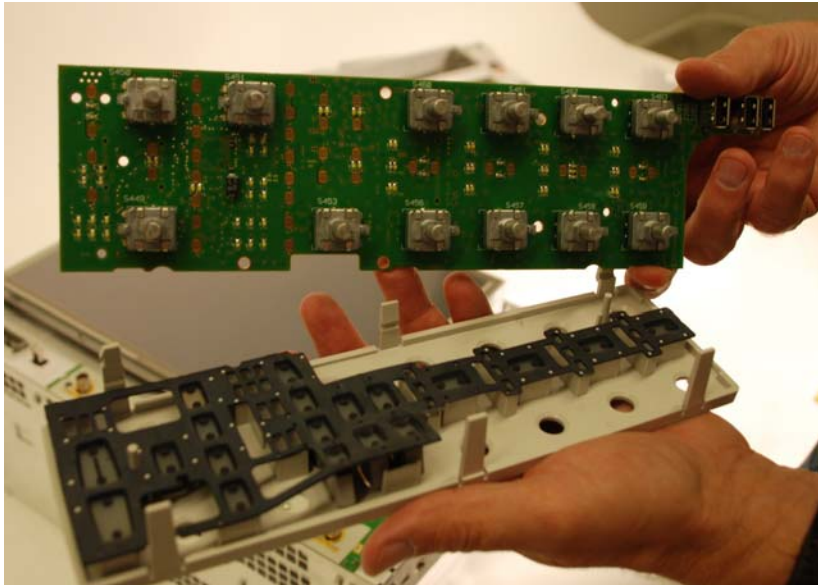


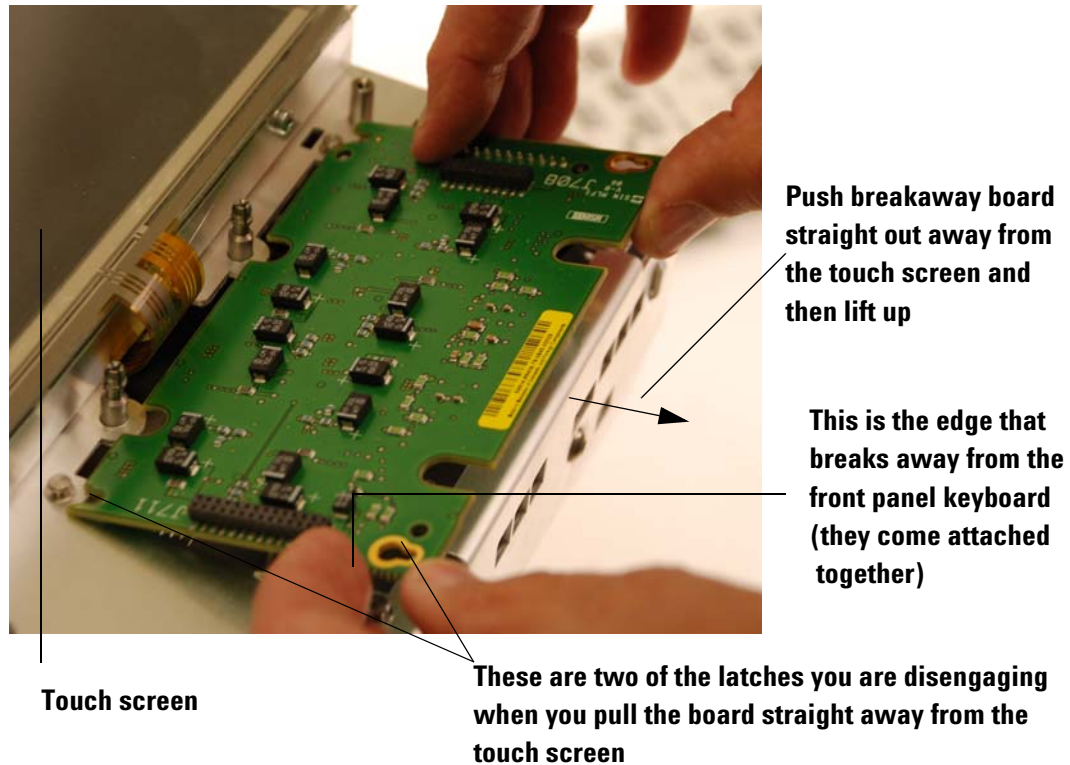
Figure 22



- 11 If you are replacing the front panel keyboard, please note that the front panel keyboard and the breakaway board that is about to be discussed come attached together. You have to break them apart and then use the two pieces. The break occurs down beneath the USB ports on the front panel keyboard.
- 12 There are four latches that connect the breakaway board to the sheet metal. To remove the breakaway board that was located underneath the front panel keyboard, pull it directly away from the touch screen to disengage these latches and then pull up on the board as shown in Figure 23.

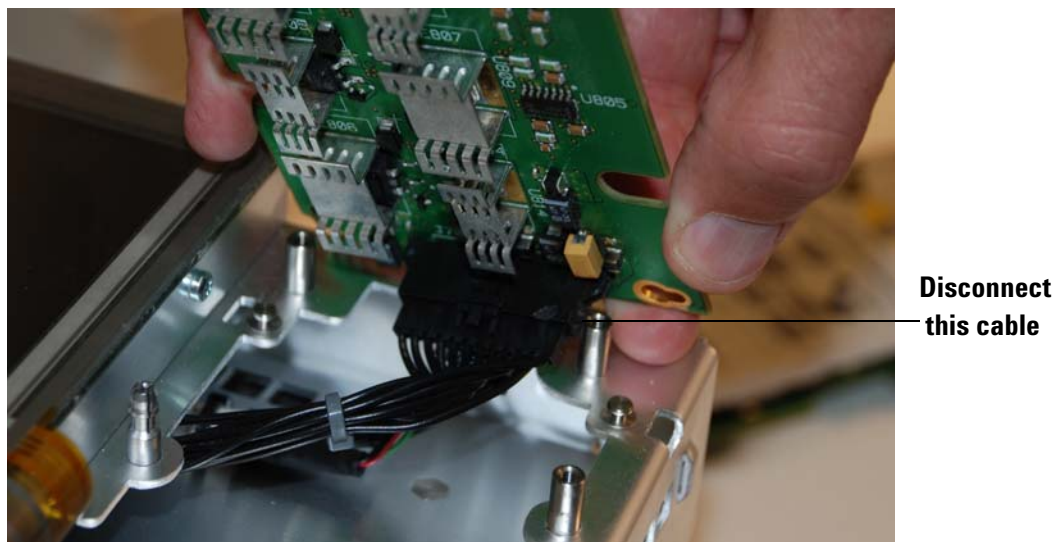
To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

Figure 23



- 13 Disconnect a cable from the back of the breakaway board (see Figure 24).

Figure 24



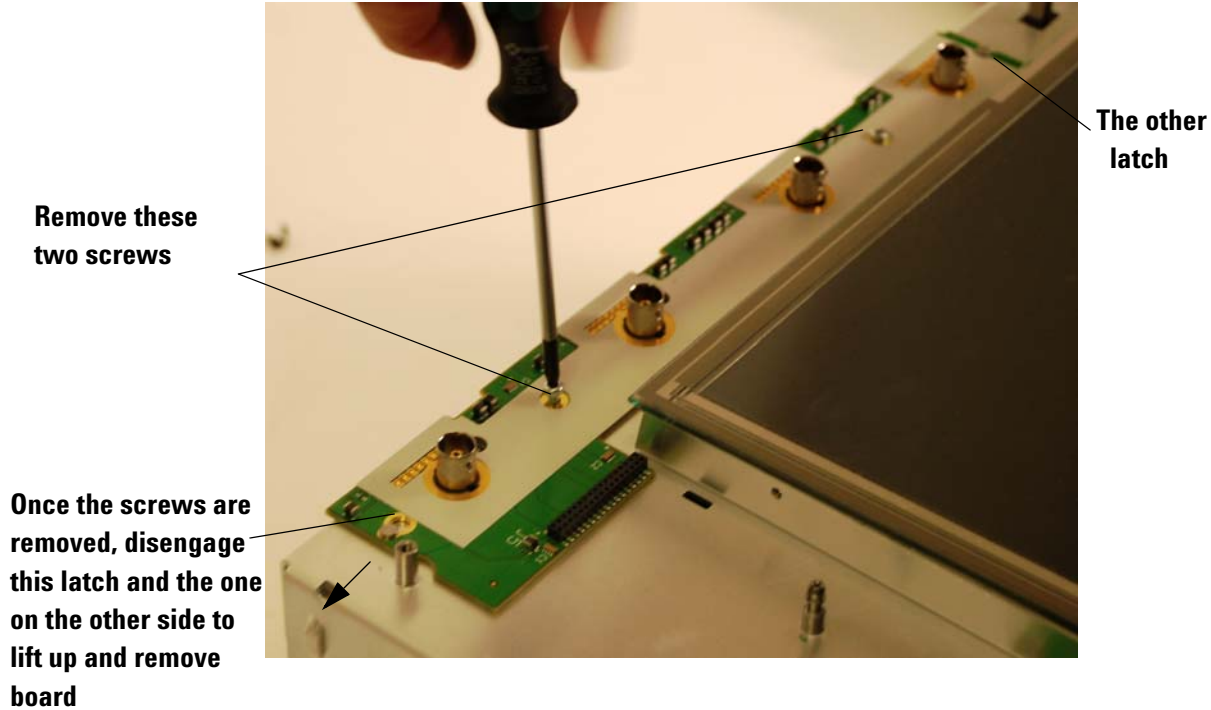
- 14 To remove the Autoprobe board, remove the two T10 screws and then slide the board to the right to disengage the two latches on either side of the board (see Figure 25). **When reattaching the Autoprobe board, do not fully tighten the two T10 screws until you have reattached the front panel keyboard to the oscilloscope and attached**

Chapter 5: Replacing Assemblies

To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

it to the Autoprobe board. You will need some room to work with and if you fully tighten the screws on the Autoprobe board, you will have none. Once the front panel keyboard is attached, tighten the Autoprobe screws to 5 in-lbs.

Figure 25



- 15 To remove the touch screen, you will need to access the back side of the sheet metal it is attached to in order to disconnect cables. There are two T15 screws on either side of the oscilloscope that need removed (Figure 26) and then the front chassis will open up as shown in Figure 27.

Figure 26

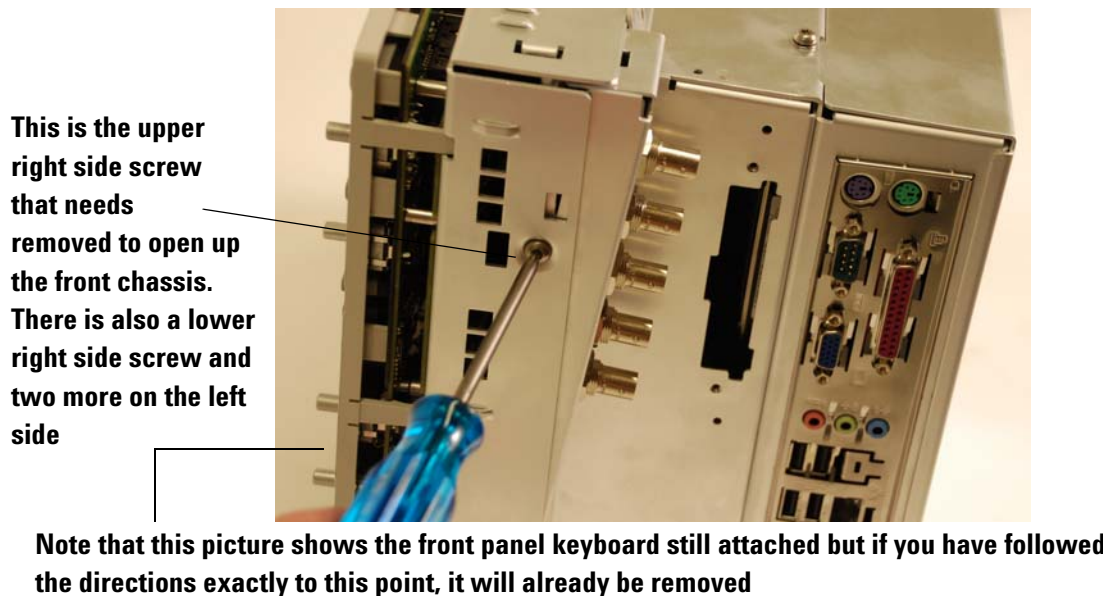
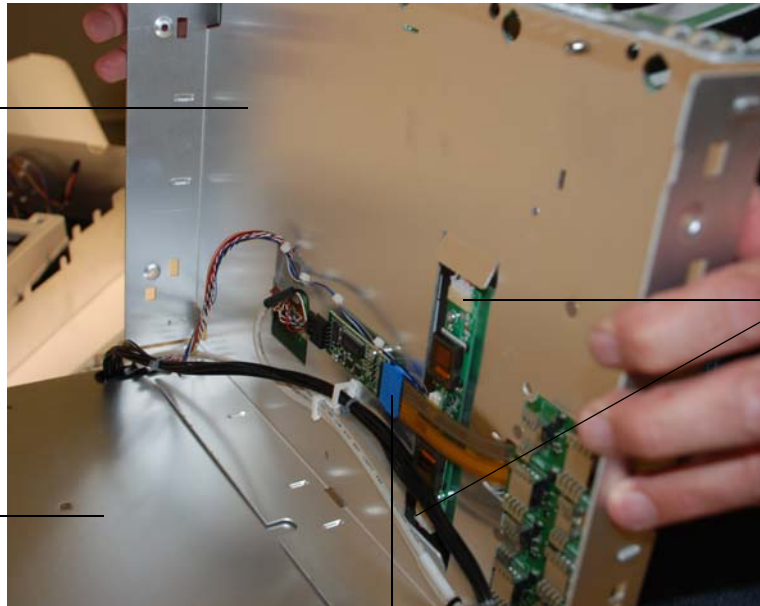


Figure 27

The touch screen is mounted on the other side of this sheet metal

Main oscilloscope body



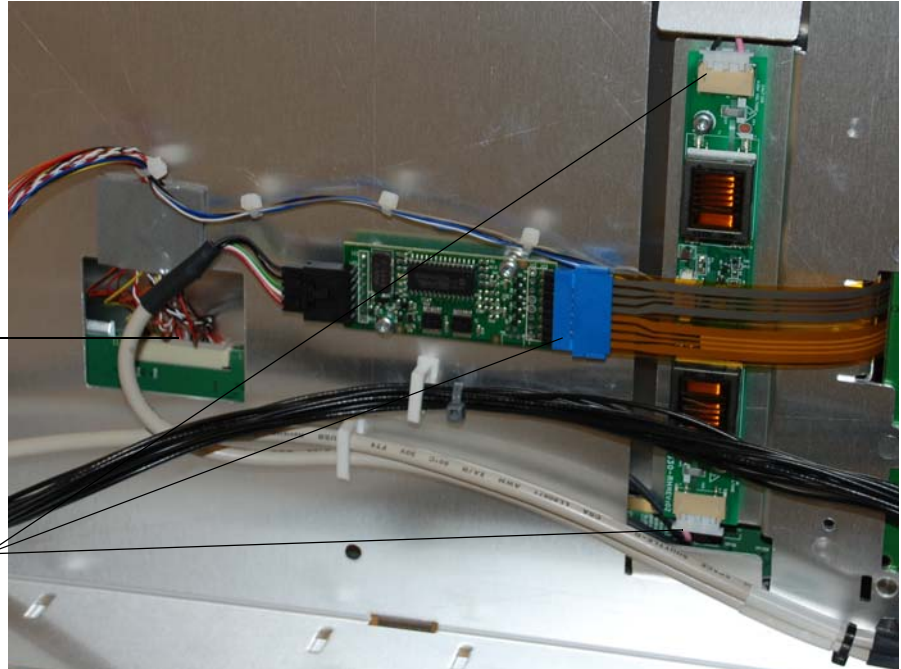
Remove these two display cables (white connectors) from the inverter board because they are connected to the touch screen display

Disconnect this cable (the one with the blue connector) because it is connected to the touch screen

Figure 28

Also disconnect this display cable

These are the three cables mentioned in the figure immediately above that need disconnected before you remove the touch screen display



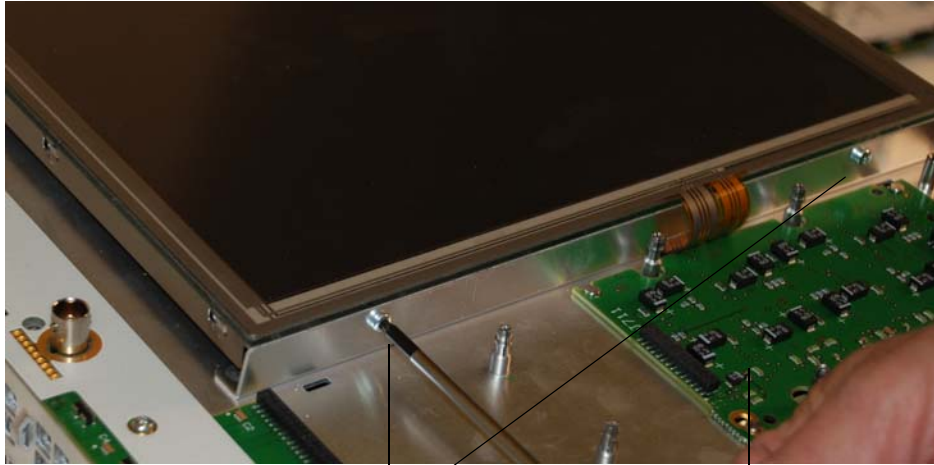
- 16 Disconnect the touch screen cable (the one with the blue connector) and the three display cables (the ones with the white connectors) as shown in Figure 27 and Figure 28.

Chapter 5: Replacing Assemblies

To remove and replace the front panel bezel, front panel keyboard, touch screen, and Autoprobe board

- 17 Remove the four T10 screws that attach the touch screen to the sheet metal (there are two on each side of the touch screen - right and left). See Figure 29. When reattaching these screws, tighten to 5 in-lbs.

Figure 29



Remove these two screws and the two on the other side of the touch screen

This board should already be removed so you can pull the touch screen cable through from the other side of the sheet metal

- 18 Final Reassembly Note: When performing these procedures in reverse to reassemble the instrument, be sure to fully press in on all edges (inner and outer edges) when you place the front bezel back on the oscilloscope.
- 19 Final Reassembly Note: Before reassembling the front chassis, be sure all cables are pulled through their appropriate openings and/or reattached to any boards located on the back side of the front chassis. Once you close the chassis, it can be difficult to reach into these small holes and pull the cables through.
- 20 Final Reassembly Note: Before placing the rear cover back on the oscilloscope, be sure to reattach the removable hard drive cover.

Figure 30

Removable hard drive cover



To remove and replace the backlight inverter board

Use this procedure to remove and replace the backlight inverter board. When necessary, refer to other removal procedures. The graphics in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

WARNING

SHOCK HAZARD!

The backlight inverter assembly, which is mounted behind the flat-panel display, operates at high voltages. DO NOT handle this assembly while it is in operation.

- 1 Disconnect the power cable and remove the handle and rear cover.
- 2 Remove the front panel bezel as described in the beginning of the previous section.
- 3 Open up the front chassis by removing the four T15 screws (two are located on the right side of the oscilloscope and two are located on the left side). See Figure 31.

Figure 31

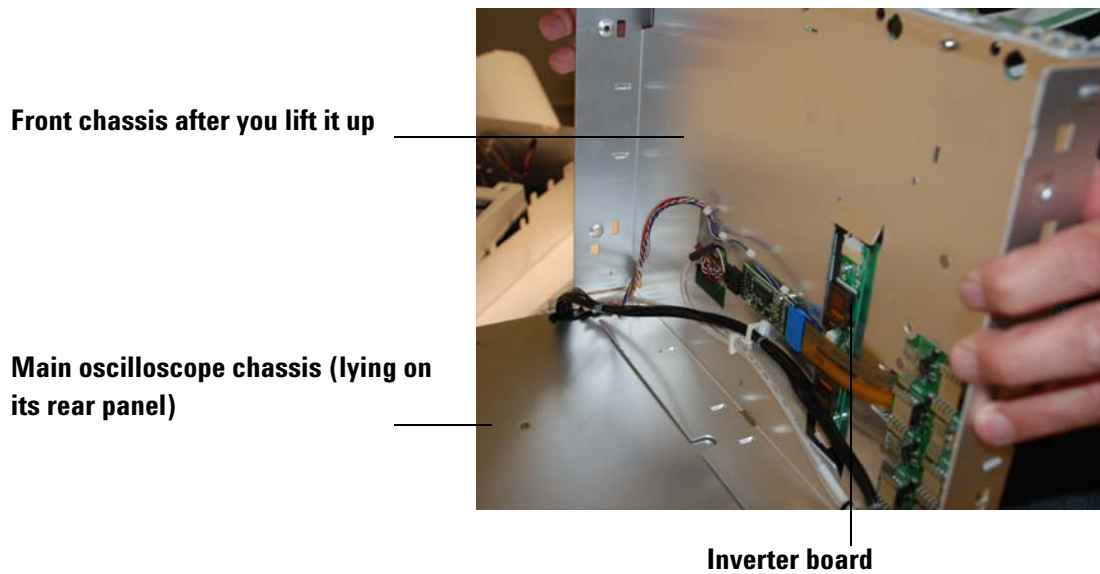
This is the upper right side screw that needs removed. There is also one below it and then two screws on the left side of the oscilloscope in the same relative locations



Chapter 5: Replacing Assemblies
To remove and replace the backlight inverter board

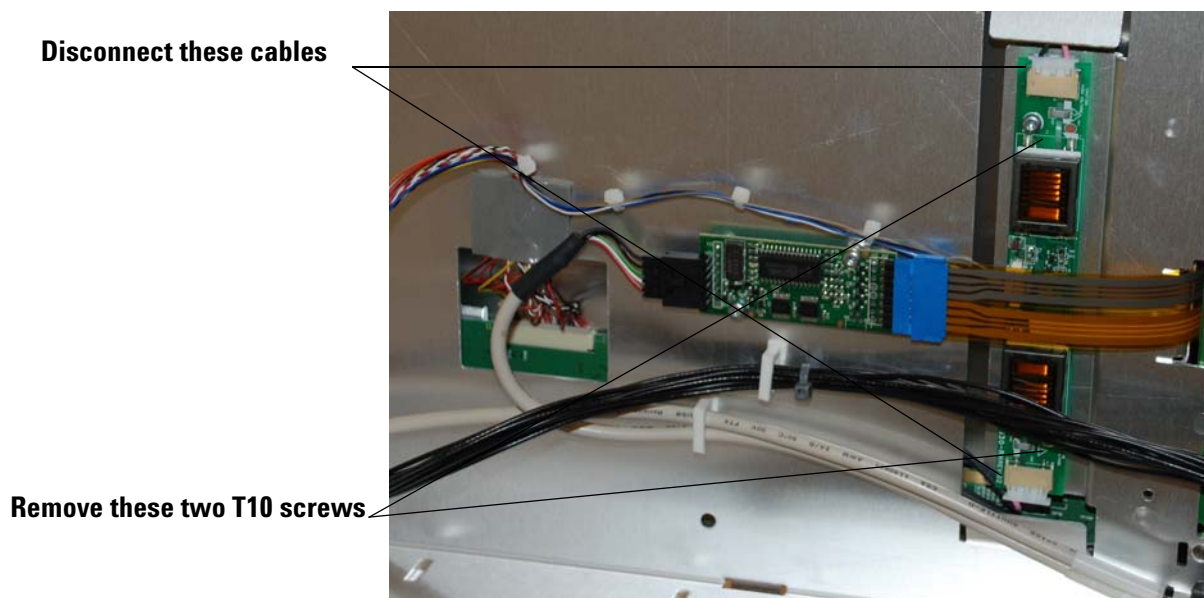
- 4 Pull the front panel chassis away from the main chassis as shown in Figure 32.

Figure 32



- 5 Disconnect the cables from the backlight inverter board and remove the two T10 screws (shown in Figure 33). You may need to temporarily remove the touch screen cable (with the blue connector) in order to remove and replace the inverter board.

Figure 33



- 6 When you replace the inverter board, tighten the screws to 5 in-lbs and be sure to align the board over the screw holes.

To remove and replace the touch screen controller board

Use this procedure to disassemble and reassemble the touch screen controller board. When necessary, refer to other removal procedures. The graphics in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

- 1 Disconnect the power cable and remove the handle and rear cover.
- 2 Remove the front panel bezel as described in a previous section.
- 3 Open up the front chassis by removing the four T15 screws (two are located on the right side of the oscilloscope and two are located on the left side). See Figure 34.

Figure 34

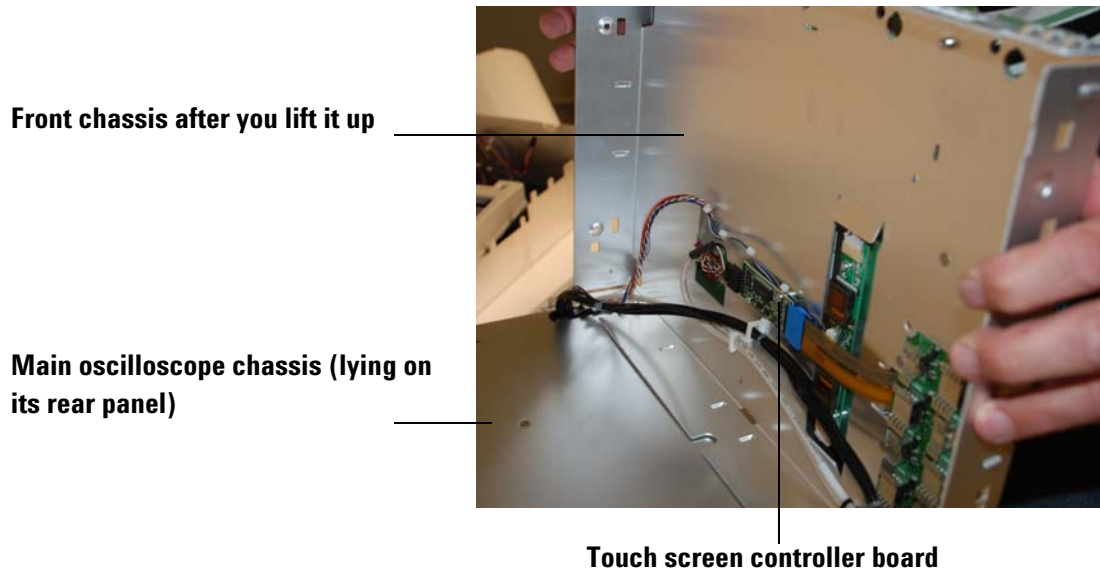
This is the upper right side screw that needs removed. There is also one below it and then two screws on the left side of the oscilloscope in the same relative locations



Chapter 5: Replacing Assemblies
To remove and replace the touch screen controller board

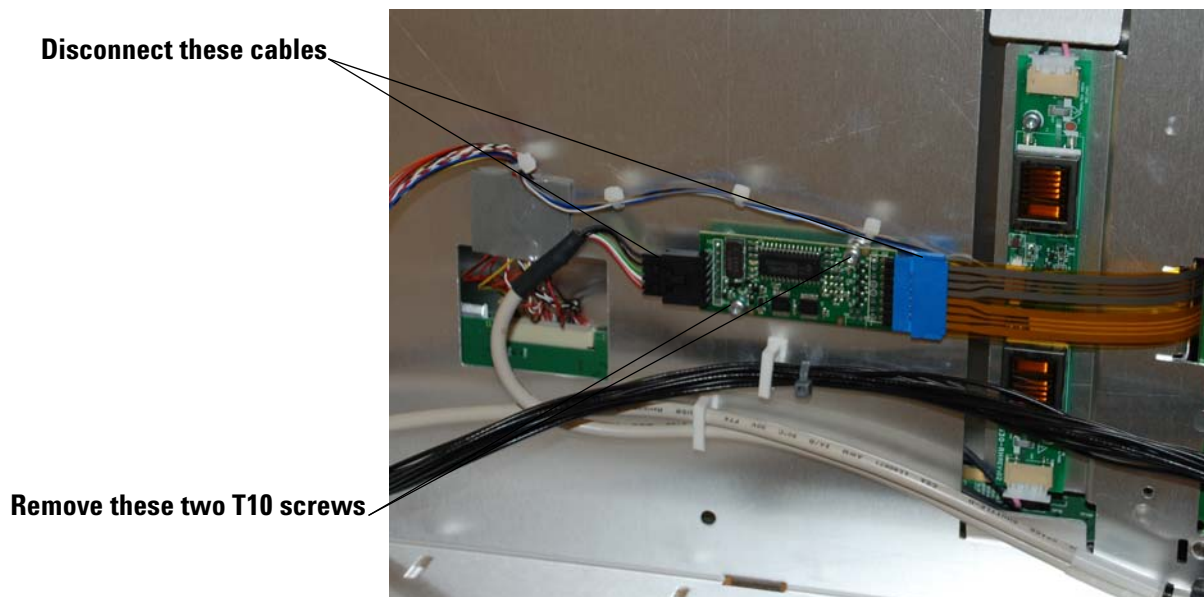
- 4 Pull the front panel chassis away from the main chassis as shown in Figure 35.

Figure 35



- 5 Disconnect the cables from the touch screen controller board and remove the two T10 screws (shown in Figure 36).

Figure 36



- 6 When you replace the touch screen controller board, tighten the screws to 5 in-lbs and be sure to align the board over the screw holes.

To remove and replace the motherboard

- 1 Disconnect the power cable and remove the handle and rear cover as described earlier.
- 2 Remove the rear sheet metal by removing one T15 screw on top and two in the back. See Figure 37, Figure 38, and Figure 39.

Figure 37

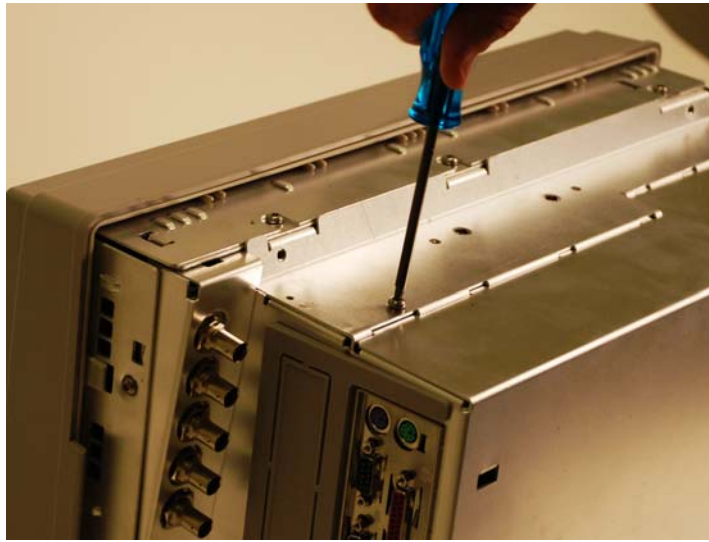
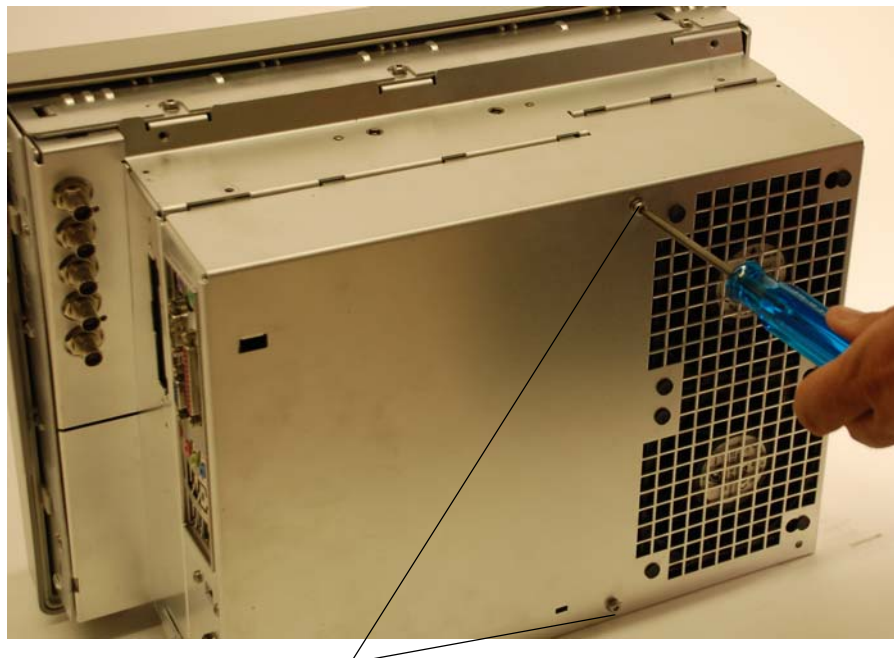


Figure 38



Remove these two screws from the back

Chapter 5: Replacing Assemblies

To remove and replace the motherboard

Figure 39



- 3 Disconnect all the cables from the motherboard.
- 4 Remove the Torx T10 screws attaching the motherboard to the frame. (Figure 40 shows what the motherboard looks like with the rear cover of the oscilloscope removed and the cables still attached.)

Figure 40



- 5 Pull the motherboard towards the front panel and then lift out.
- 6 To reassemble the motherboard, reverse the above procedure.

To remove and replace the acquisition board assembly

Use this procedure to remove and replace the acquisition board assembly. When necessary, refer to other removal procedures. The graphics in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

- 1** Disconnect the power cable and remove the rear oscilloscope cover as described in previous sections.
- 2** Remove the screws show in Figure 41, Figure 42, Figure 43, and Figure 44 to remove the sheet metal separating the motherboard compartment from the acquisition board compartment.

Chapter 5: Replacing Assemblies
To remove and replace the acquisition board assembly

Figure 41

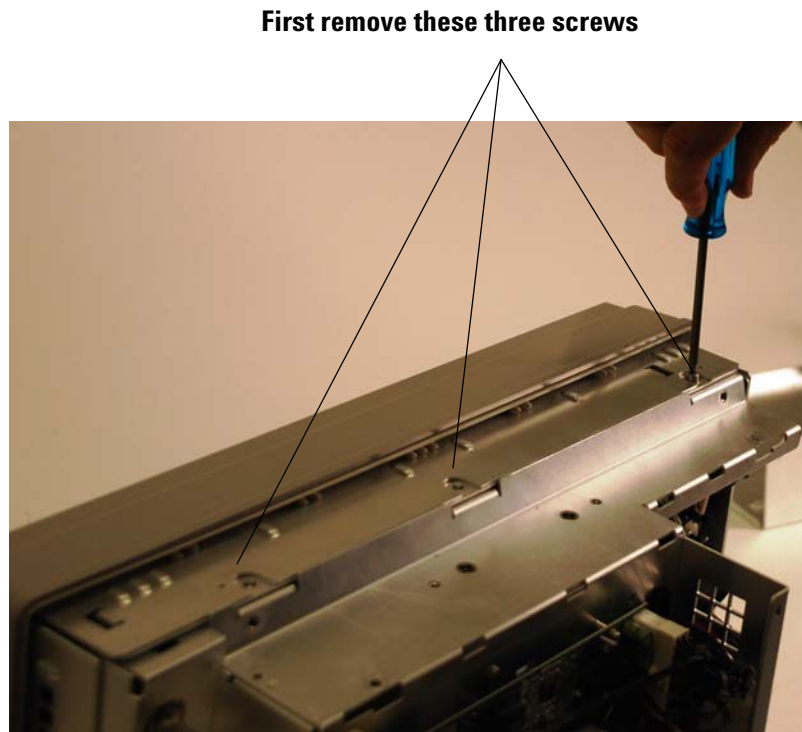


Figure 42

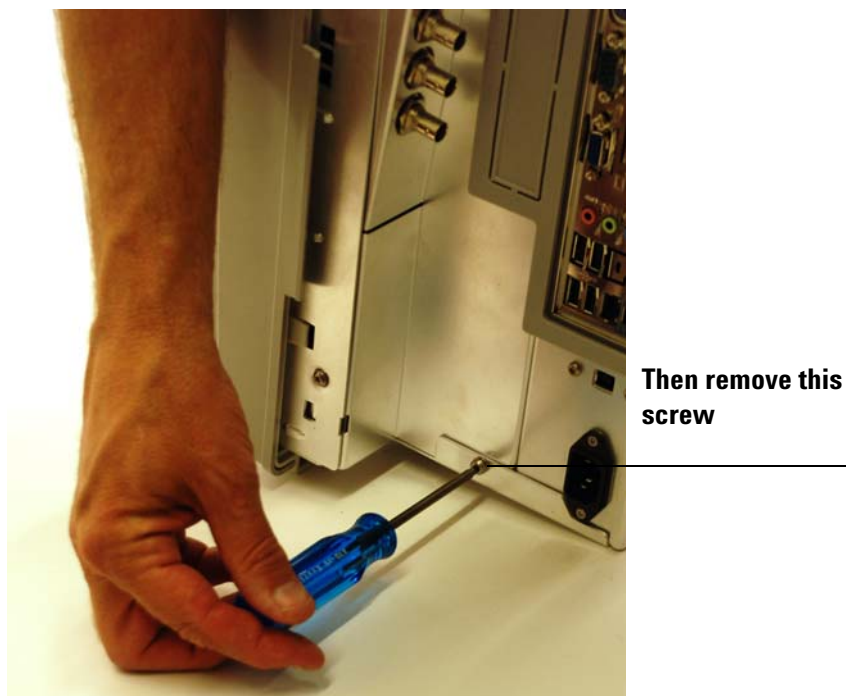
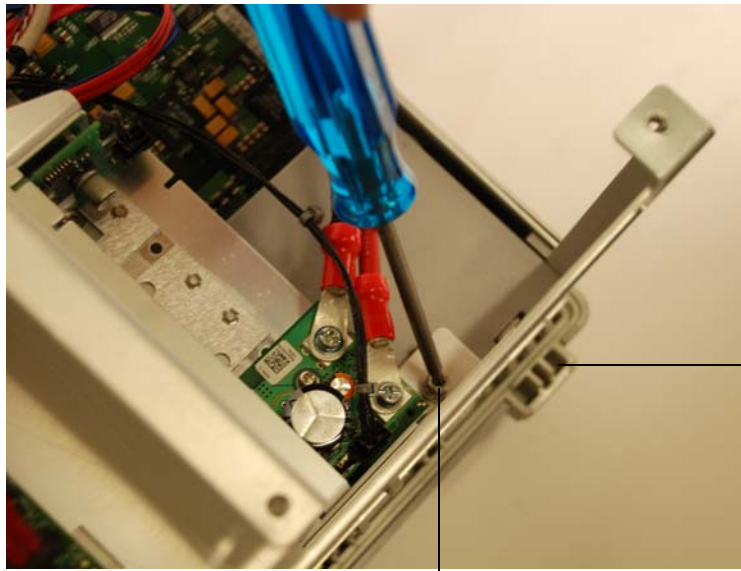


Figure 43

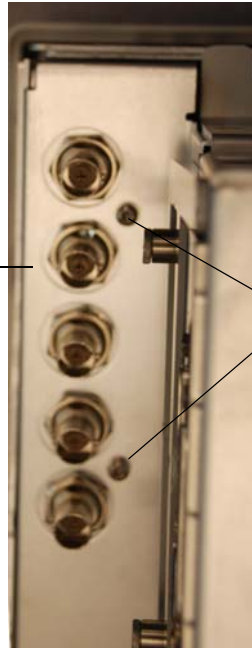


This is the lower right side of the oscilloscope (as viewed from the rear of the oscilloscope).

Then remove this screw

Figure 44

These are the BNCs located in the upper left corner of the oscilloscope's rear panel (as viewed from the rear)



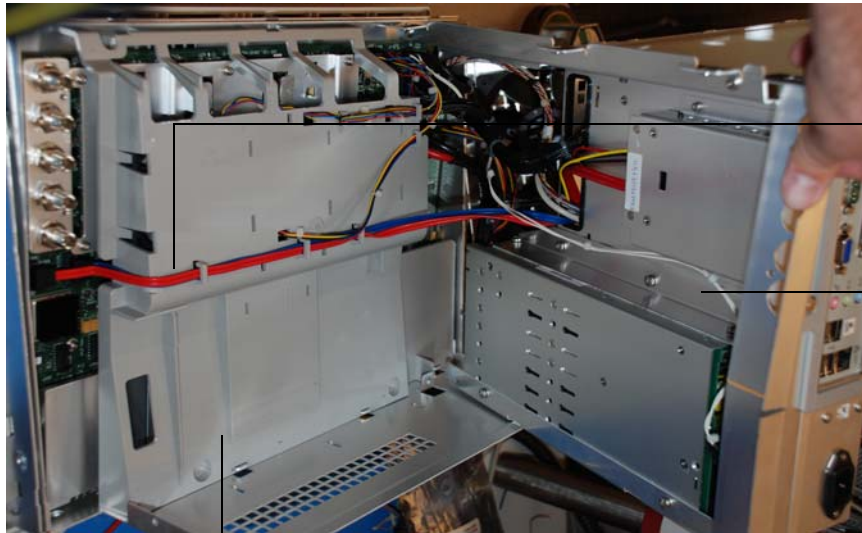
Finally, remove these two screws

- 3 Place the oscilloscope on its face (make sure the front panel cover is installed) and lift the piece of sheet metal up to access the acquisition board (as shown in Figure 45).

Chapter 5: Replacing Assemblies

To remove and replace the acquisition board assembly

Figure 45



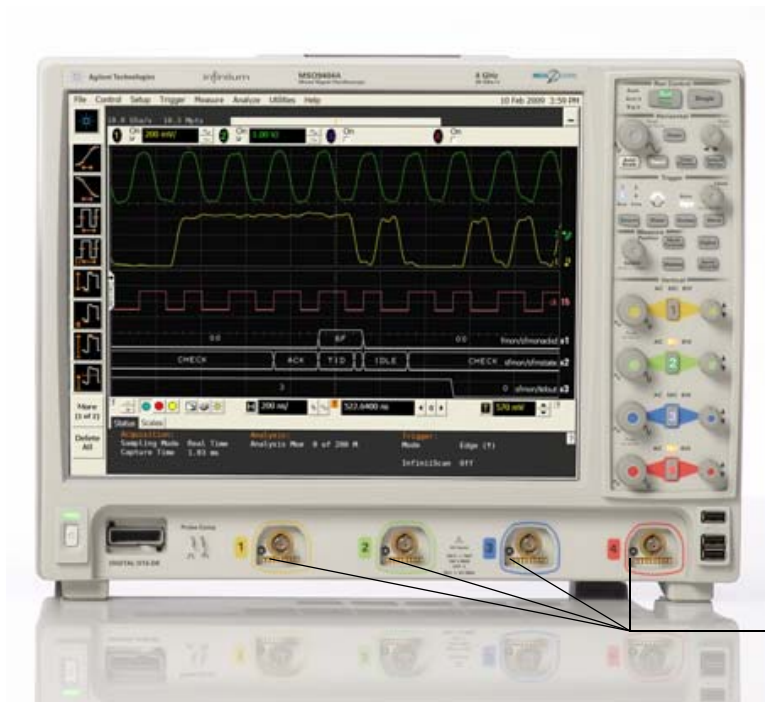
These are the SATA cables that need to be removed before you remove the air diverters

This is the upper part that you lift up on (the motherboard is located on the other side of this piece of sheet metal)

This is the air diverter that is above the acquisition board

- 4 Disconnect the SATA cables (see Figure 45) and then remove the air diverter that covers the acquisition board (see Figure 45).
- 5 Place the oscilloscope so that it is no longer resting on its front panel, but is instead sitting on its feet (in its normal operating orientation). Then remove the screws located next to each BNC input on the front panel (Figure 46).

Figure 46



These are the four screws by the front panel BNCs that need to be removed so the acquisition board can be removed.

- 6** Place the oscilloscope so it is once again sitting on its front side (use the front panel cover), disconnect any remaining cables connected to the acquisition board, remove all screws holding the acquisition board to the sheet metal, and then lift the acquisition board out.
- 7** To reassemble the acquisition assembly, reverse these instructions.

To set the calibration factors after replacing the acquisition board

The following procedure must be performed after replacing the acquisition board. This procedure needs to be performed only once after the acquisition board is replaced.

Let the oscilloscope warm up before testing

The oscilloscope under test must be warmed up (with the oscilloscope application running) for at least 30 minutes prior to the start of any performance test.

Equipment Required

Description	Critical Specifications	Recommended Model/ Part Numbers
Digital Multimeter	No substitute	Keysight 34401A
10 MHz Signal Source (required for time scale calibration)	Frequency accuracy better than 0.4 ppm	Keysight 53131A with Opt. 010
Cable Assembly	No substitute	Keysight 54855-61620
Cable Assembly	RS-232 (f)(f)	Keysight 34398A
Cable Assembly	50 Ω characteristic impedance BNC (m) connectors ~ 36 inches (91 cm) to 48 inches (122 cm) long	Keysight 8120-1840
Adapter	BNC Barrel (f)(f)	Keysight 1250-0080
Adapter	BNC shorting cap	Keysight 1250-0929
Adapter (Qty. 2)	No substitute	Keysight 54855-67604
Adapter	BNC (f) to dual banana	Keysight 1251-2277

1 Perform self tests.

- Exit the oscilloscope application.
- From a command prompt, run the oscilloscope software using the following syntax:
c:\scope\bin\agscope.exe -service

While the oscilloscope is warming up, run the self-test to ensure that the hardware is functioning properly. To run the self-test:

- Pull down the Utilities menu and select Self Test.
- Select Scope Self Test from the Self Test list.
- Click on Start Self Test to start the self test procedure.

If any of the self-tests fail, ensure that the failure is diagnosed and repaired before calibrating and testing performance.

2 Performance calibration.

After the warm up period, calibrate the oscilloscope.

- Connect the RS-232 cable to the Digital Multimeter RS-232 port and to the RS-232 port on the oscilloscope.
- Set Digital Multimeter as follows:
Interface: RS-232
Baud Rate: 9600 Baud
Parity: None: 8 bits

Language: SCPI

- c** Pull down the Utilities menu and select Calibration.
 - d** Uncheck to Cal Memory Protect box to allow calibration.
 - e** Click on Start to start the calibration procedure.
- Follow the on-screen instructions as calibration proceeds.

To remove and replace the power supply

Use this procedure to remove and replace the power supply. When necessary, refer to other removal procedures. The graphics in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

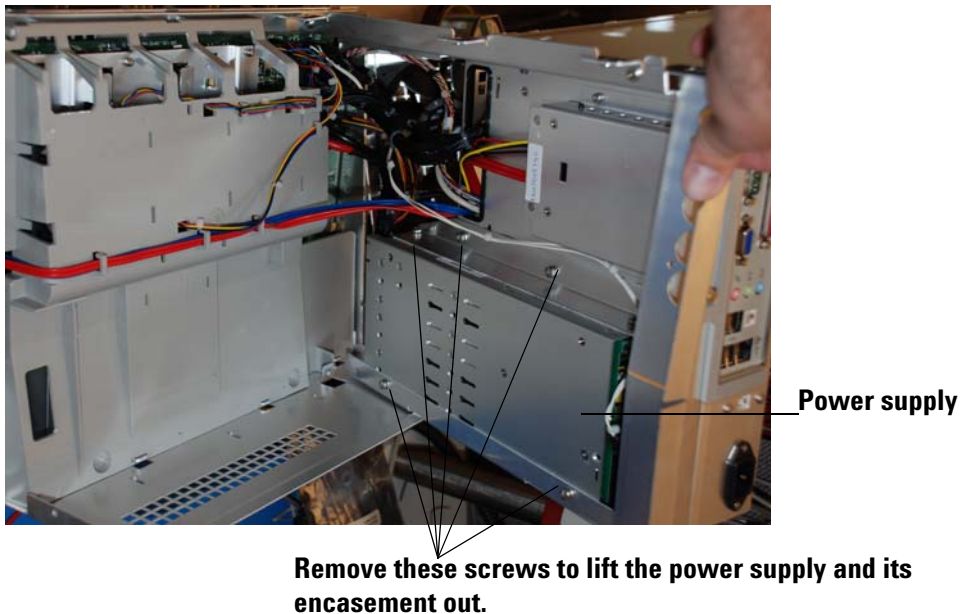
WARNING

SHOCK HAZARD!

If the power supply is defective it could have a dangerous charge on some capacitors. This charge could remain for many days after removing power from the supply.

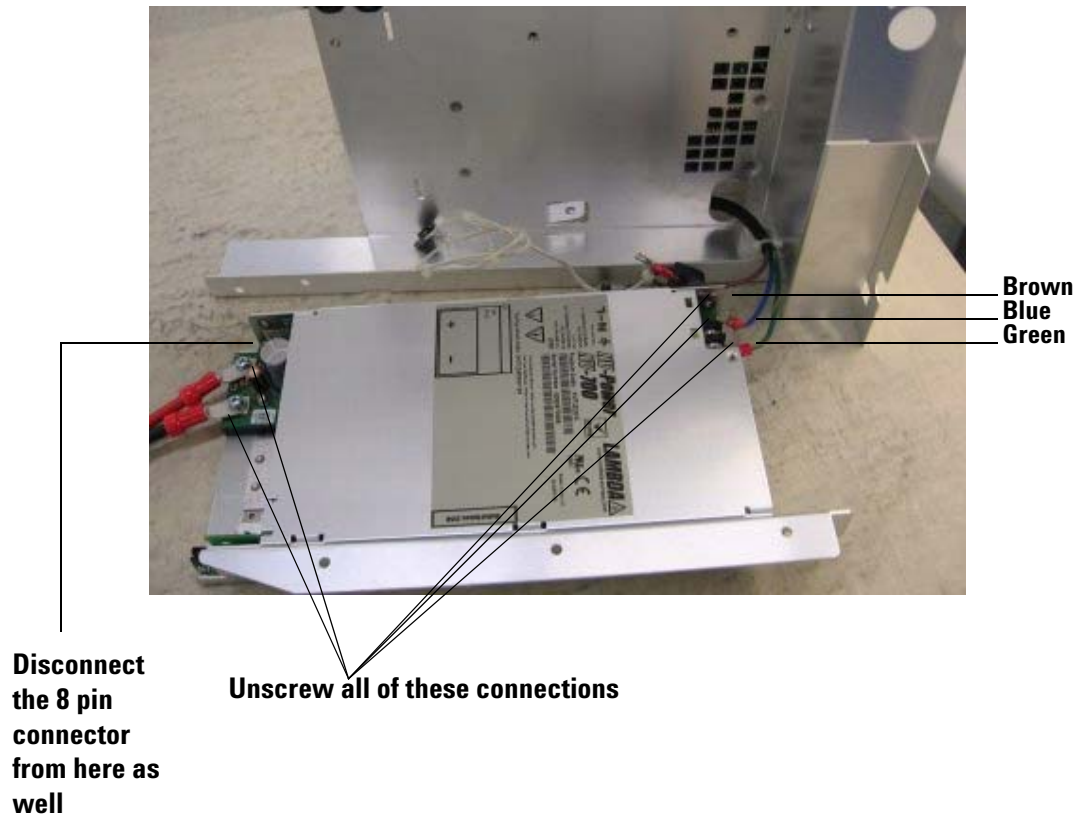
- 1 Disconnect the power cable and remove the rear cover.
- 2 Open up the acquisition board chamber by removing the sheet metal that separates the acquisition board from the motherboard (you can see how to do this in the acquisition assembly removal section).
- 3 The power supply is attached to the underside of this piece of sheet metal.

Figure 47



- 4 Remove the screws shown in Figure 47 and lift the power supply encasement out of the oscilloscope.
- 5 Remove the connections to the power supply (Figure 48).

Figure 48



- 6 Remove the power supply from the bracket.

To remove and replace the hard disk drive

Use this procedure to remove and replace the hard disk drive. When necessary, refer to other removal procedures. The graphics in this chapter are representative of the oscilloscope at the time of this printing. Your unit may look different.

- 1 Disconnect the power cable and remove the rear cover.
- 2 Open up the acquisition chamber by removing the sheet metal that separates the motherboard section from the acquisition board section (refer to the Acquisition Assembly Removal section for instructions on how to do this).
- 3 The hard drive is attached to the under side of this piece of sheet metal.
- 4 Disconnect the SATA cables from the hard disk drive, remove the screws attaching it to the sheet metal, and remove it from the oscilloscope.

Figure 49



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Replaceable Parts

This chapter includes information for ordering parts. Service support for this oscilloscope is replacement of parts to the assembly level. The replaceable parts include assemblies and chassis parts.

Ordering Replaceable Parts

Listed Parts

To order a part in the parts list, quote the Keysight Technologies part number, indicate the quantity desired, and address the order to the nearest Keysight Technologies Sales Office.

Unlisted Parts

To order a part not listed in the parts list, include the oscilloscope part number, oscilloscope serial number, a description of the part (including its function), and the number of parts required. Address the order to the nearest Keysight Technologies Sales Office.

Direct Mail Order System

Within the USA, Keysight Technologies can supply parts through a direct mail order system. There are several advantages to this system:

- Direct ordering and shipping from the Keysight Technologies parts center in California, USA.
- No maximum or minimum on any mail order. (There is a minimum amount for parts ordered through a local Keysight Technologies Sales Office when the orders require billing and invoicing.)
- Prepaid transportation. (There is a small handling charge for each order.)
- No invoices.

In order for Keysight Technologies to provide these advantages, please send a check or money order with each order.

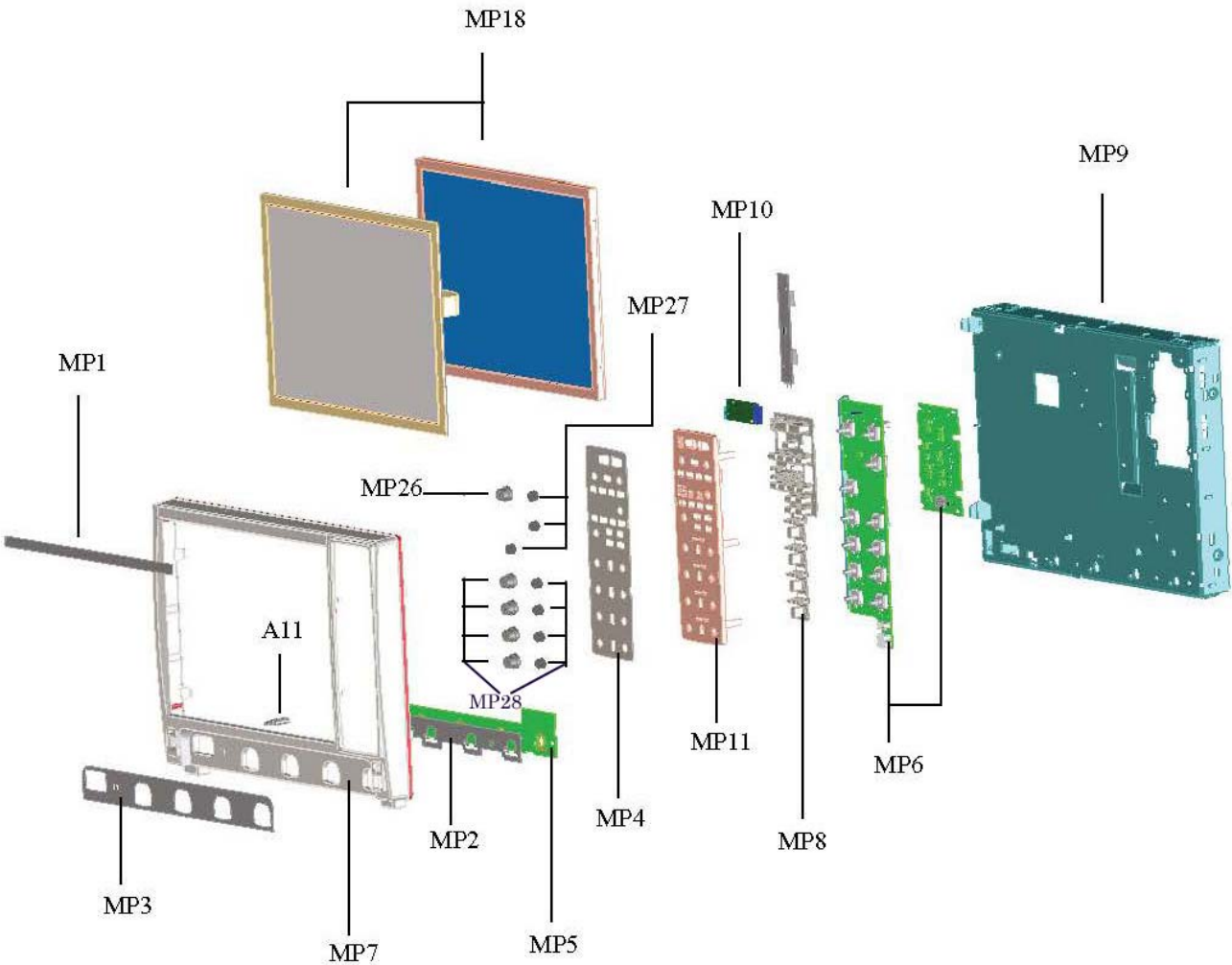
Mail order forms and specific ordering information are available through your local Keysight Technologies Sales Office. Addresses and telephone numbers are located in a separate document shipped with the manuals.

Exchange Assemblies

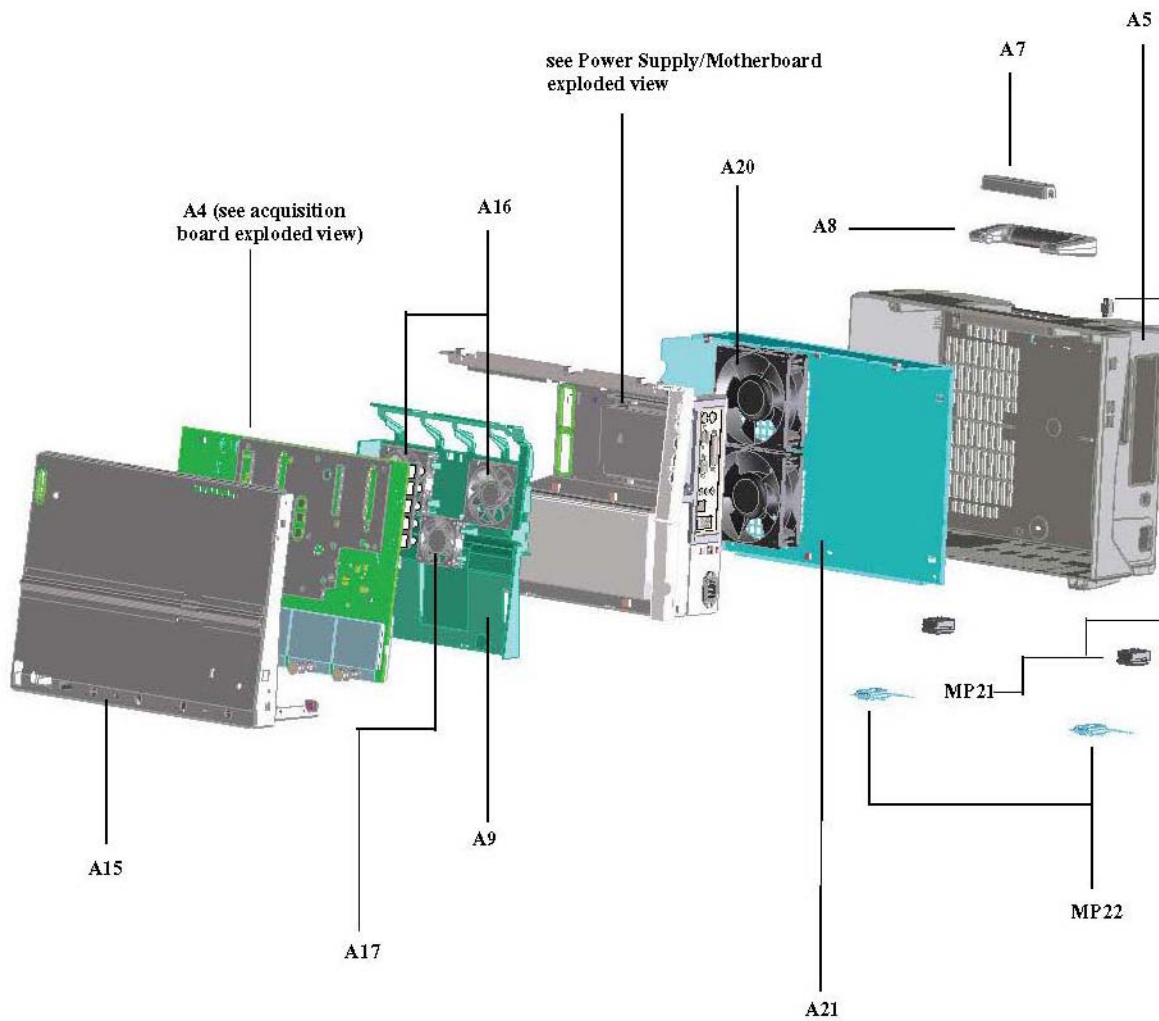
Exchange assemblies have been set up for Keysight Service Center use only.

Exploded Views

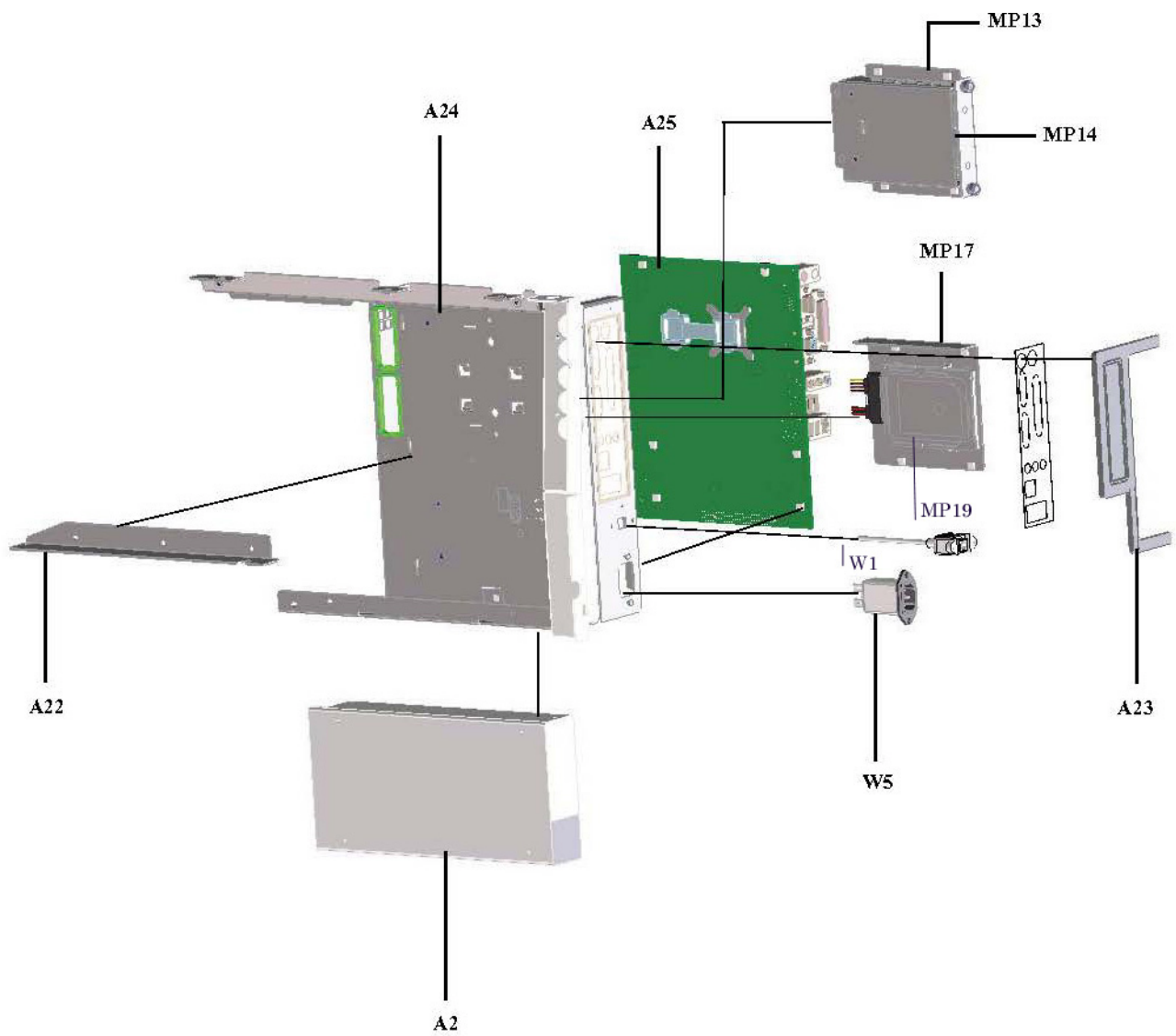
Front Frame and Front Panel



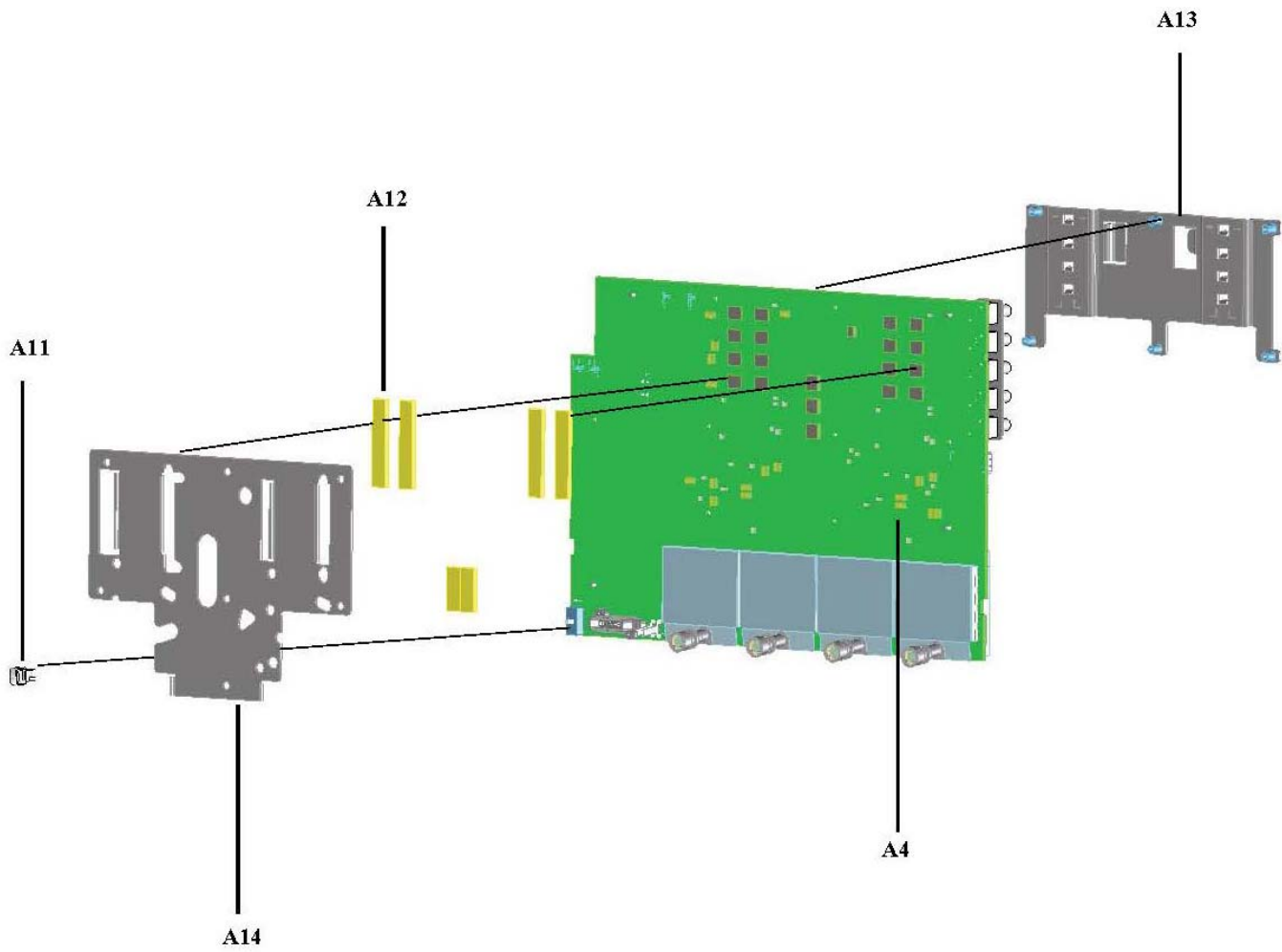
Rear Compartment Assembly



Power Supply and Motherboard



Acquisition Board



Replaceable Parts List

The following table is a list of replaceable parts.

The information given for each part consists of the following:

- Reference designation (These will be included when the exploded views are added to this Service Guide).
- Keysight Technologies part number.
- Total quantity (QTY) in oscilloscope or on assembly. The total quantity is given once and at the first appearance of the part number in the list.
- Description of the part.

Replaceable Parts

Ref. Des.	Keysight Part Number	QTY	Description
A1	Repair Center Replacement Only	1	Infiniium DSO, 600 MHz, 4 channel Oscilloscope (DS09064A)
A1	Repair Center Replacement Only	1	Infiniium DSO, 1 GHz, 4 channel Oscilloscope (DS09104A)
A1	Repair Center Replacement Only	1	Infiniium DSO, 2.5 GHz, 4 channel Oscilloscope (DS09254A)
A1	Repair Center Replacement Only	1	Infiniium DSO, 4 GHz, 4 channel Oscilloscope (DS09404A)
A1	Repair Center Replacement Only	1	Infiniium MSO, 600 MHz, 4 channel + 16 digital channel Oscilloscope (MS09064A)
A1	Repair Center Replacement Only	1	Infiniium MSO, 1 GHz, 4 channel + 16 digital channel Oscilloscope (MS09104A)
A1	Repair Center Replacement Only	1	Infiniium MSO, 2.5 GHz, 4 channel + 16 digital channel Oscilloscope (MS09254A)
A1	Repair Center Replacement Only	1	Infiniium MSO, 4 GHz, 4 channel + 16 digital channel Oscilloscope (MS09404A)
A2	0950-5060	1	Power Supply Module 700W 12 V
A3	54684-94308	1	MSO Enable Label
A4	54903-66501	1	Test Acquisition Board 600 MHz
A4	54903-69501	1	Exchange Acquisition Board 600 MHz
A4	54901-66501	1	Test Acquisition Board 1 GHz
A4	54901-69501	1	Exchange Acquisition Board 1 GHz
A4	54902-66501	1	Test Acquisition Board 2.5 GHz
A4	54902-69501	1	Exchange Acquisition Board 2.5 GHz
A4	54904-66501	1	Test Acquisition Board 4 GHz
A4	54904-69501	1	Exchange Acquisition Board 4 GHz
A5	54904-64401	1	Cabinet Assembly
A6	54904-62301	1	Accessory Pouch
A7	54904-44902	1	Handle Keeper
A8	54904-44901	1	Handle
A9	54904-44102	1	Air Duct
A10	54904-44101	1	Cover - front
A11	54904-43901	1	Shaft - power switch
A12	54904-43201	1	Thermal Pad

Chapter 6: Replaceable Parts

Replaceable Parts List

Replaceable Parts

Ref. Des.	Keysight Part Number	QTY	Description
A13	54904-01202	1	Heat Spreader
A14	54904-01203	1	Heat Spreader - bottom
A15	54904-00102	1	Deck Acquisition
A16	54904-68502	1	Fan 80 mm
A17	54904-68503	1	Fan 60 mm
A19	1400-3411	2	Saddle-Wire Side Entry
A20	54904-68709	2	Fan Assembly with extra fan mounts
A21	54904-00105	1	Rear Cover
A22	54904-00108	1	Bracket - Power Supply
A23	54904-47101	1	Filler Plate
A24	54904-00104	1	Deck - Processor Assembly
A25	0960-2789	1	Motherboard 945GM Flex-ATX Celeron-M 530 2 GB
A25	0960-2939	1	Motherboard 945GM Flex-ATX 4 GB *
	3160-4331	1	Heat sink and fan assembly M890 only *
MP1	54904-94309	1	Label DS09064A
MP1	54904-94315	1	Label DS09404A
MP1	54904-94313	1	Label DS09254A
MP1	54904-94311	1	Label DS09104A
MP1	54904-94308	1	Label MS09064A
MP1	54904-94314	1	Label MS09404A
MP1	54904-94312	1	Label MS09254A
MP1	54904-94310	1	Label MS09104A
MP1	54904-94305	1	Label DS09024H
MP1	54904-94306	1	Label DS09054H
MP1	54904-94307	1	Label DS09104H
MP1	54904-94303	1	Label DS09204H
MP1	54904-94321	1	Label DS09104AN
MP2	54904-94304	1	Label - Autoprobe
MP3	54904-94302	1	Label - I/O Front
MP4	54904-94301	1	Label - Control Panel
MP5	54904-66403	1	PCA - Autoprobe
MP6	54904-66405	1	PCA - Front Panel Keyboard
MP7	54904-60201	1	Bezel
MP8	54904-41901	1	Switch - Control Panel
MP9	54904-00101	1	Deck - front
MP10	0960-2829	1	Controller Resistive 8W
MP10	0960-2796	1	Touch screen controller board *
MP11	54904-42202	1	Keybox
MP12	0403-1116	2	Guide - PC BD BLK POLYC .05-.1 in BD thickness
MP13	54904-01201	1	Bracket - Removable HDD
MP14	54904-04101	1	Plate - Removable HDD
MP15	54904-41202	2	Clamp SATA
MP16	54904-94317	1	Label - Removable HDD Tray
MP17	54904-00107	1	Hard Disk Plate
MP18	54904-68708	1	Touchscreen / Display Assembly
MP18	0950-5445	1	Inverter DC to AC 4-watt 2-output
MP19	54904-68706	1	Hard Drive Replacement Kit WinXP M885 motherboard 0960-2789
MP19	54904-83501	1	Imaged HDD for M885 WinXP motherboard (Svc Ctr only) *
MP19	54904-68714	1	Hard Drive Replacement Kit WinXP M890 motherboard 0960-2939

Replaceable Parts

Ref. Des.	Keysight Part Number	QTY	Description
MP19	54904-83502	1	Imaged HDD for M890 WinXP motherboard (Service Centers only) *
MP19	54904-68715	1	Hard Drive Replacement Kit Win7 M890 motherboard 0960-2939
MP19	54904-83501	1	Imaged HDD for M885/XP-based 9000 series scopes
MP19	54904-83504	1	Imaged 2.5 HDD for M890 Win7 motherboard (Service Centers only) *
MP19	54932-83501	1	<u>Removable hard drive only:</u> Infiniium 90000 Q-Series Imaged HDD (Service Centers only)
MP19	54932-68717	1	<u>Removable hard drive only:</u> Replacement HDD for M890/Win7-based DS090000 Q-series scopes
MP20	54904-68709	1	Fan with Extra Fan Mounts w/wires
MP21	54904-44001	2	One lower rear foot and one upper rear bumper (order twice to get both pairs of rear feet/bumpers)
MP22	54904-41001	2	Tilt Leg (part of bucket)
MP23	54904-61615	1	MSO Cable
MP24	1250-0080	1	Adapter coaxial female BNC - female BNC
MP25	5063-2174	1	BNC Probe Tip Adapter
MP26	54913-47402	1	Knob 18 mm Flint Gray
MP27	54913-47401	1	Knob 12 mm Flint Gray
MP28	54913-94300	1	Label - Colored Knob Set
MP29	01650-61608	1	Flying Lead Set
MP30	5090-4833	1	Bag of 20 grabbers for Flying Lead Set
MP31	5959-9334	1	Bag of 5 two-inch ground leads for use with the Flying Lead Set
MP32	5063-2174	1	BNC to logic probe lead
MP33	1250-0080	1	BNC (f)-(f) barrel
W1	54904-61606	1	Cable - USB Device
W2	54904-61613	1	Cable - ATX Power
W2	54904-61619	1	Cable - ATX Power *
W3	54904-61612	1	Cable - Bulk Power (replaced by 54904-61631)
W3	54904-61631	1	Cable - Bulk Power (nickel contacts)
W3	54904-61632	1	Cable - Bulk Power (gold contacts)
W4	54904-61611	1	Cable - Standby/on-off
W4	54904-61618	1	Cable - Standby/on-off *
W5	54904-61601	1	Cable - AC input
W6	54904-61609	1	Cable - Front Panel Power
W7	54904-61603	1	Cable - LVDS/Inverter
W7	54904-61621	1	Cable - Display/Inverter/USB *
W7	54904-61607	1	Cable - Cable - Display and Inverter *
W7	54904-61617	1	Cable - Display and Inverter *
W7	54904-61620	1	Cable - CPU Power *
W8	54904-61614	4	Cable - HDD Power
W9	1520-0686		Cable Clamp
	8121-1579	1	power cord - United Kingdom
	8121-1581	1	power cord - Australia and New Zealand
	8121-2070	1	power cord - Continental Europe
	8121-1609	1	power cord - United States and Canada
	8121-1602	1	power cord - Switzerland
	8121-1601	1	power cord - Denmark
	8121-1799	1	power cord - India
	8121-1603	1	power cord - Japan
	8121-1662	1	power cord - Israel
	8121-1599	1	power cord - Argentina
	8121-1600	1	power cord - Chile

Chapter 6: Replaceable Parts

Replaceable Parts List

Replaceable Parts

Ref. Des.	Keysight Part Number	QTY	Description
	8121-1606	1	power cord - China
	8121-1641	1	power cord - South Africa
	8120-0674	1	power cord - Thailand and Philippines
	8121-1808	1	power cord - Brazil
	8121-1637	1	power cord - Taiwan
	8121-1633	1	power cord - Cambodia

*Motherboard serial #SG50540101 or higher, or MY50540101 or higher

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Theory of Operation

This *Service Guide* supports troubleshooting the Keysight Technologies oscilloscopes to assembly level. Theory of operation is included only as supplemental information. It is not comprehensive enough for component-level troubleshooting.

Block-Level Theory

The front panel provides:

- Dedicated knobs and pushbuttons for major oscilloscope functions
- An 15 inch (diagonal) color flat panel display for waveform, measurement, and graphical interface display
- Three front panel USB 2.0 ports
- Precision BNC connectors for channel input signals.
- BNC connector for auxiliary output signal
- AutoProbe interface for probe power and probe control
- A connection for probe compensation

The rear panel provides several connections:

- A parallel printer connection.
- A serial printer connection
- XGA monitor connection
- Mouse and keyboard connections
- LAN 10/1000 connection
- Auxiliary Trigger Input BNC
- 10 MHz Reference Output BNC
- 10 MHz Reference Input BNC
- TTL trigger output BNC
- Four rear panel USB 2.0 ports

The major boards of the oscilloscope are the acquisition board, autoprobe board, and front panel keyboard (there are several additional minor boards). The boards are part of a PC system complete with a motherboard, power supply, and LCD display.

Power Supply Assembly

The AC input to the power supply is 100–240 VAC $\pm 10\%$. Maximum input power is 375 W. The AC input frequency is 50 to 60 Hz.

Filtered voltages of +5 V, +3.3 V, +2.5 V, +2.25 V, +1.8 V, +1.6 V, +1.2 V, -12 V, -6 V, -5 V, and -3.8 V are supplied and distributed throughout the oscilloscope.

Monitor Assembly

The Flat Panel Display (FPD) monitor is a thin film liquid-crystal touch screen display (TFT-LCD). This FPD is an 15 inch diagonal, 1024 by 768 pixel XGA color monitor.

Acquisition System

There is one acquisition assembly. The acquisition boards contain the TUT modules, the Onboard ADC, the clock distribution, the data management ASICs, the external acquisition memory, the ADC, the communication and programming FPGA, and the supporting power supply circuitry.

Front Panel

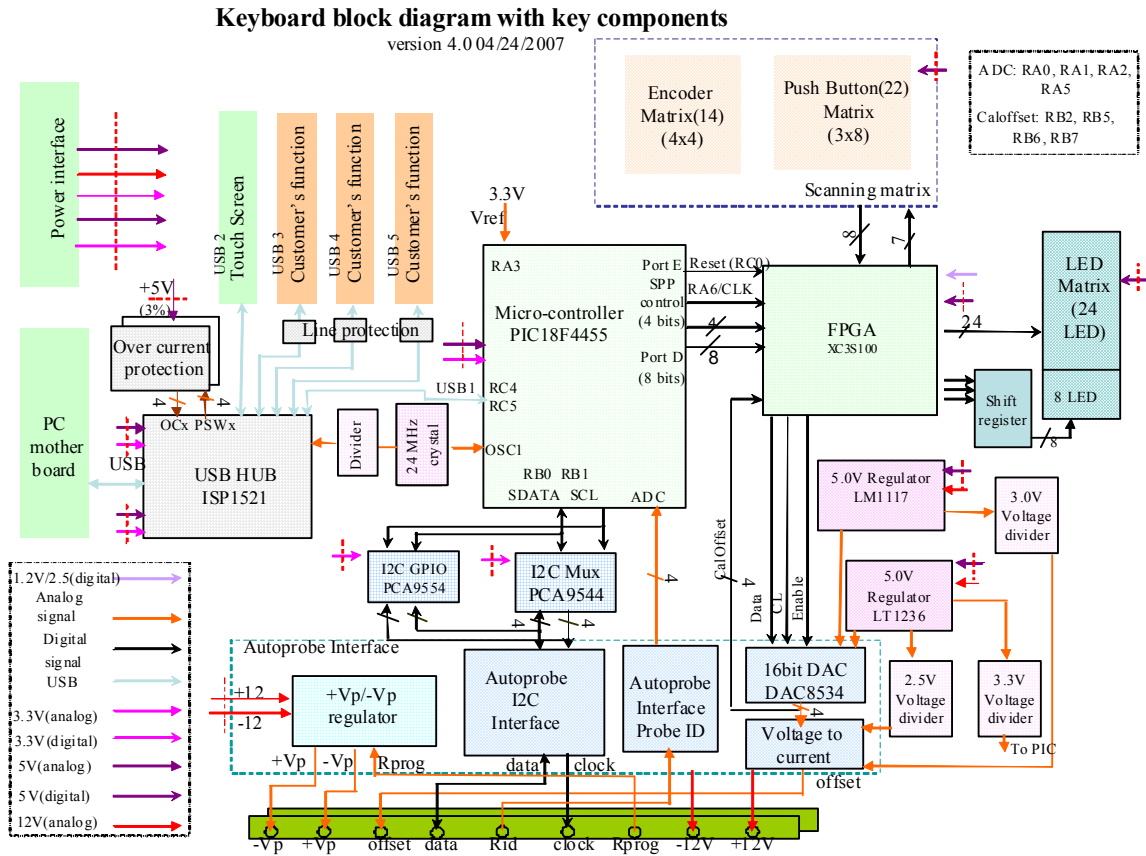
The front panel board and autoprobe board are split into three interconnecting PCAs. The front panel keyboard has a breakaway section that interfaces to the keyboard. This breakaway section receives power supply nets from the acquisition board and generates programmable voltages for the autoprobe interface.

The keyboard links to the scope PC motherboard through a high-speed USB 2.0 interface. The on-board USB hub serves the PIC microcontroller, the touch screen controller board, and up to three front panel USB connectors for a customer's peripherals.

A conductive element on the inside of each key shorts a gap on the underlying keyboard circuit board. The keyboard controller detects this short and sends the proper keypress information to the system controller on the motherboard.

There are 12 knobs located on the front panel.

Figure 7-1



Disk Drive

The hard disk drive is a high-capacity, shock-resistant unit. It is used to store the oscilloscope's operating system and certain system configuration data.

The drive can also be used to store and recall oscilloscope setups and waveforms.

Motherboard

The motherboard provides all system control and interface functions for the oscilloscope. It contains a CPU, ROM, and RAM; keyboard and mouse interfaces, serial and parallel interfaces, CDROM, hard disk drive interface, PCI buses, etc.

Display Board

The Display Board controls the flat-panel display monitor. It translates the video signals from the motherboard's on-board video system to the Low Voltage Differential Signal (LVDS) signals that drive the monitor.

System Fans

There are five fans: two larger fans that draw air out of the rear of the instrument, two medium fans that are positioned over each ADC to give additional cooling, and one small fan positioned over the trigger IC. They are all controlled by the main FPGA.

Safety Notices

This apparatus has been designed and tested in accordance with IEC Publication EN 61010-1:2001, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

Warnings

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock or fire hazard.
- If you energize this instrument by an auto transformer (for voltage reduction or mains isolation), the common terminal must be connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- Do not install substitute parts or perform any unauthorized modification to the instrument.

- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.

- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

- Do not use the instrument in a manner not specified by the manufacturer.

To clean the instrument

If the instrument requires cleaning: (1) Remove power from the instrument. (2) Clean the external surfaces of the instrument with a soft cloth dampened with a mixture of mild detergent and water. (3) Make sure that the instrument is completely dry before reconnecting it to a power source.

Safety Symbols



Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.



Hazardous voltage symbol.



Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

Notices

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CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

