

Keysight Infiniium 90000 X/L-Series Oscilloscopes

Service Guide

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Infiniium 90000 X / L-Series Oscilloscopes

Ease of use with high performance

The Keysight Infiniium 90000 X-Series 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 13 GHz to 32 GHz.
- MSO models provide 10 GSa/s at 16 channels and 20 GSa/s at 8 channels.

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 are 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

- 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 oscilloscope 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.

Solid state 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.
- Solid state drive 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.
- Use auxiliary trigger to increase triggering flexibility.

Vertical controls set attenuation and position

- 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.

In This Service Guide

This guide provides the service information for the Keysight Technologies 90000 X-Series and 90000 L-Series oscilloscopes. It is divided into seven chapters.

Chapter 1, "General Information," describes which oscilloscope models are covered by this guide, supplied accessories, and where to find the specifications for the 90000 X-Series / 90000 L-Series oscilloscopes.

Chapter 2, "Calibration," describes the types of calibrations, and how and when to run the user calibration procedure.

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

Chapter 4, "Troubleshooting," provides flowcharts and procedures for diagnosing problems for assembly-level repair.

Chapter 5, "Replacing Assemblies," provides instructions for removing and replacing assemblies in the oscilloscope.

Chapter 6, "Replaceable Parts," provides exploded parts diagrams and a list for ordering replaceable parts.

Chapter 7, "Theory of Operation," describes the basic structure of the oscilloscope and how its parts interact.

Safety notices are in the back of this book.

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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 90000 X-Series and L-Series oscilloscopes are covered in this guide.

Model	Bandwidth
MSOX/DSOX/DSAX91304A	13 GHz bandwidth
MSOX/DSOX/DSAX91604A	16 GHz bandwidth
MSOX/DSOX/DSAX92004A	20 GHz bandwidth
MSOX/DSOX/DSAX92504A	25 GHz bandwidth
MSOX/DSOX/DSAX92804A	28 GHz bandwidth
DSO/DSA93004L	30 GHz bandwidth
MSOX/DSOX/DSAX93204A	32 GHz bandwidth

The oscilloscope model can be identified by the product number on the front or rear panel.

Accessories supplied

The following accessories are supplied.

- Mouse
 - Stylus
 - Keyboard
 - Accessory pouch
 - Front panel cover
 - Calibration cable
 - Connector saver collars (qty 10)
 - Connector savers (f-f) (qty 5)
 - Power cord (see parts list in chapter 6 for country-dependent part number)
 - ESD wrist strap
 - Digital channels cable (MSO models only): Keysight part number N2815-68701
 - MSO calibrator board assembly (MSO models only): Keysight part number N2834-68703
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Specifications and Characteristics

The following table contains a partial list of specifications and characteristics for the Keysight Infiniium 90000 X-Series oscilloscopes. For a full list of specifications and characteristics, see the data sheets at www.keysight.com/find/90000x-series.

Specifications that are pertinent to each test are 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.

Environment	Indoor use only.
Ambient temperature	Operating 5 °C to +40 °C Non-operating -40 °C to +65 °C
Humidity	Operating: up to 95% relative humidity (non-condensing) at +40 °C Non-operating: up to 90% relative humidity at +65 °C
Altitude	Operating: up to 4,000 m (12,000 feet) Non-operating: up to 15,300 meters (50,000 feet)
Installation/ Measurement Category	Installation category: II Measurement category: 1
Power Requirements	100-240 V, 47-63 Hz; 800 W for 4-channel models. 100-240 V, 50 Hz; 100-208 V, 50/60 Hz; 800 W for 8-channel models.
Voltage Fluctuations	Note that the mains supply voltage fluctuations are not to exceed +/-10% of the nominal supply voltage.
Pollution Degree	The Infiniium 90000 X-Series oscilloscopes may be operated in environments of Pollution Degree 2.

Chapter 1: General Information

Specifications and Characteristics

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

A calibration is simply an oscilloscope self-adjustment. The purpose of a calibration is performance optimization.

There are four levels of calibrating an Infiniium 90000 X-Series oscilloscope, with each successive level being a superset of the previous one:

- An *environmental calibration* is a quick fine-tune of response. It includes a minimum set of calibrations and should be run when there are changes to the operating environment around the oscilloscope, such as changes in air flow, temperature, humidity, or the placement of other instruments near the oscilloscope. It can also be run prior to making critical measurements where absolute best accuracy is required. The environmental calibration takes only a few minutes to run, and is easily accessible through a button in the Calibration dialog box. Users can run this cal.
- A *user calibration*, also known as a *self calibration*, is a more rigorous set of cals that can be run by oscilloscope users. It includes the environmental cal.

With a user calibration, you may optionally choose to run time scale calibrations and interleave correction calibrations. These cals do not run by default, and they require additional equipment. A user calibration takes about 2-1/4 hours, including the time required to change cables from channel to channel.

- A *service calibration* is performed only by Keysight Service Center technicians. With a service calibration the 50 Ohm input resistance calibration is performed, in addition to everything calibrated with the user calibration. The time scale and interleave correction calibrations are run by default, though they can be turned off. Additional equipment is required to run a service calibration. A service calibration takes about 2-1/2 hours.
- A *factory calibration* includes the complete set of calibrations, including time scale and interleave correction, plus other calibrations. A factory calibration is normally performed once, during production of the oscilloscope. All of the calibration factors are stored into flash RAM on the acquisition board so that the calibration factors determined by the factory calibration are preserved even if the hard drive is replaced or reformatted.

Running an Environmental Calibration

Let the Oscilloscope Warm Up Before Adjusting
Warm up the oscilloscope for 30 minutes at ambient temperature before starting the calibration procedure. Failure to allow warm up may result in inaccurate calibration.

The environmental calibration uses signals generated in the oscilloscope to calibrate response.

When to perform an environmental calibration:

- You can perform a quick environmental cal rather than a full user cal when there are changes to the operating environment around the oscilloscope, such as changes in air flow, temperature, humidity, or the placement of other instruments near the oscilloscope. For example, you would run the quick environmental cal if the oscilloscope is moved to a test rack or chamber.

Equipment Required

Equipment	Critical Specifications	Keysight Part Number
Connector savers (5 supplied with oscilloscope)	3.5mm (f) to 3.5 mm (f)	Keysight 54916-68717 (for 20, 25, 28, 30, and 32 GHz models) Keysight 54916-68716 (for 13 GHz and 16 GHz models)
Cable (supplied with oscilloscope)	No substitute	Keysight 54916-61626

Procedure

- Let the oscilloscope warm up before running the self calibration.

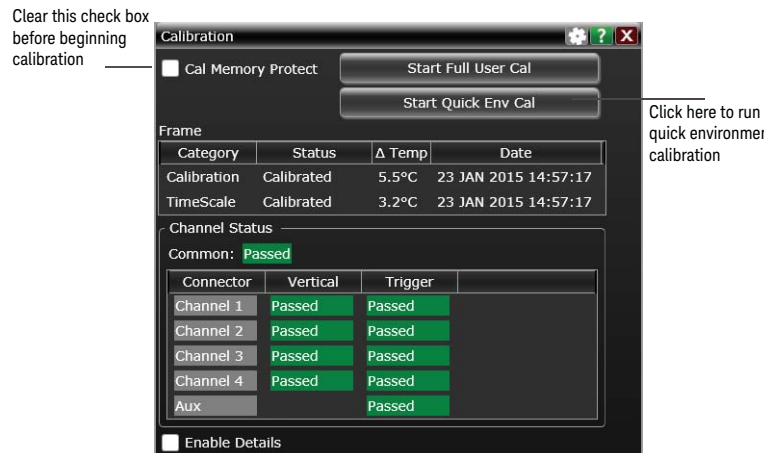
The environmental calibration should be done only after the oscilloscope has run for 30 minutes at ambient temperature with the cover installed. Calibration of an oscilloscope that has not warmed up may result in an inaccurate calibration.

- Select **Utilities > Calibration**.

- Uncheck the **Cal Memory Protect** box.

You cannot run an environmental calibration if this box is checked. See Figure 2-1.

Figure 2-1 Calibration Dialog Box



Chapter 2: Calibration

Running an Environmental Calibration

- 4 Click **Start Quick Env Cal**, then follow the instructions on the screen. The routine will prompt you to follow these steps:
 - a Disconnect everything from all inputs and Cal Out.
 - b Connect the calibration cable from Cal Out to channel 1. You must use the 54916-61626 cable assembly with two connector saver adapters for all oscilloscopes. Failure to use the appropriate calibration cable will result in an inaccurate calibration.
 - c Connect the calibration cable from Cal Out to each of the channel inputs as requested.
 - d A Passed/Failed indication appears for each calibration section. If any section fails, click the **Enable Details** box for information on the failures. Also check the calibration cables.

Running a user calibration

Let the Oscilloscope Warm Up Before Adjusting

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

The user calibration uses signals generated in the oscilloscope to calibrate channel scale, offsets, and trigger parameters. When running a user calibration, you can choose to run optional time scale and interleave response correction calibrations.

If your oscilloscope is an MSO model or has been upgraded to add MSO capability, you can choose to calibrate only the digital channels rather than both the analog and digital channels.

When to perform a user calibration:

- When it has been more than 1 year since the last time scale calibration, perform the time scale portion.
- When you replace the hard drive.
- When the oscilloscope's operating temperature (after the 30-minute warm-up period) is more than $\pm 5^{\circ}\text{C}$ different from that of the last calibration, perform the interleave response correction portion.

Equipment Required

Equipment	Critical Specifications	Keysight Part Number
Connector savers (5 supplied with oscilloscope)	3.5mm (f) to 3.5 mm (f)	Keysight 54916-68717 (for 20, 25, 28, 30, and 32 GHz models) Keysight 54916-68716 (for 13 GHz and 16 GHz models)
Cable assembly	50 Ohm characteristic impedance BNC (m) connectors, 36 inches (91 cm) to 48 inches (122 cm) long	Keysight 8120-1840
Adapter	SMA(m) to BNC(f)	Keysight 1250-1200
Cable (supplied with oscilloscope)	No substitute	Keysight 54916-61626
Digital channels cable (MSO models only)	No substitute	Keysight N2815-68701
MSO calibrator (MSO models only)	No substitute	Keysight N2834-68703

Procedure

- 1 Let the oscilloscope warm up before running the self calibration.

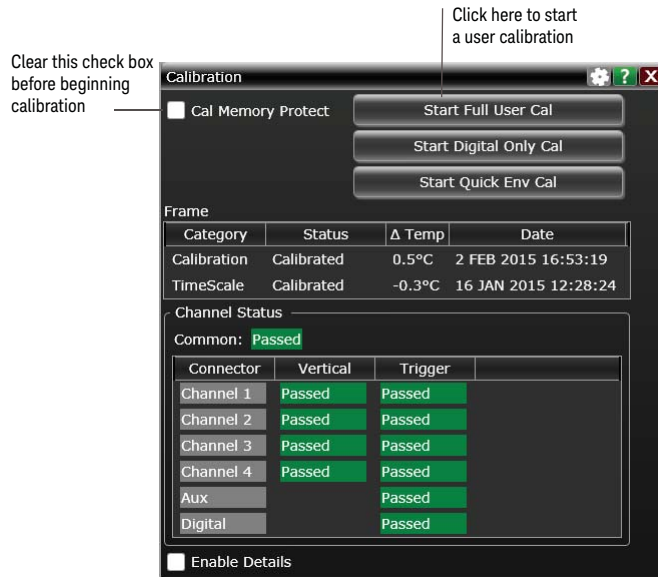
The self calibration should be done only after the oscilloscope has run for 30 minutes at ambient temperature with the cover installed. Calibration of an oscilloscope that has not warmed up may result in an inaccurate calibration.

- 2 Select **Utilities > Calibration**.
- 3 Uncheck the **Cal Memory Protect** box. You cannot run a self calibration if this box is checked. See Figure 2-2.

Chapter 2: Calibration

Running a user calibration

Figure 2-2 Calibration Dialog Box

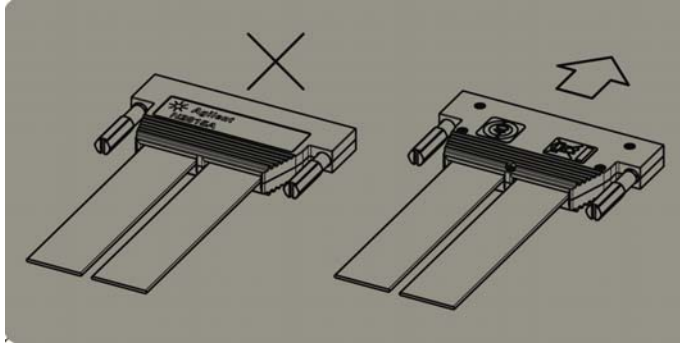


- 4 Click **Start Full User Cal**, then follow the instructions on the screen. The routine will prompt you to follow these steps:
 - a Disconnect everything from all inputs and Cal Out.
 - b Indicate whether you want to run time scale and interleave response correction calibrations. For a list of equipment required to perform the time scale calibration, refer to the “Time Scale Accuracy (TSA) Test” section in the next chapter. The interleave correction calibration requires a sine wave generator and a ≥ 67 GHz cable with 1.85 mm male connectors on each end. You will also need to use the two supplied 1.85 mm (f)-(f) connector savers. To learn more about both calibration options, click **Help** from the Calibration Options dialog box.
 - c Connect the calibration cable from Cal Out to channel 1. You must use the 54916-61626 cable assembly with two connector saver adapters for all oscilloscopes. Failure to use the appropriate calibration cable will result in an inaccurate calibration.
 - d Connect the calibration cable from Cal Out to each of the channel inputs as requested.
 - e When instructed, connect the calibration cable from the Cal Out on the front panel of the oscilloscope to the 1250-1200 SMA(m) to BNC(f) adapter and then connect the other end of the 1250-1200 adapter to the 8120-1840 BNC cable. Connect the other end of the BNC cable to the Trig In on the rear of the oscilloscope.
 - f A Passed/Failed indication appears for each calibration section. If any section fails, click the **Enable Details** box for information on the failures. Also check the calibration cables.
- 5 If you are calibrating an MSO model oscilloscope, follow the prompts to connect the digital channels cable to the digital channels connector on the rear of the oscilloscope and to the calibration connector on the MSO calibrator.

CAUTION

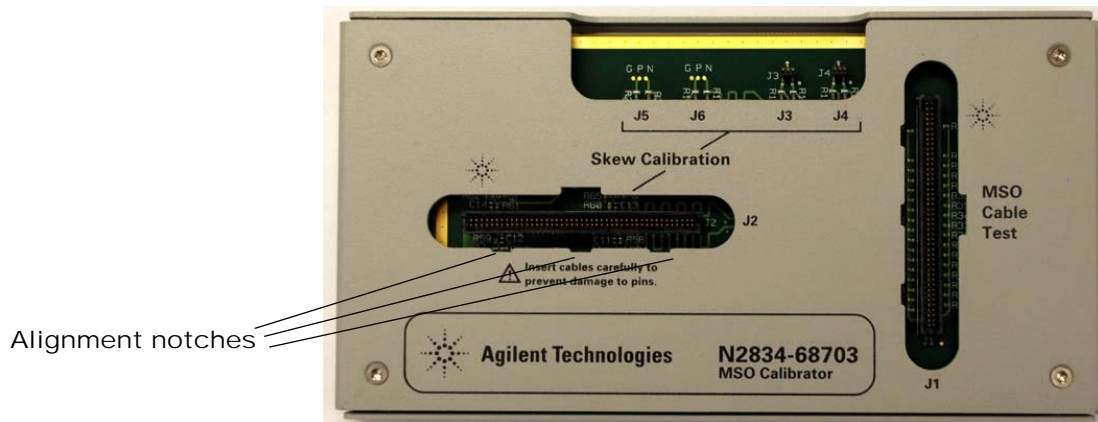
Be sure to orient the digital channels cable with the Keysight part number facing downward as shown on the rear of the oscilloscope. See Figure 2-3.

Figure 2-3 Digital channels cable orientation

**CAUTION**

Insert the digital channels cable carefully into the MSO calibrator to prevent damage to the pins. Use the notches on the cable and the MSO calibrator to orient the cable correctly. See Figure 2-4.

Figure 2-4 MSO calibrator



- 6 After the calibration procedure is completed, click **Close**.

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Full performance verification for 90000 X-Series oscilloscopes consists of three main procedures:

- 1 Performing the internal oscilloscope self tests to ensure the measurement system is functioning properly. To perform the self tests, click **Utilities > Self Test...**. Then select **Scope SelfTest** from the **Available Self Test** drop-down list box, click **Start**, and follow the instructions on the screen. If any of the self tests fail, ensure that the failure is diagnosed and repaired before calibrating and testing performance.
- 2 Calibrating the oscilloscope, as described in chapter 2.
- 3 Testing the oscilloscope to ensure that it is performing to specification. This chapter describes the performance test procedures.

This section describes performance test procedures.

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 and test limits, and provides space to record test results.

Test Order

The tests in this section may be performed in any order. 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 oscilloscopes and accessories required. The oscilloscopes 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 oscilloscopes in the recommended equipment list. However, the oscilloscopes, 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.

Vertical Performance Verification

This section contains the following vertical performance verification tests:

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

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 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	≤ 3.5 V: $\pm(2\%$ of channel offset + 1% of full scale + 1 mV) > 3.5 V: $\pm(2\%$ of channel offset + 1% of full scale)
Full scale is defined as 8 vertical divisions. Magnification is used below 10 mV/div. Below 10 mV/div, full scale is defined as 80 mV. The major scale settings are 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV and 1 V.	

Equipment Required

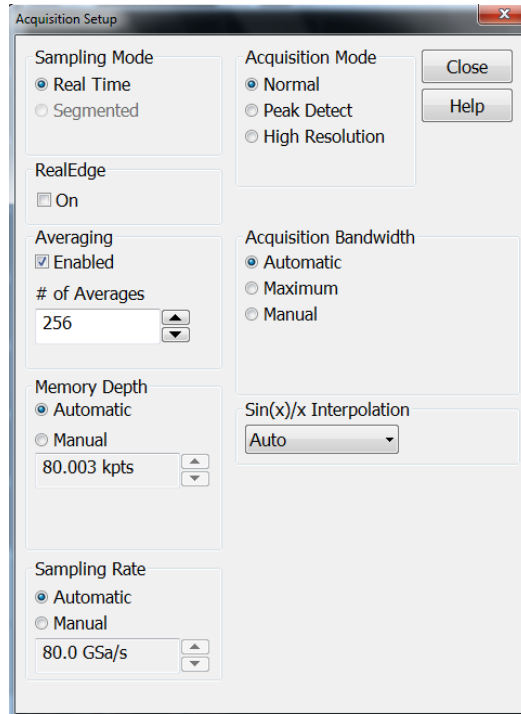
Description	Critical Specifications	Recommended Model/ Part Numbers
Digital Multimeter	DC voltage measurement accuracy better than $\pm 0.1\%$ of reading	Keysight 34401A or Keysight 3458A
Cable Assembly (2 required)	50Ω characteristic impedance, BNC (m) connectors	Keysight 8120-1840
Adapter	BNC Tee (m)(f)(f)	Keysight 1250-0781
Adapter	BNC (f) to dual banana	Keysight 1251-2277
Connector Saver	3.5 mm (f)-(f), shipped with each MSO/DSO/DSAX 90000A and DSO/DSA93004L Series oscilloscope	Keysight 5061-5311 (used with 20 , 25 , 28 , 30 , and 32 GHz oscilloscope models) Keysight 1250-3758 (used with 13 GHz and 16 GHz oscilloscope models)
Adapter (2 required)	BNC (f) to SMA (m) adapter	Keysight 1250-1200

NOTE: The offset accuracy specification has two terms $\pm(\text{offset gain} + \text{zero error})$. The offset gain specification is $\pm 2\%$ of channel offset while the zero error specification is $\pm(1\%$ of full scale + 1 mV) for ≤ 3.5 V and 1% of full scale for > 3.5 V. The offset accuracy test procedure tests each of these terms individually.

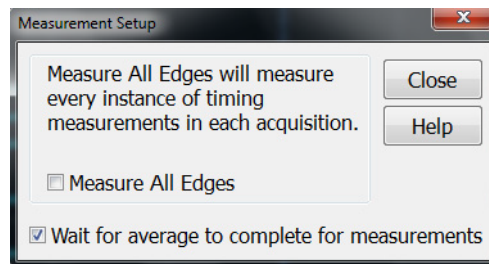
Zero Error Test Procedure

- 1 Disconnect all cables from the scope channel inputs.
- 2 Press [Default Setup], then configure the scope as follows:
 - a Select **Setup > Acquisition**.

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



- 3 Filter out waveform noise by forcing the measurement calculations to wait until the average is computed.
a Select **Measure > Setup**.

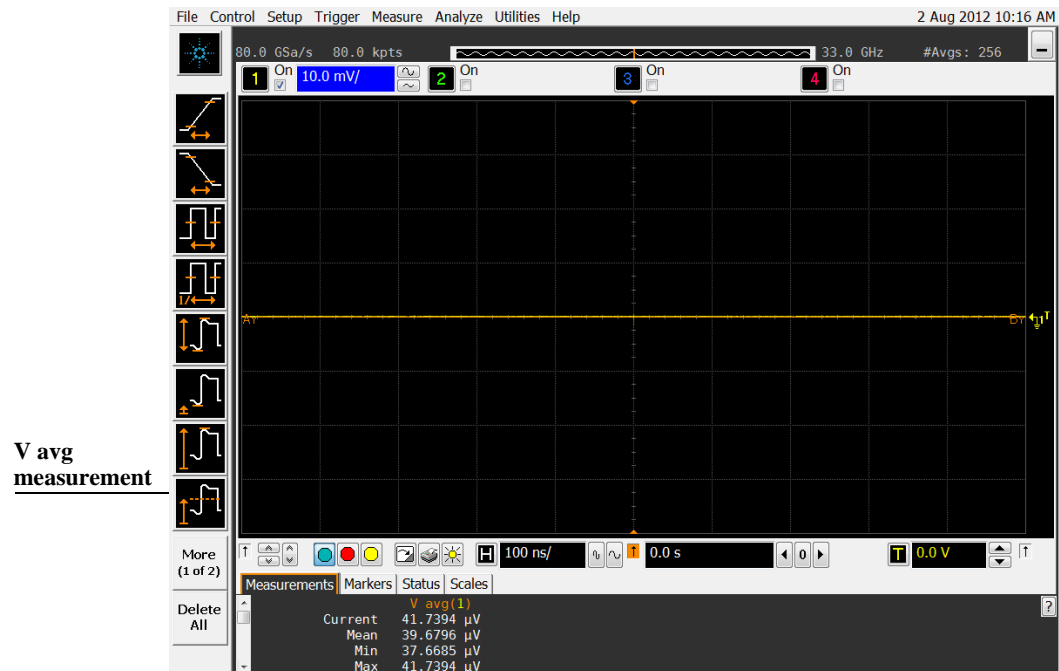


- b Check the **Wait for average to complete for measurements** box.
c Click **Close**.
4 Configure the scope to measure Average voltage on channel 1 as follows:
a Change the vertical scale of channel 1 to 10 mV/div.

Chapter 3: Testing Performance

Offset Accuracy Test

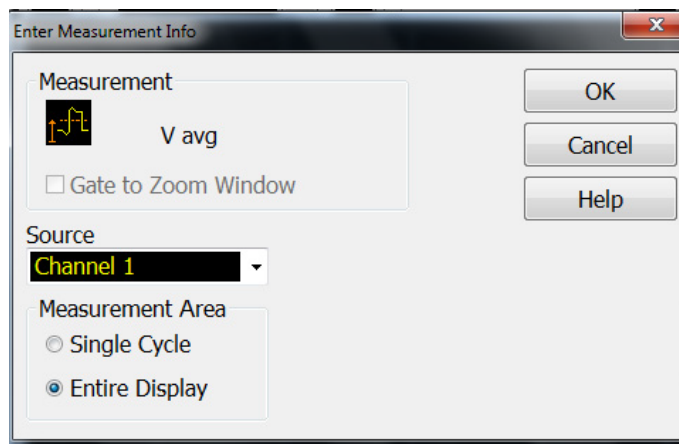
- b Click the V avg measurement on the left side of the screen.



- 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



- 5 Press **[Clear Display]** on the scope and wait for the #Avgs value (top right corner of screen) to return to 256. Record the scope's mean V avg reading in the Zero Error Test 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.

Record the
mean reading

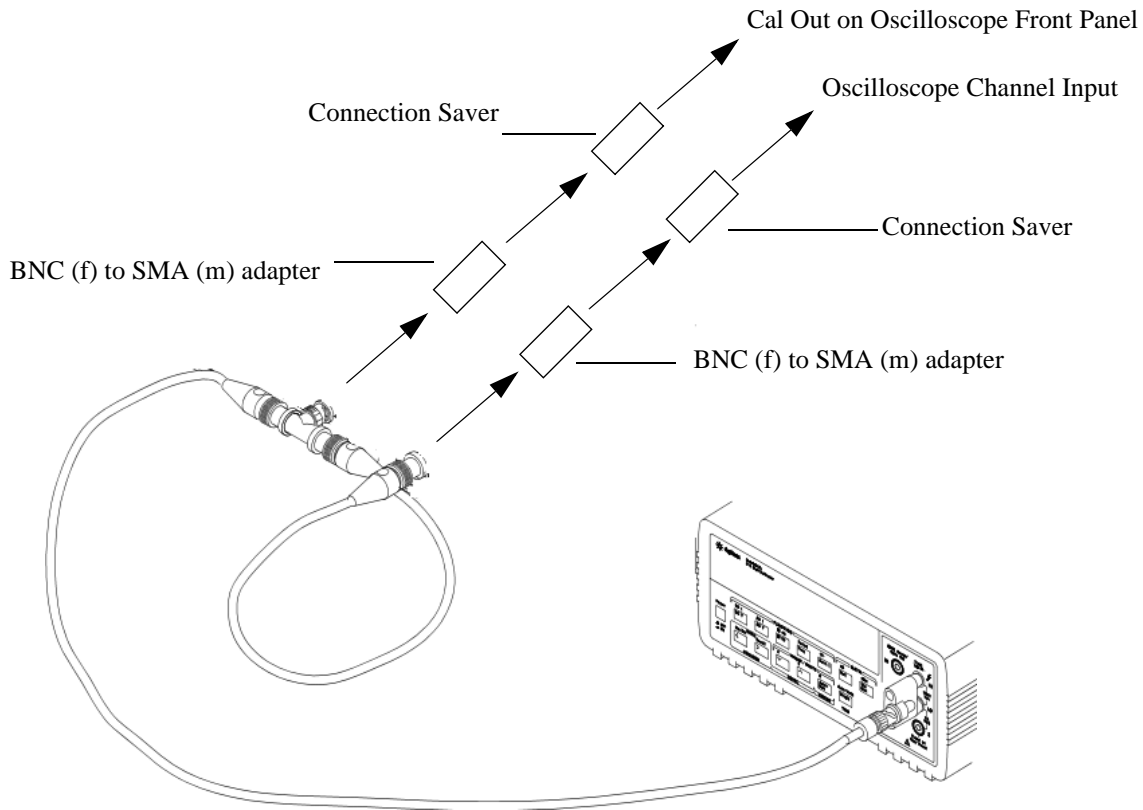


- 6 Change the vertical scale of channel 1 to 20 mV/div, press **[Clear Display]**, wait for the #Avgs value (top right corner of screen) to return to 256, and then record the scope V avg reading in the Zero Error Test section of the Performance Test Record.
- 7 Repeat step 5 for the remaining vertical scale settings for channel 1 in the Zero Error Test section of the Performance Test Record.
- 8 Press **[Default Setup]**, then turn off channel 1 and turn channel 2 display on.
- 9 Configure the scope to measure V avg on Channel 2 as follows:
 - a Select **Setup > 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 10 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
- 10 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 Zero Error Test section of the Performance Test Record.
- 11 Repeat step 9 for the remaining vertical scale settings for channel 2 in the Zero Error section of the Performance Test Record.
- 12 Repeat steps 7 through 10 for channels 3 and 4.

Offset Gain Test

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

Connections



Notes:

- Where the BNC Tee adapter is used, it is important to connect it directly to the scope channel input using the BNC (f) to SMA (m) adapter and the connection savers 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.
- 256 averages are used in the scope measurements of this section to reduce measurement noise and to reduce the measurement error due to resolution.

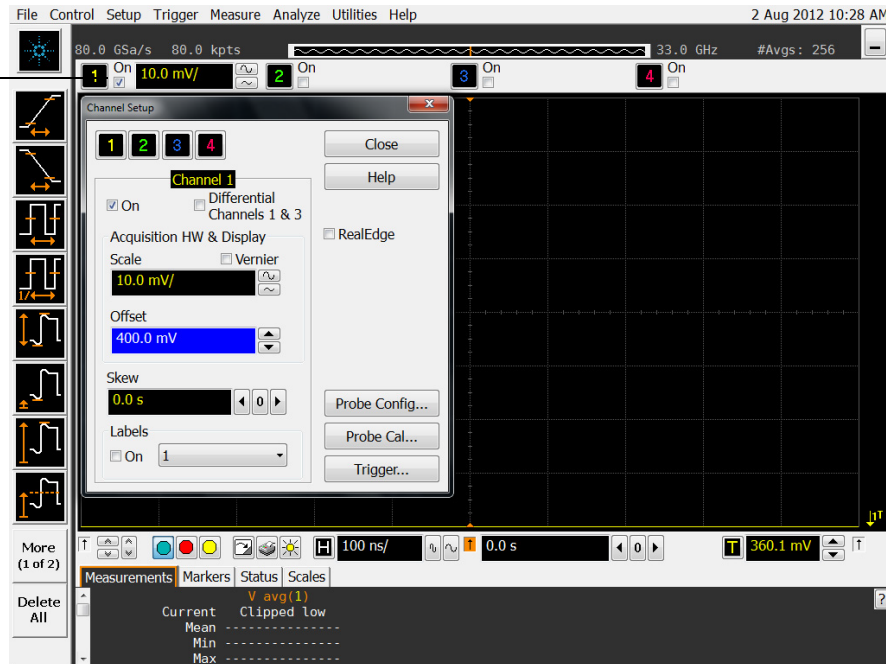
- 2 Set up the DMM to perform DC voltage measurements.
- 3 Configure the scope to measure V avg on Channel 1 as follows:
 - a Press **[Default Setup]**.
 - b Select **Setup > Acquisition**. When the Acquisition Setup window appears, enable averaging and set the # of averages to 256.
 - c Change the vertical scale of channel 1 to 10 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

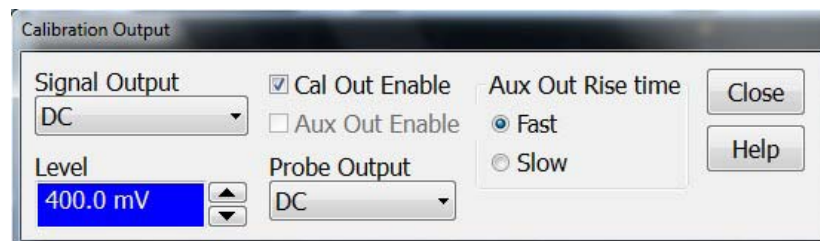
Measurement area = Entire Display

- 4 Set the channel 1 offset value to 400.0 mV by using the front panel control or:
 - 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 400.0 mV in the dialog box.

Channel 1
setup icon



- 5 Set the Cal Out voltage ($V_{\text{Cal Out}}$) to +400.0 mV as follows:
 - a Select **Utilities > Calibration Output**.
 - b Change the Signal Output function to DC (top left corner).
 - c Set the Level to 400.0 mV.
 - d Click **Close**.



- 6 Press **[Clear Display]** on the scope, wait for the #Aves value (top right corner of screen) to return to 256, and then record the DMM voltage reading as $V_{\text{DMM}+}$ and the scope Vavg reading as $V_{\text{Scope}+}$ in the Offset Gain Test section of the Performance Test Record.

Chapter 3: Testing Performance

Offset Accuracy Test

- 7 Change the channel 1 offset value to -400.0 mV.
- 8 Set the Cal Out voltage to -400.0 mV.
- 9 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 Gain Test section of the Performance Test Record.
- 10 Change the channel 1 offset value to 0 mV.
- 11 Set the Cal Out voltage to 0 mV.
- 12 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_{DMM0} and the scope Vavg reading as V_{Scope0} in the Offset Gain Test section of the Performance Test Record.
- 13 Calculate the offset gain error using the following expressions and record the value in the Offset Gain Test section of the Performance Test Record. The offset gain error is the greater (maximum magnitude) of either:

$$\left(\frac{V_{scope+} - V_{scope0}}{V_{DMM+} - V_{DMM0}} - 1 \right) 100$$

or

$$\left(\frac{V_{scope-} - V_{scope0}}{V_{DMM-} - V_{DMM0}} - 1 \right) 100$$

- 14 Repeat steps 4 to 13 for the remaining channel 1 vertical scale settings in the Offset Gain Test section of the Performance Test Record. For each measurement, set both the Cal Out voltage ($V_{Cal Out}$) and the Channel offset voltage to the positive $V_{Cal Out}$ value and then to the negative $V_{Cal Out}$ value in the "V_{Cal Out} Setting" column of the Offset Gain Test table in the Performance Test Record for each of the vertical scale settings.
- 15 Move the Tee connector to the next channel input and repeat steps 4 to 13 for channels 2 to 4.

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 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
Full scale is defined as 8 vertical divisions. Magnification is used below 10 mV/div. Below 10 mV/div full scale is defined as 80 mV. The major scale settings are 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV and 1 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
Adapter	BNC Tee (m)(f)(f)	Keysight 1250-0781
Adapter	BNC (f) to dual banana	Keysight 1251-2277
Connector Saver	3.5 mm (f)-(f), shipped with each MSO/DSO/DSAX 90000A and DSO/DSA93004L Series oscilloscope	Keysight 5061-5311 (used with 20, 25, 28, 30, and 32 GHz oscilloscope models) Keysight 1250-3758 (used with 13 GHz and 16 GHz oscilloscope models)
Adapter (2 required)	BNC (f) to SMA (m) adapter	Keysight 1250-1200

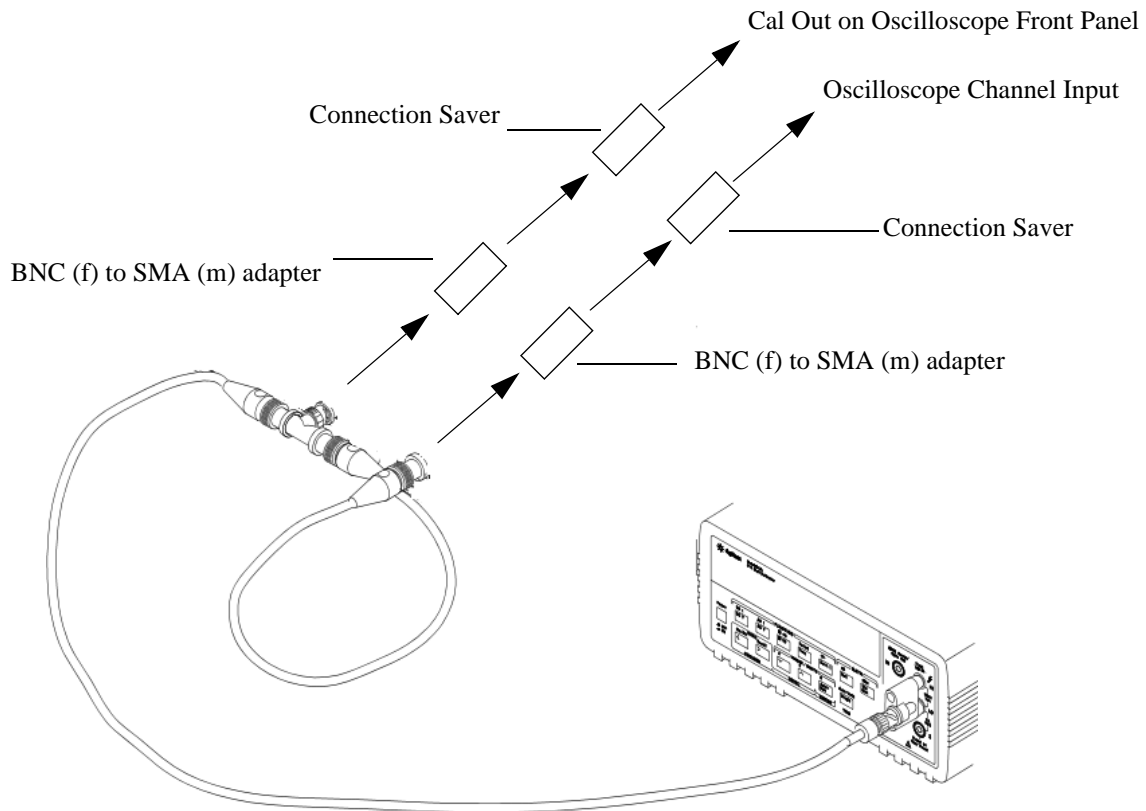
Chapter 3: Testing Performance

DC Gain Accuracy Test

Procedure

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

Connections

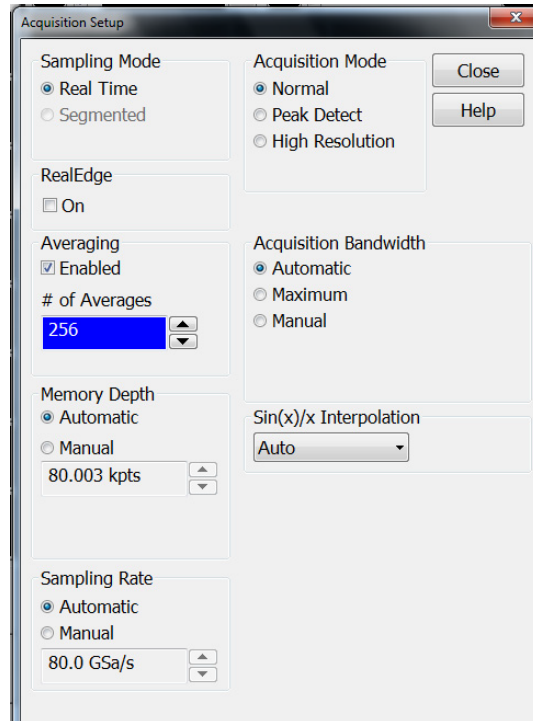


Notes:

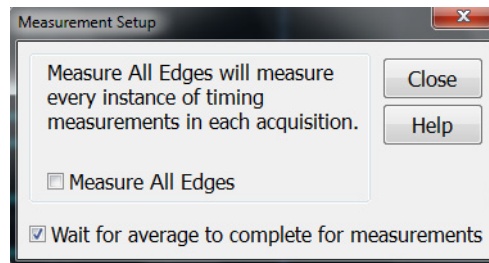
- Where the BNC Tee adapter is used, it is important to connect it directly to the scope channel input using the BNC (f) to SMA (m) adapter and the connection saver to minimize ground potential differences and to ensure that the DMM measures the input voltage to the scope channel as accurately as possible. 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.
- 256 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 Select **Setup > Acquisition**.

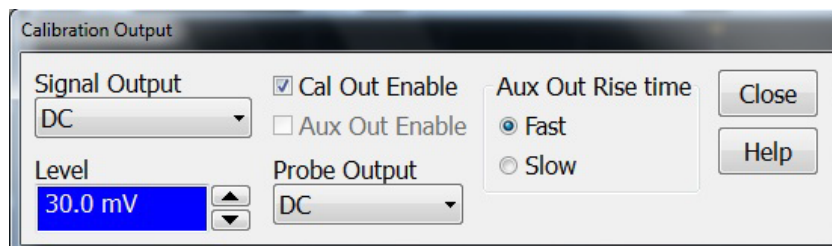
- b When the Acquisition Setup window appears, enable averaging and set the # of averages to 256 as shown below.



- 3 Filter out waveform noise by forcing the measurement calculations to wait until the average is computed.
- Select **Measure > Setup**.
 - Check the **Wait for average to complete for measurements** box.



- Click **Close**.
- 4 Set the Cal Out voltage ($V_{\text{Cal Out}}$) to +30 mV as follows:
- Select **Utilities > Calibration Output**.
 - Change the Signal Output function to DC (top left corner).
 - Set the Level to 30 mV.
 - Click **Close**.

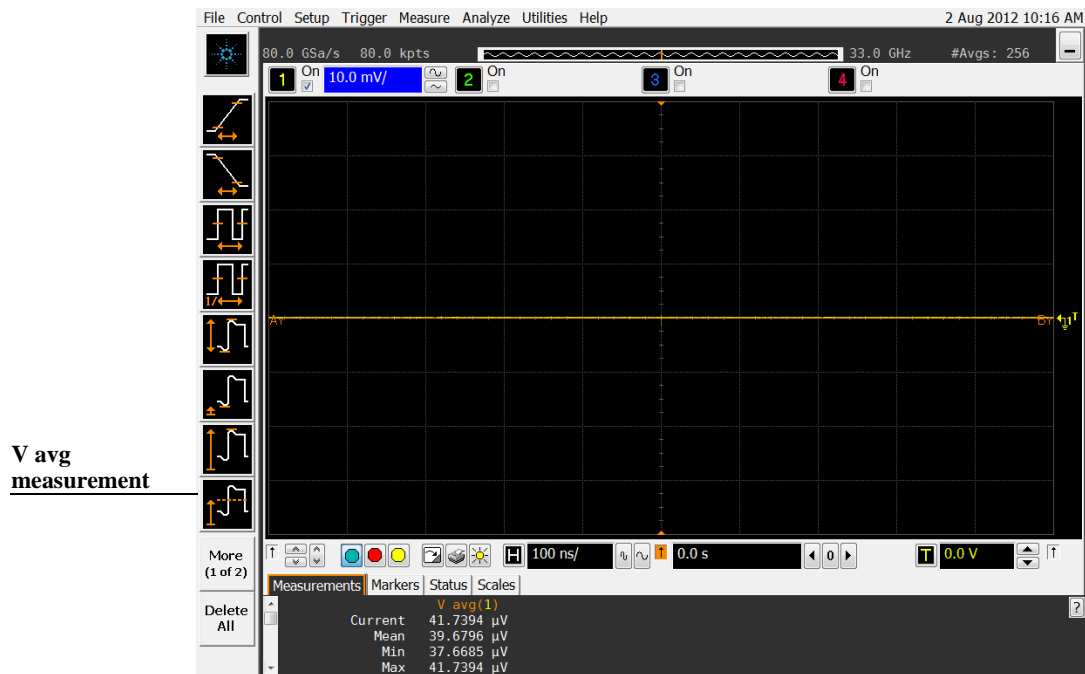


- 5 Set the channel 1 vertical scale value to 10 mV/div by using the front panel control or:

Chapter 3: Testing Performance

DC Gain Accuracy Test

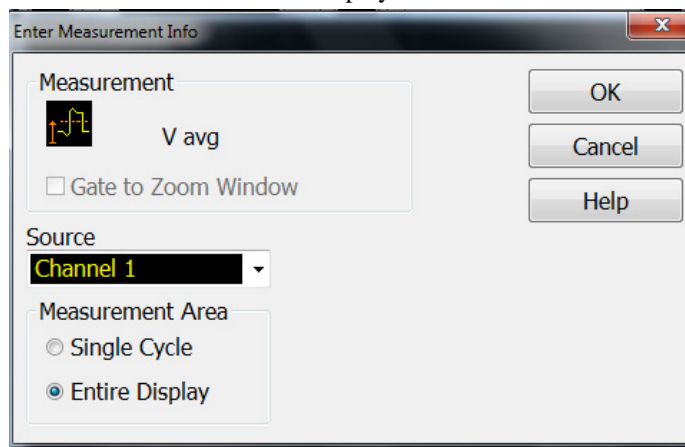
- Pull down the Setup menu and select Channel 1 or click the Channel 1 setup icon.
- Change the vertical scale of channel 1 to 10 mV/div.
- Select the Vavg measurement as shown below.



- 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

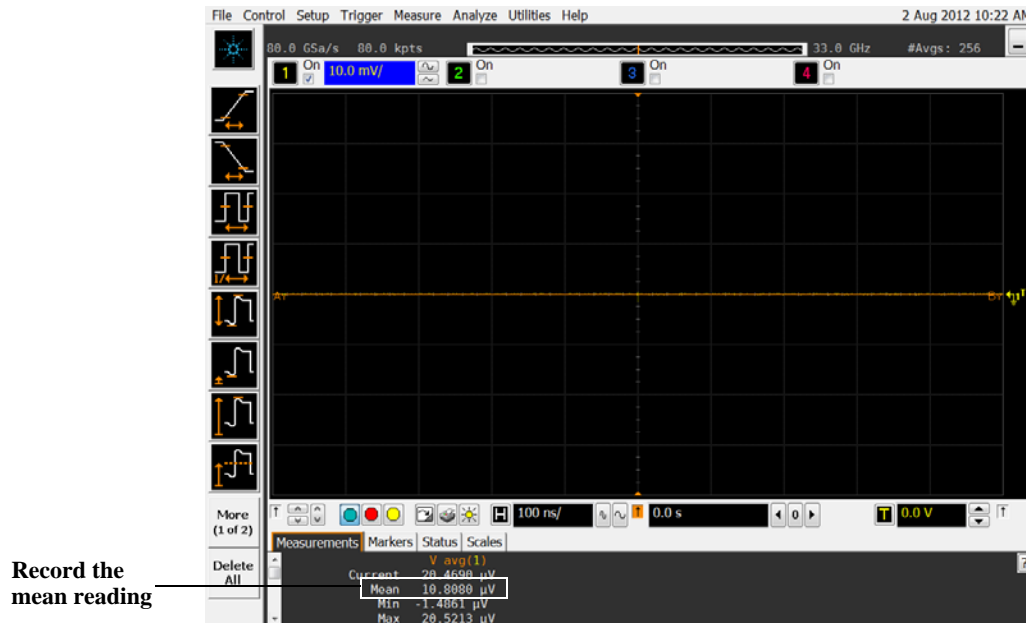
Measurement Area = Entire Display



- Press **[Clear Display]** on the scope, wait for the #Aves value (top right corner of screen) to return to 256, and then record the scope's mean V avg reading in the DC Gain Accuracy Test 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 #Aves value to return to 256, and then record the scope reading.



- 7 Change the Cal Out voltage to -30 mV.
- 8 Press **[Clear Display]** on the scope, wait for the #Aves value to return to 256 and then record the DMM voltage reading and the scope V avg reading in the DC Gain Test section of the Performance Test Record.
- 9 Calculate the DC gain using the following expression and record this value in the DC Gain Test section of the Performance Test Record.

For vertical scale setting of less than 1 volt use the following equation:

$$DCGainError = \frac{\Delta V_{out}}{\Delta V_{in}} = \left(\left(\frac{V_{scope+} - V_{scope-}}{V_{DMM+} - V_{DMM-}} - 1 \right) \cdot 75 \right)$$

For vertical scale = 1 V use the following equation:

$$DCGainError = \frac{\Delta V_{out}}{\Delta V_{in}} = \left(\frac{V_{scope+} - V_{scope-}}{V_{DMM+} - V_{DMM-}} - 1 \right) \cdot 60$$

- 10 Repeat steps 3 to 8 for the remaining channel 1 vertical scale settings in the DC Gain Test section of the Performance Test Record. For each measurement, set both the Cal Out voltage (V_{CalOut}) and the Channel offset voltage to the positive V_{CalOut} value and then to the negative V_{CalOut} value in the “ V_{CalOut} Setting” column of the DC Gain Test table in the Performance Test Record for each of the vertical scale settings used.
- 11 Move the Tee connector to the next channel input and repeat steps 3 to 9 for channels 2 to 4.

Analog Bandwidth -- Maximum Frequency 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 must be warmed up (with the oscilloscope application running) for at least 30 minutes prior to the start of any performance test.

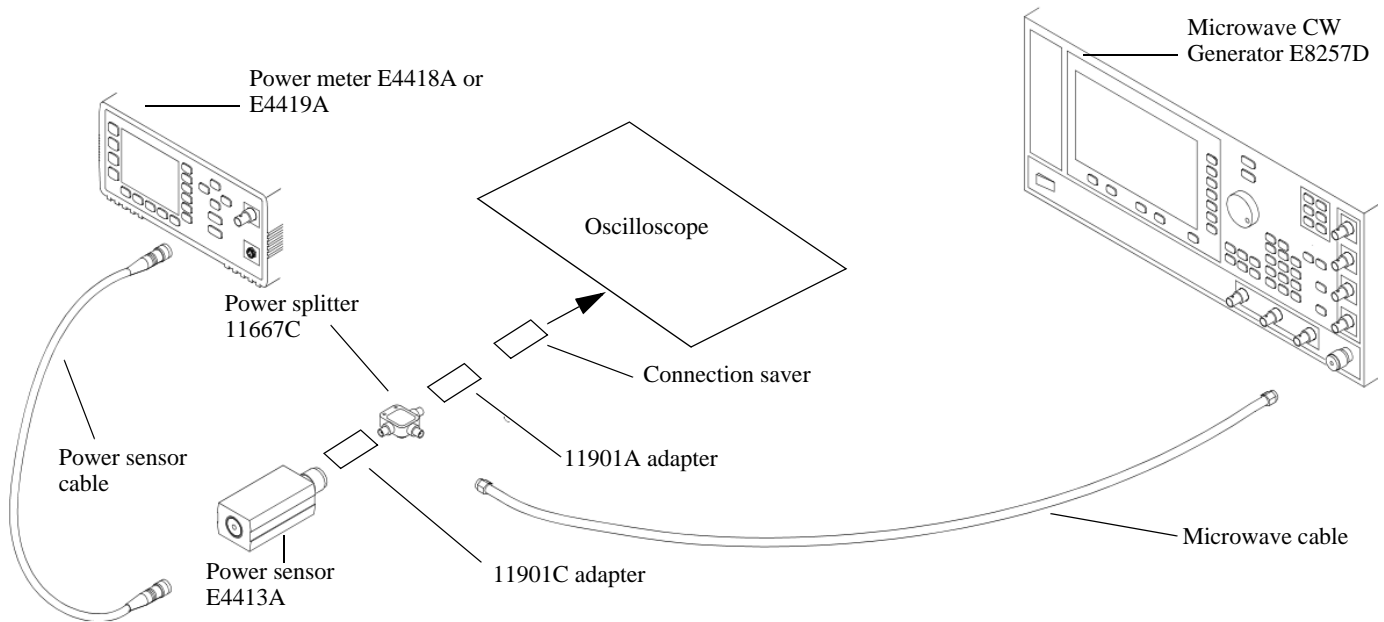
Specification

Analog Bandwidth (-3 dB)	
MSO/DSO/DSAX91304A	13.0 GHz
MSO/DSO/DSAX91604A	16.0 GHz
MSO/DSO/DSAX92004A	20.0 GHz
MSO/DSO/DSAX92504A	25.0 GHz
MSO/DSO/DSAX92804A	28.0 GHz
DSO/DSA93004L	30.0 GHz
MSO/DSO/DSAX93204A	32.0 GHz

Equipment Required

Description	Critical Specifications	Recommended Model/ Part Numbers
Microwave CW Generator	Maximum Frequency ≥ 32 GHz Power range: -20 dBm to +16 dBm into 50 Ω Output resistance = 50 Ω	Keysight E8257D with Opt 540
Power Splitter	2 Resistor Power Splitter Max Frequency ≥ 32 GHz	Keysight 11667C
Power Meter	Keysight E-series with power sensor compatibility	Keysight E4418B or E4419B
Power Sensor	Maximum Frequency ≥ 32 GHz Power range: -24 dBm to +16 dBm	Keysight 8487A or Keysight E4413B with 8485A-033
Microwave Cable	50 Ω Characteristic Impedance 2.4 mm (m) to 2.4 mm (m) SMA connectors Max Frequency ≥ 32 GHz	Keysight N5180-60204
Adapter	2.4 mm (m) to 3.5 mm (m) (qty. 1)	Keysight 11901A
Adapter	2.4 mm (m) to 3.5 mm (f) (qty. 2)	Keysight 11901C
Connector Saver	3.5 mm (f)-(f), shipped with MSO/DSO/DSAX 90000A and DSO/DSA93004L models	Keysight 5061-5311 (used with 20, 25, 28, 30, and 32 GHz oscilloscope models) Keysight 1250-3758 (used with 13 and 16 GHz oscilloscope models)

Connections



Notes

- Connect output 1 of the 11667C splitter to the scope Channel n input directly using the 11901A adapter and a connector saver (either 5061-5311 or 1250-3758 depending on the oscilloscope's bandwidth), without any additional cabling or adapters.
- Connect the power sensor directly to output 2 of the power splitter using the 11901C adapter without any additional cabling or adapters.
- Connect the microwave cable directly to output 3 of the power splitter using the 11901C adapter without any additional cabling or adapters.
- Minimize the use of other adapters.
- Ensure that 2.4 mm and 3.5 mm connectors are tightened properly:
8 in-lbs (90 N-cm) for 3.5 mm
8 in-lbs (90 N-cm) for 2.4 mm

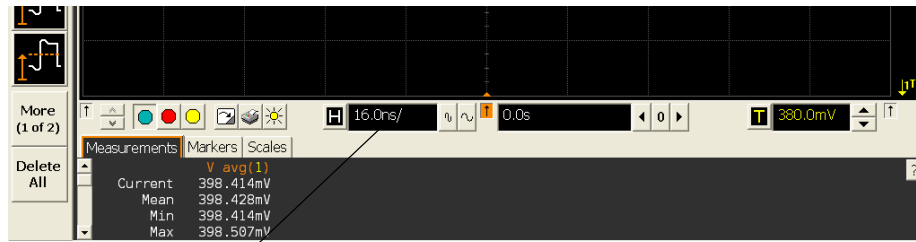
Procedure

- 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 oscilloscope 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 10 mV/div.

Chapter 3: Testing Performance

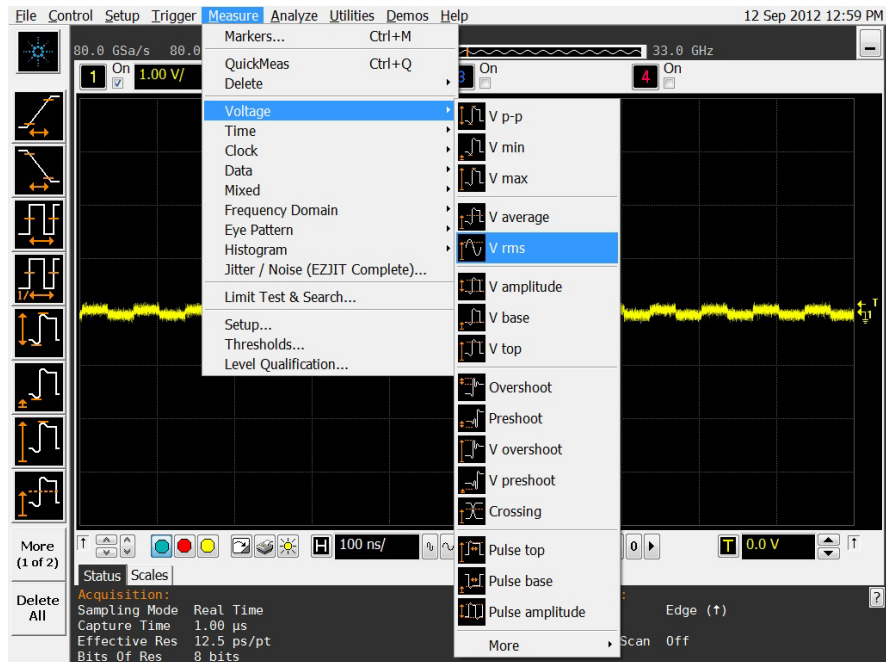
Analog Bandwidth -- Maximum Frequency Test

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

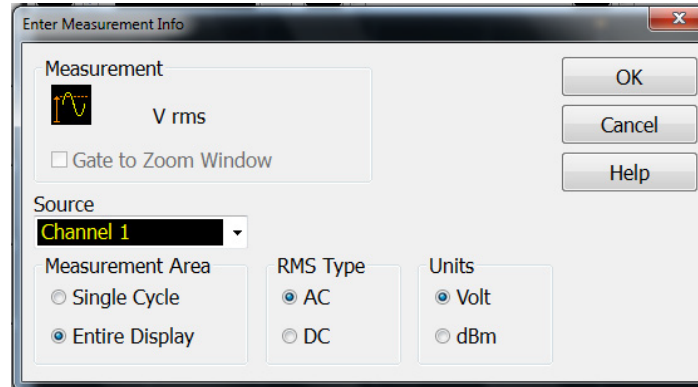


Click here and enter 16 ns

- d Select **Setup > Acquisition** and then set up the acquisition parameters as follows:
Sin(x)/x Interpolation = Auto
Analog Averaging = Disabled
Analog Memory Depth = Automatic
Analog Sampling rate = 80 GSa/s (maximum)
- e Select **Measure > Voltage > V rms**.



- f When the Enter Measurement Info 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	Generator Signal Amplitude (Vp-p)	Generator Signal Amplitude (dBm)
10 mV/div	0.08	-18
20 mV/div	0.16	-12
50 mV/div	0.4	-4
100 mV/div	0.8	+2
200 mV/div	1.6	+8
500 mV/div	4.0	+16
1 V/div	6.3	+20

- 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 (V_{in} @ 50 MHz).

Chapter 3: Testing Performance

Analog Bandwidth -- Maximum Frequency Test

- 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 (Vout @ 50 MHz).

Notes

- For all scope readings in this procedure, use the mean value in the Measurements display area at the bottom of the screen.

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.

- 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			
	MSO/DSO/DSA X 91304A	MSO/DSO/DSA X 91604A	MSO/DSO/DSA X 92004A	MSO/DSO/DSAX 92504A
Maximum Frequency	13 GHz	16 GHz	20 GHz	25 GHz
Scope Time Base Setting	50 ps/div	50 ps/div	50 ps/div	50 ps/div
	Model			
	MSO/DSO/DSA X 92804A	DSO/DSA 93004L	MSO/DSO/DSA X 93204A	
Maximum Frequency	28 GHz	30 GHz	32 GHz	
Scope Time Base Setting	50 ps/div	50 ps/div	50 ps/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

- 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:

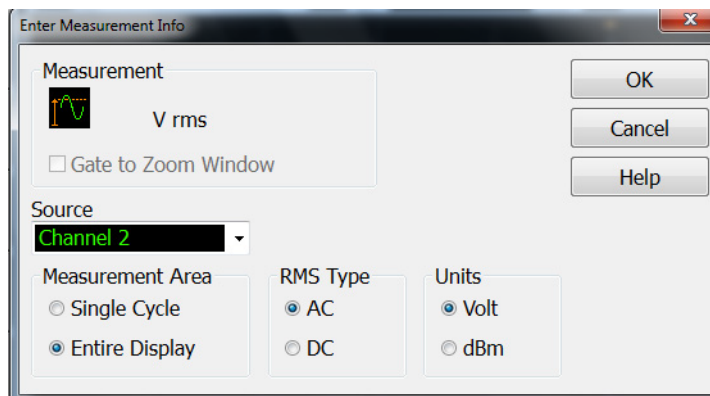
$$Gain_{Max\ Freq} = 20 \log_{10} \left[\frac{13.825\ mV / 13.461\ mV}{1.0023} \right] = 0.212\ dB$$

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.

Chapter 3: Testing Performance

Analog Bandwidth -- Maximum Frequency Test

- 16 Change the scope setup as follows:
 - a Change the channel vertical scale to 20 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 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 10 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 10 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 10 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) Test

This procedure verifies the maximum TSA specification for the oscilloscope.

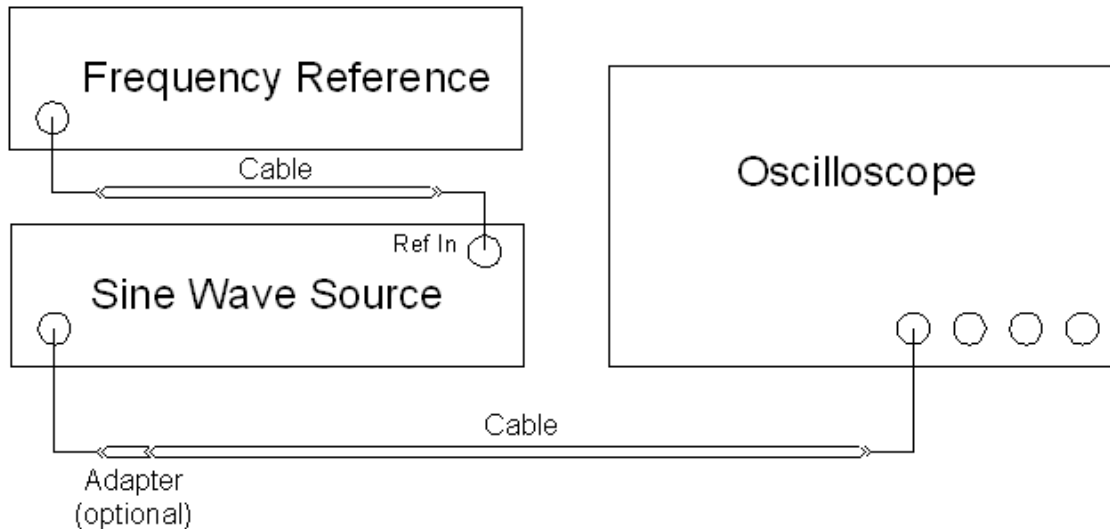
Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Synthesized sine wave source	Output Frequency: ≥ 10 MHz Output Amplitude: 0 dBm Frequency Resolution: 0.1 Hz	Keysight E8267D PSG
10 MHz frequency reference	Output Frequency: 10 MHz Absolute Frequency Error: $< \pm 0.0275$ ppm	Keysight 53132A opt. 012 frequency counter
RF cable	50 ohm characteristic impedance (no substitute) BNC (m) connectors Max Frequency: ≥ 50 MHz	Keysight 8120-1840
Adapters, assorted	3.5 mm (f) to Precision BNC (m) 3.5 mm (f) to 3.5 mm (f)	Keysight 54855-67604 Keysight 83059B

Chapter 3: Testing Performance Time Scale Accuracy (TSA) Test

Connections

Connect the equipment as shown in the following figure.



Procedure

- 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.
- 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. To do this, go under **Measure > Thresholds** in the top menu. Then select **Custom: level +/- Hysteresis** and enter 20 mV into the **Hysteresis** field and 0 V into the **Threshold Level** field.
- 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 since calibration (in years) in the table. The calibration date can be found in the Calibration menu window.
- 14 Calculate the test limits using the following formula and record them in the table.
Test Limits = $\pm(0.100 + 0.100 \times \text{Years Since Calibration})$
- 15 Record the results in the Performance Test Record.

Performance Test Record

Keysight Technologies

Keysight 90000-X Series / 90000-L 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 _____

Offset Accuracy Test

Zero Error Test

Vertical Scale	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
10 mV/div	-1.8 mV to +1.8 mV				
20 mV/div	-2.6 mV to +2.6 mV				
50 mV/div	-5.0 mV to +5.0 mV				
100 mV/div	-9.0 mV to +9.0 mV				
200 mV/div	-17.0 mV to +17.0 mV				
500 mV/div	-41.0 mV to +41.0 mV				
1 V/div	-81.0 mV to +81.0 mV				

Chapter 3: Testing Performance

Performance Test Record

Offset Gain Test

Vertical Scale	V _{Cal} Out Setting	V _{DMM} +	V _{DMM} -	V _{DMM} 0	V _{Scope} +	V _{Scope} -	V _{Scope} 0	Calculated Offset Gain Error	Offset Gain Error Test Limits
Channel 1									
10 mV/div	±400 mV								±2 %
20 mV/div	±400 mV								±2 %
50 mV/div	±700 mV								±2 %
100 mV/div	±1.2 V								±2 %
200 mV/div	±2.2 V								±2 %
500 mV/div	±2.4 V								±2 %
1 V/div	±2.4 V								±2 %
Channel 2									
10 mV/div	±400 mV								±2 %
20 mV/div	±400 mV								±2 %
50 mV/div	±700 mV								±2 %
100 mV/div	±1.2 V								±2 %
200 mV/div	±2.2 V								±2 %
500 mV/div	±2.4 V								±2 %
1 V/div	±2.4 V								±2 %
Channel 3									
10 mV/div	±400 mV								±2 %
20 mV/div	±400 mV								±2 %
50 mV/div	±700 mV								±2 %
100 mV/div	±1.2 V								±2 %
200 mV/div	±2.2 V								±2 %
500 mV/div	±2.4 V								±2 %
1 V/div	±2.4 V								±2 %
Channel 4									
10 mV/div	±400 mV								±2 %
20 mV/div	±400 mV								±2 %
50 mV/div	±700 mV								±2 %
100 mV/div	±1.2 V								±2 %
200 mV/div	±2.2 V								±2 %
500 mV/div	±2.4 V								±2 %
1 V/div	±2.4 V								±2 %

DC Gain Accuracy Test

Vertical Scale	V _{Cal Out} Setting	V _{DMM+}	V _{DM} M-	V _{Scope+}	V _{Scope-}	Calculate d DC Gain Error	DC Gain Error Test Limits
Channel 1							
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	±2.4 V						±2 %
Channel 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	±2.4 V						±2 %
Channel 3							
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	±2.4 V						±2 %
Channel 4							
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	±2.4 V						±2 %

Chapter 3: Testing Performance

Performance Test Record

Analog Bandwidth - Maximum Frequency Check

Max frequency: MSO/DSO/DSAX91304A = 13 GHz, MSO/DSO/DSAX91604A = 16 GHz, MSO/DSO/DSAX92004A = 20 GHz, MSO/DSO/DSAX92504A = 25 GHz, MSO/DSO/DSAX92804A = 28 GHz, DSO/DSA93004L = 30 GHz, MSO/DSO/DSAX93204A = 32 GHz .

Vertical Scale	Measurement					
	Vin @ 50 MHz	Vout @ 50 MHz	Calculated Gain @ 50 MHz (Test Limit = greater than -3 dB)	Vin @ Max Freq	Vout @ Max Freq	Calculated Gain @ Max Freq (Test Limit = greater than -3 dB)
Channel 1						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						
Channel 2						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						
Channel 3						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						
Channel 4						
10 mV/div						
20 mV/div						
50 mV/div						
100 mV/div						
200 mV/div						
500 mV/div						
1 V/div						

Time Scale Accuracy

Measured Time Scale Error (ppm)	Years Since Calibration (years)	Low Test Limit (ppm)	High Test Limit (ppm)	Pass/Fail
_____	_____	_____	_____	_____

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Troubleshooting

The service strategy for troubleshooting Keysight 90000 X-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.

Read the Safety Notices at the back of this guide before servicing the oscilloscope. Before performing any procedure, review any cautions and warnings included in the procedures.

The only equipment you need for troubleshooting to the assembly level is basic electronic troubleshooting tools such as a digital multimeter. If you need to remove and replace any assembly, refer to the "Replacing Assemblies" chapter.

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.

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 let these fan blades come in contact 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.

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.

Primary Trouble Isolation

The main procedural tool in this chapter is the flowchart. The Primary Trouble Isolation flowchart in [Figure 4-1](#) shows the entire troubleshooting path from a failed oscilloscope to a working one, and directs you to other sections in this chapter where the procedures are described in detail. Reference letters on the flowcharts in this chapter point to procedural steps that explain the brief instructions in the flowchart.

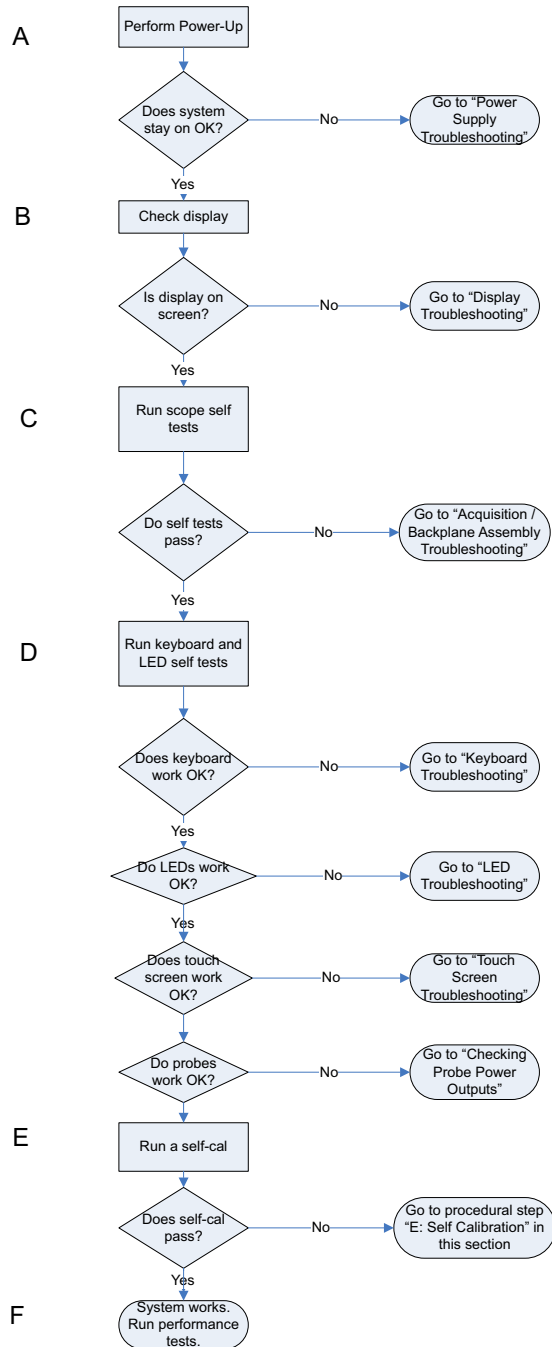


Figure 4-1 Primary Trouble Isolation Flowchart

Chapter 4: Troubleshooting

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 4-2](#), depending on the setup selected before the oscilloscope was turned off.

Figure 4-2 Power-on display



If the oscilloscope turns off without you pressing the front panel power button, go to the “Power Supply Troubleshooting” section of this chapter.

If the oscilloscope does not start up at all, unplug the oscilloscope, wait 30 seconds, plug the oscilloscope back in, and turn the power on. If it still does not start up, go to the “Setting Up the BIOS” and “Motherboard Verification” sections of this chapter.

B Check the display.

If the screen is black or has a scrambled display, go to the “Display Troubleshooting” section of this chapter.

If the display shows MEMCON1, MEMCON2, MEMCON3, or MEMCON4 errors during boot-up of the oscilloscope software, the lower acquisition board is faulty and requires replacement. MEMCON5, MEMCON6, MEMCON7, and MEMCON8 errors indicate the upper acquisition board is faulty and requires replacement.

C Run the oscilloscope self-tests.

- 1 Select Self Test from the Utilities menu.
- 2 Select Scope Self Test from the Self Test drop-down list box.
- 3 Click **Start Test** and follow the instructions on the screen.

If any of the self tests fail, go to the “Acquisition/Backplane Assembly Troubleshooting” section of this chapter for further troubleshooting.

D Check the front panel response by running the Keyboard and LED self tests.

Follow these steps 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 Test**.

The Front Panel Keyboard Test window appears with a symbolic representation of the keyboard. See

Figure 4-3.

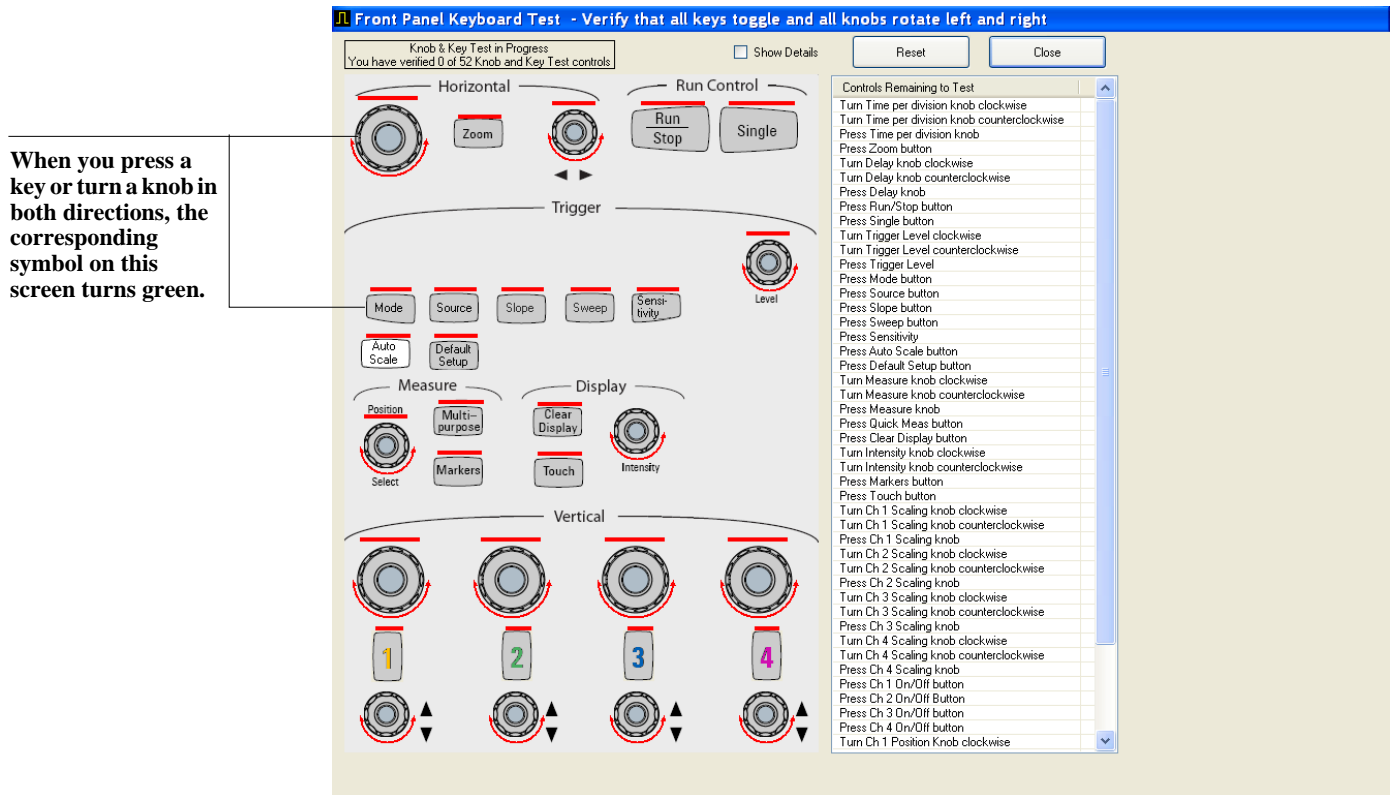


Figure 4-3 Knob and key self test screen

- 3 Press each key on the keyboard until you have pressed all keys. When you press a key or push a knob, the bar above the corresponding key/knob symbol on the display should change from red to green.
 - 4 Turn each knob in both directions until you have turned all knobs. 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.
 - 5 When you are finished, click **Close**.
 - 6 If any of the knobs or keys do not work, go to “Keyboard Troubleshooting” later in this chapter.
- Follow these steps 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 Front Panel LED Test screen appears, showing a symbolic representation of all front panel LED indicators. See Figure 4-4.

Chapter 4: Troubleshooting

Primary Trouble Isolation

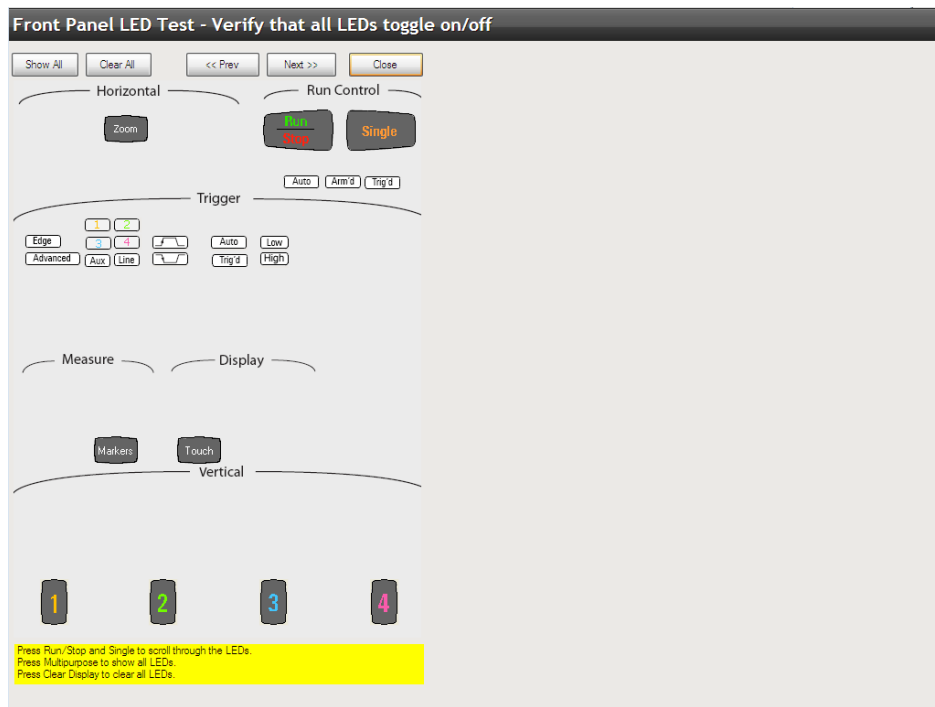


Figure 4-4 LED test screen

- 3 Repeatedly press **[Single]** on the front panel to step through and highlight each LED symbol in the test screen. You can also step through the LEDs by pressing the **<< Prev** or **Next >>** buttons on the 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, and 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 “LED Troubleshooting” later in this chapter.
 - 6 If both tests pass, make sure the touch screen and probes work properly and then go to step E.
- E** Run a self calibration.
- 1 Complete a self calibration by following the procedures in chapter 2.
 - 2 If the calibration test fails, look at the details to find the channel associated with the fail.
 - If the failure is associated with channel 1, look at the specific calibration that failed. If it was a trigger cal, a timebase cal, or an interpolator gain cal, replace the backplane board because it is likely the problem. If the cal still fails, replace the lower acquisition board.
 - If the failure is associated with channel 1 but is not a trigger cal, a timebase cal, or an interpolator gain cal, replace the lower acquisition board. If the cal still fails, replace the backplane board.
 - If the failure is not associated with channel 1, replace the acquisition board associated with that channel (channels 1 and 2 - lower acquisition board, channels 3 and 4 - upper acquisition board).
 - If all four channels have cal failures, the problem may be with the calibrator located on the backplane board, so replace that board first. If the calibration test passes, go to step F.
- F** The system is operational. Verify that the oscilloscope meets all warranted specifications by following the procedures in the “Testing Performance” chapter.

Power Supply Troubleshooting

This section provides information to help you isolate the problem to the assembly level when the power system is not operating.

There are three main types of faults:

- Under-voltage faults
- Over-temperature faults
- Over-voltage faults

To determine what type of fault is occurring, and what assembly needs to be replaced, follow these steps:

- 1 Unplug the oscilloscope so the +5V standby power supply can fully discharge.
- 2 Wait 30 seconds.
- 3 Plug the oscilloscope back in.
- 4 Wait 5 seconds.
- 5 Press the front panel power button and count how many seconds it takes for the oscilloscope to lose power again. Keep the oscilloscope plugged in when it loses power.
 - If it takes about 2 seconds for the oscilloscope to lose power, you likely have an under-voltage fault.
 - If it takes 4 seconds or more for the oscilloscope to lose power, you likely have an over-temperature fault.
 - If the oscilloscope never powers up, or flickers then shuts off immediately, you likely have an over-voltage fault or a defective bulk +12V power supply.

There are two sets of LEDs on the backplane assembly and one set on each acquisition assembly. Seeing which of these LEDs are illuminated will help you identify the reason for the power failure.

WARNING

SHOCK HAZARD!

The maintenance described in this section is performed with power supplied to the oscilloscope and with the protective covers removed. Only trained service personnel who are aware of the hazards involved should perform the maintenance. Read the safety notices at the back of this guide before proceeding. Failure to observe safety precautions may result in electric shock.

WARNING

SHOCK HAZARD!

Once the bulk +12V power supply is removed from the oscilloscope, two AC leads located on the supply are exposed and severe shock can result if touched. Extreme care should be taken to avoid contact with these leads when removing or testing the bulk +12V power supply.

To locate all four sets of LEDs, remove the handle, outer oscilloscope cover, and inner top cover to expose the motherboard cavity and top edges of the backplane assembly.

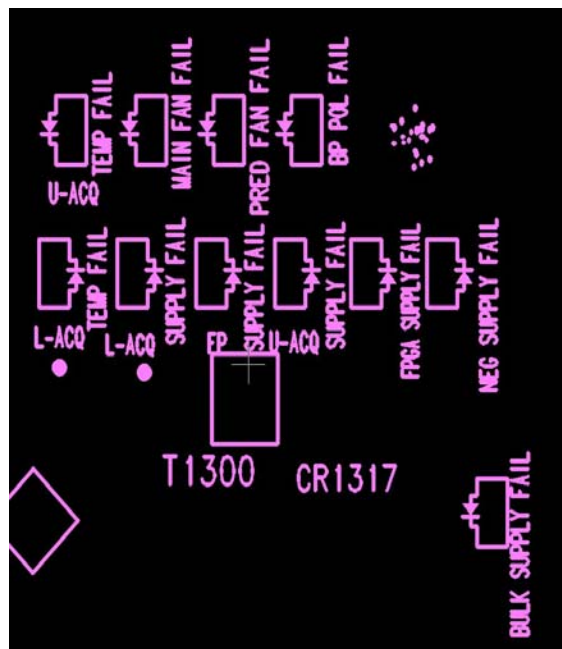
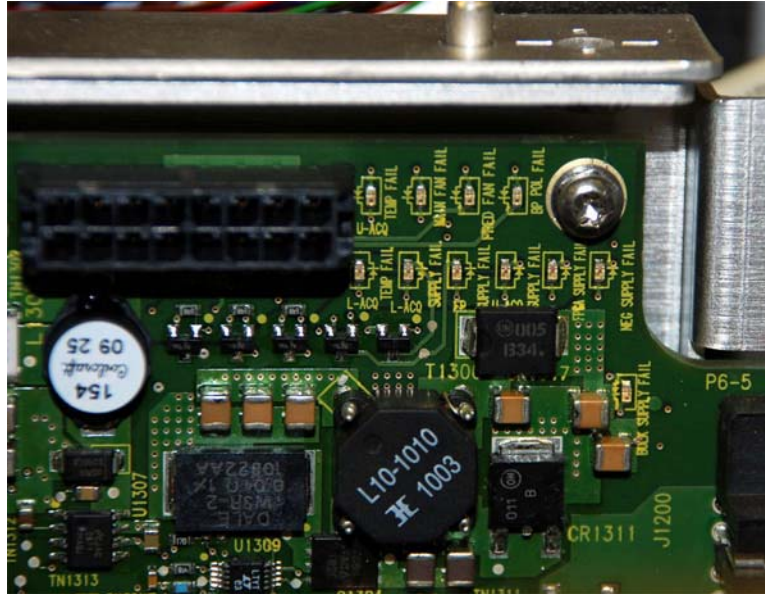
The first set of LEDs is located in the upper right corner of the backplane assembly (see [Figure 4-5](#)). Six of the LEDs indicate an under-voltage fault, and four indicate an over-temperature fault. Another LED in this group is BULK SUPPLY FAIL, located below NEG SUPPLY FAIL. It lights up if the bulk

Chapter 4: Troubleshooting

Power Supply Troubleshooting

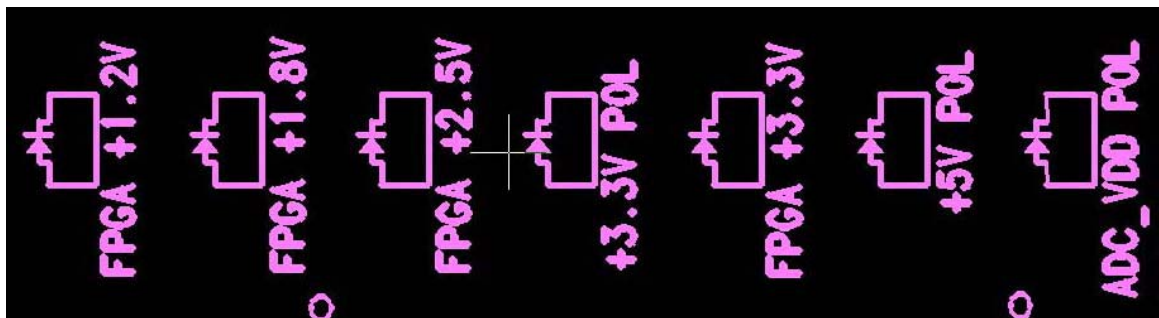
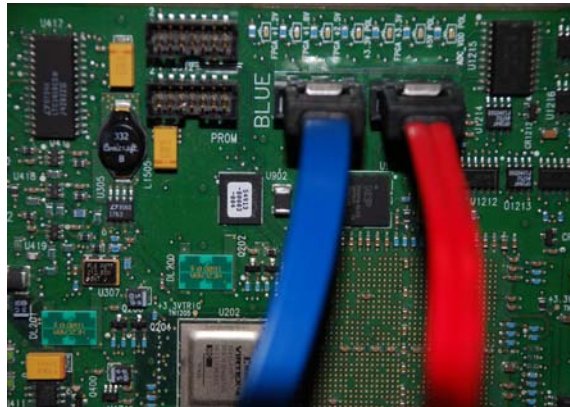
supply needs replacing.

Figure 4-5 Under-voltage, over-temperature, and bulk supply indicator LEDs on backplane assembly



The other three groups of LEDs indicate over-voltage faults. One group is located near the center of the top edge of the backplane assembly just above the blue and red SATA cables (see [Figure 4-6](#)).

Figure 4-6 Over-voltage indicator LEDs on backplane assembly



If any of these LEDs are lit, the backplane assembly must be replaced.

Locate the other two groups of over-voltage fault LEDs along the edges of the two acquisition assemblies. They are visible through the bottom fan opening located on the left side of the oscilloscope, nearest the rear panel (see [Figure 4-7](#) and [Figure 4-8](#)).

Chapter 4: Troubleshooting

Power Supply Troubleshooting

Figure 4-7 Over-voltage indicator LEDs on acquisition assembly behind fan

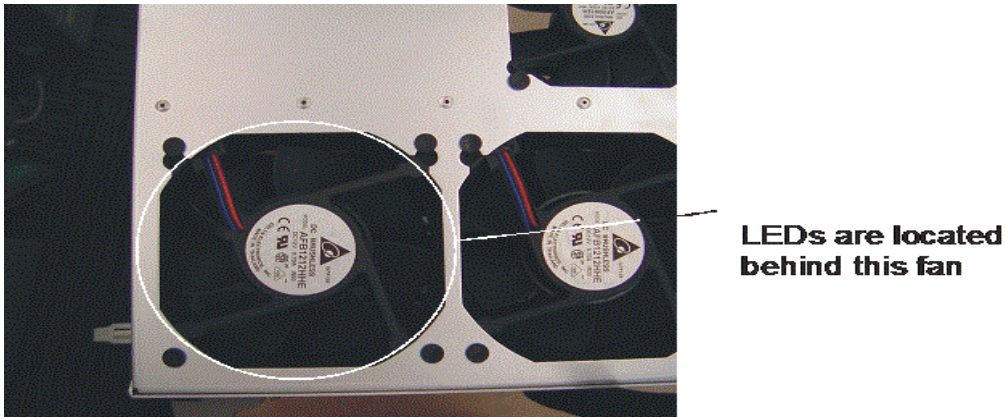
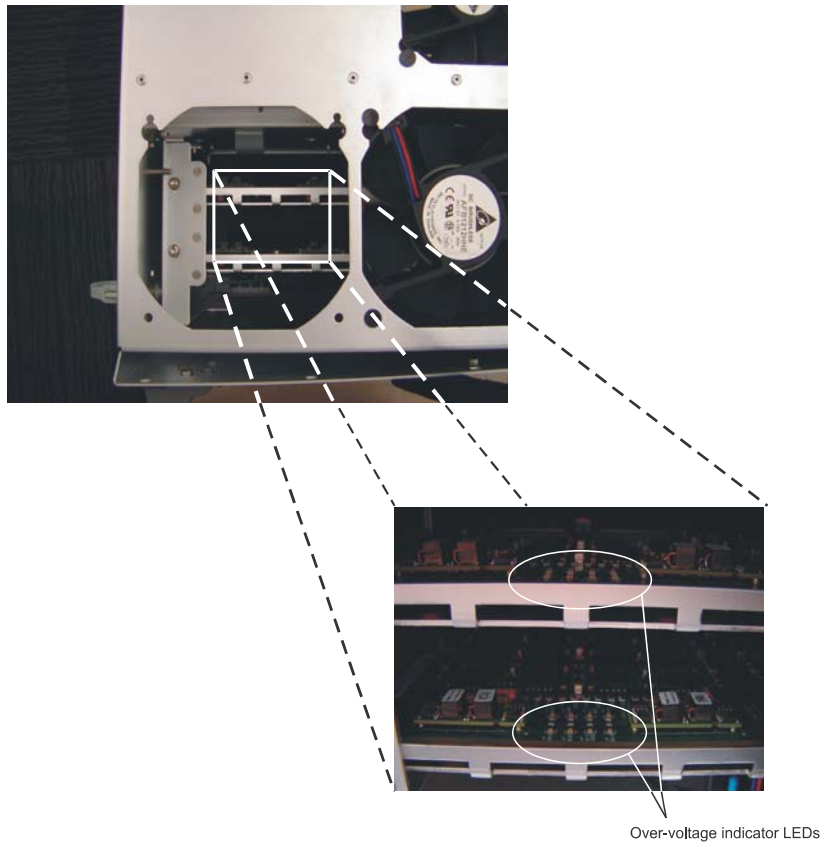


Figure 4-8 shows the fan opening with the fan removed. You do not need to remove the fan to diagnose a problem; you can see the LEDs through the fan.

Figure 4-8 Over-voltage indicator LEDs with fan removed



The acquisition assembly nearest the bottom of the oscilloscope is the channels 1 and 2 acquisition assembly (LOWER ACQ) and the one above it is the channels 3 and 4 acquisition assembly (UPPER ACQ). If you look through the fan and see any of the over-voltage LEDs lit, that acquisition assembly needs to be replaced.

The following table shows each LED, the type of fault it indicates, and what to do if that LED indicator is illuminated.

LED	Type of Fault	What To Do
-----	---------------	------------

Group of 11 LEDs on Backplane Assembly

LED	Type of Fault	What To Do
L-ACQ TEMP FAIL	Over-temperature	Go to “If the L-ACQ TEMP FAIL or U-ACQ TEMP FAIL LED is Lit”
L-ACQ SUPPLY FAIL	Under-voltage	Replace channels 1 and 2 acquisition assembly (LOWER ACQ)
FP SUPPLY FAIL	Under-voltage	Go to “If the FP SUPPLY FAIL LED is Lit”
U-ACQ SUPPLY FAIL	Under-voltage	Replace channels 3 and 4 acquisition assembly (UPPER ACQ)
FPGA SUPPLY FAIL	Under-voltage	Replace backplane assembly
NEG SUPPLY FAIL	Under-voltage	Replace backplane assembly
U-ACQ TEMP FAIL	Over-temperature	Go to “If the L-ACQ TEMP FAIL or U-ACQ TEMP FAIL LED is Lit”
MAIN FAN FAIL	Over-temperature	Go to “If the MAIN FAN FAIL LED is Lit”
PRED FAN FAIL	Over-temperature	Go to “If the PRED FAN FAIL LED is Lit”
BP POL FAIL	Under-voltage	Replace backplane assembly
BULK SUPPLY FAIL		Replace bulk supply

Group of 7 LEDs on Backplane Assembly

FPGA +1.2V	Over-voltage	Replace backplane assembly
FPGA +1.8V	Over-voltage	Replace backplane assembly
FPGA +2.5V	Over-voltage	Replace backplane assembly
+3.3V POL	Over-voltage	Replace backplane assembly
FPGA +3.3V	Over-voltage	Replace backplane assembly
+5V POL	Over-voltage	Replace backplane assembly
ADC_VDO POL	Over-voltage	Replace backplane assembly

LEDs on Each Acquisition Board

U1101 oV	Over-voltage	Replace acquisition assembly
U303L oV	Over-voltage	Replace acquisition assembly
U1600 oV	Over-voltage	Replace acquisition assembly
U1100 oV	Over-voltage	Replace acquisition assembly
U300 3.3V oV	Over-voltage	Replace acquisition assembly
U300 2.5V oV	Over-voltage	Replace acquisition assembly
U303R oV	Over-voltage	Replace acquisition assembly
U1601 oV	Over-voltage	Replace acquisition assembly

If the FP SUPPLY FAIL LED is Lit

If the FP SUPPLY FAIL LED is the only one lit, there might be a problem with one of the supplies that goes to the front panel assembly, or a problem on the front panel assembly. Unplug the front panel power connector (see cable connector circled in [Figure 4-9](#)) and turn the oscilloscope on again. If no other under-voltage indicator LEDs on the backplane assembly turn on, the fault is on the front panel assembly and it should be replaced. If either the BP POL FAIL or NEG SUPPLY FAIL LEDs turn on, then replace the backplane assembly and confirm that the fault goes away with the front panel power reconnected to the backplane assembly.

Figure 4-9 Front Panel Power Cable Connector



If the oscilloscope turns off again and no under-voltage fault indicator LEDs are lit, the bulk +12V supply may be defective and may need to be replaced.

Be sure to verify the operation of the AC OK and DC OK signals first. The AC OK signal indicates that the applied AC signal is within the specified input range (TTL high logic level indicates that AC input is good). It is possible for this signal to indicate that the AC input is not within the requested range even though it is correct. The DC OK signal indicates whether the main output from the supply (+12.6V) is good (TTL high logic level indicates the DC output is good). It is possible for this output to be false even though the supply output is correct.

It is also possible that there is a short circuit on the bulk +12V supply trace somewhere in the system, which would also cause the unit not to power on. If so, you need to isolate the assembly that is shorted. You do not need to remove the acquisition or backplane assemblies to perform the following steps.

- 1 With the power turned off, disconnect the bulk +12V supply (see [Figure 4-10](#)), but do not remove the supply from the oscilloscope.
- 2 On the backplane assembly, measure the resistance across the FET (Q1409, located in the upper right corner of the backplane) between +12V and ground as shown in [Figure 4-13](#), or measure the resistance across the bulk supply input pins on the backplane assembly. Make sure the red lead is plugged into the HI output and the black lead is plugged into the LO or COMMON input of the DVM. On a good backplane assembly, you should measure about 700 ohms. If there is a short on this board, you would measure something very near 0 ohms.
- 3 If there is a short, disconnect the power cable to the front panel (see [Figure 4-9](#)) and redo the resistance measurement.

- 4 If the short is gone, replace the front panel assembly and verify that the oscilloscope now powers on.
- 5 If there is still a short circuit, disconnect the two large connectors that provide power to the motherboard (J1201 and J1202) from the backplane assembly (see the circled cable connections in [Figure 4-11](#)) and redo the resistance measurements across the FET (Q1409) or the bulk supply input pins on the backplane assembly.
- 6 If the short is gone, replace the motherboard assembly and confirm that the unit will power on.

Figure 4-10 Power supply disconnect



Figure 4-11 Cable connection into backplane



- 7 If there is still a short circuit, remove both acquisition boards and unplug them from the backplane assembly.
- 8 Measure each assembly individually to see if there is a short between the +12V trace and ground (see [Figure 4-12](#)). You should see a resistance of about 2000 ohms between the +12V trace and ground on a good acquisition assembly. Make sure you make the measurement using a DVM with the red lead plugged into the HI input and the black lead plugged into the LO or COMMON input of the DVM. If there is a short between these two traces, the reading you get will be very low (near 0 ohms). Replace either assembly if needed.

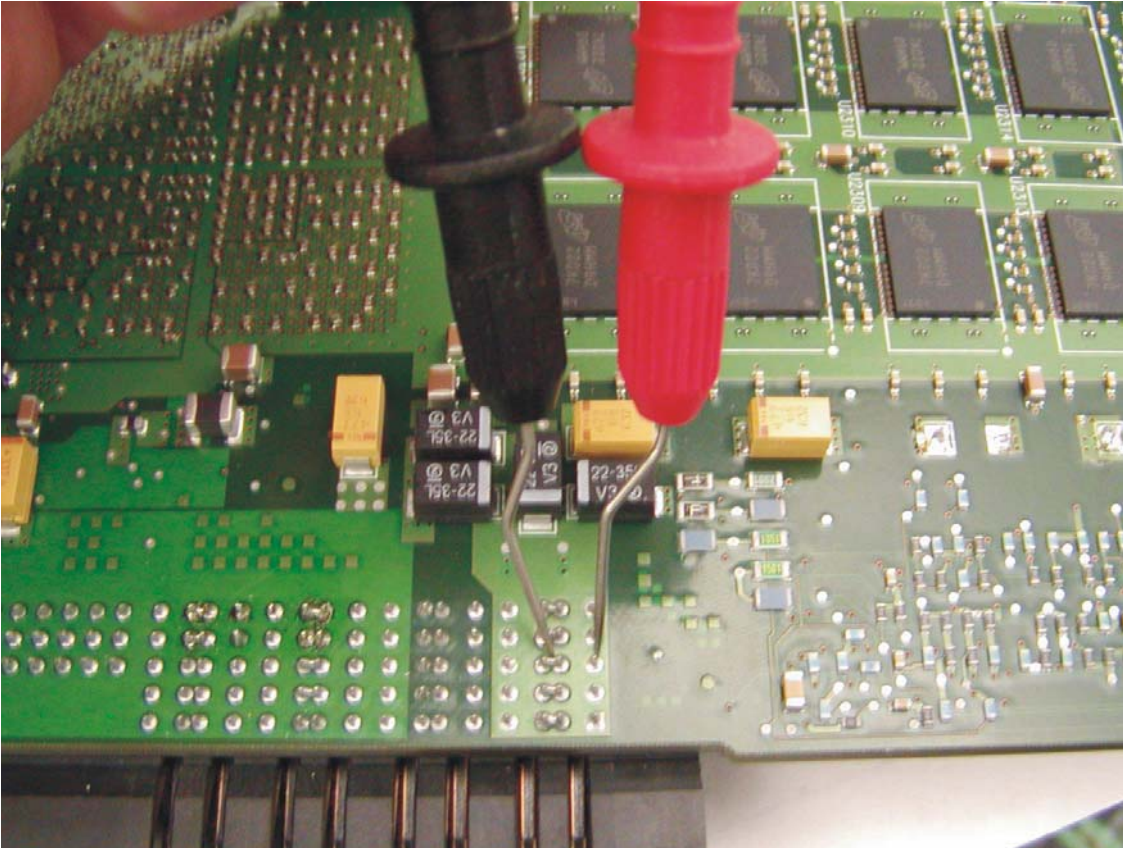


Figure 4-12 Measuring the acquisition assembly resistance between +12V and ground

If no shorts are found on the bulk +12V supply trace or if you have fixed all the shorts and the oscilloscope still will not turn on, follow these steps, which include replacing parts with known good parts until you discover the problem.

- 1** Replace the bulk +12V power supply with a known good supply.
- 2** If the oscilloscope still does not power on, replace the motherboard with a known good one.
- 3** If the oscilloscope still does not power on, then the backplane assembly is causing the problem and must be replaced.
- 4** Once the faulty board or switch is discovered, be sure to reinstall all other parts that were removed, as they were not the cause of the problem.

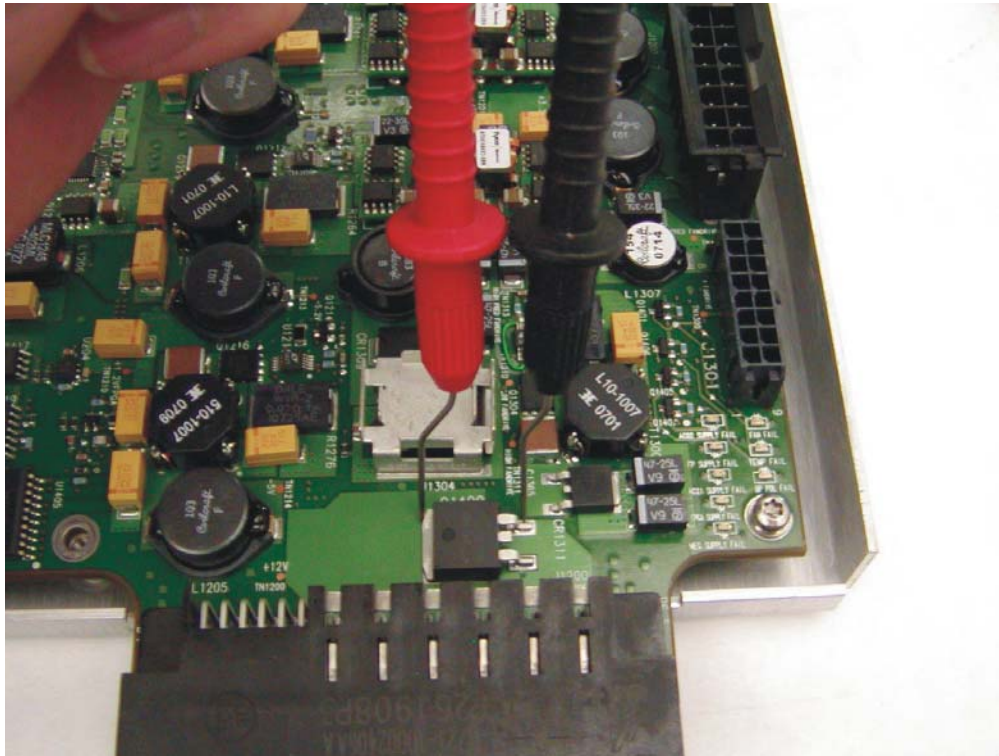


Figure 4-13 Measuring the backplane assembly resistance between +12V and ground across Q1409.

If the MAIN FAN FAIL LED is Lit

If the MAIN FAN FAIL LED is lit, the problem is a cooling system failure.

Four fans are located on the left side of the oscilloscope to cool it. It is possible that the circuitry that generates the reference potential for the fans has failed. This circuitry failure would cause the fans to stop turning and the oscilloscope to shut down.

It is unlikely that all four case fans would become faulty simultaneously and stop turning. It is more likely that the high side drive circuitry for the case fans failed.

Follow these steps to diagnose a main fan failure:

- 1 Reset the sensing and shutdown logic by removing the AC power until the green LED on the motherboard goes out (or just wait 30 seconds).
- 2 Move around to the left side of the oscilloscope so you can see the case fans ([Figure 4-14](#)).

Figure 4-14 Case fans



- 3 Apply AC power to the oscilloscope and turn it on if it does not start up automatically. Visually check to see if any of the fans are not turning. If none of the fans are turning, it is likely a problem with the high side drive circuitry for the case fans. In that case, you would replace the backplane assembly. If any of the fans are turning, then they are probably not the cause of your shutdown problem. (You should still replace any fans that are not turning, however.)

WARNING

INJURY CAN RESULT!

The following procedure requires you to touch fan hubs with objects or to use objects to stop the fan blades from moving. Use caution when working near the cooling fans with the covers removed from the oscilloscope. The cooling fan blades are exposed on one side and can be hazardous. Be careful not to touch the moving fan blades with any part of your body.

If the oscilloscope still shuts down, follow these steps:

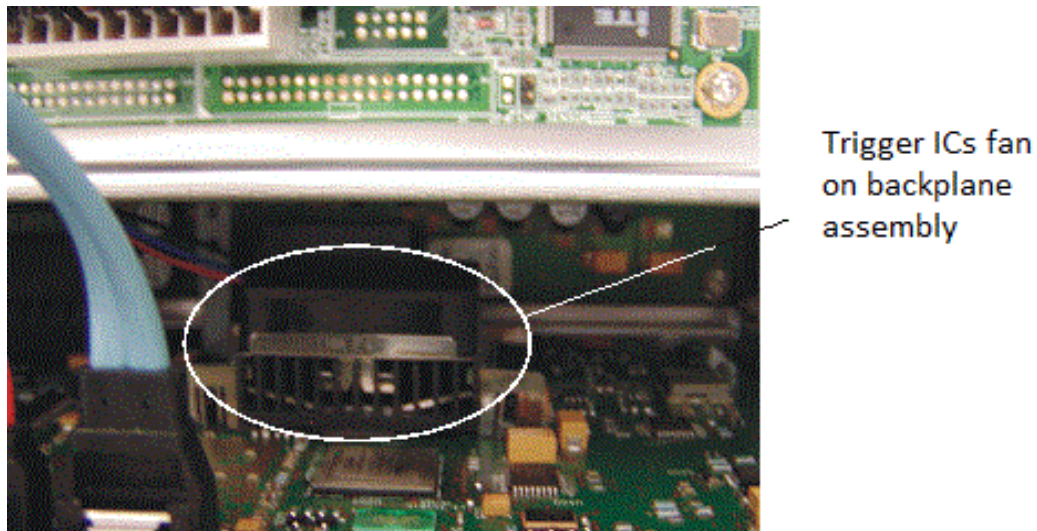
- 1 Replace all the case fans.
- 2 Reset the logic by removing AC power for 30 seconds and make all of the case fans so they cannot rotate. For example, have two people hold the four fan hubs or insert an object between the blades of each of the fans.
- 3 Power the oscilloscope back on. If it shuts down again, the fan sensing and shutdown function is operating properly. Replace the backplane.

If the PRED FAN FAIL LED is Lit

In addition to four case fans, there is also a single fan attached to the backplane assembly that cools the trigger ICs. It is possible that this fan failed, or that the rotation sensor for the fan failed. This sensor lets the oscilloscope know that the fan is turning. If the sensor is faulty, the oscilloscope may think the fan is not working when it actually is.

If the PRED FAN FAIL indicator LED on the backplane assembly is lit, the system thinks there is a trigger ICs fan failure. To check, reset the sensing and shutdown logic by removing the AC power until the green LED on the motherboard goes out (or just wait 30 seconds). Then position yourself so you can see the trigger ICs fan on the backplane assembly. Because this fan is on the bottom of the backplane it is somewhat hidden by the acquisition assembly. Look down the backplane board to see it from above. (See [Figure 4-15](#).)

Figure 4-15 Trigger ICs fan on backplane assembly



Apply AC power and turn the oscilloscope on if it does not start up on its own. Notice whether the trigger ICs fan is turning. If it is not, replace it and redo this part of the diagnostic test. If it is turning and the oscilloscope still turns off again, then consider these possibilities:

- If the trigger ICs fan was turning, the problem is most likely that the rotation sensor on the ICs fan is defective. Replace the trigger ICs fan and redo this part of the diagnostic test.
- If the oscilloscope stays on after you reset the shutdown logic (by removing AC power for 30 seconds) and powered it back on, then you have fixed the shutdown problem.
- If the oscilloscope shuts down again after you have replaced the trigger ICs fan, then the problem could be that the rotation sensor for all the fans located on the backplane assembly failed, so replace the backplane assembly and redo this part of the diagnostic test.

If the L-ACQ TEMP FAIL or U-ACQ TEMP FAIL LED is Lit

If the oscilloscope shuts down and either the L-ACQ TEMP FAIL or U-ACQ TEMP FAIL indicator LEDs is lit, then one of the scope channels is getting too hot or the temperature sensing circuitry has failed. Normally, you would have to turn the oscilloscope on and leave it on for awhile before you would see a shutdown caused by temperature problems. If all the fans are turning, it is unlikely that the oscilloscope would shut down due to temperature unless the airflow is being restricted or the input air is already too hot to cool the insides of the oscilloscope.

It is possible that all the case fans and the trigger ICs are working, but the oscilloscope still shuts down because of temperature due to one or more of the channels malfunctioning and drawing too much current. If so, you would need to replace the indicated acquisition assembly. It is also possible for one of the heat sinks on one of the acquisition assemblies' critical parts to become detached and cause that part to overheat and shut down the oscilloscope.

Setting 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. To configure the motherboard BIOS parameters to the default settings, follow these steps:

- 1 Connect the power cable to the 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, F11 to Boot Menu.

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 Optimal Defaults** and press **Enter** for optimized values, or go to **Load Failsafe Defaults** and press **Enter** for fail-safe values. Select **OK** 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**.

Motherboard Verification

If you have been through the Power Supply Troubleshooting section of this chapter and the oscilloscope still does not stay powered up, the problem may be with the motherboard. To diagnose this problem, follow these steps.

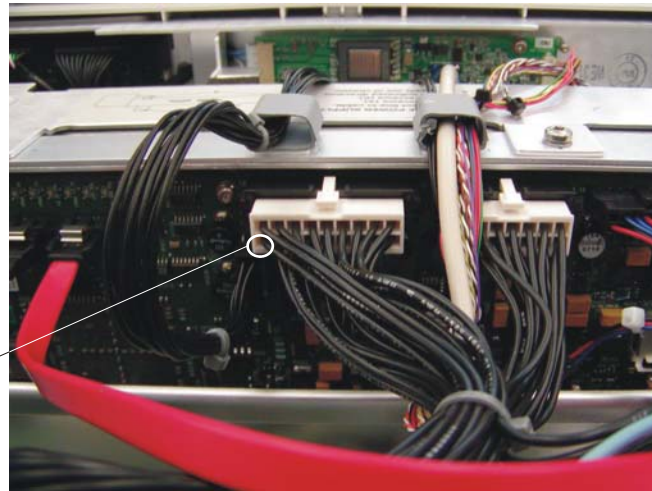
- 1 Remove the handle, outer case, and top shield.
- 2 Turn the oscilloscope on.

If the unit beeps once after about 5 to 10 seconds but fails to boot up, the motherboard is defective and needs to be replaced.

If the unit fails to beep after it is powered on, then measure the potential relative to the chassis at pin 9 of J1201 (Figure 4-16). Pin 9 is the reset line for the motherboard. It is controlled by the backplane. You should measure about 3.3V. If the potential you measure is correct, but the unit still has not beeped and started up, the motherboard is defective and needs to be replaced.

Figure 4-16 Measure potential relative to chassis at pin 9 of J1201

Pin 9 is located underneath this connection (bottom left hand pin if facing backplane assembly from rear of oscilloscope)



- 3 If the potential you measure is not correct, shut the oscilloscope down and unplug the AC cord from the rear of the instrument.
- 4 Unplug the front panel power cable (Figure 4-9), the two large power cables that go to the motherboard (J1201 and J1202 as shown in Figure 4-11), and the red and blue SATA cables (J900 and J901) from the backplane assembly. Do not allow the two SATA cables to touch the backplane assembly and cause a short circuit.
- 5 Plug the AC power back into the oscilloscope and turn the unit on if it does not come on automatically.
- 6 Measure the potential relative to the chassis at pin 9 of J1201 again.

If you measure the required 3.3V, the motherboard is defective and needs to be replaced.

If you did not measure the correct voltage, the backplane assembly is defective and must be replaced.
- 7 Be aware that there could be a fault on the motherboard that caused the backplane assembly to fail so before you plug the motherboard cables back into the new backplane assembly, measure the resistance to the chassis from the pin 9 contact in the connector that plugs into J1201. If you measure a very low resistance or a short circuit to the chassis, replace the motherboard and then assemble the instrument and confirm the unit beeps and boots up properly.

Display Troubleshooting

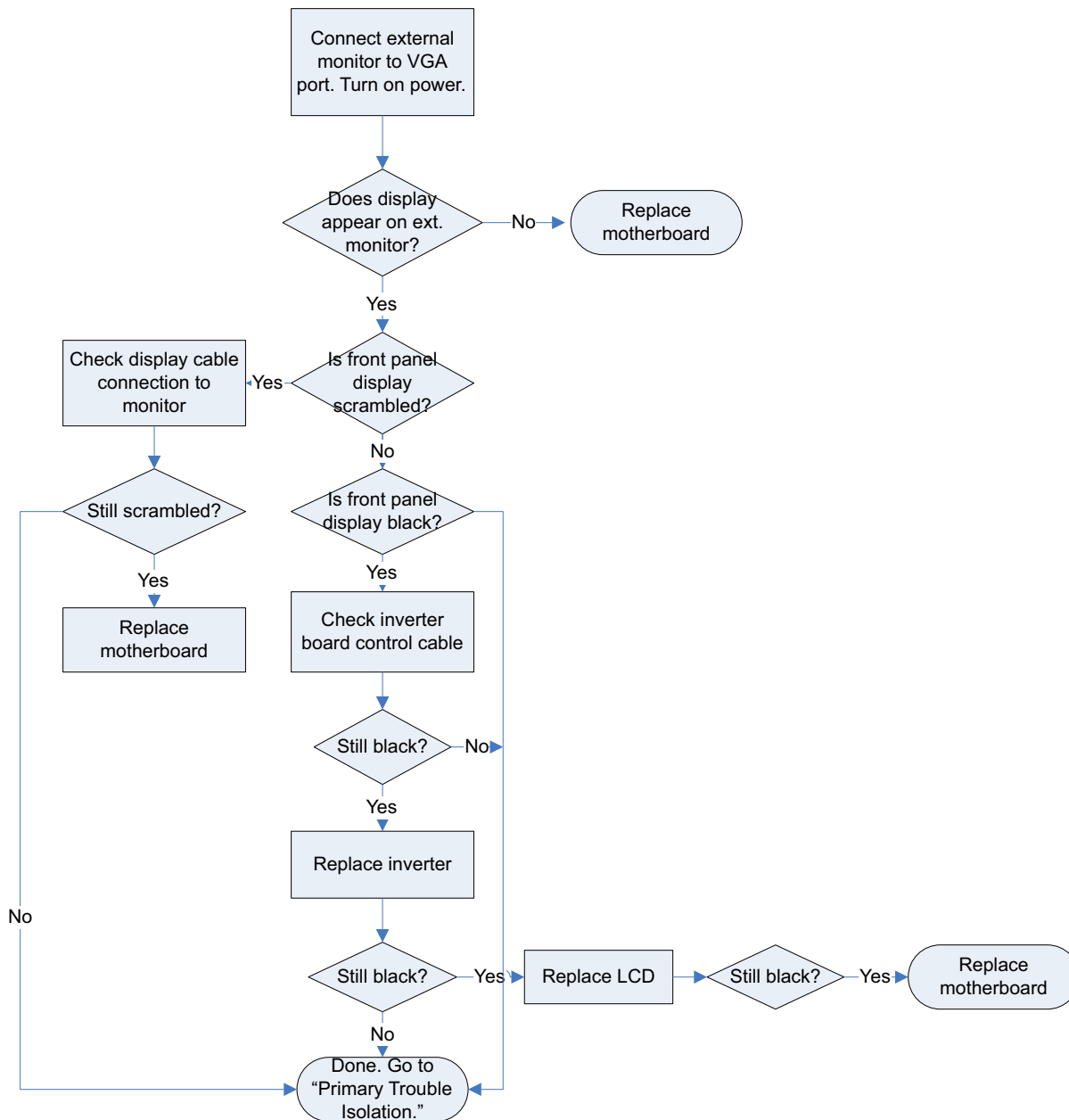


Figure 4-17 Display Troubleshooting Flowchart

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 let these fan blades come in contact with any part of your body.

For information on how to replace the display parts, see the "Replacing Assemblies" chapter.

Acquisition/Backplane Assembly Troubleshooting

This section describes which board assembly to replace if any of the scope self tests fail. When the self-test error message file is generated it is sent to the following location:

C:\ProgramData\Agilent\Infiniium\selftest\selftestlog.txt

The error message usually indicates the channel with the error. Channels 1 and 2 are on the lower acquisition board. Channels 3 and 4 are on the upper acquisition board. Replace the acquisition assembly that has the error.

If the error message does not indicate a channel, refer to the following table to determine which assembly to replace.

Test Group and Test Name	Error Type	Assembly to Replace
Timebase Test Group		
Timebase Interpolator Test		Backplane assembly
ADC Test Group		
ADC Register Tests	ADC1, ADC2, ADC3, ADC4	Lower acquisition assembly
	ADC5, ADC6, ADC7, ADC8	Upper acquisition assembly
ADC Voltage Test Points	ADC1, ADC2, ADC3, ADC4	Lower acquisition assembly
	ADC5, ADC6, ADC7, ADC8	Upper acquisition assembly
Acquisition Memory Test Group		
Hedwig MBIST		
Hedwig Register Tests		
Hedwig-DDR2 Addr & Data Test	MEMCON_1, MEMCON_2, MEMCON_3, MEMCON_4	Lower acquisition assembly
	MEMCON_5, MEMCON_6, MEMCON_7, MEMCON_8	Upper acquisition assembly
Hedwig DDR2 Stress Test	Memory Controller 1-4	Lower acquisition assembly
	Memory Controller 5-8	Upper acquisition assembly
Hedwig DDR2 Interface	Hedwig1, Hedwig2, Hedwig3, Hedwig4	Lower acquisition assembly
	Hedwig5, Hedwig6, Hedwig7, Hedwig8	Upper acquisition assembly
Misc. Scope Test Group		
Temp Sensor Tests	Hedwig0, Hedwig1, Hedwig2, Hedwig3, Oak0	Lower acquisition assembly
	Hedwig4, Hedwig5, Hedwig6, Hedwig7, Oak2	Upper acquisition assembly
	Pred1, Pred2, MainFPGA	Backplane assembly
Acq Flash RAM Tests	Test is currently not being run.	

Keyboard Troubleshooting

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 nonoperating 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.

LED Troubleshooting

If you see a failure with the on/off switch backlight LED, replace the On/Off board. If the LED will still not illuminate, replace the motherboard and see if this fixes the problem. If the LED still does not work, the last option is to check the on/off cable connecting the On/Off board to the motherboard.

If any of the other LEDs are not working on the front panel, the first step is to troubleshoot the acquisition assemblies to make sure they are working. If they are working, 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, be sure to reinstall all boards that were replaced, but that were not causing the problem.

Touch Screen Troubleshooting

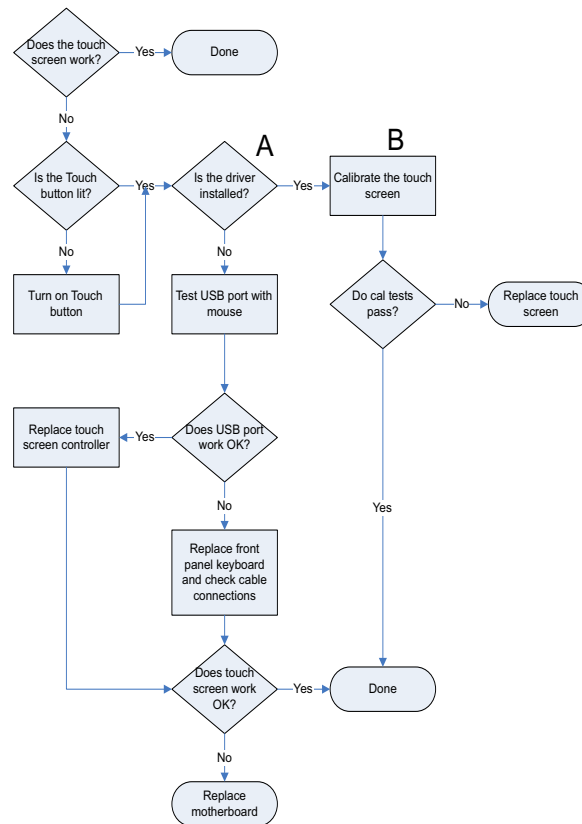


Figure 4-18 Touch screen flowchart

- A** To find the driver, bring up the Start menu, right click **Computer**, then go to **Manage > Device Manager > Human Interface devices** and look for **USB HID Touch Screen Controller**. To ensure that it is enabled and working properly, right click the file name and select **Properties**. The General tab in the Properties menu should display a message stating that the device is working properly.
- B** To calibrate the touch screen, go to **All Programs > Microchip TSHARC Control Panel**. Select the Calibration tab, then press **Begin Calibration** and follow the instructions.

Checking Probe Power Outputs

Probe power outputs are on the front panel, in the lower left corner of the 3.5mm inputs.

Refer to [Figure 4-19](#) to check the power output at the connectors. Measure the voltages with respect to the ground terminal on the front panel, located near Aux Out. Measure the voltages at pins 2 and 5 only (+12V and -12V). These supplies, and all others, come from the front panel.

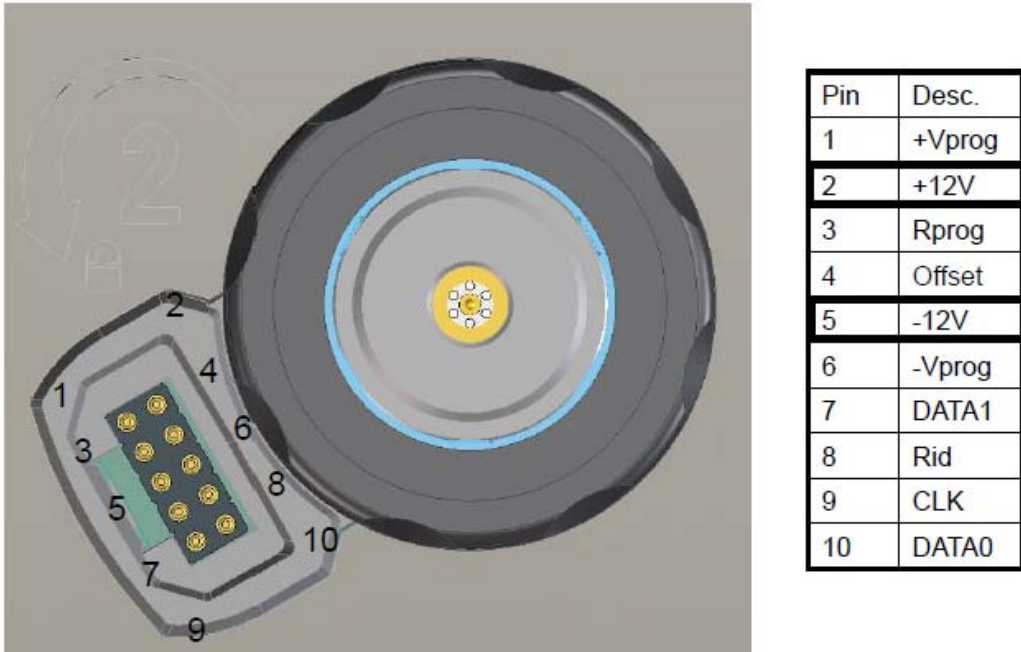


Figure 4-19 AutoProbe II pins

MSO Assembly Troubleshooting

This section describes problems that may occur when an MSO assembly is installed, and how to troubleshoot them. The MSO printed circuit assembly is located below the lower acquisition board, with the components facing downward.

LEDs on MSO Assemblies

The MSO printed circuit board has two sets of LEDs. One set is visible from the right side of the oscilloscope, and the other set is visible from the left side.

MSO LEDs on the right side of the oscilloscope

To see the LEDs on the right side, look straight in through the vent holes and see the lights pointed toward the bottom of the oscilloscope. These two red LEDs turn on when the oscilloscope is turned on, indicating that the comparators are off. The LEDs stay on until the FPGA is programmed by the scope application software; then the software turns the LEDs off when it turns the comparators on.

If the LEDs turn on after the application is running, a thermal problem likely was detected. A warning appears. To resolve the problem, shut down the scope and allow it to cool. Make sure the fan holes are not blocked, and allow at least 4 inches of space next to the oscilloscope. Restart the scope and verify that all fans are working.

MSO LEDs on the left side of the oscilloscope

The LEDs on the left side can be seen only as a reflection in the lower sheet metal as you look through the fans. These LEDs are off until the FPGA is programmed successfully, which occurs shortly after the scope application starts.

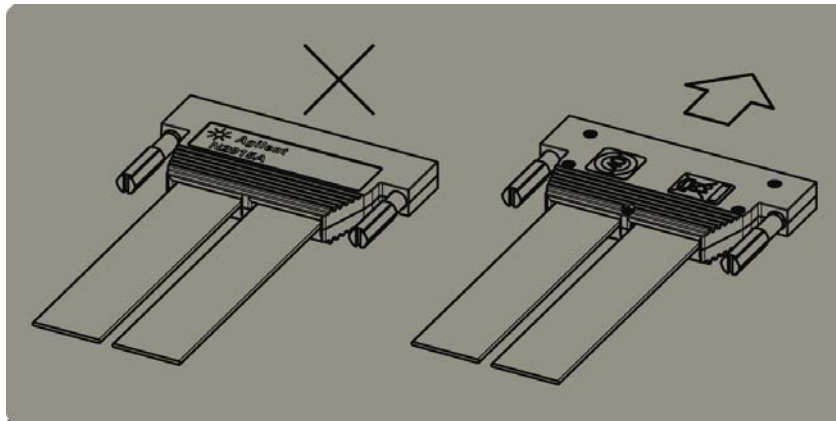
One of the LEDs turns on and remains on after the FPGA is programmed. The other LED will start blinking steadily at about 1.6 Hz if the 250 MHz clock coming from the backplane board is working properly. If the LED is not blinking steadily, verify that the backplane board has been modified correctly to be used with the MSO board:

- The end tabs of connector J1102 should be trimmed down so the mating connector on the MSO board will connect properly.
- In the clock area on the top side of the backplane board, R352 and R353 should be loaded with 0 ohm resistors. The same area on the bottom side of the board should not have resistors on R330 and R332. If this clock rework has not been done, the scope application will display an error message indicating an option card DAC failure when the application starts up.
- If the backplane board part number is 54916-66402 and the raw board rev number is less than 006, the board is unusable and must be replaced.

MSO Cable Connection

The MSO cable must be oriented as shown on the back of the oscilloscope when it is connected. If it is oriented upside-down, the pins may bend and cause a faulty connection. Make sure the cable is connected properly and that the pins remain straight. Refer to Figure 4-20.

Figure 4-20 MSO cable direction



Before You Contact Keysight

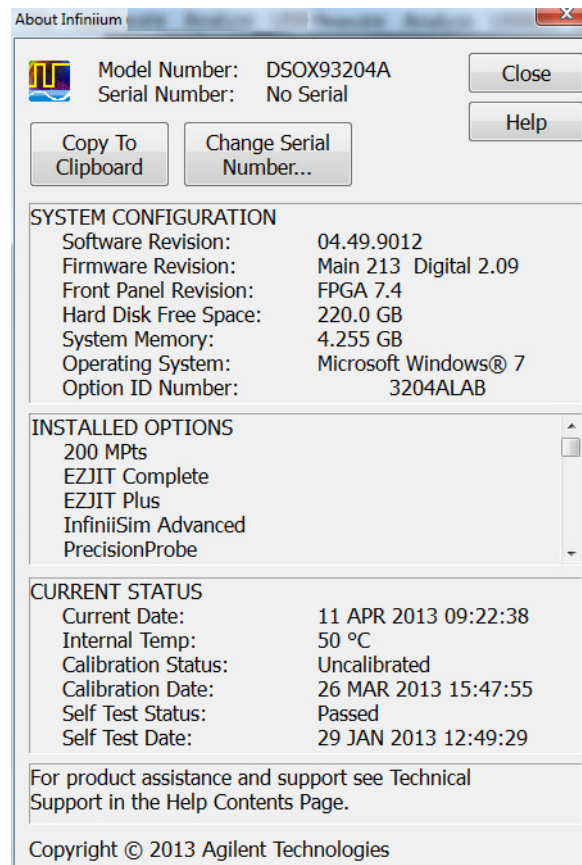
If you have read this Troubleshooting chapter and have unresolved questions about troubleshooting the oscilloscope, be ready to provide system information such as the current software version and installed options. This information will be useful when you contact Keysight Technologies.

To find and save system information, follow these steps:

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

A dialog box similar to the one in Figure 4-21 appears.

Figure 4-21 About Infiniium Information



- 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.

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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 oscilloscopes.

In general, the procedures are placed in the order to follow for removing a particular assembly. The procedures listed first are for assemblies that must be removed first.

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

Tools Required

The following tools are required for these procedures.

- Torx drivers: T10, T20
- Socket wrench: 9/16 inch
- Torque wrench: 3.5 mm (8 in-lbs)
- Flat-blade screwdriver: medium size (3/16 inch)
- Power drivers: 5 in-lbs, 18 in-lbs

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.

Safety Precautions

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 that 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.

WARNING**SHOCK HAZARD!**

When the bulk 12V power supply is removed from the oscilloscope, two AC leads are exposed. Therefore, the power cable should be disconnected from the bulk 12V power supply before the supply is removed. Be careful to avoid contact with these leads as severe shock could result.

To return the oscilloscope to Keysight Technologies for service

Before shipping the oscilloscope, contact a Keysight Technologies Service Center for more details.

- 1** Write the following information on a tag and attach it to the oscilloscope.
 - Name and address of owner
 - Oscilloscope model number
 - Oscilloscope serial number
 - 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.

If the original shipping materials are not 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 the oscilloscope by model number and full serial number.

Chapter 5: Replacing Assemblies

To remove and replace the cover, top plate, and bottom plate

To remove and replace the cover, top plate, and bottom plate

Use this procedure to remove and replace the cover, top plate, and bottom plate. 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 top of the oscilloscope if it is attached.
- 5 Remove the two M4 screws securing the side handles on both sides of the oscilloscope. When installing, torque to 18 in-lbs.

Figure 5-1



- 6 Remove the six M4 screws that secure the rear feet (three in each foot). When installing, torque to 18 in-lbs.

Figure 5-2



- 7 Remove the three M4 screws located on the top edge of the rear panel of the oscilloscope (torque to 18 in-lbs when installing), then turn the instrument on its side and remove the ten

M3 screws located on the underside of the oscilloscope that attach the outer cover to the chassis (torque to 5 in-lbs when installing).

Figure 5-3



Figure 5-4



- 8 Carefully slide the cover toward the rear of the instrument and off the chassis.

Figure 5-5

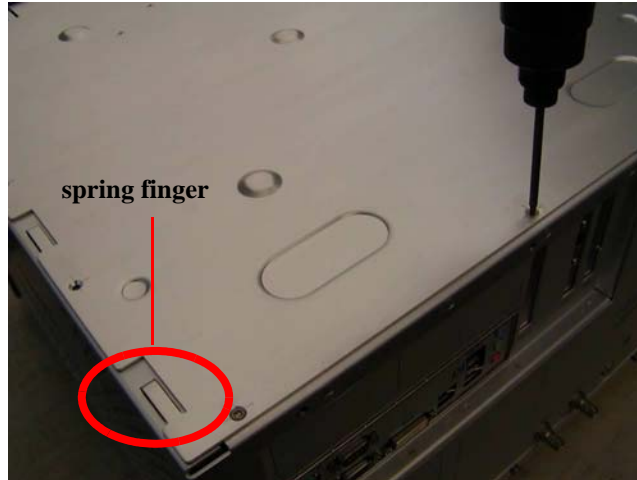


Chapter 5: Replacing Assemblies

To remove and replace the cover, top plate, and bottom plate

- 9 Once the cover is off, you can remove the top plate by removing the three M3 screws from its rear edges and then pulling the plate toward the rear panel to dislodge the spring fingers. Then lift the top plate off of the chassis. **CAUTION:** When re-installing the top plate, ensure all 11 spring fingers engage the chassis and front panel as designed. Torque the screws to 5 in-lbs.

Figure 5-6



- 10 To remove the bottom plate, flip the oscilloscope upside down and remove the M4 and M3 screws from the bottom panel as shown in Figure 5-7. A guide pin in the lip of the plate will align with a hole in the rear panel of the chassis when installing (also torque M3 screws to 5 in-lbs and M4 screws to 18 in-lbs when installing). Slide the bottom panel up and away from the chassis.

Figure 5-7



- 11 To replace the cover, top plate, and bottom plate, reverse this procedure. Note that all sheet metal holes that are supposed to have screws placed in them are marked by lines on four sides of the hole as shown in Figure 5-8.

Figure 5-8



To remove and replace the front panel assembly

- 1 Disconnect the power cable and remove the cover, top plate, and bottom plate as described earlier.
- 2 If you are removing the keyboard, grasp and pull on all knobs located on the front panel to remove them (Figure 5-9). If you are not removing the keyboard, this step is not necessary.

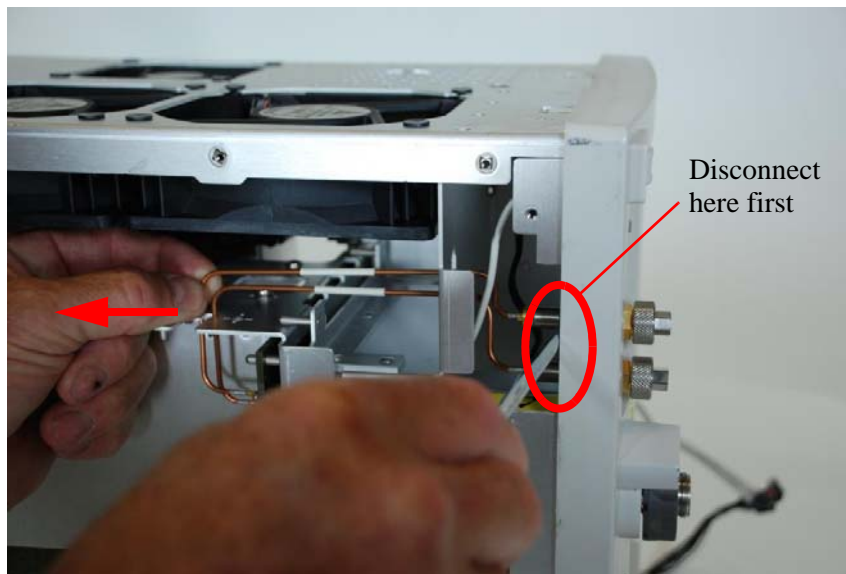
Figure 5-9



- 3 Disconnect the display cable and on/off cable from the motherboard end of the cables.
- 4 Disconnect the USB and front panel power cables from the front panel (these are accessible from the top side of the oscilloscope).
- 5 Turn the oscilloscope upside down and disconnect the two semi-rigid Cal Out/ Aux Out cables from both the front panel and backplane board. As Figure 5-10 shows, first disconnect the cables from the rear side of the Cal Out connections and then pull straight back to remove the cables from the backplane board. CAUTION: Be sure to pull straight back to avoid bending or breaking the connection to the backplane board.

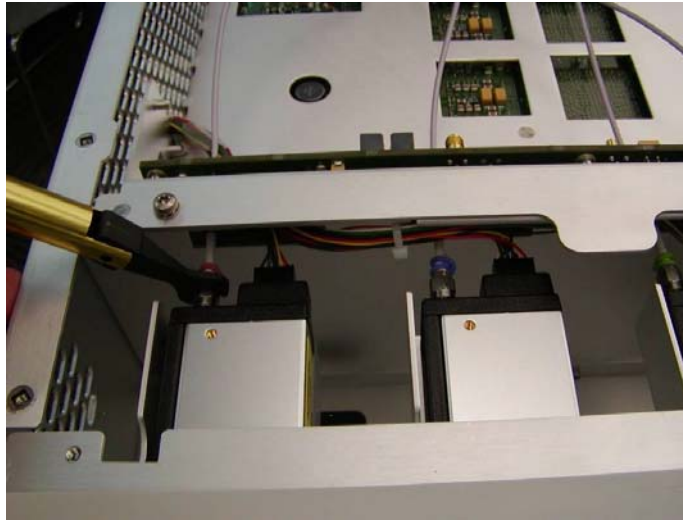
When reconnecting these cables, torque the Cal Out connection to 8 in-lbs.

Figure 5-10



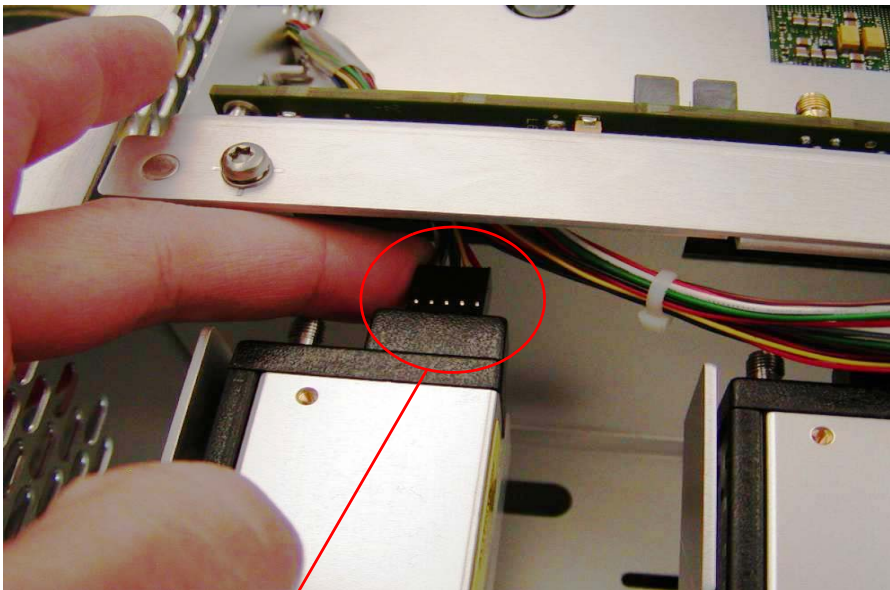
- 6 Disconnect each input cable. (When reconnecting, you can determine the appropriate connections by matching the colored o-ring to the bezel color. Tighten to 8 in-lbs using a calibrated 5/16" open end torque wrench.) See Figure 5-11.

Figure 5-11



- 7 Remove the attenuator power cable from each input channel attenuator as shown in Figure 5-12. The attenuators are keyed to match the connectors.

Figure 5-12

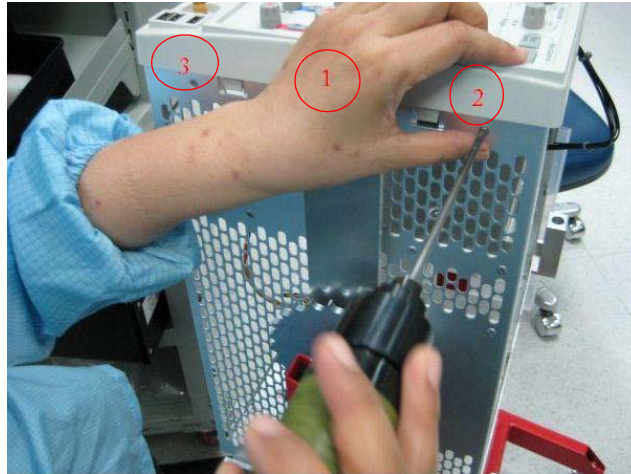


Remove this connection from each channel attenuator
and then route the entire cable through the backplane board

- 8 Remove the six M3 screws that attach the side of the chassis and the front panel assembly. (Torque to 5 in-lbs when installing and the screws must be tightened in the order shown in Figure 5-13 below.)

Chapter 5: Replacing Assemblies
To remove and replace the front panel assembly

Figure 5-13



- 9 Tilt the front panel up to see the cables connected to it. Either disconnect them from the front panel side of the connection or route the display cable, on/off cable, and USB front/touch screen cable through the grommet on the chassis after disconnecting them from the other side of their connections (Figure 5-14).

Figure 5-14



CAUTION

When setting the front panel on the chassis to install the front panel assembly onto the oscilloscope, make sure not to damage the cables.

- 10 To replace the front panel assembly, reverse this procedure.

To remove and replace front panel assembly parts

Remove the front panel assembly as described in the previous section.

Front Panel Clutches

WARNING

This step will ruin the clutches. You will have to replace them with new ones.

- 1 Use a thin item such as a ribbon to protect the oscilloscope from scratches, and pull on the dark gray plastic clutches to pop them off of the oscilloscope.
- 2 Use your fingers to pull off the knobs.

Front Panel Bezel and Front Panel Circuit Assembly

- 1 Grasp and pull all of the knobs off of the front panel as shown in the previous section.
- 2 There are two tabs on each side, one tab on top, and one tab on the bottom. Pop these tabs with your fingers to dislodge the front panel bezel. (Reverse directions to attach the front panel bezel.)
- 3 To remove the front panel circuit assembly, unsnap the board from the deck as shown below. You may need a flat-blade screwdriver to dislodge the tabs.

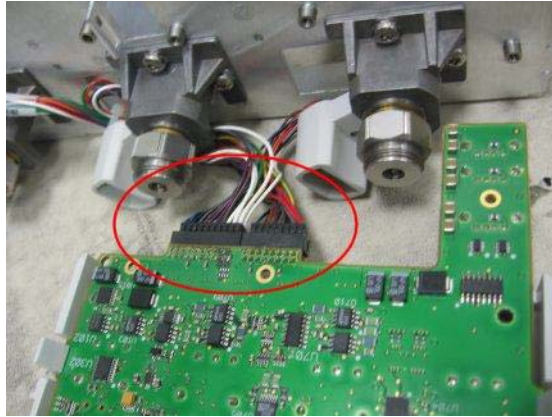
Figure 5-15



Chapter 5: Replacing Assemblies
To remove and replace front panel assembly parts

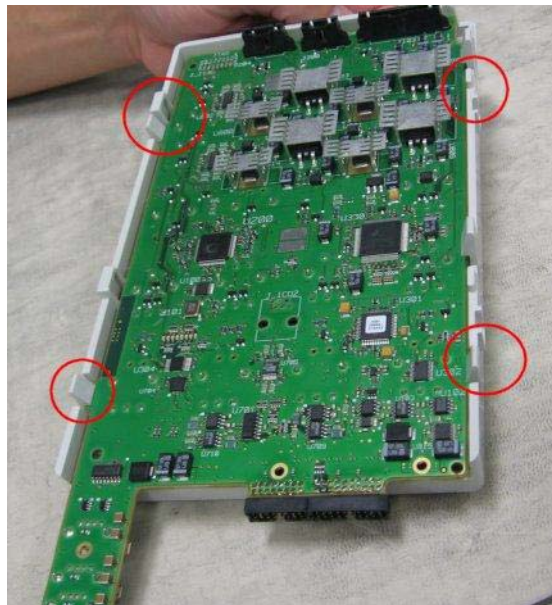
- 4 Disconnect the cables shown below from the board.

Figure 5-16



- 5 Disengage the four tabs holding the board to the keypad as shown below.

Figure 5-17



- 6 To reassemble the front panel circuit board, reverse these steps.

Display Assembly

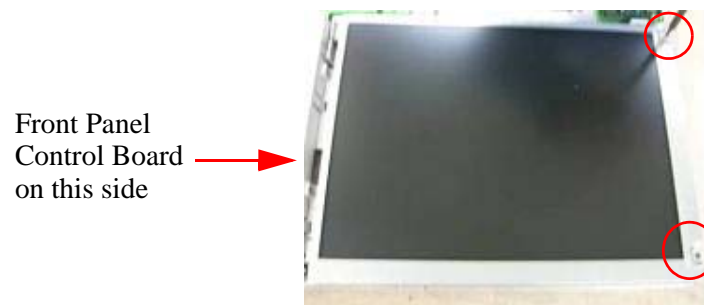
- 1 Remove the front panel assembly and front panel bezel as described previously.
- 2 Remove the inverter shield from the deck by angling it as shown below.

Figure 5-18



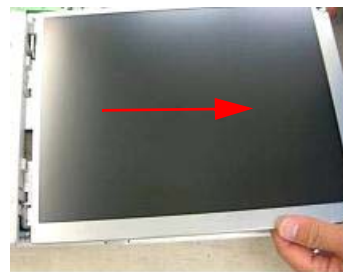
- 3 Remove the two screws holding the display to the chassis as shown below.

Figure 5-19



- 4 Slide the display away from the control panel to disengage the tabs.

Figure 5-20



- 5 You can now disconnect any cables connected to the display.

To remove and replace the motherboard

- 1 Disconnect the power cable and remove the cover and top plate as described previously.
- 2 Disconnect all the cables from the motherboard (see page 106).
- 3 Remove the M3 screws attaching the motherboard to the frame. When installing, torque to 5 in-lbs.
- 4 Loosen the four screws in the large fan as shown below.

Figure 5-21



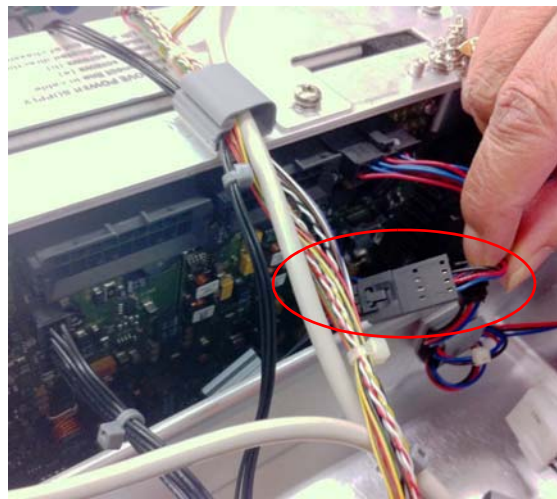
- 5 Pull the motherboard toward the front panel and then lift out.
To reassemble the motherboard, reverse the above procedure.

To remove and replace the acquisition boards/backplane/optional MSO assembly

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

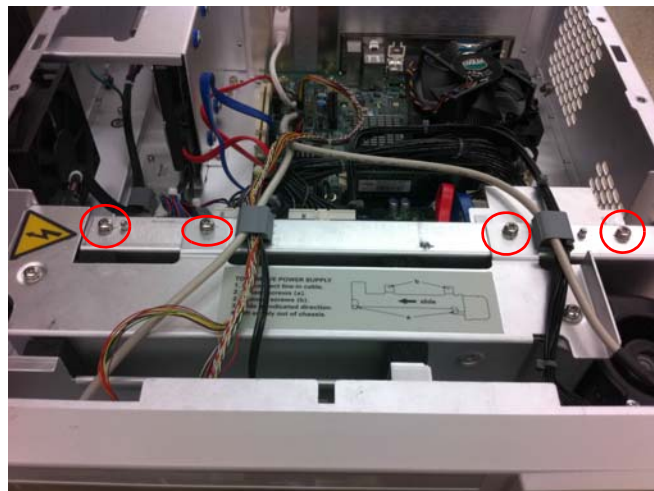
- 1 Disconnect the power cable and remove the cover, top plate, and bottom plate as described previously.
- 2 From the top side of the oscilloscope, remove the eight cables connected to the backplane board. One of these cables is the IC fan cable, circled in Figure 5-22. It is toward the bottom of the backplane board so you need to look down the board to see it and then follow the cable up to where you can disconnect it.

Figure 5-22



- 3 Remove the four screws on top of the backplane board.

Figure 5-23



Chapter 5: Replacing Assemblies

To remove and replace the acquisition boards/backplane/optional MSO assembly

- 4 Using a hand screwdriver first and then a torque driver, loosen the two screws located at the bottom of the power supply and then push the power supply to the side to disengage its connection to the backplane board. With it pushed to the side, use a hand screwdriver to carefully start the screws back down into a set of new holes to keep the power supply in place when you flip the oscilloscope over in an upcoming step.

Figure 5-24



The first screw
to loosen

Figure 5-25

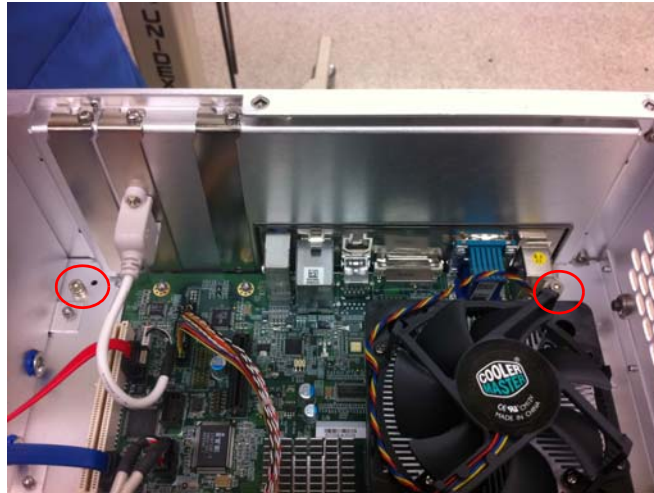


Tighten the screw
back into this hole
after sliding the
power supply

The second screw
to loosen

- 5 Loosen the two screws near the motherboard / rear panel.

Figure 5-26



- 6 Turn the oscilloscope upside down and remove the SMA connections to the bottom of the backplane board (Figure 5-27). When reconnecting, route these cables underneath the input cables. Also when reconnecting cables, the cables are labeled as are the connections on the backplane board so you can ensure you properly connect each cable to its correct location.

Figure 5-27



- 7 Disconnect the two semi-rigid Cal Out/Aux Out cables from both the front panel and backplane board. As Figure 5-28 shows, first disconnect the cables from the rear side of the Cal Out / Aux Out connections and then pull straight back to remove the cables from the backplane

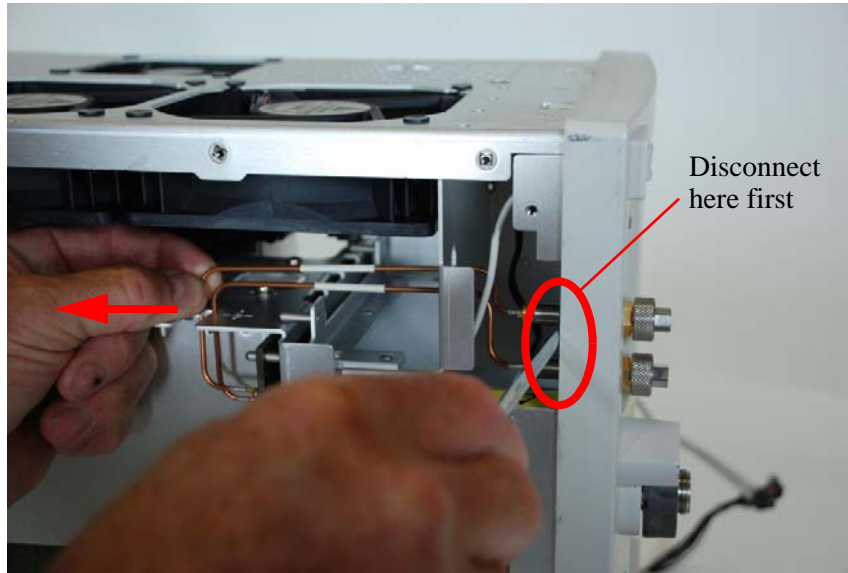
Chapter 5: Replacing Assemblies

To remove and replace the acquisition boards/backplane/optional MSO assembly

board. CAUTION: Be sure to pull straight back to avoid bending or breaking the connection to the backplane board.

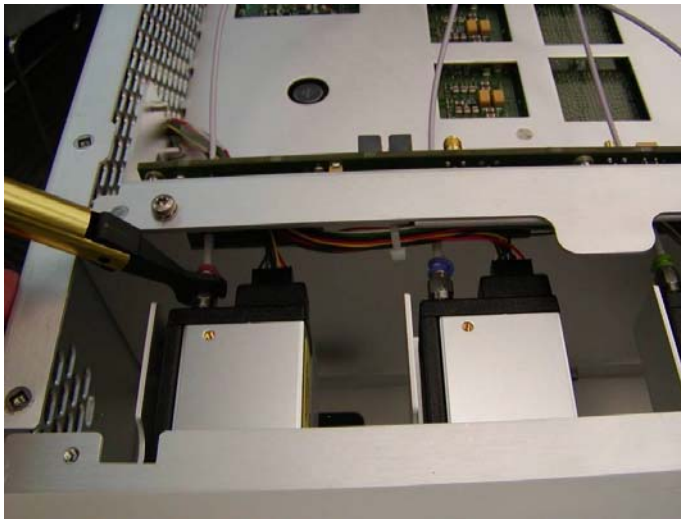
When reconnecting these cables, torque the Cal Out/Aux Out connections to 8 in-lbs.

Figure 5-28



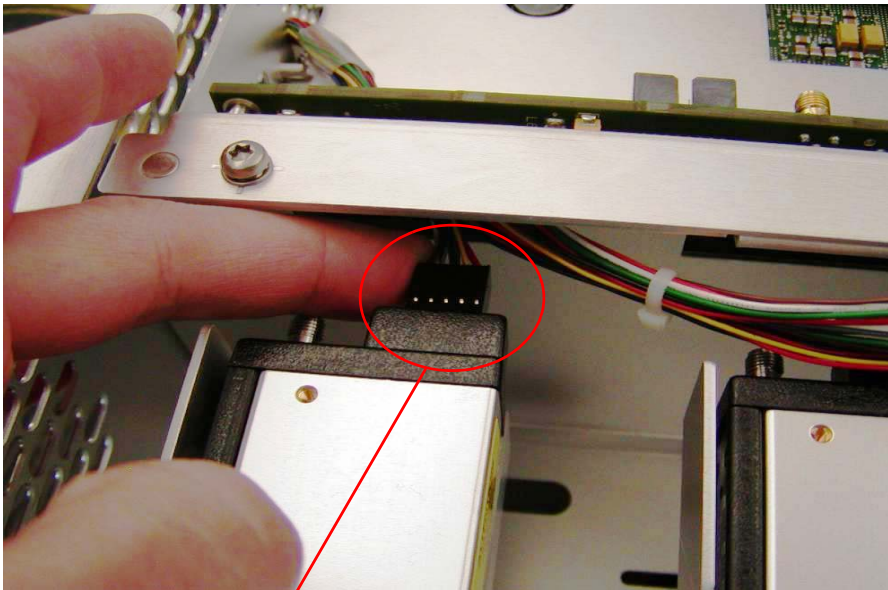
- 8 Disconnect each input cable and route them through the openings in the backplane. (When reconnecting, you can determine the appropriate connections by matching the colored o-ring to the bezel color. Tighten to 8 in-lbs using a calibrated 5/16-inch open end torque wrench.)

Figure 5-29



- 9 Remove the attenuator power cable from each input channel attenuator and route the cable through the grommet in the backplane (Figure 5-30). The attenuators are keyed to match the connectors.

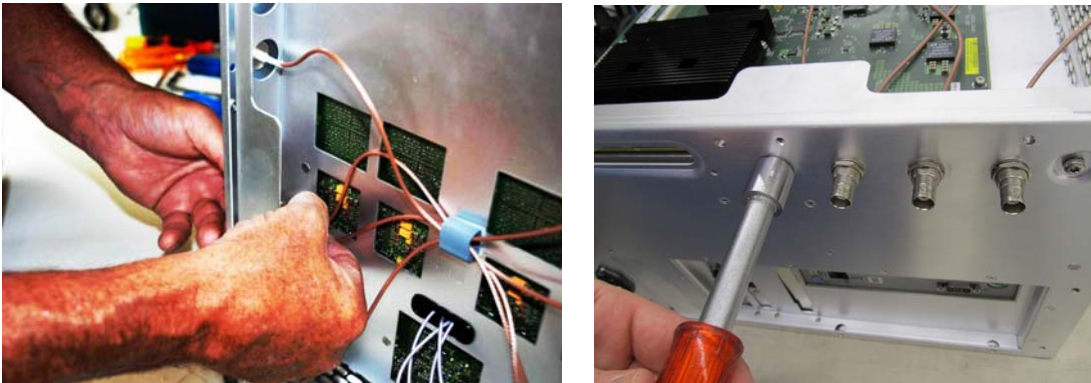
Figure 5-30



Remove this connection from each channel attenuator and then route the entire cable through the backplane board

- 10 Remove the rear panel BNCs (Figure 5-31). The figure on the right shows the rear panel with the optional MSO assembly.

Figure 5-31

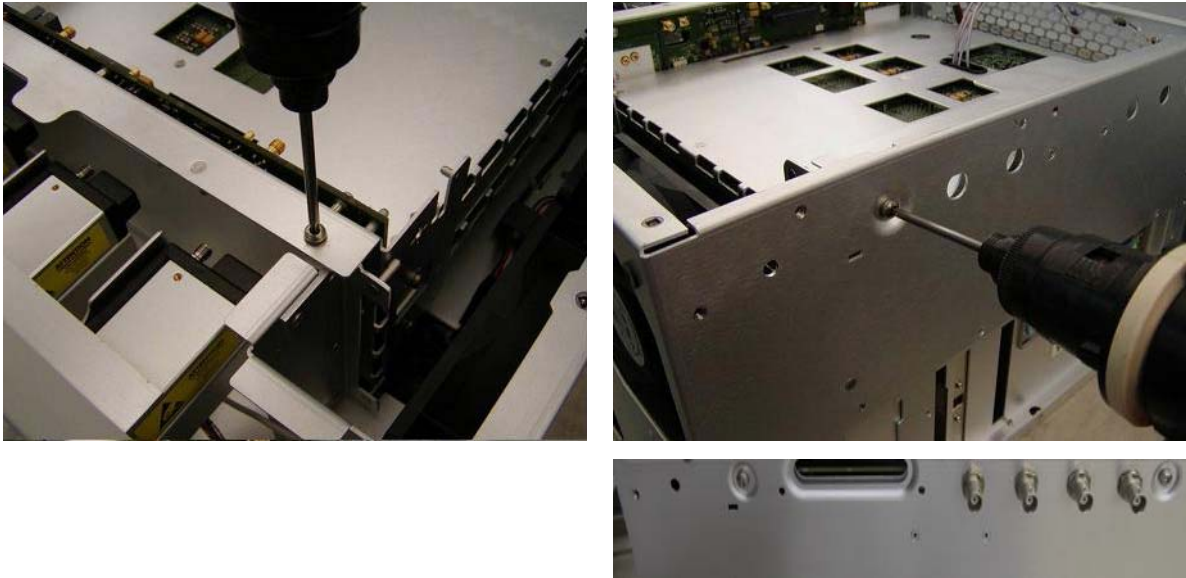


- 11 Remove the two M4 screws from top of the backplane board and two M4 screws from the rear of the instrument as shown below. The bottom photo shows the rear screws with the optional MSO assembly.

Chapter 5: Replacing Assemblies

To remove and replace the acquisition boards/backplane/optional MSO assembly

Figure 5-32



- 12 Ensure all cables are disconnected from the backplane board. (You will need to look from both the top and bottom of the oscilloscope to see them all and reach them.)
- 13 Lift the entire acquisition boards/backplane/optional MSO assembly out of the chassis (Figure 5-33).

Figure 5-33

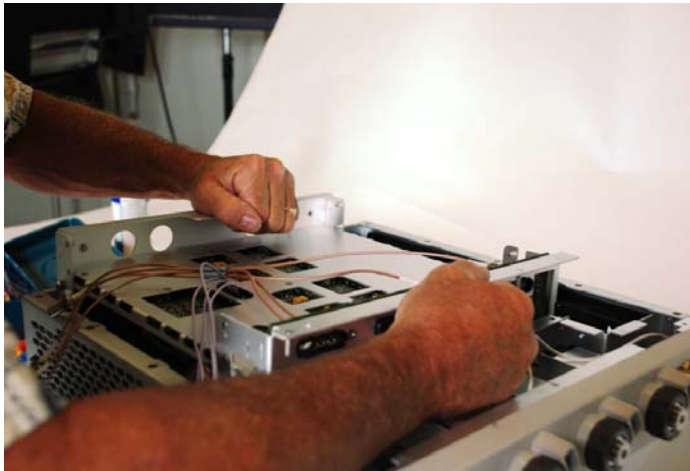


Figure 5-34 and Figure 5-35 show the removed assemblies, with and without the optional MSO assembly.

Figure 5-34

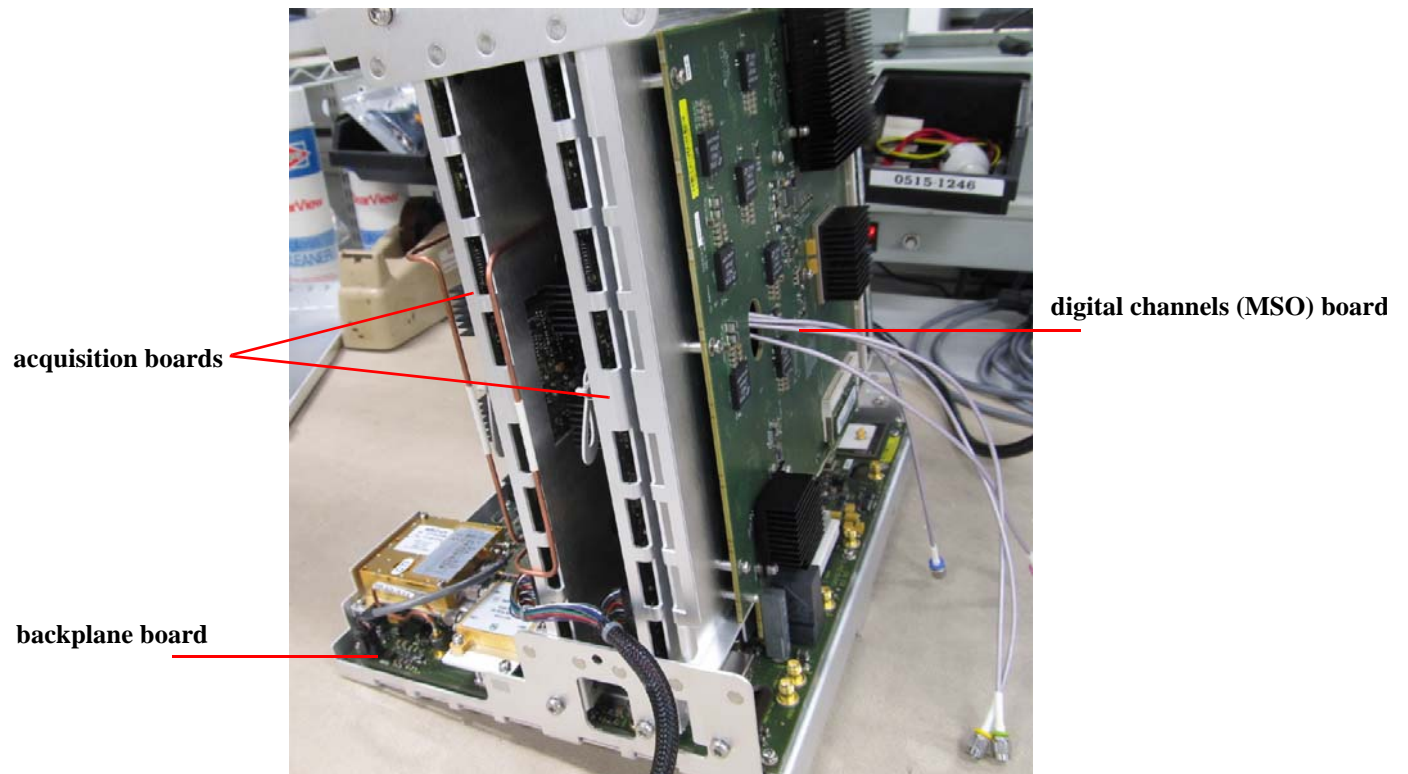
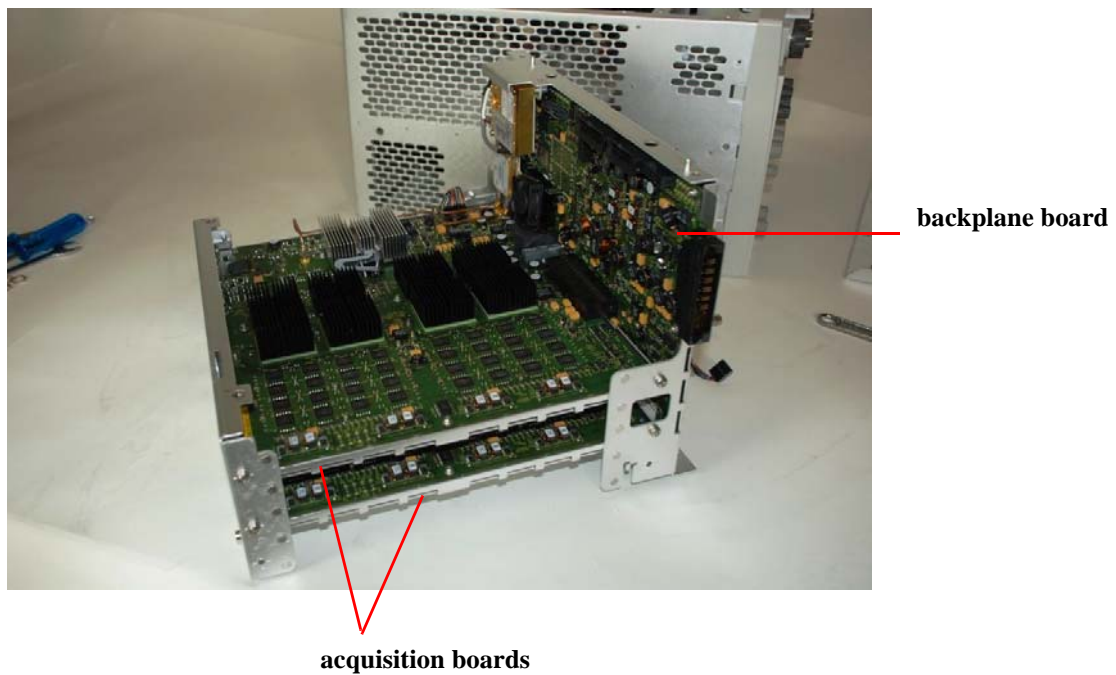


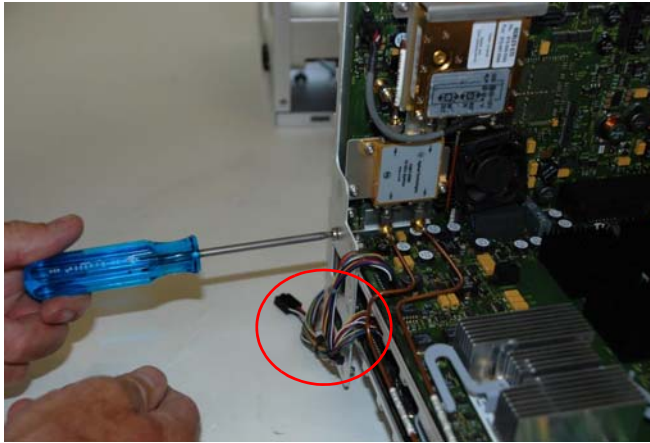
Figure 5-35



To remove the backplane assembly from the acquisition/optional MSO assembly

- 1 Remove the entire acquisition/backplane/optional MSO assembly as described in the previous section.
- 2 Remove the four M4 screws (two per acquisition assembly) on the side of the backplane assembly (Figure 5-36). If the scope is an MSO model, also remove the two M4 screws connecting the MSO assembly.
- 3 Disconnect the cables circled in red in Figure 5-36.

Figure 5-36



- 4 Disconnect the two semi-rigid cables from the acquisition boards, circled in red in Figure 5-37.

Figure 5-37



- 5 Remove the four M4 screws from the foot of the assembly (six M4 screws if the scope is an MSO model). Some of the screws are circled in blue in the photos of Figure 5-37. When replacing the screws, torque to 18 in-lbs.
- 6 Use the handles on the acquisition tray to separate the backplane assembly from each of the

acquisition assemblies, and remove the MSO assembly on MSO models. This step requires some force as the assemblies have numerous connections and pins.

- 7 If the scope is an MSO model, carefully guide the cables from the acquisition boards through the slots in the MSO assembly.

Figure 5-38



- 8 Remove the M3 screws to remove each board from its respective subassembly chassis.
- 9 Note that a new backplane board does not come with the Oscillator and Splitter Assembly so you will need to move these from the old backplane board to the new one.

The semi-rigid cable shown in Figure 5-39 must be installed correctly.

Chapter 5: Replacing Assemblies

To remove the backplane assembly from the acquisition/optional MSO assembly

Figure 5-39

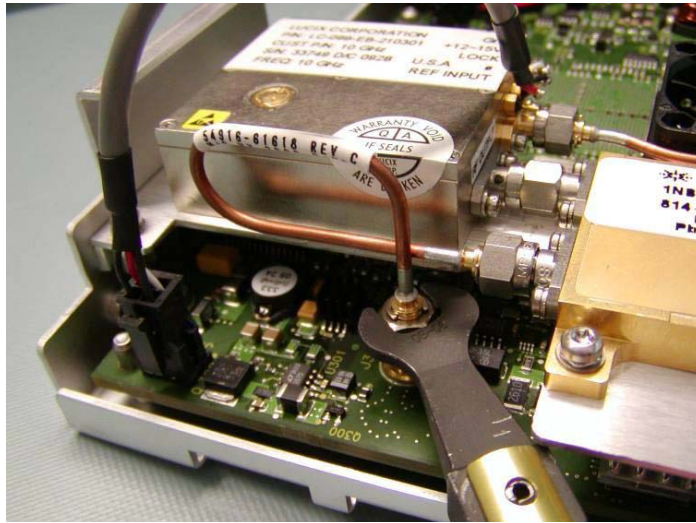
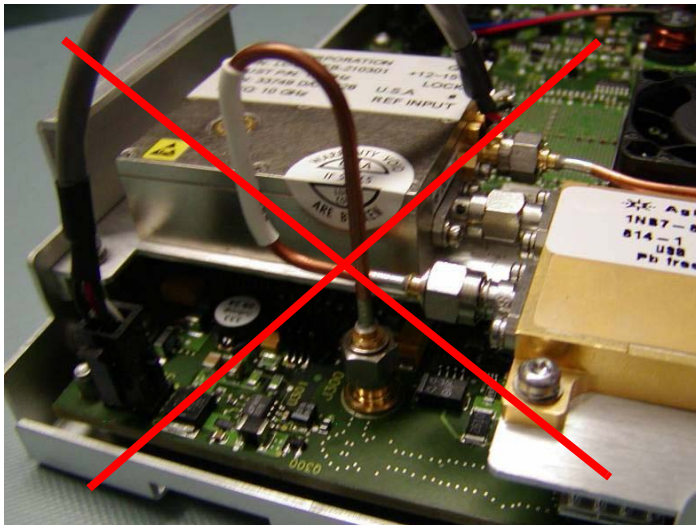


Figure 5-40



10 To reassemble the backplane/acquisition assembly, reverse these instructions.

To set the calibration factors after replacing the acquisition board

The calibration/self test procedure must be performed after replacing the acquisition board. Consult the calibration chapter in this service guide.

Let the oscilloscope warm up before testing or calibrating.

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

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 cover and top plate as described previously.
- 2 Disconnect the cables connected to the hard drive.
- 3 Remove the four M3 screws shown below. Tighten to 5 in-lbs when assembling.

Figure 5-41



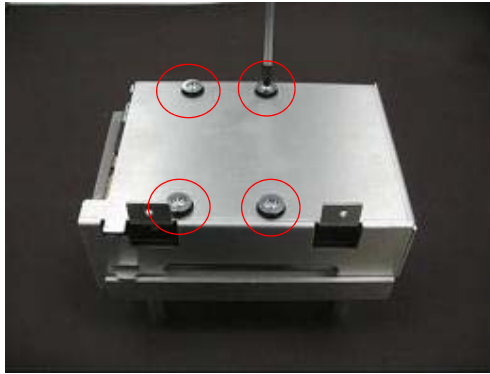
- 4 Remove the M3 screw from the rear panel as shown below.

Figure 5-42



- 5 With the hard disk drive and its frame removed, you can remove the hard disk drive from the frame by removing the four screws shown in Figure 5-43.

Figure 5-43



- 6 To replace the hard disk drive, reverse this procedure.

Cable removal (for replacing the motherboard)

This section shows the various cables that need to be removed when replacing the motherboard.

- 1 Disconnect the power cable and remove the top cover.
- 2 Disconnect all cables from the motherboard.

Below is an overview picture showing the cables that need to be removed from the motherboard.

Figure 5-44



Figure 5-45 shows the cables connected to the backplane board as viewed from the rear of the oscilloscope.

Figure 5-45



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.

WARNING

SHOCK HAZARD!

When the power supply is removed, two AC leads are exposed. Take extra care not to contact these leads.

- 1 Disconnect the power cable and remove the top cover as described previously.
- 2 Disconnect the AC power cable from the bulk 12V power supply.
Figure 5-46 shows where the AC power cable connects to the bulk 12V power supply.

Figure 5-46



- 3 Follow the instructions on the label attached to the top of the power supply to remove it.

To remove and replace the fans

WARNING

AVOID INJURY!

The fan blades are exposed both inside and outside the chassis. Disconnect the power cable before working around the fan. Use extreme caution in working with the oscilloscope to avoid injury.

Use this procedure to remove and replace the fans. 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 cover and top plate.
- 2 Disconnect the fan harness cables.
- 3 Clip off the end of the top two fan mounts from the fan as shown, leaving the bottom mounts attached, and slide the fan out. Repeat for each fan that needs to be replaced.

Figure 5-47



- 4 To replace the fan, reverse this procedure.

CAUTION

AVOID OVERHEATING THE OSCILLOSCOPE

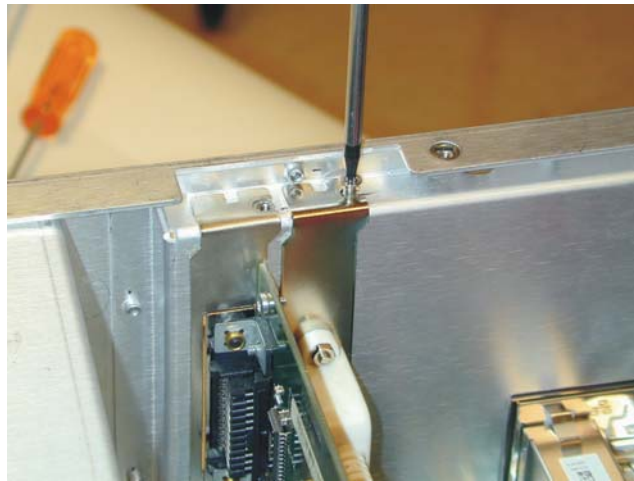
When replacing the fan, be sure the direction of the fan air flow is coming from the inside to the outside of the oscilloscope. Check the flow arrows on the fan and check for proper flow once power is applied to the oscilloscope. Improper air flow can overheat the oscilloscope.

To remove and replace the USB or GPIB port

Use this procedure to remove and replace the USB or GPIB port (GPIB is an option and may not be on your oscilloscope). The procedure is exactly the same for both of these ports so only one will be shown here. 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 cover and top plate.
- 2 Remove the screw from top edge of chassis (Figure 5-48).

Figure 5-48



- 3 Undo the connection to the motherboard by disconnecting the cable.
- 4 Pull the port out of the instrument.
- 5 To replace one of these ports, reverse the directions.

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Replaceable Parts

This chapter describes how to order replaceable assemblies and parts for the Keysight 90000 X-Series oscilloscopes. Service support for this oscilloscope is replacement of parts to the assembly level.

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.

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

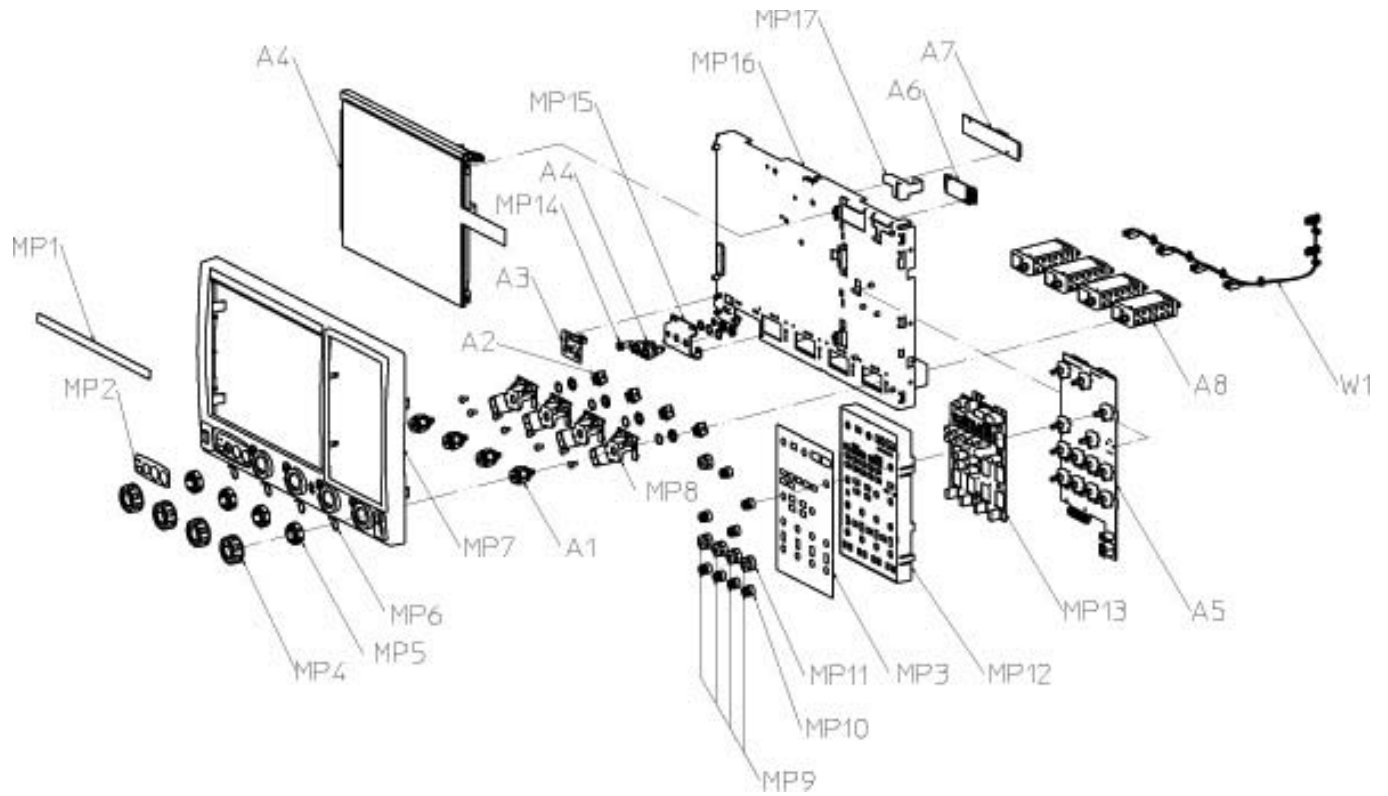
Mail order forms and specific ordering information are available through your local Keysight Technologies Sales Office. Addresses and telephone numbers are located in a separate document shipped with the manuals.

Exchange Assemblies

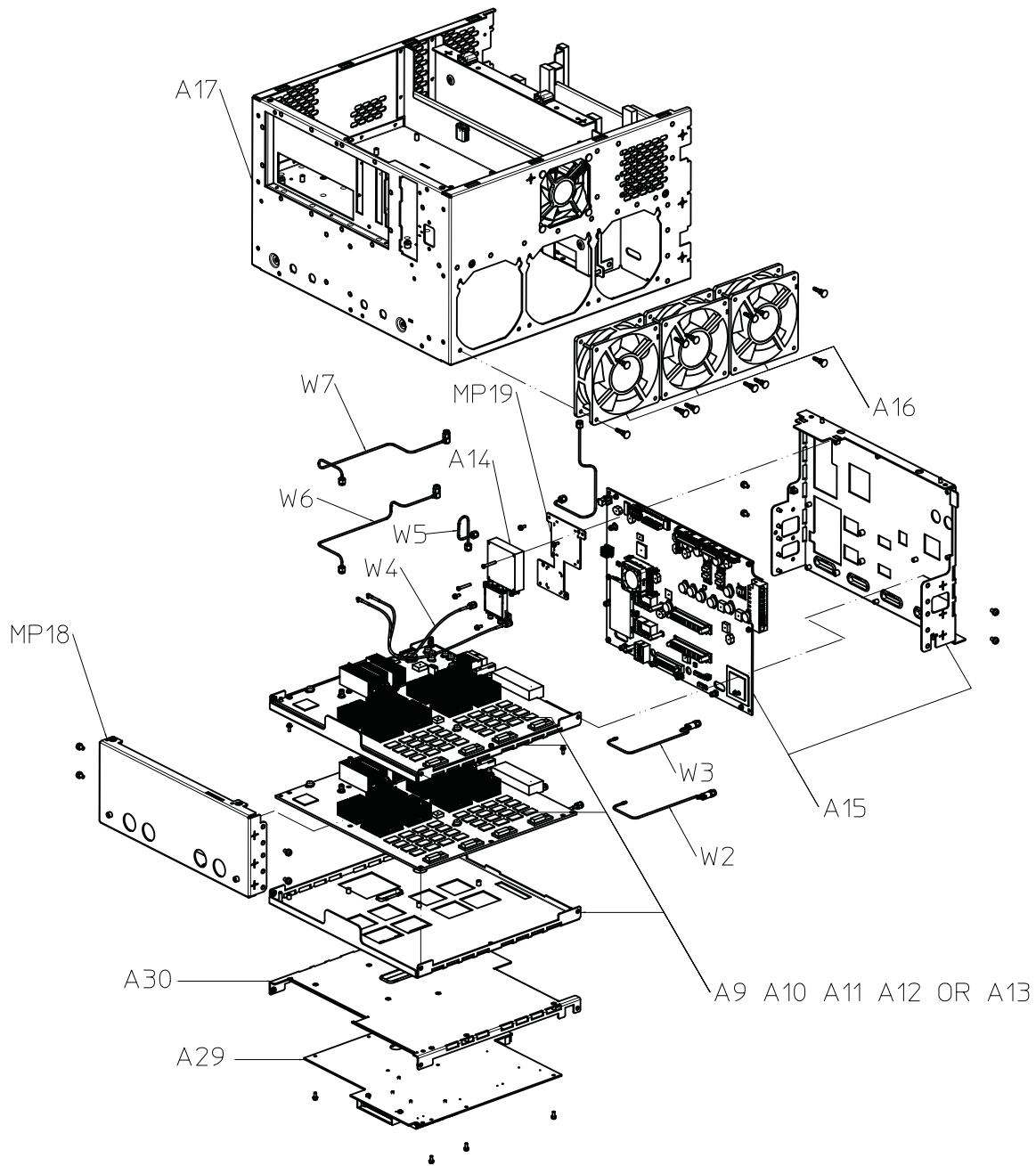
Exchange assemblies have been set up for Keysight Service Center use only.

Exploded Views

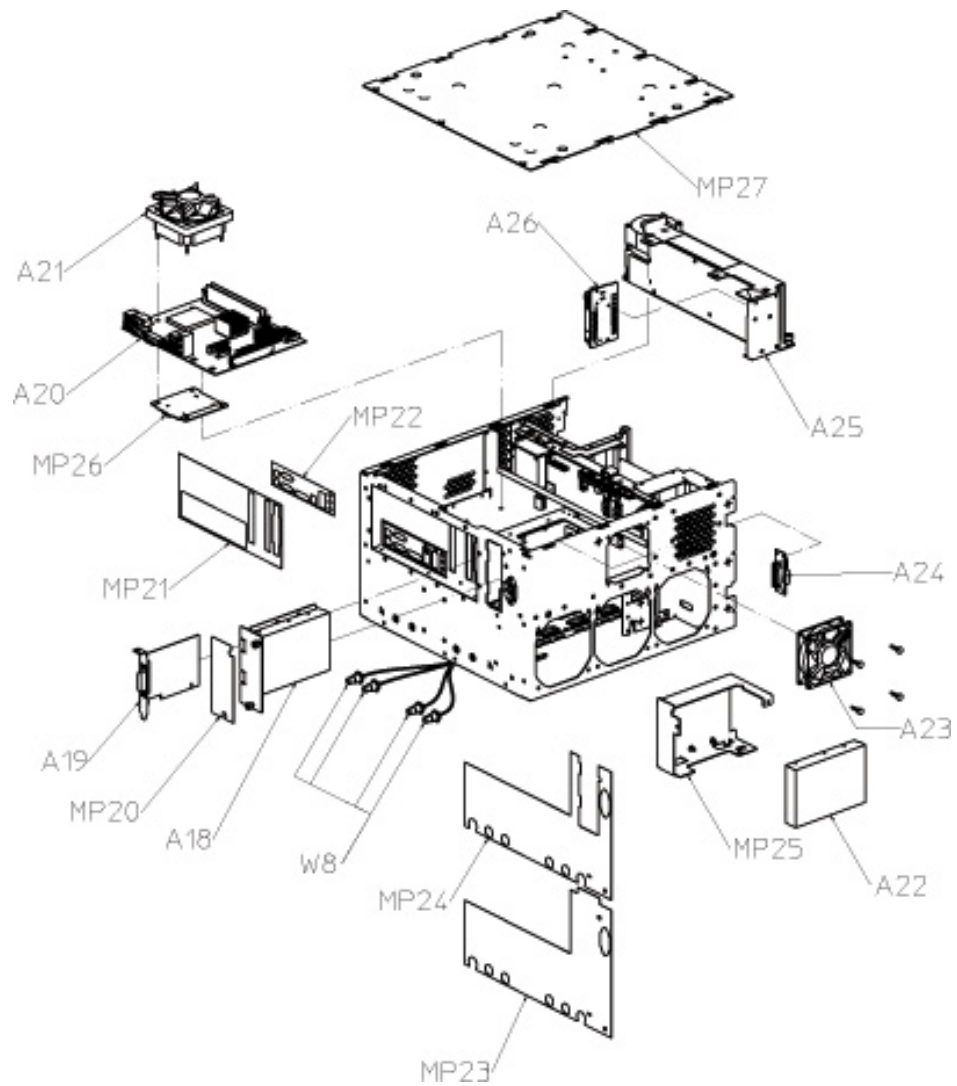
Front Frame and Front Panel



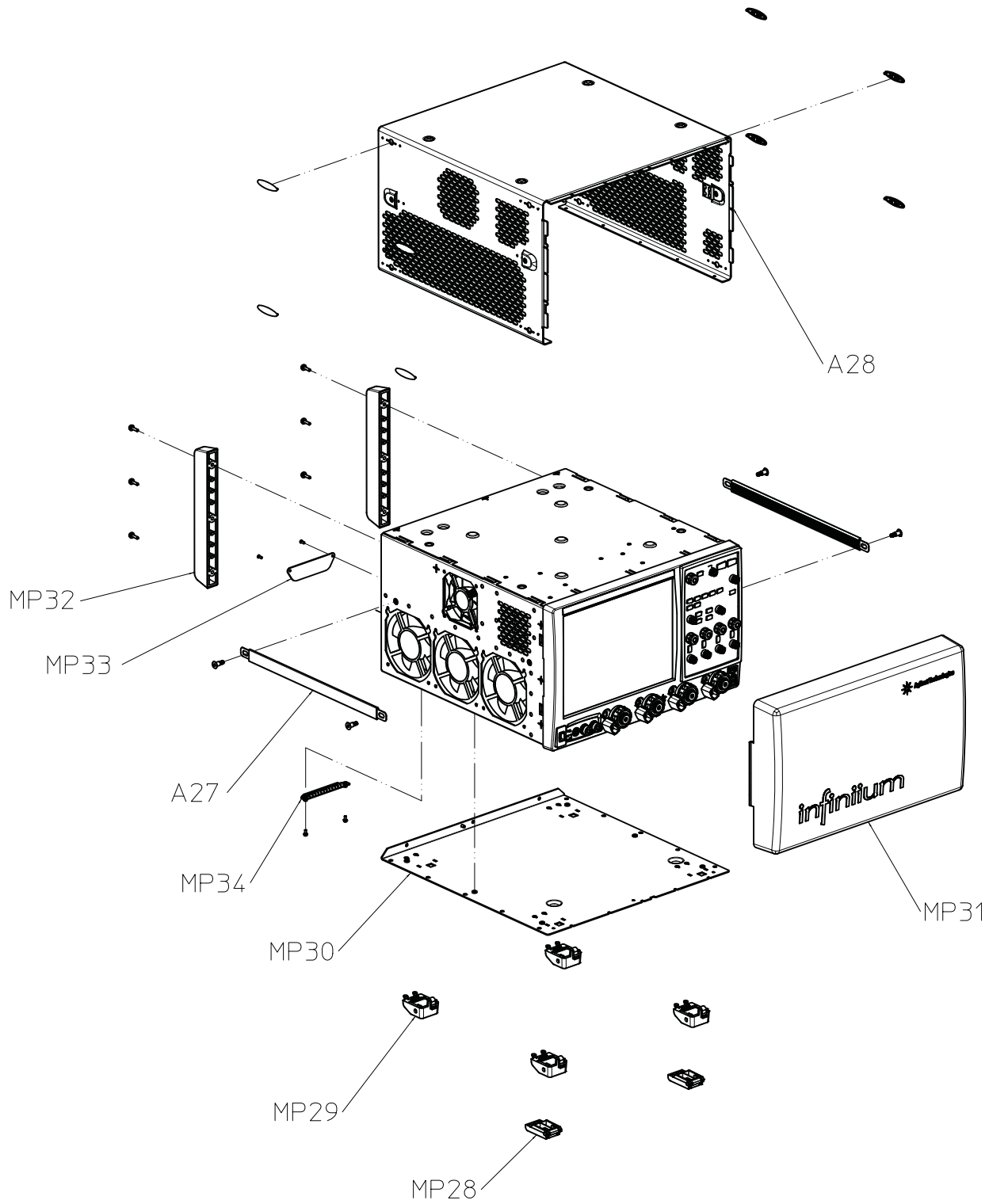
Fan and Acquisition Assembly



Power Supply and PC Motherboard



Sleeve



Replaceable Parts List

The following table is a list of replaceable parts. Information given for each part includes:

- Reference designation in exploded views
- Keysight Technologies part number
- Total quantity (QTY) in the oscilloscope or an assembly
- Description of the part

Replaceable Parts

Ref. Des.	Keysight Part Number	QTY	Description
A1	5062-1247	1	Assembly - 3.5 mm Connector
A2	54916-66404	1	PCA Autoprobe Board ^a
A2	54916-66414	1	PCA Autoprobe Board
A2	54916-68719	1	Autoprobe boards and cable assembly repair kit for DSOX90000-Series scopes
A3	54916-66406	1	On/Off Printed Circuit Assembly
A4	54913-68714	1	Touchscreen / Display Assembly
A4	08673-67601	1	Connector Assembly - Output
A5	54916-66405	1	PCA Keyboard
A6	0960-2796	1	Touch Screen Controller Board 5V-DC
A7	0950-5446	1	Inverter Dual Backlight (lifetime buy of 0950-4068)
A7	0950-4068	1	Replaced by 0950-5446
A8	33325-60019	1	Step Attenuator - Front Panel (RoHS version of 33325-60013)
A8	33325-60013	1	Replaced by 33325-60019
A9	54916-66501	2	Acquisition Printed Circuit Assembly 16 to 32 GHz
A9	54916-66701	2	Acquisition Printed Circuit Assembly 16 to 32 GHz - replaces 54916-66501
A9	54916-69501	2	Acquisition Printed Circuit Assembly 16 to 32 GHz - Exchange
A9	54916-69701	2	Acquisition Printed Circuit Assembly 16 to 32 GHz - Exchange, replaces 54916-69501
A10	54916-66511	2	Acquisition Printed Circuit Assembly 16 to 28 GHz
A10	54916-66701	2	Acquisition Printed Circuit Assembly 16 to 28 GHz - replaces 54916-66511
A10	54916-69511	2	Acquisition Printed Circuit Assembly 16 to 28 GHz - Exchange
A10	54916-69701	2	Acquisition Printed Circuit Assembly 16 to 28 GHz - Exchange, replaces 54916-69511
A11	54916-66521	2	Acquisition Printed Circuit Assembly 16 to 25 GHz
A11	54916-66721	2	Acquisition Printed Circuit Assembly 16 to 25 GHz - replaces 54916-66521
A11	54916-69521	2	Acquisition Printed Circuit Assembly 16 to 25 GHz - Exchange
A11	54916-69721	2	Acquisition Printed Circuit Assembly 16 to 25 GHz - Exchange, replaces 54916-69521
A12	54916-66531	2	Acquisition Printed Circuit Assembly 16 to 20 GHz
A12	54916-66721	2	Acquisition Printed Circuit Assembly 16 to 20 GHz - replaces 54916-66531
A12	54916-69531	2	Acquisition Printed Circuit Assembly 16 to 20 GHz - Exchange
A12	54916-69721	2	Acquisition Printed Circuit Assembly 16 to 20 GHz - Exchange, replaces 54916-69531
A13	54916-66541	2	Acquisition Printed Circuit Assembly 16 GHz
A13	54916-66721	2	Acquisition Printed Circuit Assembly 16 GHz - replaces 54916-66541
A13	54916-69541	2	Acquisition Printed Circuit Assembly 16 GHz - Exchange
A13	54916-69721	2	Acquisition Printed Circuit Assembly 16 GHz - Exchange, replaces 54916-69541
A14	1813-2449	1	Crystal - Oscillator 10 GHz with cable

Chapter 6: Replaceable Parts

Replaceable Parts List

Replaceable Parts

Ref. Des.	Keysight Part Number	QT Y	Description
A15	54916-66512	1	Backplane Printed Circuit Assembly - replaced by 54916-66522
A15	54916-69512	1	Backplane Printed Circuit Assembly - Exchange, replaced by 54916-69522
A15	54916-66522	1	Backplane Printed Circuit Assembly - replaces 54916-66512
A15	54916-69522	1	Backplane Printed Circuit Assembly - Exchange, replaces 54916-69512
A15	54916-66722	1	Backplane PCA for MSOX Infiniium products - tested
A15	54916-69722	1	Backplane PCA for MSOX Infiniium products - Exchange
A16	54913-68710	1	Fan Replacement Kit 120 MM
A17	54916-00103	1	Chassis with additional slot on rear panel
A17	54916-00102	1	Chassis without additional slot on rear panel
A18	54913-60006	1	RHDD Cartridge
A19	82350-66512	1	GPIO Interface Card
A20	0960-2869	1	Motherboard Printed Circuit Assembly for M890
A21	3160-4243	1	Fan with heat sink
A22	54913-83505	1	Infiniium series Imaged HDD for M890/WinXP (Service Centers only)
A22	54913-68717	1	Replacement Infiniium series Imaged HDD for M890/WinXP
A22	54913-83506	1	Infiniium series Imaged HDD for M890/Win7, 500 GB 7200RPM Serial-ATA (Service Centers only)
A22	54913-68718	1	Replacement HDD for M890/Win7-based DSO90000 series scopes
A22	54932-83501	1	Removable hard drive only: Imaged Solid State HDD for M890/Win7-based 90000 X-series scopes (Service Centers only)
A22	54932-68717	1	Replacement Removable hard drive only: Imaged Solid State HDD for M890/Win7-based 90000 X-series scopes
A23	54913-68711	1	Fan Replacement Kit 90 MM
A24	54916-66410	1	PCA RHDD Board
A25	0950-5196	1	Power Supply
A25	54916-00504	1	Power Supply Frame
A25	54913-66403	1	Power Supply Bridge PCA
A26	54916-66403	1	PCA PS Bridge
A27	54916-64901	1	Handle Assembly
A28	54916-68708	1	Cover Assembly
A29	N2834-66501	1	Acquisition Printed Circuit Assembly - MSO
A29	N2834-69501	1	Acquisition Printed Circuit Assembly - MSO - Exchange
A30	54916-00506	1	Frame for MSO board
MP1	54916-94310	1	Label DSOX91604A
MP1	54916-94311	1	Label DSOX92004A
MP1	54916-94312	1	Label DSOX92504A
MP1	54916-94313	1	Label DSOX92804A
MP1	54916-94315	1	Label DSO93004L
MP1	54916-94314	1	Label DSOX93204A
MP1	54916-94316	1	Label DSOX91304A
MP1	54916-94320	1	Label DSAX91604A
MP1	54916-94321	1	Label DSAX92004A
MP1	54916-94322	1	Label DSAX92504A
MP1	54916-94323	1	Label DSAX92804A
MP1	54916-94325	1	Label DSA93004L
MP1	54916-94324	1	Label DSAX93204A
MP1	54916-94329	1	Label DSAX91304A
MP1	54916-94330	1	Label MSOX91604A
MP1	54916-94331	1	Label MSOX92004A
MP1	54916-94332	1	Label MSOX92504A

Replaceable Parts

Ref. Des.	Keysight Part Number	QT Y	Description
MP1	54916-94333	1	Label MSOX92804A
MP1	54916-94334	1	Label MSOX93204A
MP1	54916-94336	1	Label MSOX91304A
MP2	54916-94302	1	Label - I/O Front
MP3	54916-94301	1	Label - Control Panel
MP4	54916-47401	1	Outer clutch
MP5	54916-45001	1	Inner clutch
MP6	54916-07101	1	Input Connector Ground Spring
MP7	54916-42201	1	Bezel
MP8	54916-42001	1	Casting - Probe Mate
MP9	54913-94300	1	Colored Knob Labels
MP10	54916-47411	8	Knob 12 mm slate gray
MP11	54916-47412	5	Knob 18 mm slate gray
MP12	54913-40201	1	Panel - Control
MP13	54916-41901	1	Switch Control Panel
MP14	54542-26101	1	Ground lug
MP15	54916-01206	1	Bracket - Cal Connectors
MP16	54916-00101	1	Deck - Front Panel
MP17	54916-00601	1	Shield - Inverter
MP18	54916-00204	1	Panel - Rear for 54916-00103 chassis
MP18	54916-00201	1	Panel - Rear for 54916-00102 chassis
MP19	54916-01205	1	Bracket - Oscillator
MP20	54913-94307	1	Label - RHDD
MP21	54916-94328	1	Label - PC Rear Panel for 54916-00103 chassis
MP21	54916-94308	1	Label - PC Rear Panel for 54916-00102 chassis
MP22	54916-94309	1	Label - PC I/O
MP23	54916-94326	1	Label - Rear Panel for 54916-00103 chassis
MP23	54916-94306	1	Label - Rear Panel for 54916-00102 chassis
MP24	54916-94327	1	Label - Rear Panel with RHDD for 54916-00103 chassis
MP24	54916-94318	1	Label - Rear Panel with RHDD for 54916-00102 chassis
MP25	54913-01202	1	Bracket - Hard Drive
MP26	54916-04112	1	Plate - CPU Adapter
MP27	54916-00202	1	Panel - Top
MP28	54916-41002	2	Foot - Tilt Lever
MP29	54916-41001	4	Foot - Tilt Base
MP30	54916-00205	1	Bottom Plate for 54916-00103 chassis
MP30	54916-00203	1	Bottom Plate for 54916-00102 chassis
MP31	54916-44101	1	Cover - Front
MP32	54913-41001	2	Foot - Rear
MP33	54916-04107	1	Cover - Serial for 54916-00103 chassis
MP34	54916-07102	1	MSO probe ground spring
W1	54916-61615	1	Cable - Attenuator
W2	54916-61625	1	Cable - SR Aux Out
W3	54916-61624	1	Cable - SR Step Out
W4	54916-61601	1	Cable - Input
W5	54916-61618	1	Cable - SR Backplane Clock Out
W6	54916-61620	1	Cable - SR Clock Ch1 + Ch2
W7	54916-61621	4	Cable - SR Clock Ch3 + Ch4
W8	54916-61622	4	Cable - Aux BNC/SMA
	54916-60003	10	Connector Saver Collars

Chapter 6: Replaceable Parts

Replaceable Parts List

Replaceable Parts

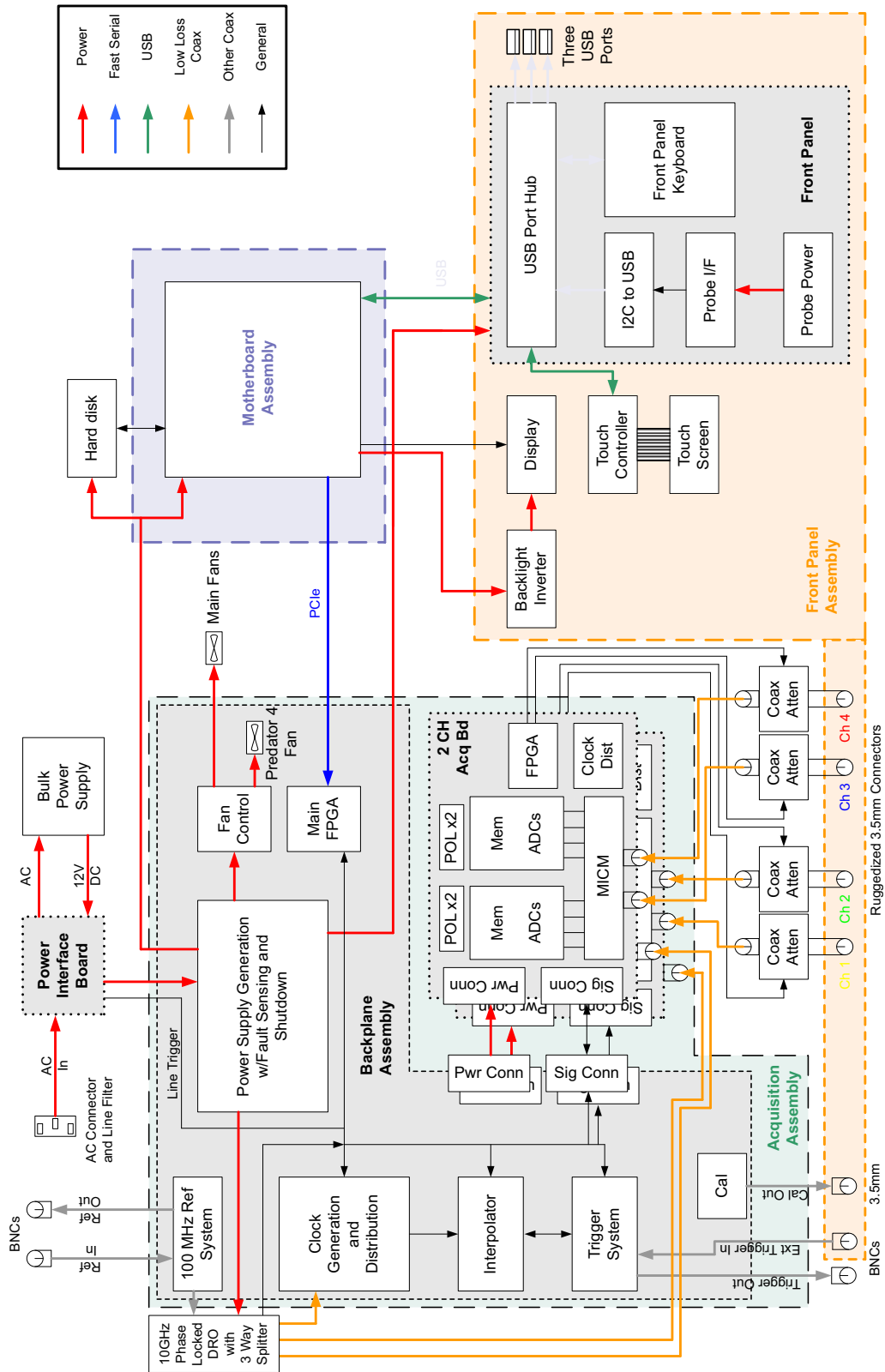
Ref. Des.	Keysight Part Number	QT Y	Description
	54916-60004	10	Connector Saver Collars
	54916-61603	1	Cable - PC Power
	54913-61604	1	Cable - On/Off
	54913-61605	1	Cable - Power front
	54913-61608	1	Cable - Display
	54916-61606	1	Cable - USB Front /Touchscreen
	54916-61617	1	Cable - Autoprobe for older scopes ^a
	54916-61637	1	Cable - Autoprobe
	54916-61619	1	Cable - SR Oscillator Reference
	54916-61626	1	Cable - Calibration
	54916-61628	1	Cable - SMA/SMB Vertical 0.3 m
	7120-6153	1	Label - ground
	1520-0686	1	Shock mount - fan complete with delta fan
	1400-3191	1	Clip - latching, snap-in pressure sensitive
	N2815-68701	1	Serial card cable
	54916-94326	1	Label - Rear panel
	N2834-68703	1	MSO calibrator board assembly
	54916-94337	1	Label - MSO cable direction
	9010-0305	1	Windows software sticker
	9320-6648	1	Label - hipot
	N2834-66502	1	PCA - MSO Calibrator
	8120-5392	1	Power cord - United Kingdom
	8120-5393	1	Power cord - Australia and New Zealand
	8120-5336	1	Power cord - Continental Europe
	8120-5395	1	Power cord - United States and Canada
	8120-5397	1	Power cord - Switzerland
	8120-5398	1	Power cord - Denmark
	8120-5399	1	Power cord - India
	8120-5400	1	Power cord - Japan
	8121-0955	1	Power cord - Israel
	8120-8390	1	Power cord - Argentina
	8120-8389	1	Power cord - Chile
	8121-1632	1	Power cord - China
	8120-5399	1	Power cord - South Africa
	8121-1660	1	Power cord - Thailand
	8121-1858	1	Power cord - Brazil
	8121-1636	1	Power cord - Taiwan
	8121-1640	1	Power cord - Cambodia

- a. There was a connector change on the older A2 54916-66404 board and 54916-61617 cable. When SPO is out of stock, order the 54916-68719 replacement kit. The kit has four Autoprobe boards (54916-66414) and one cable (54916-61637).

Motherboard Assembly	124
Acquisition Assembly	125
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Power Supply Assembly	133
MSO Assembly	134

Theory of Operation

Figure 7-1 Oscilloscope block diagram



Theory of Operation

This chapter describes the basic structure of the oscilloscope and how the parts interact. The oscilloscopes are comprised of five or six main assemblies, depending on the model of the oscilloscope: a motherboard assembly, an acquisition assembly, a backplane assembly, a front panel assembly, and a power supply assembly for all models, plus a Mixed Signal Oscilloscope (MSO) assembly for all MSO models. Figure 7-1 shows a block diagram of the oscilloscope.

Motherboard Assembly

The motherboard provides all system control and interface functions for the oscilloscope. The motherboard contains a microprocessor, a hard disk drive interface, ROM, RAM, keyboard and mouse interfaces, connections to the front panel board, and serial interfaces.

Pressing the on/off button sends a signal to the motherboard. The motherboard then signals the backplane assembly, which in turn sends a signal to tell the bulk 12V power supply to turn on. When the power supply turns on, the remaining power supplies are enabled and powered on. Then the main FPGA on the backplane assembly gets self-configured from its PROM. Once it's configured, the main FPGA asserts a signal to tell the motherboard to power up and become fully functional.

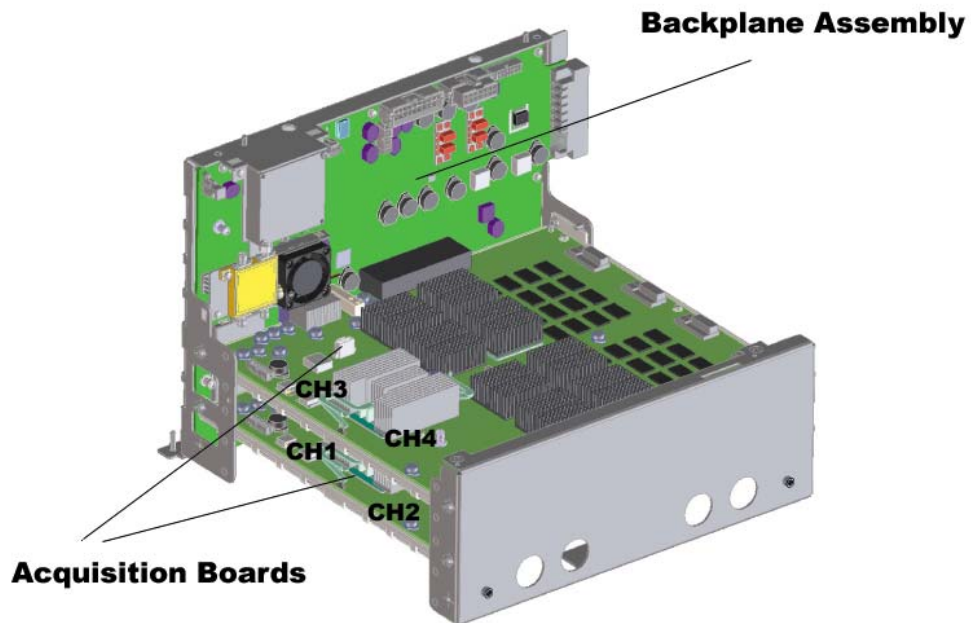
The hard disk drive is a high-capacity, shock-resistant unit that stores the oscilloscope operating system, the oscilloscope application, compliance application information, calibration data, other data files, and drivers for the boards and oscilloscope. The hard disk drive can also be used to store and recall oscilloscope setups and waveforms.

Note that it is important for the hard disk drive image to match the motherboard. If they do not match, the oscilloscope may not have the correct Windows software drivers.

Acquisition Assembly

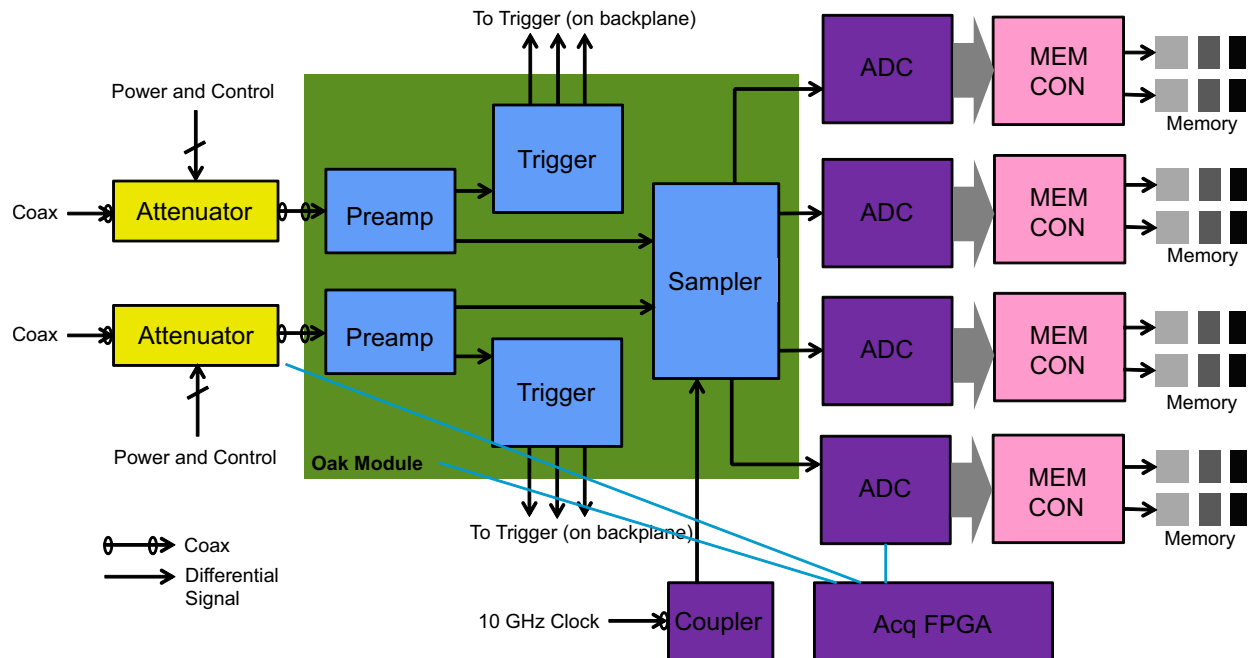
The acquisition assembly consists of two identical acquisition boards. These two boards connect to the backplane board as shown in Figure 7-2.

Figure 7-2 Acquisition and backplane assemblies



The upper acquisition board circuitry samples, digitizes, and stores the signals for channels 3 and 4; the lower acquisition board does the same for channels 1 and 2. Both acquisition boards contain the Oak module (a full-custom ball grid array multi-chip module), the Onboard ADC, clock distribution, data management ASICs, external acquisition memory, ADCs, communication and programming FPGAs, and supporting power supply circuitry. Figure 7-3 shows a block diagram of the acquisition boards including the Oak module.

Figure 7-3 Oak module and acquisition components

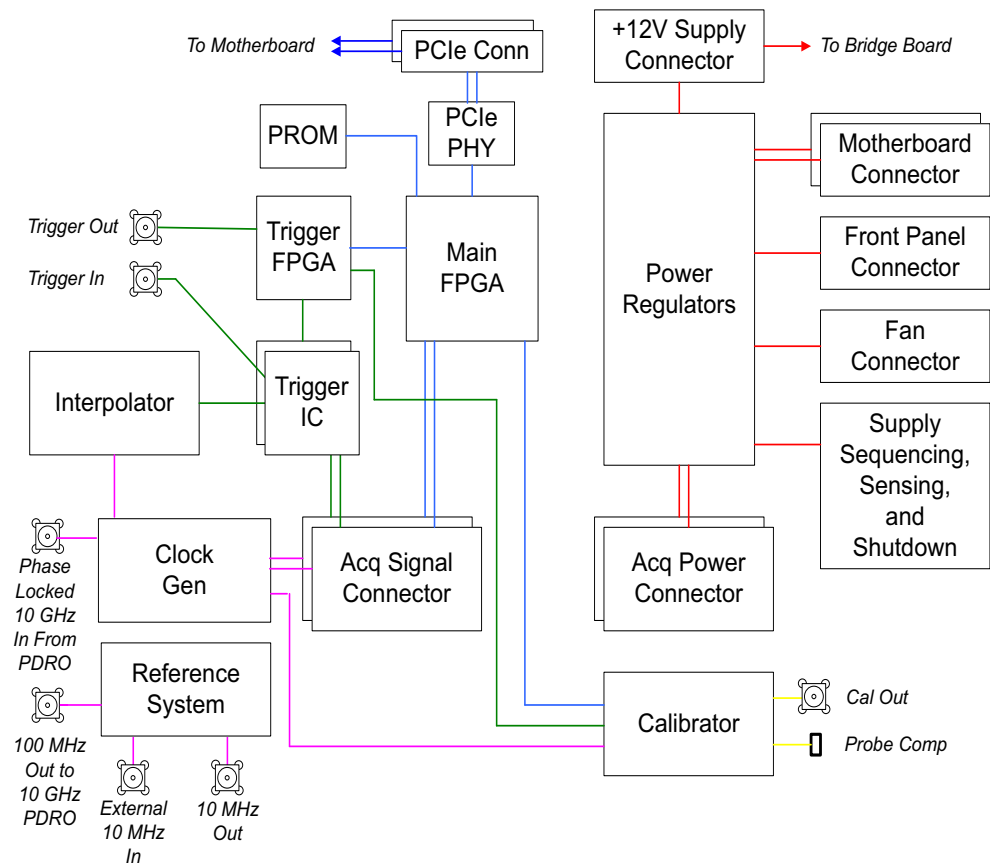


The acquisition front end starts at the front panel input connectors, then goes through the attenuators, cabling, and Oak module. The differential outputs from Oak then go into one differential input pair of the ADC. Each ADC has two sets of differential inputs.

Backplane Assembly

The backplane assembly is a device on the PCI Express (PCIe) bus connected by two SATA cables to the motherboard. The backplane assembly receives +12V DC power through a power interface board from the bulk supply, and all voltages are derived from switching power regulators and other circuitry. Most of the switching and circuitry are on the backplane board, with some distribution and generation done on the acquisition boards. Figure 7-4 shows a block diagram of the backplane board.

Figure 7-4 Backplane block diagram

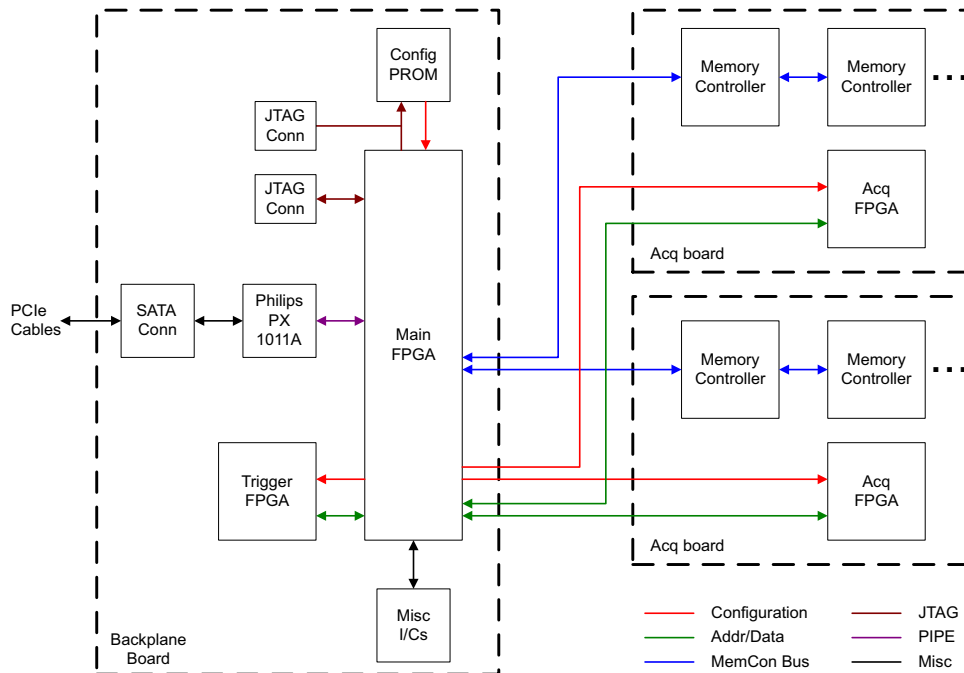


The colors in the diagram represent different signal groups. The backplane provides power (red), clock generation (pink), trigger (green), and calibrator (yellow) functions to the oscilloscope, as well as communications and control for the PC software (blue). The PC connects to the measurement system through PCIe to the main FPGA. Connections to all other circuits go through the main FPGA.

Main FPGA

The main FPGA (field-programmable gate array) is the only communication link from the oscilloscope hardware to the PC system. All system controls and data pass through the main FPGA. Figure 7-5 shows the connections to the main FPGA.

Figure 7-5 Main communication FPGA connections



During a successful power-up, a PROM configures the FPGA over an 8-bit bus. The PROM comes pre-loaded with the required bits, but can be re-programmed through its JTAG port with software or through a Xilinx programming cable plugged into a normally no-loaded connector.

Once the FPGA is configured, the FPGA controls the power sequencing system, which allows the rest of the system to power up and become fully functional. When everything is ready the FPGA sends a reset to the PC motherboard so that Windows and the oscilloscope software can start up.

The FPGA is a device on the PCIe bus (x1) interfaced with an external Philips PHY. The PHY drives the PCIe signals out two SATA connectors. Two SATA cables are required to connect the backplane board to the motherboard. Because running PCIe over SATA cables is not a standard usage, a special motherboard is required that has an x1 port wired into two SATA connectors. When Windows is booted up, the main communication FPGA must show up in the device listing (as Infiniium Acquisition) for the oscilloscope application to run and control the oscilloscope hardware.

The main FPGA contains several registers that can be used to control peripherals and fan speed, configure and communicate with other FPGAs, and pass sampled data to the PC for reconstruction of the measured waveform on the oscilloscope display. In addition, the FPGA generates PCI interrupts for all oscilloscope-related special events such as a front-end overload, the timer done, or a stopped cooling fan.

The main FPGA uses three identical buses to communicate with three different downstream FPGAs. The buses are 8-bit parallel buses with miscellaneous control signals. One bus is used to control the trigger functions in the backplane board and one bus connects to each of the two acquisition boards. A separate bus for each FPGA minimizes timing problems and reflections. The FPGAs on the acquisition assemblies are used to control the oscilloscope functions on each of those assemblies. On power-up, after the PC software recognizes the two acquisition assemblies, it loads the trigger FPGA and the acquisition FPGAs using these buses. When programming is complete, the PC communicates with the

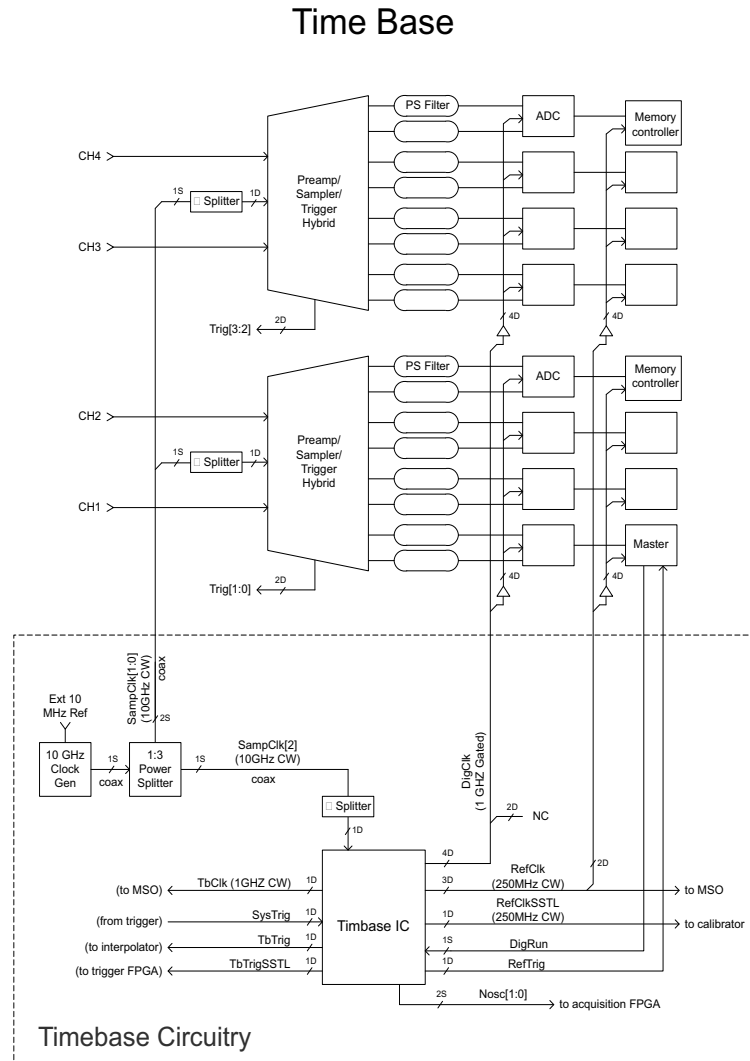
downstream FPGA over the same buses.

The main FPGA provides access to the memory controllers over a separate bus to each acquisition board. The acquired data is retrieved from the acquisition boards over these buses.

Timebase System

The oscilloscope timebase system generates and distributes all of the clock signals that control or are synchronized to waveform acquisition. Figure 7-6 shows the timebase system including its circuitry.

Figure 7-6 Time base



The fundamental sample clock is a single-ended 10 GHz signal distributed to each Oak module and the Wahoo timebase IC through semi-rigid coax. In each case, the single-ended signal is converted to a differential signal using a bandpass filtered 180° phase splitter implemented using microwave structures on shielded inner layers of the PCB.

The Wahoo timebase IC divides the 10 GHz CW clock down into multiple 1 GHz and 250 MHz clocks. The 1 GHz DigClk clocks are gated by DigRun so that the ADCs can be synchronized with each other. Wahoo also performs some of the time interpolator functionality by synchronizing the system trigger to the 1 GHz DigClk and generating the first two MSBs of the trigger interpolation value.

The 10 GHz SampClk 10G signal is divided down to 1 GHz for use as TbClk and DigClk.

TbClk is divided by four to generate RefClk, which drives the memory controllers and the calibrator chip. These four 250 MHz outputs are phased in quadrature to minimize the coupling of sub-harmonics into the DigClk signals. The RefClk signal that goes to the calibrator chip must be disabled when not in used by the calibrator system.

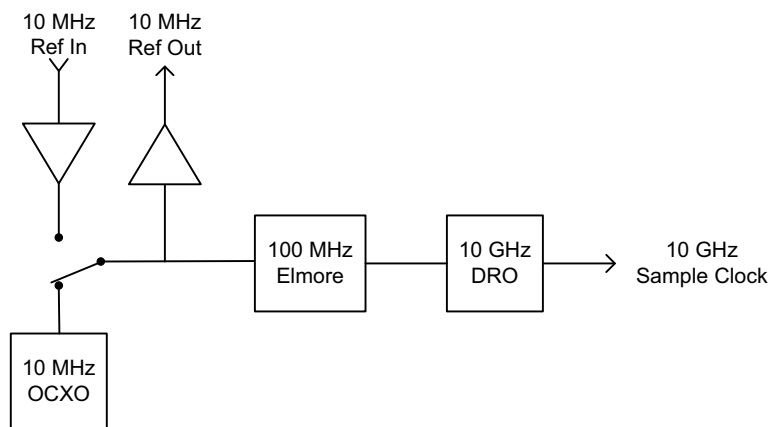
SysTrig is the primary output from the trigger system. It is synchronous to the trigger event and asynchronous to the time base clock, TbClk. Wahoo synchronizes SysTrig to the timebase clock with low probability of metastability, producing the TbTrig signal. TbTrig pulses high once immediately after every rising edge of SysTrig.

Wahoo also produces a trigger signal that is synchronous to RefClk. This signal, RefTrig, pulses high once immediately after every rising edge of SysTrig. RefTrig tells the memory controller when a trigger event has occurred. It is important to note that although DigRun and RefTrig are both synchronous to RefClk, their phase relationship to RefClk is not important. As long as their phase relationship is consistent, the memory controller can adjust for it. Finally Wahoo records the phase relationship between RefTrig and TbTrig, and provides it as the 2-bit digital value, Nosc. Nosc[0] is driven by the 500 MHz clock and Nosc[1] is driven by the 250 MHz clock.

10 GHz Clock Generation

The fundamental frequency reference of the oscilloscope's timebase clock is a low-noise precision 10 MHz signal. This 10 MHz reference can originate from the internal oven-controlled crystal oscillator or from an external 10 MHz reference signal. Fine frequency adjustment of the internal crystal oscillator is possible with a DAC line (OSC_FREQ_ADJ). During calibration you can use a precision 10 MHz source to tune the frequency. A bandpass-filtered, AC-coupled copy of either the internal 10 MHz reference or a user-selectable external 10 MHz reference is sent through a cable to a rear-panel BNC connector for use as a reference source for some other instrument. This connection is a 50 Ohm output designed to drive a single 50 Ohm input. When phase-locking multiple instruments, the 10 MHz references are usually daisy-chained together. Refer to Figure 7-7 for a block diagram showing clock generation.

Figure 7-7 10 GHz clock generation



The external 10 MHz reference is applied through a rear-panel BNC connector and runs to the backplane assembly. Users can select between an internal and external reference through a dialog box in the oscilloscope application. A detector circuit consisting of a detector diode and a non-inverting op-amp gain stage followed by a window comparator ensures the user supplies a 10 MHz signal of the correct amplitude (-5 dBm minimum to +10 dBm maximum). The detector circuit produces a warning if the external reference input signal is too small or too

large, but not if the signal is within the specified operating range. The frequency of this external reference must be very close to 10 MHz (typically ± 20 ppm) or the 100 MHz oscillator will not be able to lock to it.

The internal and external reference inputs are applied to each input of a very high isolation RF switch. The isolation between the two inputs is greater than 100 dB to prevent the internal and external 10 MHz clocks from interfering with each other. This 10 MHz reference, either internal or external, is split into two signal paths. One path goes to the rear panel as described earlier for use as a reference for some other instrument, and the second path is limited and filtered for use as the reference input to the 100 MHz phase-locked oscillator. The signal that goes to the rear panel is very close to the same amplitude as either the internal reference oscillator output amplitude or the input amplitude of the external signal applied to the external reference input connector, depending on which one the user selected. The reference signal that goes to the 100 MHz oscillator input is a sine wave of amplitude 0 dBm ± 3 dB.

The actual 10 GHz sample clock is generated with a DRO that is phase-locked to the 100 MHz oscillator output.

Trigger System

The trigger system contains an FPGA that is used to coordinate the trigger system operation and two trigger ICs. The FPGA uses a 212.5 MHz clock that is synchronous to the main communication FPGA clock. The trigger ICs are the main trigger-handling chips, programmed with a serial interface from the main communication FPGA. Each trigger IC also receives two DAC signals that set the internal clock and data timers. The trigger IC is used for setting the timing for the logic trigger from 0.3 ns to 20 ns. The trigger FPGA is used for times greater than 20 ns.

Front Panel Assembly

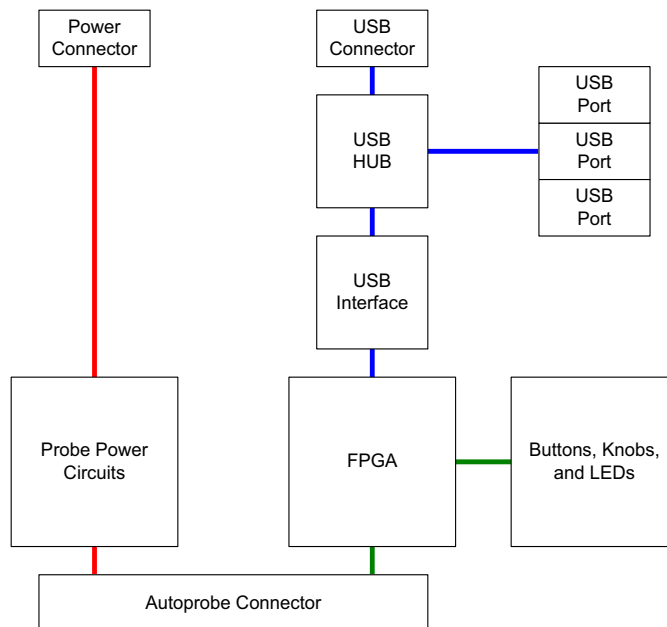
The front panel assembly consists of a front panel board, on/off board, display board, touch screen and controller, AutoProbe II interface board for probe power and probe control, backlight inverter board, front panel connectors, and cabling connectors for the AutoProbe II interface.

Front Panel Board

The front panel board provides the main user interface to the instrument through dedicated knobs and pushbuttons. It also provides power and communication to the probe interface. The front panel board receives power from the backplane board through a dedicated cable. The communication link to the board is USB to the motherboard. The on-board USB hub serves the FPGA microcontroller, the touch screen controller board, and three front panel USB connectors for peripherals.

Figure 7-8 shows a simplified block diagram of the oscilloscope front panel.

Figure 7-8 Front panel



On/Off Board

The on/off board interfaces with the motherboard to provide the on/off switch function, and with the backplane to provide the probe compensation output. Power indicator LEDs backlight the on/off pushbutton and are driven by the motherboard. The probe compensation lugs connect to the calibrator output on the backplane through an SMB connector coax cable. An ESD protection diode sits on the on/off board, connecting the signal and ground probe compensation lugs.

AutoProbe II Board

The AutoProbe II board uses an I²C interface to communicate with the probes.

Power Supply Assembly

The power supply assembly consists of a power interface board and a bulk +12V power supply. The power interface board does filtering and provides 60 Hz line trigger to the oscilloscope.

MSO Assembly

The MSO assembly consists of a printed circuit assembly that fits below the lower acquisition board. It provides digital channel capability.

Figure 7-9 shows the circuitry of the MSO board. Figure 7-10 shows how the FPGA on the MSO board communicates with the Main FPGA on the backplane board.

Figure 7-9 MSO Printed Circuit Assembly

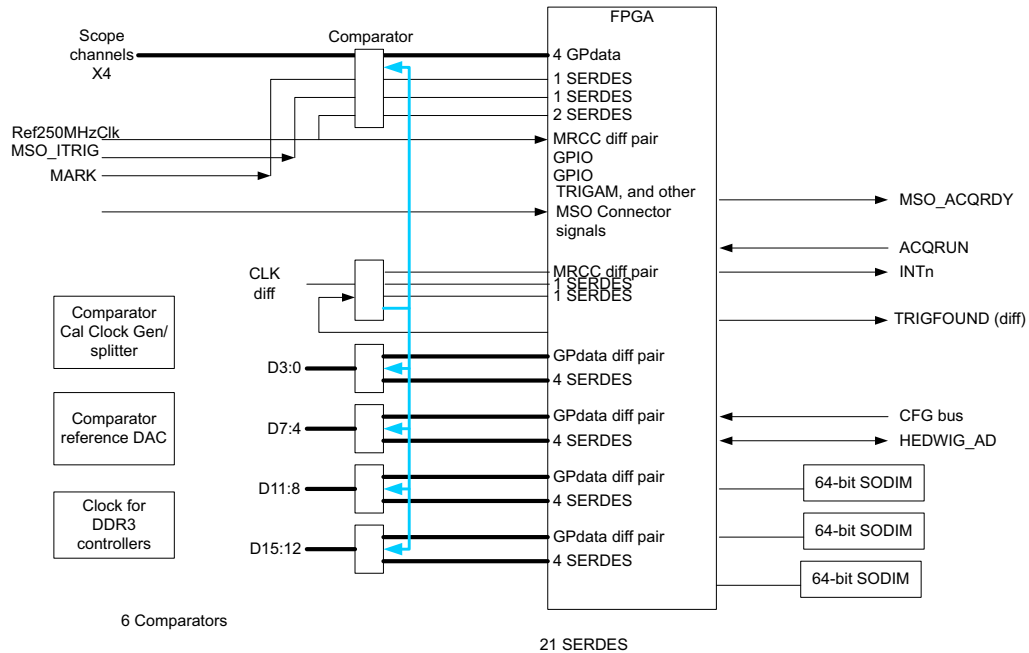
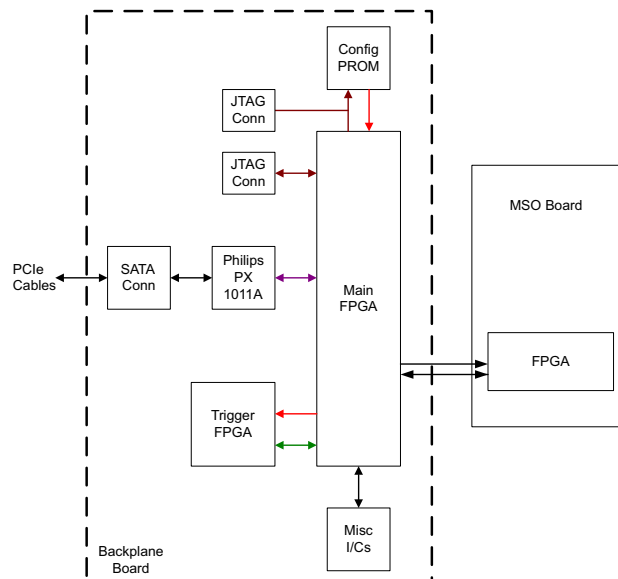


Figure 7-10 MSO Board FPGA



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 be inserted only 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 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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