
Keysight Infiniium V-Series Oscilloscopes

Notices

© Keysight Technologies 2015-2017, 2021-2023

No part of this manual may be reproduced in any form or by any means (including electronic storage and retrieval or translation into a foreign language) without prior agreement and written consent from Keysight Technologies, Inc. as governed by United States and international copyright laws.

Manual Part Number

54919-97020

Edition

Ninth edition, September 2023
Available in electronic format only

Published by:
Keysight Technologies, Inc.
1900 Garden of the Gods Rd.
Colorado Springs, CO 80907 USA

Trademarks

Infiniteon is a registered trademark of Infineon Technologies AG. The Infiniteon mark is used with the kind approval of Infineon Technologies, AG.

Warranty

The material contained in this document is provided “as is,” and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, Keysight disclaims all warranties, either express or implied, with regard to this manual and any information contained herein, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Keysight shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or of any information contained herein. Should Keysight and the user have a separate written agreement with warranty terms covering the material in this document that conflict with these terms, the warranty terms in the separate agreement will control.

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

U.S. Government Rights

The Software is "commercial computer software," as defined by Federal Acquisition Regulation ("FAR") 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement ("DFARS") 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

Safety Notices

CAUTION

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

WARNING

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met.

For more safety information, refer to the *For Your Safety* booklet included with your Infiniteon oscilloscope.

Contents

1 General Information / 7

- Instruments Covered by this Service Guide / 8
- Accessories Supplied / 8
- Specifications and Characteristics / 9
- Measurement Category / 11
 - Measurement Category / 11
 - Measurement Category Definitions / 11
- Preventing Damage to the Oscilloscope Inputs / 12
- Power Considerations / 13

2 Calibration / 15

- What is a Calibration? / 16
- Running an Environmental Calibration / 17
 - Equipment Required / 17
 - Procedure / 17
- Running a User Calibration / 19
 - Equipment Required / 19
 - Procedure / 20

3 Testing Performance / 23

- Verifying System Performance / 24
 - Performance Test Interval / 24
 - Performance Test Record / 24
 - Test Order / 24
 - Test Equipment / 24
- Vertical Performance Verification / 25
 - Offset Accuracy Test / 26
 - DC Gain Accuracy Test / 33
 - Analog Bandwidth–Maximum Frequency Test / 37
 - Time Scale Accuracy (TSA) Test / 44
- Performance Test Record / 47

4 Troubleshooting / 53

- Service Strategy / 54
- Verifying Basic Operation / 55
 - Power Up the Oscilloscope / 55
 - Check the display / 56
 - Run the oscilloscope self-tests / 56
 - Run the keyboard, LED, and touch screen self tests / 56
 - Run a user calibration / 59
 - Verify system performance / 59
- Power Supply Troubleshooting / 60
 - If the L-ACQ TEMP FAIL or U-ACQ TEMP FAIL LED is lit / 65
 - If the FP SUPPLY FAIL LED is lit / 66
 - If the MAIN FAN FAIL LED is lit / 69
 - If the PRED FAN FAIL LED is lit / 70
- Setting Up the BIOS / 72
- Motherboard Verification / 73
- Display Troubleshooting / 75
- Acquisition/Backplane Assembly Troubleshooting / 76
- Keyboard Troubleshooting / 77
- Front Panel LED Troubleshooting / 78
- Touch Screen Troubleshooting / 79
- Checking Probe Power Outputs / 80
- MSO Assembly Troubleshooting / 81
- Hardware Serial Trigger Assembly Troubleshooting / 83
- Before You Contact Keysight / 84

5 Replacing Assemblies / 85

- Returning the oscilloscope to Keysight Technologies for service / 86
- Tools Required / 87
- Safety Precautions / 88
- CAUTION: Close SMA Cable Ports / 89
- Removing and replacing the top panel and bottom panel / 90
- Removing and replacing the front panel assembly / 92
- Removing and replacing front panel assembly parts / 98

Removing the display assembly	/ 101
Removing and replacing the motherboard	/ 103
Removing and replacing the acquisition boards/backplane/MSO assembly	/ 109
Removing the backplane assembly from the acquisition assembly	/ 117
Replacing the backplane board	/ 122
Replacing an acquisition board	/ 127
Setting the calibration factors after replacing an acquisition board	/ 130
Removing and replacing the hard disk drive	/ 131
Removing and replacing the power supply	/ 132
Removing and replacing fans	/ 134
Removing and replacing the optional GPIB port	/ 136

6 Replaceable Parts / 139

Ordering Replaceable Parts	/ 140
Exploded Views	/ 141
Replaceable Parts List	/ 145

7 Theory of Operation / 151

Theory of Operation	/ 153
Motherboard assembly	/ 154
Acquisition assembly	/ 155
Backplane assembly	/ 157
Front Panel Assembly	/ 163
Power Supply Assembly	/ 164
MSO assembly	/ 165
Hardware Serial Trigger Assembly	/ 167

1 General Information

Instruments Covered by this Service Guide	8
Accessories Supplied	8
Specifications and Characteristics	9
Measurement Category	11
Preventing Damage to the Oscilloscope Inputs	12
Power Considerations	13

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 back of 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 V-Series oscilloscopes are covered in this guide.

Model	Bandwidth
MSOV/DSOV/DSAV 084A	8 GHz bandwidth
MSOV/DSOV/DSAV 134A	13 GHz bandwidth
MSOV/DSOV/DSAV 164A	16 GHz bandwidth
MSOV/DSOV/DSAV 204A	20 GHz bandwidth
MSOV/DSOV/DSAV 254A	25 GHz bandwidth
MSOV/DSOV/DSAV 334A	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 with the oscilloscope:

- mouse
- keyboard
- front panel cover
- calibration cable
- connector saver collars (10)
- connector savers (f-f) (5)
- power cord
- ESD mat with ground cord set
- digital channels cable (MSO models only)
- MSO calibrator board assembly (MSO models only)

Specifications and Characteristics

The following table contains a partial list of specifications and characteristics for the Keysight Infiniium V-Series oscilloscopes. For a complete list, see the data sheet at www.keysight.com/find/V-series.

Warranted specifications are tested in **Chapter 3**, “Testing Performance”. Specifications are valid after a 30-minute warm-up period, and within $\pm 5^{\circ}\text{C}$ from the temperature at which the last user 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 meters (12,000 feet) Non-operating: up to 15,300 meters (50,000 feet)
Installation Category	II
Weight	52.2 lbs.
Dimensions	10.5 in. tall (27 cm), 17.2 in. wide (44 cm), and 20.2 in. deep (51 cm)
Safety	CAN/CSA-C22.2 No. 61010-1-12(R2017) CAN/CSA-C22.2 No. 61010-2-030:18 UL Std. No. 61010-1 (3.1 Edition) UL Std. No. 61010-2-30 (2nd Edition) CAN/CSA-C22.2 No. 6101030-12 UL Std. No. 61010-2-30 (1st Edition)
Power Requirements	100-240 VAC $\pm 10\%$ at 50/60 Hz; Input power not to exceed 800 W
Voltage Fluctuations	The mains supply voltage fluctuations are not to exceed $\pm 10\%$ of the nominal supply voltage.
Pollution Degree	The Infiniium V-Series oscilloscopes may be operated in environments of Pollution Degree 2.

Pollution Degree Definitions	<p data-bbox="747 262 1453 367">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 data-bbox="747 399 1453 504">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 data-bbox="747 535 1453 709">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>
------------------------------	---

Measurement Category

Measurement Category

The Infiniium V-Series oscilloscopes are not intended to be used for measurements in Measurement Category II, III, or IV.

WARNING

The product is for use only on circuits that are NOT directly connected to mains. It is NOT intended for measurements on CAT II, CAT III, or CAT IV circuits.

Measurement Category Definitions

The "Not rated for CAT II, III, IV" measurement category is for measurements performed on circuits not directly connected to MAINS. Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS derived circuits. In the latter case, transient stresses are variable; for that reason, the transient withstand capability of the equipment is made known to the user.

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

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

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

Preventing Damage to the Oscilloscope Inputs

Avoid damaging the oscilloscope inputs by knowing the approximate signal level to be measured. Overpowering the front end can cause damage to the front end components. The maximum input signal level of V-Series oscilloscopes is ± 5 V.

When connecting probes, adapters, or cables to the Infiniium V-Series oscilloscope, use caution to avoid damaging the oscilloscope's channel input circuits due to electrostatic discharge (ESD).

CAUTION

When a probe, adapter, or cable is connected to the V-Series oscilloscope, the oscilloscope's channel input circuits can be damaged by ESD. Avoid applying static discharges to anything connected to the oscilloscope. Be sure the oscilloscope is properly earth-grounded to prevent buildup of static charge. Wear a wrist strap or heel strap.

CAUTION

Loose cables, much like loose capacitors, can hold electrostatic charges. The free end of a cable touching a charged surface can cause oscilloscope input damage. Before connecting any cable to an oscilloscope input, short the center and outer conductors of the cable together to ground momentarily. Alternatively, connect to a 50 Ω termination adapter to discharge the cables.

WARNING

Use Only Grounded Instruments.

Do not connect the ground lead of a probe to a potential other than earth ground. Always make sure the probe and the oscilloscope are grounded properly.

Power Considerations

CAUTION

Do not use this instrument with a power cord other than the one provided by Keysight. The power cord provided is matched to the country of the origin of the order. Other power cords may not have appropriate ratings. Therefore, you must not replace the detachable MAINS supply cords by inadequately RATED cords.

- The power receptacle must match the provided power cord plug.
- Do not use extension cords or power strips.
- Do not use outlets < 100 VAC.
- Do not use a 3-prong to 2-prong adapter.
- Do not have loose outlet connections.

1 General Information

2 Calibration

What is a Calibration?	16
Running an Environmental Calibration	17
Running a User Calibration	19

What is a 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 V-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 calcs 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 calcs 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 Ω 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 only once, during production of the oscilloscope. All of the factory 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

NOTE

The oscilloscope must be warmed up (with the oscilloscope application running) for at least 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. Running an environmental calibration does not invalidate the oscilloscope's Certificate of Calibration.

When to perform an environmental calibration:

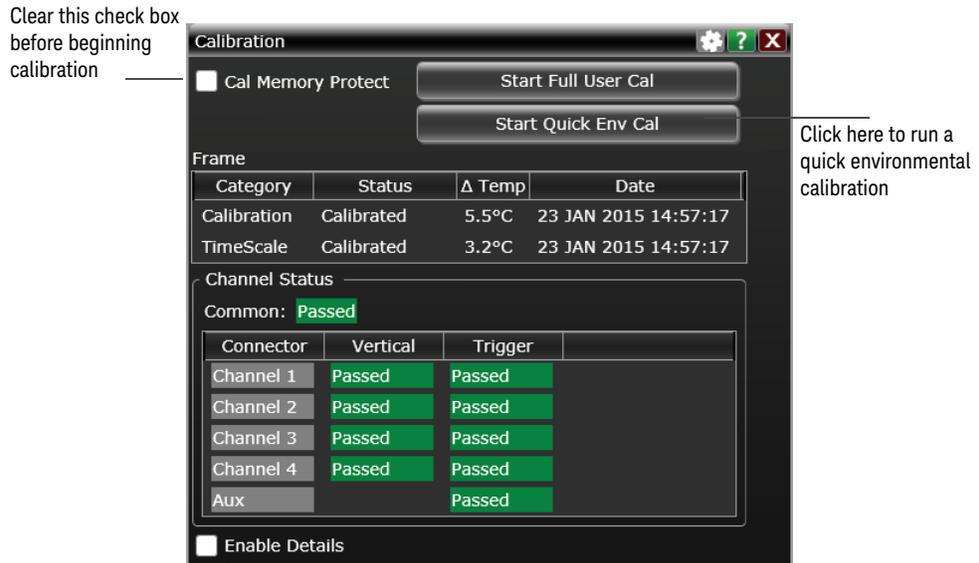
- You can perform a quick environmental cal rather than a full user cal when there are changes to the operating environment around the oscilloscope, such as changes in air flow, temperature, humidity, or the placement of other instruments near the oscilloscope. For example, you would run the quick environmental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

Equipment Required

Equipment	Critical specifications	Recommended part number
Connector savers (5 supplied with oscilloscope)	3.5 mm (f) to 3.5 mm (f)	54916-68717 (for models \geq 20 GHz)
		54916-68716 (for models \leq 16 GHz)
Cable (supplied with oscilloscope)	No substitute	Keysight 54916-61626

Procedure

- Let the oscilloscope warm up before running the environmental calibration.
The environmental calibration should be done only after the oscilloscope has run for 30 minutes at ambient temperature. Calibration of an oscilloscope that has not warmed up may result in inaccurate calibration.
- Choose **Utilities > Calibration...**
- Uncheck the **Cal Memory Protect** box. You cannot run an environmental calibration if this box is checked.



- 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. Failure to use the appropriate calibration cable will result in an inaccurate calibration.
 - c Connect the calibration cable from Cal Out to each channel input 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

NOTE

The oscilloscope must be warmed up (with the oscilloscope application running) for at least 30 minutes at ambient temperature 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 running the user calibration.
- When the oscilloscope's operating temperature (after the 30-minute warm-up period) is more than ± 5 °C different from that of the last calibration, perform the interleave response correction portion when running the user calibration.

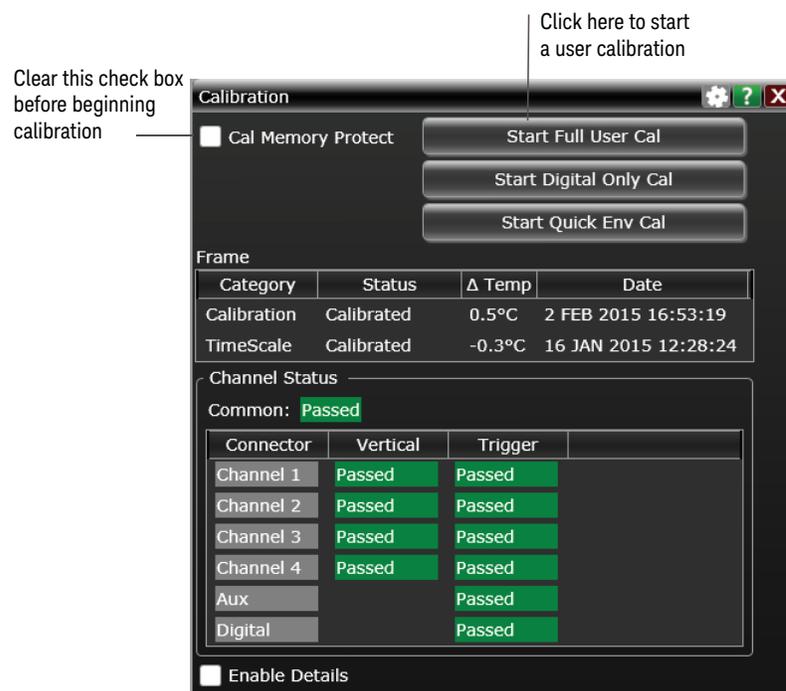
Performing a user calibration will invalidate the oscilloscope's Certificate of Calibration. If NIST (National Institute of Standards and Technology) traceability is required, perform the procedures in [Chapter 3](#) using traceable sources.

Equipment Required

Equipment	Critical specifications	Recommended part number
Connector savers (5 supplied with oscilloscope)	3.5 mm (f) to 3.5 mm (f)	54916-68717 (for models \geq 20 GHz) 54916-68716 (for models \leq 16 GHz)
Cable assembly	50 Ω characteristic impedance BNC (m) connectors, 36 inches (91 cm) to 48 inches (122 cm) long	8120-1840
Adapter	SMA (m) to BNC (f)	1250-1200
Cable (supplied with oscilloscope)	No substitute	54916-61626
Digital channels cable (MSO models only)	No substitute	N2815-68701
MSO calibrator (MSO models only)	No substitute	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. Calibration of an oscilloscope that has not warmed up may result in inaccurate calibration.
- 2 Choose **Utilities > Calibration...**
- 3 Uncheck the **Cal Memory Protect** box. You cannot run a self calibration if this box is checked.

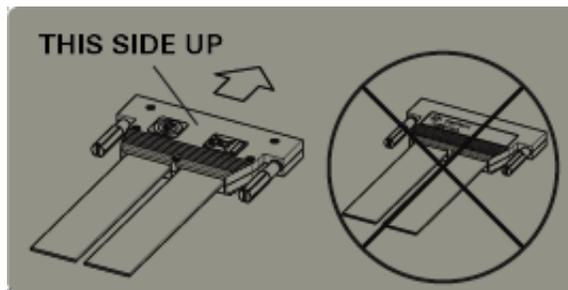


- 4 Click **Start Full User Cal**, then follow the instructions on the screen. The routine will prompt you to follow these steps:
 - a Disconnect everything from all inputs and Cal Out.
 - b Indicate whether you want to run time scale and interleave response correction calibrations. For a list of equipment 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. Failure to use the appropriate calibration cable will result in an inaccurate calibration.

- d Connect the calibration cable from Cal Out to each channel input 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 accessory I/O connector on the rear of the oscilloscope and to the calibration connector on the MSO calibrator.

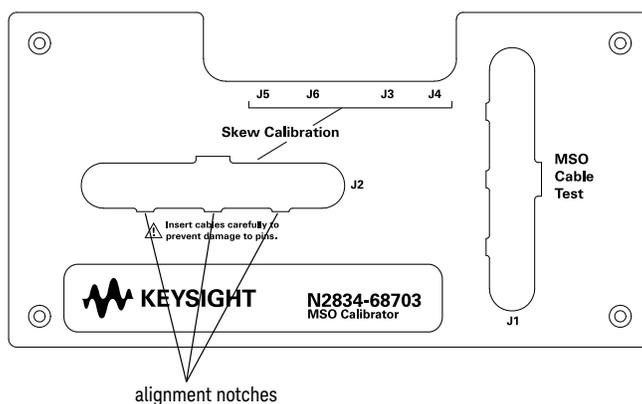
CAUTION

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



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.



- 6 When the calibration procedure is complete, click **Close**.

2 Calibration

3 Testing Performance

Verifying System Performance	24
Vertical Performance Verification	25
Offset Accuracy Test	26
DC Gain Accuracy Test	33
Analog Bandwidth–Maximum Frequency Test	37
Time Scale Accuracy (TSA) Test	44
Performance Test Record	47

Full performance verification for V-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.

Verifying System Performance

This chapter 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 as it represents an incremental approach to performance verification. This approach may be useful if you are trying 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 equipment and accessories required. The test equipment in these lists are currently available for sale by Keysight at the time this document was written. In some cases, the test procedures use features specific to the test equipment in the recommended equipment list. However, other equipment, cables, and accessories that satisfy the critical specifications in these lists may be substituted for the recommended models with some modification to the test procedures.

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

Vertical Performance Verification

This section describes 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.

NOTE

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 7.5 mV/div. Below 7.5 mV/div, full scale is defined as 60 mV. The major scale settings are 1 mV/div, 2 mV/div, 5 mV/div, 10 mV/div, 20 mV/div, 50 mV/div, 100 mV/div, 200 mV/div, 500 mV/div, and 1 V/div.	

Equipment Required

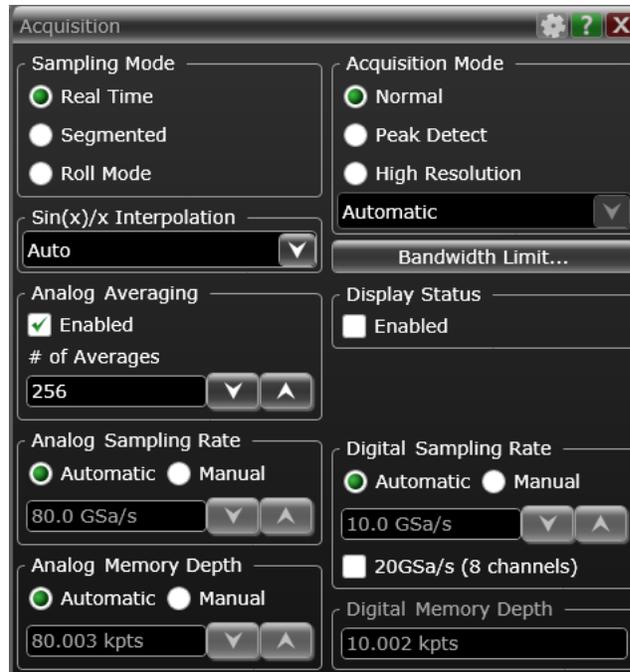
Equipment	Critical specifications	Recommended model/part #
Digital Multimeter	DC voltage measurement accuracy better than $\pm 0.1\%$ of reading	34411A or 3458A
Cable Assembly (2 required)	50Ω characteristic impedance, BNC (m) connectors	8120-1840
Adapter	BNC Tee (m)(f)(f)	1250-0781
Adapter	BNC (f) to dual banana	1251-2277
Connector Savers (5 supplied with oscilloscope)	3.5 mm (f) - (f)	54919-68717 (for oscilloscope models ≥ 20 GHz) 54916-68716 (for oscilloscope models ≤ 16 GHz)
Adapter (2 required)	BNC (f) to SMA (m) adapter	1250-1200

NOTE

The offset accuracy specification has two terms: \pm (offset gain + 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 oscilloscope channel inputs.
- 2 Click **Control > Factory Default**.
- 3 Click **Setup > Acquisition....** In the Acquisition dialog box, enable averaging and set # of Averages to 256.



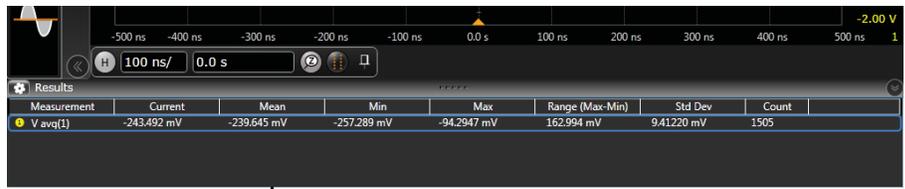
- 4 Configure the oscilloscope to measure the average voltage (V avg) on channel 1 as follows:
 - a Change the vertical scale of channel 1 to 10 mV/div.
 - b Click the Vertical Meas tab on the left side of the waveform window, then drag and drop the Average measurement icon onto the channel 1 waveform.



- 5 Press **[Clear Display]** on the oscilloscope and wait for the number of averages display (top right area of the screen) to return to 256. Record the oscilloscope’s mean V avg reading in the Offset Accuracy–Zero Error Test section of the Performance Test Record.

NOTE

- For all oscilloscope readings in this procedure, use the mean value in the Measurement Results area at the bottom of the screen.
- If a question mark appears in front of any values in the Results area, press **[Clear Display]** on the oscilloscope, wait for the number of averages to return to 256, and then record the oscilloscope reading. The question mark indicates that the oscilloscope could not make a reliable measurement.

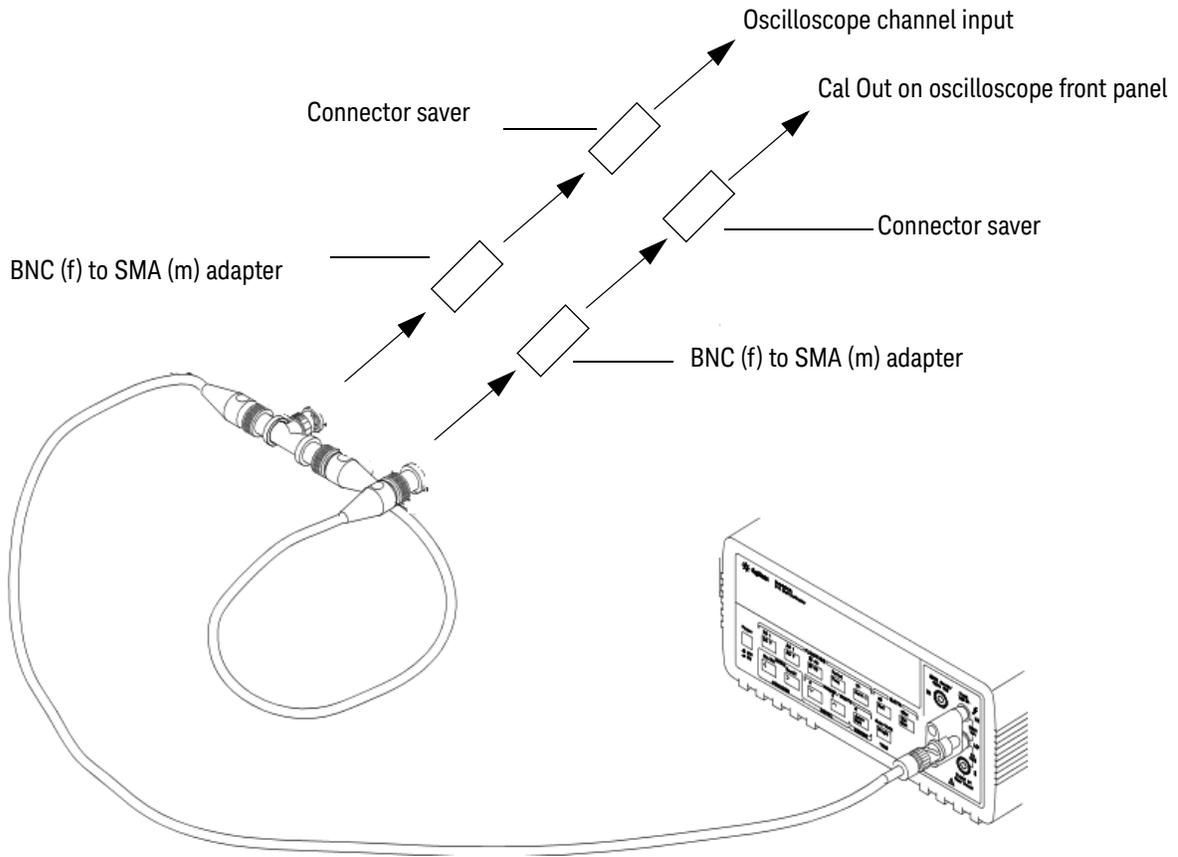


Record the Mean reading

- 6 Change the vertical scale of channel 1 to 20 mV/div, wait for the number of averages to return to 256, and then record the V avg reading in the Offset Accuracy—Zero Error Test section of the Performance Test Record.
- 7 Repeat step 6 for the remaining vertical scale settings for channel 1 in the Zero Error Test section of the Performance Test Record.
- 8 Click **Control > Factory Default**, then turn off channel 1 and turn the channel 2 display on.
- 9 Configure the oscilloscope to measure the average voltage on channel 2 as follows:
 - a Click **Setup > Acquisition....** In the Acquisition dialog box, enable averaging and set # of Averages to 256.
 - b Change the vertical scale of channel 2 to 10 mV/div.
 - c Drag and drop the Average voltage measurement icon from the left side of the screen onto the channel 2 waveform.
- 10 Press **[Clear Display]** on the oscilloscope, wait for the number of averages to return to 256, and then record the oscilloscope's mean V avg reading in the Offset Accuracy—Zero Error Test section of the Performance Test Record.
- 11 Repeat steps 9b and 10 for the remaining vertical scale settings for channel 2.
- 12 Repeat steps 8 through 11 for channels 3 and 4.

Offset Gain Test Procedure

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

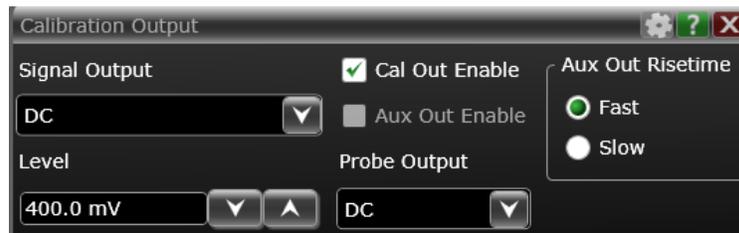


NOTE

- Where the BNC Tee adapter is used, it is important to connect it directly to the oscilloscope channel input using the BNC (f) to SMA (m) adapter and the connector savers to minimize ground potential differences and to ensure that the DMM measures the input voltage to the oscilloscope channel as accurately as possible. Differences in ground potential can be a significant source of measurement error, particularly at high scope sensitivities.
- It also helps to reduce ground potential differences if the oscilloscope and DMM are connected to the same AC supply circuit.
- 256 averages are used in the oscilloscope 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 Click **Control > Factory Default**.

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



- 5 Configure the oscilloscope to measure the average voltage on the channel under test as follows:
 - a Make sure the channel under test is enabled.
 - b Click **Setup > Acquisition....** In the Acquisition dialog box, enable averaging and set # of Averages to 256.
 - c Change the vertical scale to 10 mV/div.
 - d Set the offset value of the channel under test to 400 mV.
 - e Drag and drop the Average voltage measurement icon onto the waveform.
- 6 Press [**Clear Display**] on the oscilloscope, wait for the number of averages to return to 256, and then record the DMM voltage reading as $V_{\text{DMM}+}$ and the scope V avg reading as $V_{\text{Scope}+}$ in the Offset Accuracy—Offset Gain Test section of the Performance Test Record.
- 7 Change the offset value of the channel under test to -400.0 mV.
- 8 Set the Cal Out voltage to -400.0 mV.
- 9 Change the vertical scale to 10 mV/div.
- 10 Press [**Clear Display**] on the oscilloscope, wait for the number of averages to return to 256, and then record the DMM voltage reading as $V_{\text{DMM}-}$ and the scope V avg reading as $V_{\text{Scope}-}$ in the Offset Accuracy—Offset Gain Test section of the Performance Test Record.
- 11 Change the offset value of the channel under test to 0 mV.
- 12 Set the Cal Out voltage to 0 mV.
- 13 Press [**Clear Display**] on the oscilloscope, wait for the number of averages to return to 256, and then record the DMM voltage reading as $V_{\text{DMM}0}$ and the scope V avg reading as $V_{\text{Scope}0}$ in the Offset Accuracy—Offset Gain Test section of the Performance Test Record.

- 14** Calculate the offset gain error using the following expressions and record the value in the Offset Accuracy–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

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

- 15** Repeat steps 4, 5c, 5d, and 6 to 14 for the remaining vertical scale settings for the channel under test. Record the results in the Offset Accuracy–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 Accuracy–Offset Gain Test table in the Performance Test Record for each of the vertical scale settings.
- 16** Move the Tee connector to the next channel input and repeat steps 4 to 14 for channels 2 to 4.

DC Gain Accuracy Test

CAUTION

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

NOTE

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

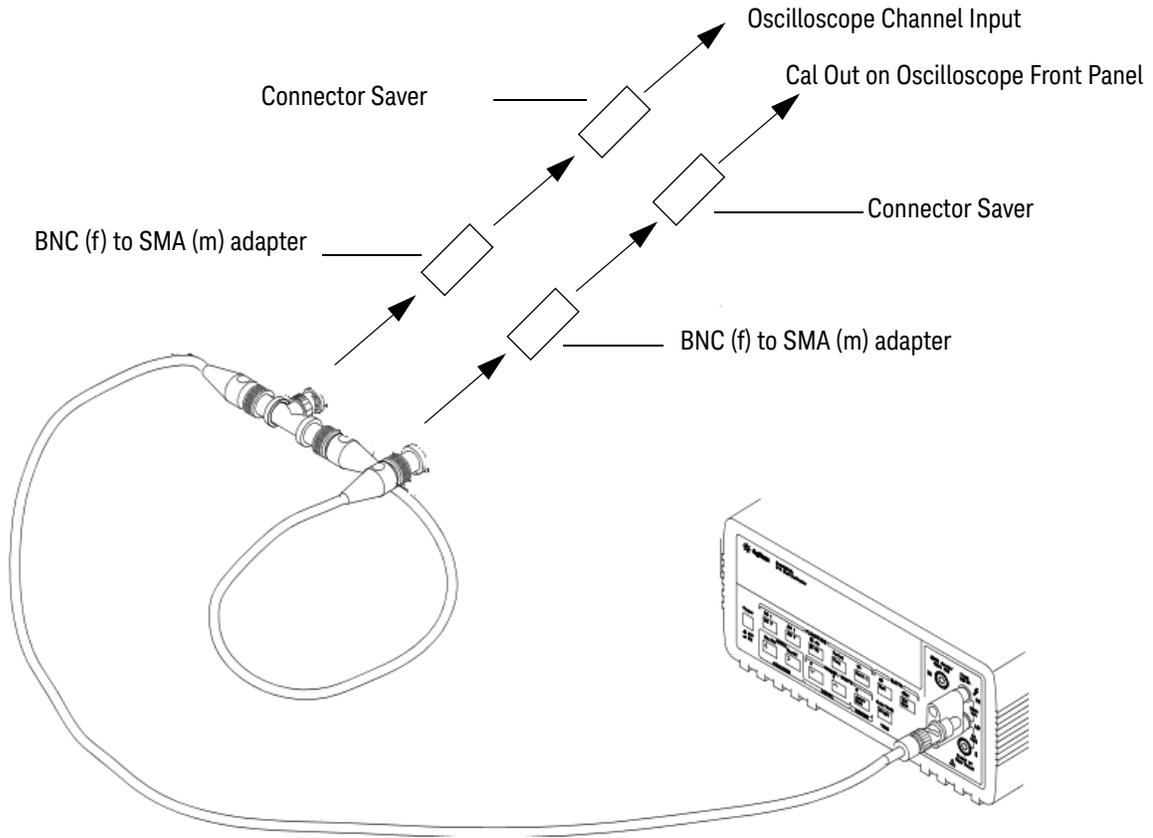
DC Gain Accuracy	$\pm 2\%$ of full scale at full resolution channel scale ($\pm 2.5\%$ for ≤ 5 mV/div).
Full scale is defined as 8 vertical divisions. Magnification is used below 7.5 mV/div. Below 7.5 mV/div, full scale is defined as 60 mV. The major scale settings are 1 mV/div, 2 mV/div, 5 mV/div, 10 mV/div, 20 mV/div, 50 mV/div, 100 mV/div, 200 mV/div, 500 mV/div, and 1 V/div.	

Equipment Required

Description	Critical specifications	Recommended model/part #
Digital Multimeter	DC voltage measurement accuracy better than $\pm 0.1\%$ of reading	34411A
Cable Assembly (2 required)	50 Ω characteristic impedance, BNC (m) connectors	8120-1840
Adapter	BNC Tee (m)(f)(f)	1250-0781
Adapter	BNC (f) to dual banana	1251-2277
Connector Saver	3.5 mm (f)-(f), shipped with each V-Series oscilloscope 2.4 mm (f) to 3.5 mm (f) adapter	54919-68717 (for models ≥ 20 GHz) 54916-68716 (for models ≤ 16 GHz)
Adapter (2 required)	BNC (f) to SMA (m) adapter	1250-1200

Procedure

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



NOTE

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

- 2 Click **Control > Factory Default**, then configure the oscilloscope as follows:
 - a Click **Setup > Acquisition....**
 - a In the Acquisition dialog box, enable averaging and set # of Averages to 256.
- 3 Set the Cal Out voltage ($V_{\text{Cal Out}}$) to +30 mV as follows:
 - a Click **Utilities > Calibration Output....**
 - b Change the Signal Output function to DC.
 - c Set the Level to 30 mV.



- 4 Set the vertical scale of the channel under test to 10 mV/div.
- 5 Drag and drop the Average voltage measurement icon onto the channel 1 waveform.
- 6 Press **[Clear Display]** on the oscilloscope, wait for the number of averages to return to 256, and then record the DMM voltage reading as $V_{\text{DMM+}}$ and the scope V avg reading as $V_{\text{Scope+}}$ in the DC Gain Accuracy Test section of the Performance Test Record.

NOTE

- For all oscilloscope readings in this procedure, use the mean value in the Results area at the bottom of the screen.
- If a question mark appears in front of any of the values in the Results area, press **[Clear Display]** on the oscilloscope, wait for the number of averages to return to 256, and then record the oscilloscope reading. The question mark indicates that the oscilloscope could not make a reliable measurement.



Record the
Mean reading

- 7 Change the Cal Out voltage to -30 mV.

- 8 Press **[Clear Display]** on the oscilloscope, wait for the number of averages to return to 256, and then record the DMM voltage reading as V_{DMM-} and the scope V avg reading as V_{Scope-} in the DC Gain Accuracy Test section of the Performance Test Record.
- 9 Calculate the DC gain using the following expression and record this value in the Calculated DC Gain Error column of the DC Gain Accuracy Test section of the Performance Test Record.

For vertical scale values < 1 V use the following equation:

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

For vertical scale values = 1 V use the following equation:

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

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

Analog Bandwidth—Maximum Frequency Test

CAUTION

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

NOTE

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.

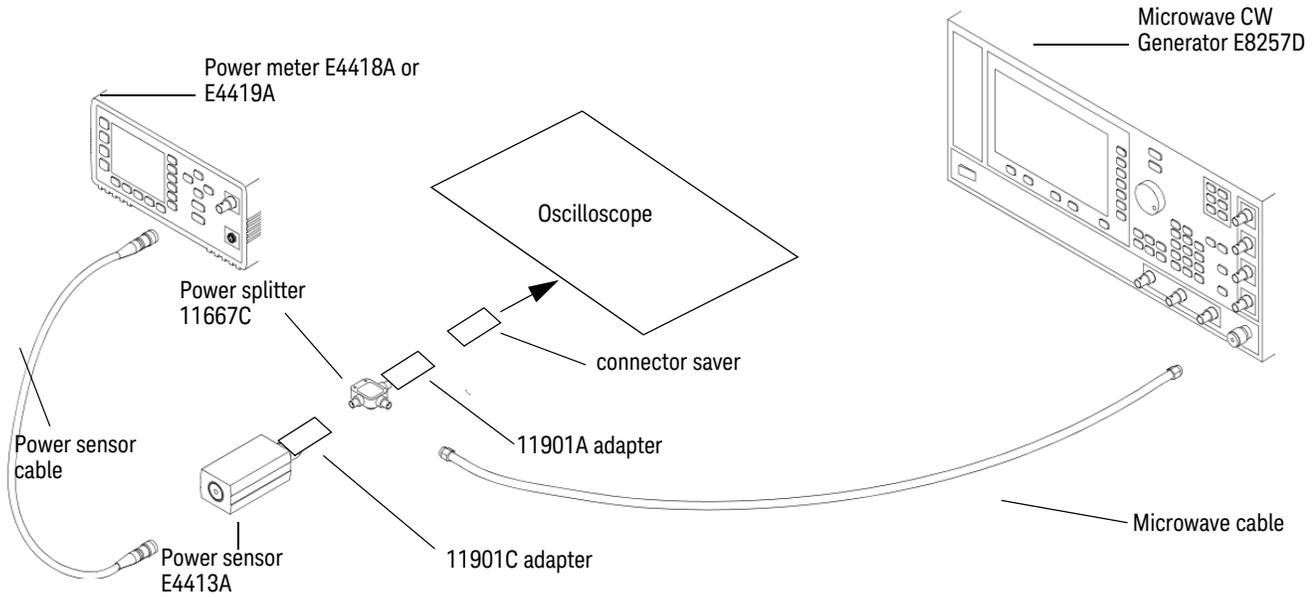
Specifications

Analog Bandwidth (-3 dB)	
MSO/DSO/DSAV084A	8.0 GHz
MSO/DSO/DSAV134A	13.0 GHz
MSO/DSO/DSAV164A	16.0 GHz
MSO/DSO/DSAV204A	20.0 GHz
MSO/DSO/DSAV254A	25.0 GHz
MSO/DSO/DSAV334A	32.0 GHz

Equipment Required

Description	Critical specifications	Recommended model/part #
Microwave CW Generator	Maximum Frequency ≥ 32 GHz Power range: -20 dBm to +16 dBm into 50Ω Output resistance = 50Ω	E8257D with Opt 540
Power Splitter	2 Resistor Power Splitter Max Frequency ≥ 32 GHz	11667C
Power Meter	Keysight E-series with power sensor compatibility	E4418B or E4419B
Power Sensor	Maximum Frequency ≥ 32 GHz Power range: -24 dBm to +16 dBm	8487A, or E4413B with 8485A-033
Microwave Cable	50Ω Characteristic Impedance 2.4 mm (m) to 2.4 mm (m) connectors Max Frequency ≥ 32 GHz	N5180-60204
Adapter	2.4 mm (m) to 3.5 mm (m) (qty. 1)	11901A
Adapter	2.4 mm (m) to 3.5 mm (f) (qty. 2)	11901C
Connector Saver	3.5 mm (f)-(f), shipped with oscilloscope	54919-68717 (for models ≥ 20 GHz) 54916-68716 (for models ≤ 16 GHz)

Connections



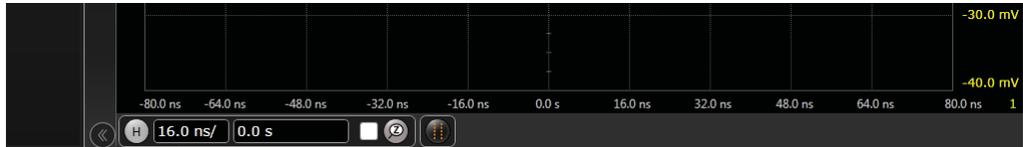
NOTE

- Connect output 1 of the 11667C splitter to the scope channel N input directly using the 11901A adapter and a connector saver, 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 the connectors are tightened properly to 8 in-lbs (90 N-cm).

Procedure

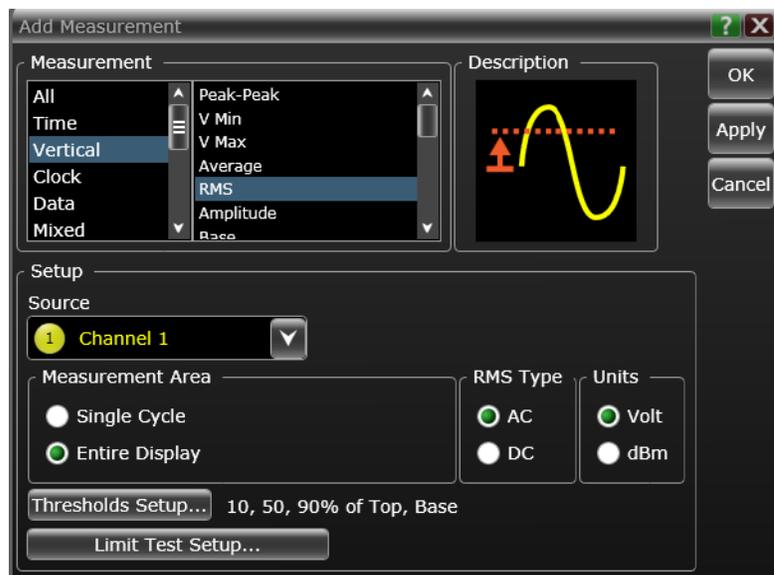
- 1 Preset the power meter.
- 2 Ensure that the power sensor is disconnected from any source and zero the meter.
- 3 Connect the power sensor to the power meter's Power Ref connector and calibrate the meter.
- 4 Make the connections to oscilloscope channel 1 as shown in the preceding connection diagram.
- 5 Set up the power meter to display measurements in units of Watts.

- 6 Click **Control > Factory Default**, then configure the oscilloscope as follows:
 - a Ensure the channel under test is displayed and all other channels are turned off.
 - b Set the vertical scale of the channel under test to 10 mV/div.
 - c Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).



Enter horizontal scale

- d Click **Setup > Acquisition...** and make sure the acquisition parameters are set up as follows:
 - Memory Depth = Automatic
 - Sampling rate = 80 GSa/s (maximum)
 - Sin(x)/x Interpolation = Auto
 - Averaging = Disabled
- e Click **Measure > Add Measurement...**
- f In the Add Measurement dialog box, select the Vertical RMS measurement and configure it 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 four divisions.

Use the following table to determine the approximate required signal amplitude.

The amplitude values in the tables 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 oscilloscope.

Nominal Generator Amplitude Settings

Oscilloscope 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 oscilloscope 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).

- 9 Press **[Clear Display]** on the oscilloscope and record the scope V_{rms} reading in the Analog Bandwidth–Maximum Frequency Check section of the Performance Test Record (V_{out} @ 50 MHz).

NOTE

For all oscilloscope readings in this procedure, use the mean value in the Results area at the bottom of the screen.

- 10 Calculate the reference gain as follows:

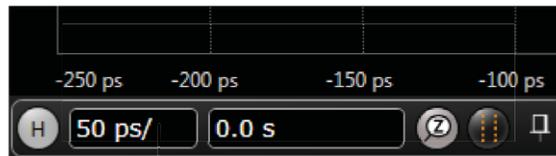
$$Gain_{50\text{ MHz}} = \frac{V_{out @50\text{ MHz}}}{V_{in @50\text{ MHz}}}$$

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					
	DSOV084A DSAV084A MSOV084A	DSOV134A DSAV134A MSOV134A	DSOV164A DSAV164A MSOV164A	DSOV204A DSAV204A MSOV204A	DSOV254A DSAV254A MSOV254A	DSOV334A DSAV334A MSOV334A
Maximum Frequency	8 GHz	13 GHz	16 GHz	20 GHz	25 GHz	32 GHz
Scope Horizontal Scale	50 ps/div					

- 12 Change the oscilloscope horizontal scale to the value for the model under test in the preceding table.



Enter horizontal scale

- 13 Measure the input power to the oscilloscope 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 μW, then $V_{in} = (4.0 \times 10^{-6} \times 50\Omega)^{1/2} = 14.1\text{ mVrms}$.

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 oscilloscope 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 (Vout @ Max Frequency) = 13.825 mV, (Vin @ 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.

- 16 Change the oscilloscope setup as follows:
- Change the channel vertical scale to 20 mV/div.
 - Reset the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
- 17 Change the generator output as follows:
- Reset the generator frequency to 50 MHz.
 - Change the amplitude to the value suggested for this scale setting in the Nominal Generator Amplitude Settings table.
- 18 Repeat steps 8, 9, and 10 to measure the reference gain at 50 MHz for this scale setting.
- 19 Repeat steps 11 through 14 to measure the gain at maximum frequency for this scale setting.
- 20 Repeat steps 15 through 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 oscilloscope configuration as follows:
- Click **Control > Factory Default**.
 - 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).
 - Click **Trigger > Setup Trigger...** and change the source to channel 2.
 - Click **Measure > Add Measurement...** Select the RMS voltage measurement, Channel 2 as the source, Entire Display as the Measurement Area, and AC for the RMS Type.
- 22 Repeat steps 7 to 20 to complete measuring gains for channel 2.

- 23** Move the splitter to channel 3 and change the oscilloscope configuration as follows:
- Press **[Default Setup]**.
 - Ensure channel 3 is displayed and all other channels are turned off.
 - Set the vertical scale of channel 3 to 10 mV/div.
 - Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
 - Click **Trigger > Setup Trigger...** and change the source to channel 3.
 - Click **Measure > Add Measurement...** Select the RMS voltage measurement, Channel 3 as the source, the Entire Display as the Measurement Area, and AC for the RMS Type.
- 24** Repeat steps 7 to 20 to complete measuring gains for channel 3.
- 25** Move the splitter to channel 4 and change the oscilloscope configuration as follows:
- Press **[Default Setup]**.
 - Ensure Channel 4 is displayed and all other channels are turned off.
 - Set the vertical scale of channel 4 to 10 mV/div.
 - Set the horizontal scale to 16 ns/div (to display 8 cycles of a 50 MHz waveform).
 - Click **Trigger > Setup Trigger...** and change the source to Channel 4.
 - Click **Measure > Add Measurement...** Select the RMS voltage measurement, Channel 4 as the source, the Entire Display as the Measurement Area, and AC for the RMS Type.
- 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.

Description

TSA refers to the absolute accuracy of an oscilloscope's time scale. Because TSA depends directly on frequency of a crystal oscillator, it is comprised of two components: an initial accuracy component and an aging component.

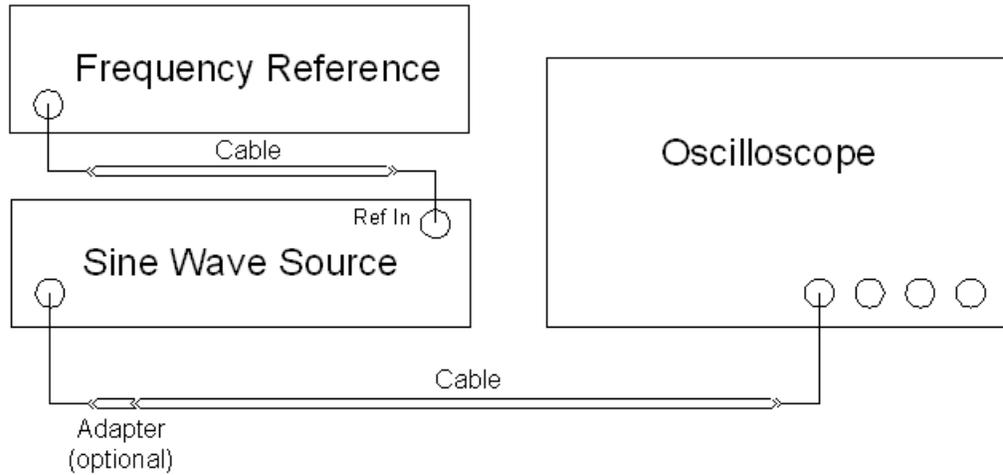
The initial accuracy component applies to the oscilloscope's accuracy immediately after a time base calibration, whether performed at the factory, by a customer, or by a Keysight service center. The aging component scales linearly from the time since the last time base calibration, and adds to the initial accuracy component.

Equipment Required

Description	Critical specifications	Recommended model/part #
Synthesized sine wave source	Output Frequency: ≥ 10 MHz Output Amplitude: 0 dBm Frequency Resolution: 0.1 Hz	E8257D PSG
10 MHz frequency reference	Output Frequency: 10 MHz Absolute Freq. Error: $< \pm 0.0275$ ppm	53132A opt. 012 frequency counter
RF cable	50 Ω characteristic impedance (no substitute) BNC (m) connectors Max Frequency: ≥ 50 MHz	8120-1840
Adapters, assorted	3.5 mm (f) to Precision BNC (m) 3.5 mm (f) to 3.5 mm (f)	54855-67604 83059B

Connections

Connect the equipment as shown here.



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 the source amplitude such that the displayed sine wave is 600 mVpp.
- 3 Click **Control > Factory Default**.
- 4 Set the vertical scale of channel 1 to 100 mV/div.
- 5 Set the oscilloscope's sampling rate to 100 kSa/s.
- 6 Set the oscilloscope'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:
 - a Click **Measure > Thresholds...**
 - b Select **Custom: level +/- hysteresis** from the Thresholds drop-down list box.
 - c Enter 20 mV in the **Hysteresis** field and 0 V in 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. Record the result in the Measured Time Scale Error (ppm) column of the Time Scale Accuracy table.

13 Record the time since calibration (in years) in the table. The calibration date can be found in the Calibration window (**Utilities > Calibration...**).

14 Calculate the test limits using the following formula and record them in the table.

$$\text{Test Limits} = \pm(0.100 + 0.100 \times \text{Years Since Calibration})$$

15 Record the results in the Performance Test Record.

Performance Test Record

Keysight Technologies		Keysight Infiniium V-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—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				

Offset Accuracy–Offset Gain Test

Vertical Scale	V _{Cal Out} Setting	V _{DMM+}	V _{Scope+}	V _{DMM-}	V _{Scope-}	V _{DMM0}	V _{Scope0}	Calc. 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 _{Scope+}	V _{DMM-}	V _{Scope-}	Calc. 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 %

Max frequency:

MSO/DSO/DSAV084A = 8 GHz, MSO/DSO/DSAV134A = 13 GHz,

MSO/DSO/DSAV164A = 16 GHz, MSO/DSO/DSAV204A = 20 GHz,

MSO/DSO/DSAV254A = 25 GHz, MSO/DSO/DSAV334A = 32 GHz,

Analog Bandwidth–Maximum Frequency Check

Vertical Scale	Measurement					
	Vin @ 50 MHz	Vout @ 50 MHz	Calculated Gain @ 50 MHz	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
_____	_____	_____	_____	_____

3 Testing Performance

4 Troubleshooting

Service Strategy	54
Verifying Basic Operation	55
Power Supply Troubleshooting	60
Setting Up the BIOS	72
Motherboard Verification	73
Display Troubleshooting	75
Acquisition/Backplane Assembly Troubleshooting	76
Keyboard Troubleshooting	77
Front Panel LED Troubleshooting	78
Touch Screen Troubleshooting	79
Checking Probe Power Outputs	80
MSO Assembly Troubleshooting	81
Hardware Serial Trigger Assembly Troubleshooting	83
Before You Contact Keysight	84

Service Strategy

The service strategy for troubleshooting Infiniium V-Series oscilloscopes is to isolate problems to a faulty assembly, then use the disassembly and assembly procedures in **Chapter 5**, "Replacing Assemblies", to replace the defective assembly.

Read the Safety booklet that came with the oscilloscope before servicing the oscilloscope. Before performing any procedure, review it for any cautions and warnings.

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 assemblies, refer to **Chapter 5**, "Replacing Assemblies".

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 by pressing **[Default Setup]** on the front panel.

WARNING

INJURY CAN RESULT! Use caution when the oscilloscope fan blades are exposed as they can cause injury.

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. Lack of training and awareness 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.

Verifying Basic Operation

Follow the procedures in this section to verify the basic operation of the oscilloscope. Where problems occur, you are directed to the section that provides detailed troubleshooting help.

Power Up the Oscilloscope

- 1 Connect the power cord to the rear of the oscilloscope, then to a suitable AC voltage source.

Ensure that you have the correct power cord (see Chapter 6, “**Replaceable Parts List**”). The power cord provided is matched to the country of origin.

- 2 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. The LEDs on the front panel should all illuminate brightly for several seconds, then dim. If the LEDs do not light up, refer to “**Front Panel LED Troubleshooting**” later in this chapter.

When the system is done starting up, the grid will appear on the screen. The exact appearance may look slightly different than shown below, depending on the setup selected before the oscilloscope was turned off.



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.

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 (channels 1 and 2) is faulty and requires replacement. MEMCON5, MEMCON6, MEMCON7, and MEMCON8 errors indicate the upper acquisition board (channels 3 and 4) is faulty and requires replacement.

Run the oscilloscope self-tests

Running the oscilloscope self-tests performs a series of internal procedures to verify that the oscilloscope is working properly.

- 1 Click **Utilities > Self Test...**
- 2 Select **Scope SelfTest** from the Available Self Tests drop-down list box.
- 3 Click **Start** 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.

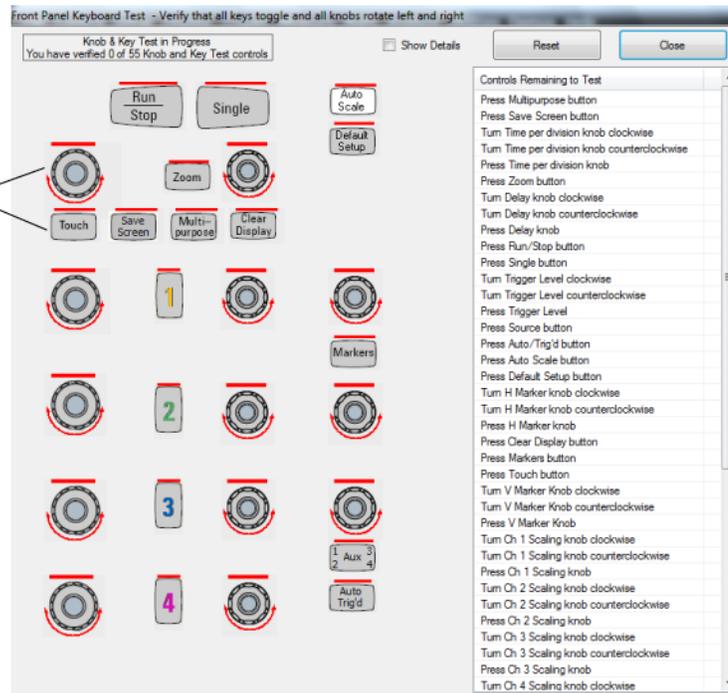
Run the keyboard, LED, and touch screen self tests

To verify correct keyboard operation:

- 1 Click **Utilities > Self Test...**
- 2 Select **Keyboard Test** from the Self Test drop-down list box, then click **Start**.

The Front Panel Keyboard Test window appears, showing a symbolic representation of the keyboard.

When you press a key or turn a knob in each direction, the corresponding symbol on this screen turns green.



Knob and key self-test screen

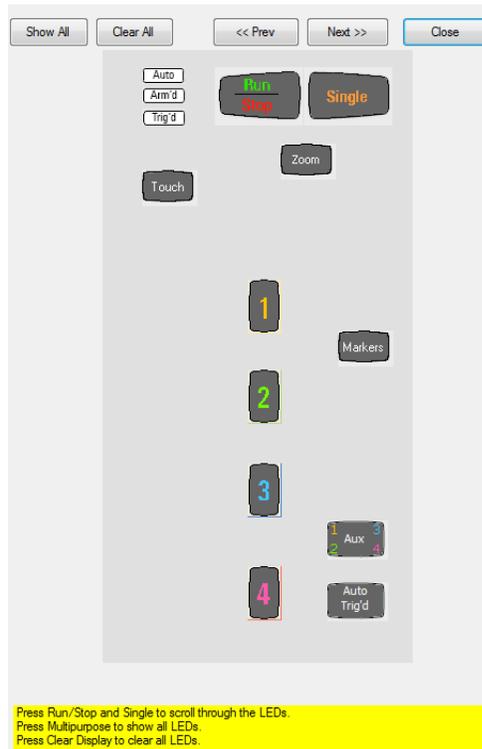
- 3 Press each key on the keyboard until you have pressed all keys. When you press a key or push a knob, the bar above the corresponding key/knob symbol on the display should change from red to green.
- 4 Turn each knob in both directions until you have turned all knobs. When you turn a knob in one direction, half the rotation arrow under the corresponding knob symbol should turn green. When you 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**.

If any of the knobs or keys do not work, go to **“Keyboard Troubleshooting”** later in this chapter.

To test the front panel LED indicators:

- 1 Click **Utilities > Self Test...**
- 2 Select **LED Test** from the Available Self Tests drop-down list box, then click **Start**.

The Front Panel LED Test window appears, showing a symbolic representation of all front panel LED indicators.



LED test screen

- 3 Repeatedly press the **[Single]** button on the front panel to step through and highlight each LED symbol in the test screen. You can also step through the LEDs by pressing the **<< Prev** or **Next >>** buttons on the screen. Verify that the corresponding LEDs on the front panel are the only ones illuminated. Pressing the **[Multi Purpose]** button on the front panel illuminates all the LEDs, and pressing the **[Clear Display]** button on the front panel turns off all the LEDs.
- 4 When you are finished, click **Close**.

If any of the LEDs do not work, go to “**Front Panel LED Troubleshooting**” later in this chapter.

To verify correct touch screen operation:

- 1 Click **Utilities > Self Test...**
- 2 Select **Touch Screen Test** from the Available Self Tests drop-down list box, then click **Start** and follow the on-screen instructions.
- 3 If the touch screen is not working properly, go to “**Touch Screen Troubleshooting**” in this chapter.

Run a user calibration

- 1 Complete a user 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 failure.
 - If the failure is associated with channel 1, look at the specific calibration that failed. If it was a trigger cal, a time scale cal, or an interpolator gain cal, replace the backplane board because it is likely the problem. If the cal still fails, replace the bottom acquisition board.
 - If the failure is associated with channel 1 but is not a trigger cal, a time scale cal, or an interpolator gain cal, replace the bottom 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 (where channels 1 and 2 = bottom acquisition board, channels 3 and 4 = top 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.

Verify system performance

After you have verified the basic operation of the oscilloscope, you need to verify that it 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 properly.

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 +5 V 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 +12 V 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

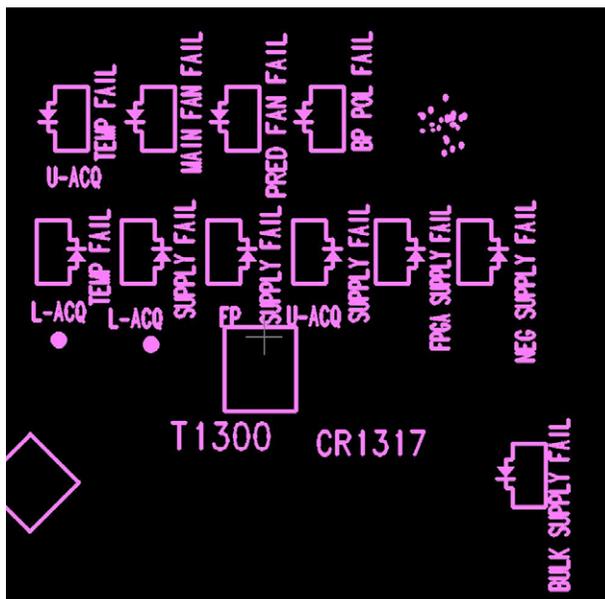
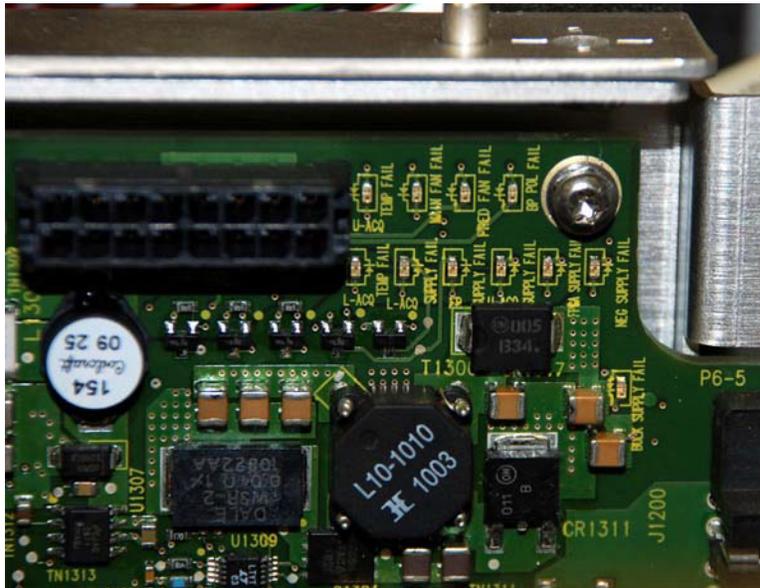
SHOCK HAZARD! The maintenance described in this section is performed with power supplied to the oscilloscope and with the protective covers removed. Only trained service personnel who are aware of the hazards involved should perform the maintenance. Failure to observe safety precautions may result in electric shock.

WARNING

SHOCK HAZARD! Once the bulk +12 V 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 +12 V power supply.

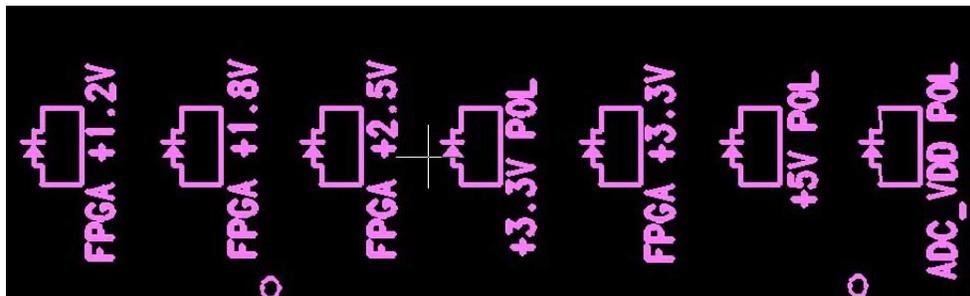
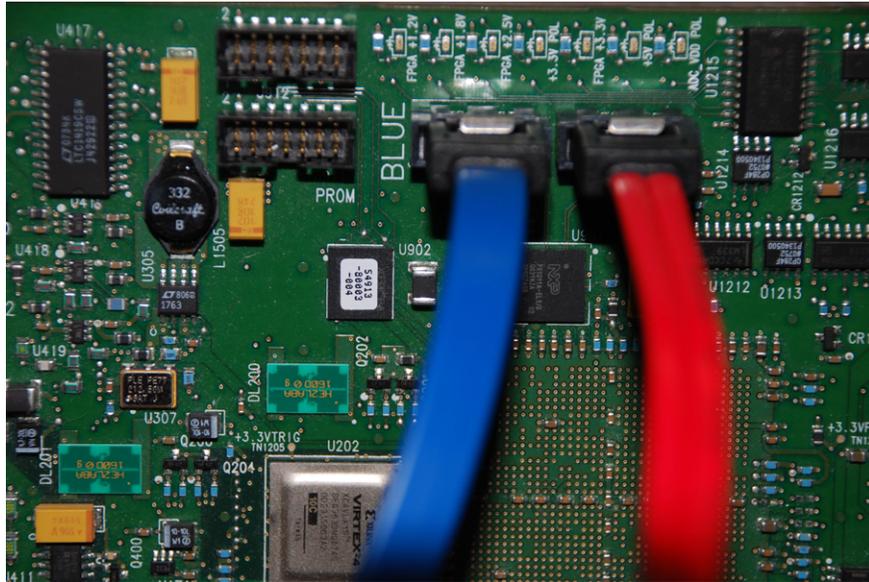
To locate all four sets of LEDs, remove the top panel to expose the motherboard cavity and top edges of the backplane assembly.

The first set of LEDs is located in the upper right corner of the backplane assembly (see the following two figures). 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 supply needs replacing.



Under-voltage, over-temperature, and bulk supply indicators on backplane assembly

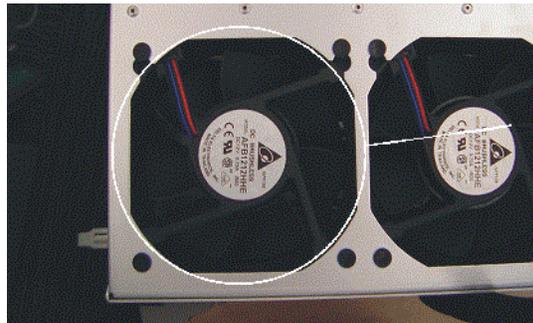
The other three groups of LEDs indicate over-voltage faults. One group is located near the center of the top edge of the backplane assembly just above the blue and red SATA cables (see the two figures below).



Over-voltage indicator LEDs on backplane assembly

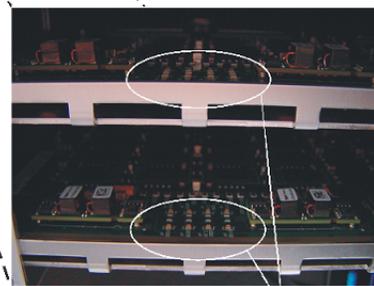
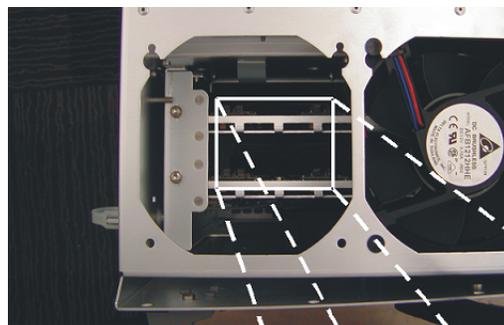
If any of these LEDs are lit, the backplane assembly must be replaced.

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 the following figures).



LEDs are located behind this fan

Over-voltage indicator LEDs on acquisition assembly behind fan



Over-voltage indicator LEDs

Over-voltage indicator LEDs with fan removed

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

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

Table 1 Group of 11 LEDs on backplane assembly

LED	Types 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

Table 2 Group of 7 LEDs on backplane assembly

LED	Types of Fault	What To Do
FPGA +1.2 V	Over-voltage	Replace backplane assembly
FPGA +1.8 V	Over-voltage	Replace backplane assembly
FPGA +2.5 V	Over-voltage	Replace backplane assembly
+3.3 V POL	Over-voltage	Replace backplane assembly
FPGA +3.3 V	Over-voltage	Replace backplane assembly
+5 V POL	Over-voltage	Replace backplane assembly
ADC_VDO POL	Over-voltage	Replace backplane assembly

Table 3 LEDs on each acquisition board

LED	Types of Fault	What To Do
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 3.3 V oV	Over-voltage	Replace acquisition assembly
U300 2.5 V oV	Over-voltage	Replace acquisition assembly
U303R oV	Over-voltage	Replace acquisition assembly
U1601 oV	Over-voltage	Replace acquisition assembly

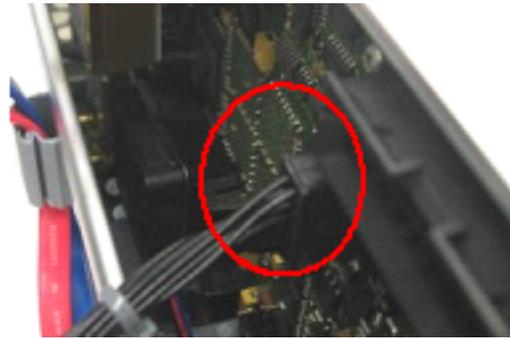
If the L-ACQ TEMP FAIL or U-ACQ TEMP FAIL LED is lit

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.

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 below) 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.



Front panel power cable connector

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

Before replacing the supply, be sure to verify the operation of the AC OK and DC OK signals. 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 (+12.6 V) 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.

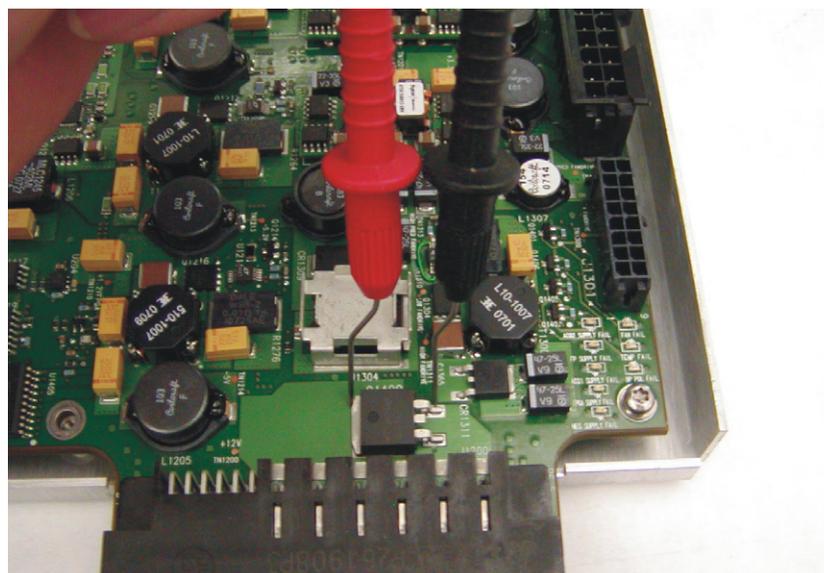
It is also possible that there is a short circuit on the bulk +12 V supply trace somewhere in the system, which would also cause the unit not to power on. If so, you need to isolate the assembly that is shorted. You do not need to remove the acquisition or backplane assemblies to perform the following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

- 1 With the power turned off, disconnect the bulk +12 V supply, but do not remove the supply from the oscilloscope.



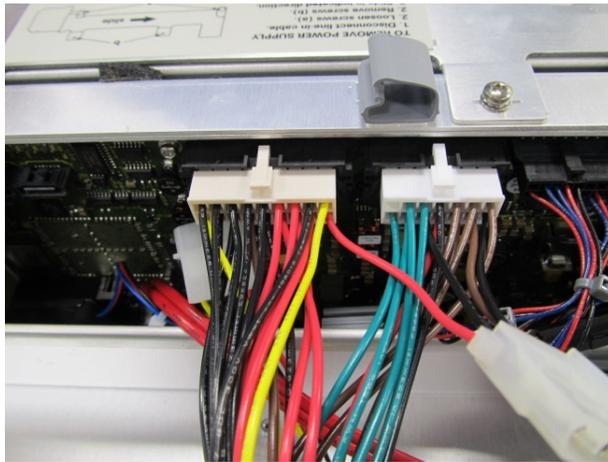
Power supply disconnect

- 2 On the backplane assembly, measure the resistance across the FET (Q1409, located in the upper right corner of the backplane) between +12 V and ground as shown below, 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.



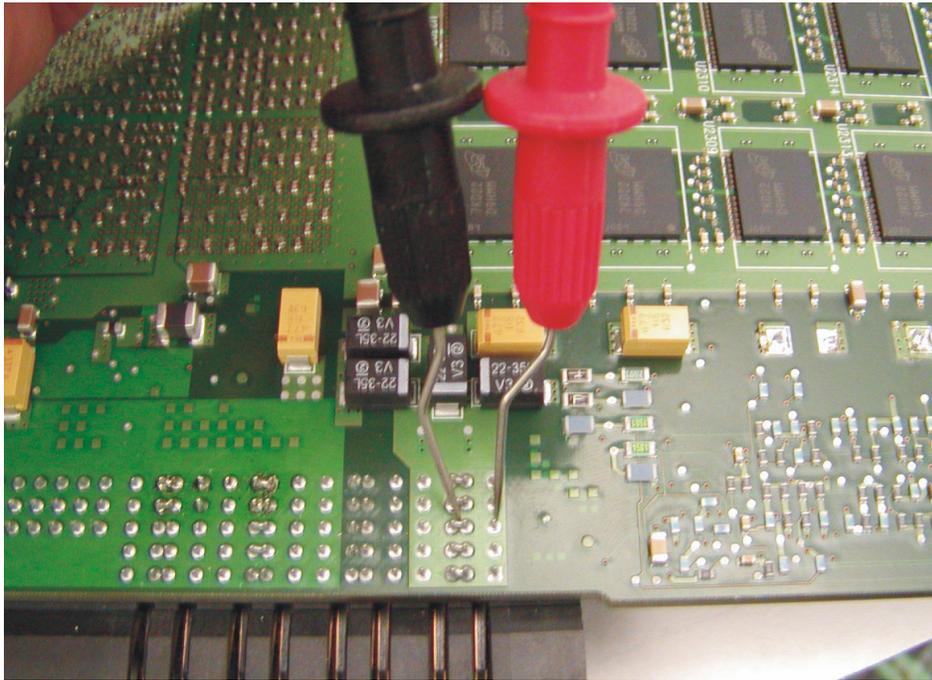
Measuring the backplane assembly resistance between +12 V and ground across Q1409

- 3 If there is a short, disconnect the power cable to the front panel 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 as shown below and redo the resistance measurements across the FET (Q1409) or the bulk supply input pins on the backplane assembly.



Cable connection into backplane

- 6 If the short is gone, replace the motherboard assembly and confirm that the unit powers on.
- 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 +12 V trace and ground (see following figure). You should see a resistance of about 2000 ohms between the +12 V 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.



Measuring the acquisition assembly resistance between +12 V and ground

If no shorts are found on the bulk +12 V 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 +12 V 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.

If the MAIN FAN FAIL LED is lit

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

Three fans are located on the left side of the oscilloscope to cool it. The circuitry that generates the reference potential for the fans may have failed. This circuitry failure would cause the fans to stop turning and the oscilloscope to shut down.

It is unlikely that all three 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 to the left side of the oscilloscope so you can see the 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 fan blades with the cover removed from the oscilloscope. The cooling fan blades are exposed on one side and can be hazardous. Be careful not to let the moving fan blades come in contact with any part of your body.

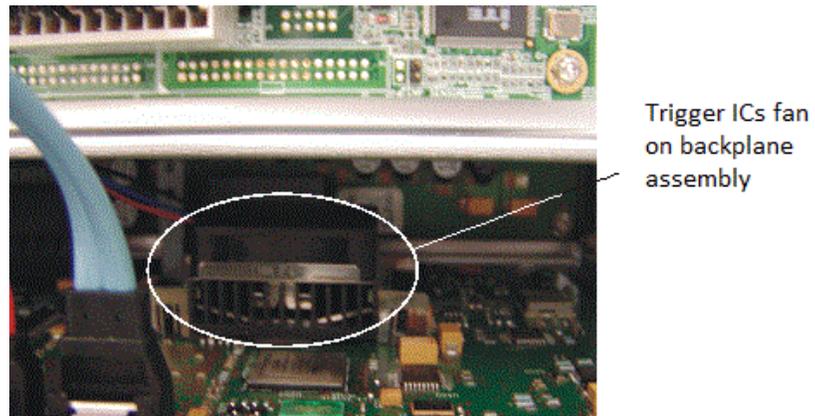
If the oscilloscope still shuts down, follow these steps:

- 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 three 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 the following figure.)



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.

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]** as soon as the following prompt appears on the bottom of the screen:

Press DEL to enter SETUP, F12 to select boot device.

If the prompt does not appear, or the oscilloscope does not appear to be functioning, check the J1201 and J1202 motherboard power cable connectors. Otherwise, continue with the next step.

- 4 Go to F3 Optimized Defaults and press **[Enter]**. Select Yes 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 Yes, then press **[Enter]**.

Motherboard Verification

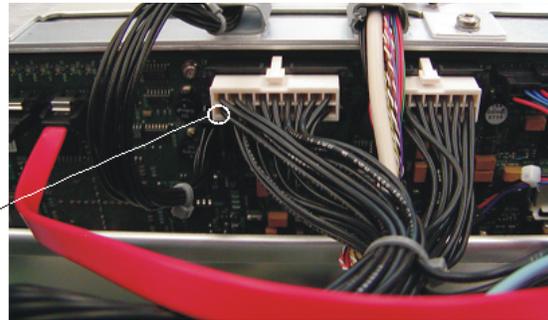
If you have been through the Power Supply Troubleshooting section of this chapter and the oscilloscope still does not stay powered up, the problem may be with the motherboard. To diagnose this problem, follow these steps.

- 1 Remove the top panel.
- 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 on the backplane board (see figure below). Pin 9 is the reset line for the motherboard and is controlled by the backplane. You should measure about 3.3 V. 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.

Pin 9 is under
this connection
(bottom left pin)



Measure potential relative to chassis at pin 9 of J1201

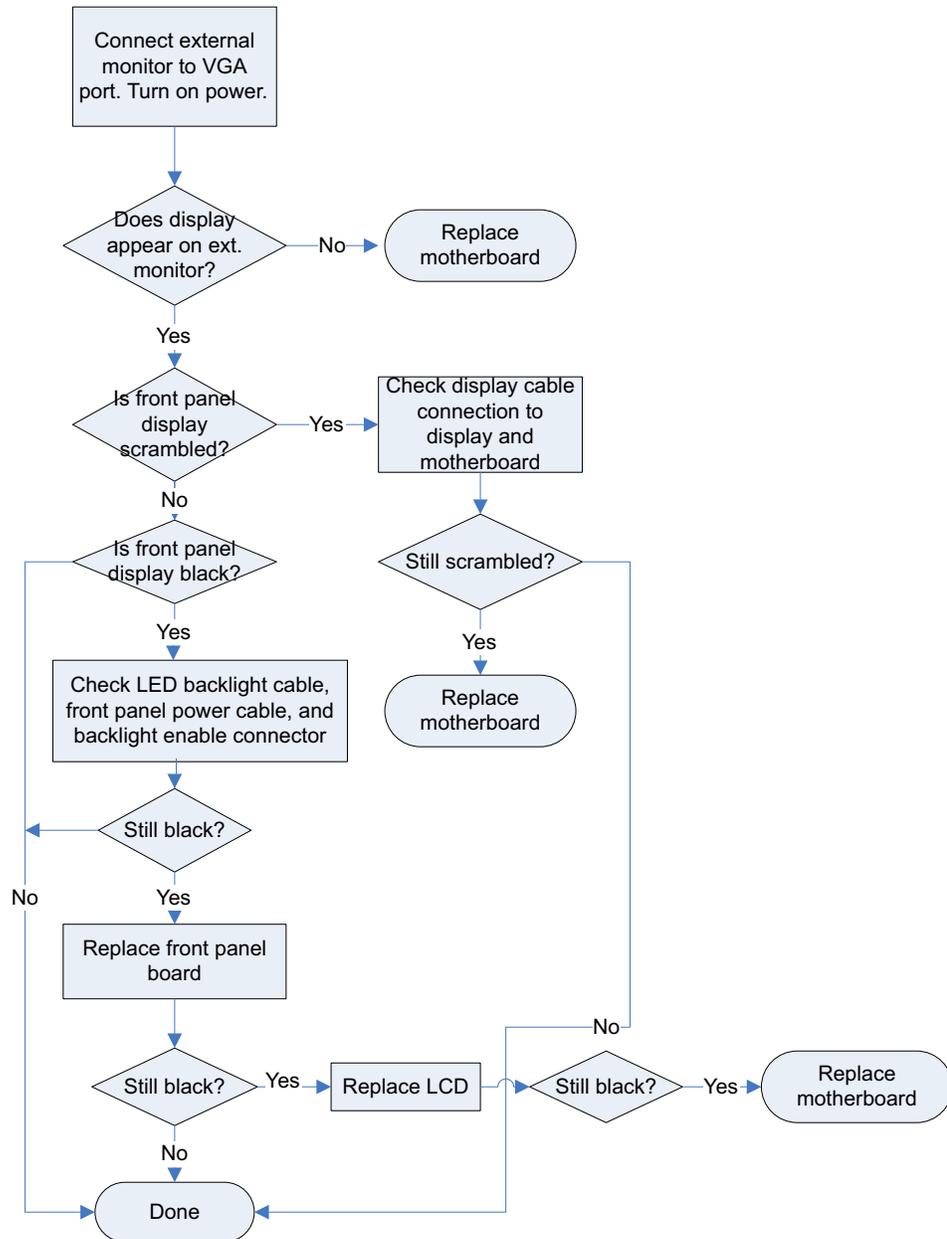
- 3 If the potential you measure is not correct, shut the oscilloscope down and unplug the AC cord from the rear of the instrument.
- 4 Unplug the front panel power cable, the two large power cables that go to the motherboard (J1201 and J1202), and the red and blue SATA cables (J900 and J901) from the PCIe-to-SATA adapter board on 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 3.3 V, 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 PCIe-to-SATA converter on 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



Display troubleshooting flowchart

NOTE

When you connect an external monitor the first time, it may display the start-up BIOS information and then go blank when Windows starts up. If so, use the Windows settings to enable the external monitor.

Acquisition/Backplane Assembly Troubleshooting

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

C:\ProgramData\Infiniium\selftest\SelfTestLog.txt

The error message usually indicates the channel with the error. When identifying which acquisition assembly to replace, remember that the acquisition assembly nearest the bottom of the oscilloscope is for channels 1 and 2. Channels 3 and 4 are on the upper acquisition assembly. 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	Test Name	Error Type	Assembly to Replace
Timebase	Timebase Interpolator Test		Backplane
ADC	ADC Register Tests	ADC1, ADC2, ADC3, ADC4	Lower acquisition
		ADC5, ADC6, ADC7, ADC8	Upper acquisition
	ADC Voltage Test Points	ADC1, ADC2, ADC3, ADC4	Lower acquisition
		ADC5, ADC6, ADC7, ADC8	Upper acquisition
Acquisition Memory	Hedwig MBIST		
	Hedwig Register		
	Hedwig-DDR2 ADDR & Data	MEMCON_1, MEMCON_2, MEMCON_3, MEMCON_4,	Lower acquisition
		MEMCON_5, MEMCON_6, MEMCON_7, MEMCON_8,	Upper acquisition
	Hedwig DDR2 Stress	Memory Controller 1-4	Lower acquisition
		Memory Controller 1-8	Upper acquisition
	Hedwig DDR2 Interface	Hedwig1, Hedwig2, Hedwig3, Hedwig4	Lower acquisition
		Hedwig5, Hedwig6, Hedwig7, Hedwig8	Upper acquisition
Misc. Scope	Temp Sensor	Hedwig0, Hedwig1, Hedwig2, Hedwig3, Oak0	Lower acquisition
		Hedwig4, Hedwig5, Hedwig6, Hedwig7, Oak2	Upper acquisition
	Acq Flash RAM	Pred1, Pred2, MainFPGA	Backplane
		Test is not currently being run.	

Keyboard Troubleshooting

Use this procedure only if you had keyboard failures in the keyboard self-test procedure. If any knobs fail, replace the front panel board.

- 1 Remove the front panel assembly. (See Chapter 5, “**Replacing Assemblies**” for instructions.)
- 2 Unclip the front panel board from the keyboard assembly.
- 3 Separate the elastomeric keypad 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.

- 4 Visually inspect the keypad, checking for missing black “pills” or contamination that may prevent proper contact.
 - If the elastomeric keypad has any damage, replace it.
 - If the elastomeric keypad is not damaged, replace the front panel board.

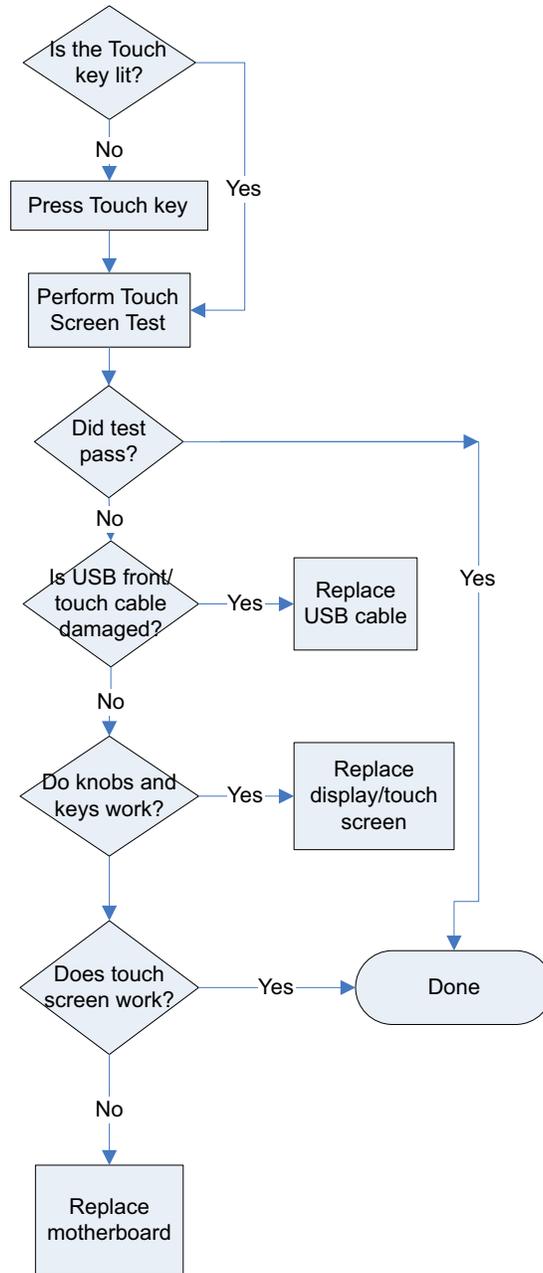
Front Panel LED Troubleshooting

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, check the on/off cable connecting the On/Off board to the motherboard, and check the connections of all cables on the on/off board and the motherboard.

If any of the other LEDs on the front panel are not working, 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

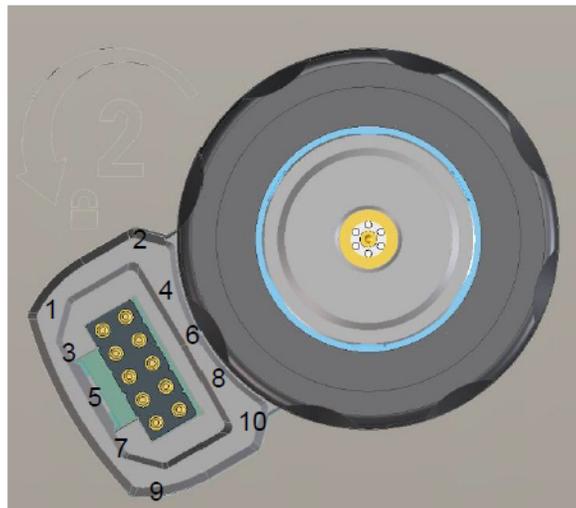


Touch screen troubleshooting flowchart

Checking Probe Power Outputs

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

Refer to the following figure to check the power output at the connectors. Measure the voltages with respect to the ground terminal on the front panel. Measure the voltages at pins 2 and 5 only (+12 V and -12 V).



Pin	Desc.
1	+Vprog
2	+12V
3	Rprog
4	Offset
5	-12V
6	-Vprog
7	DATA1
8	Rid
9	CLK
10	DATA0

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.

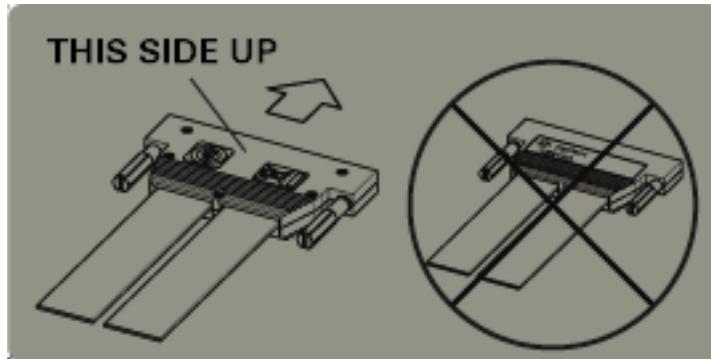
If the LEDs turn on after the application is running, a thermal problem likely was detected. A warning appears. To resolve the problem, shut down the scope and allow it to cool. Make sure the fan holes are not blocked, and allow at least 4 inches of space next to the oscilloscope. Restart the scope and 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 was modified correctly to be used with the MSO board. That is, 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, you will see an error message indicating an option card DAC failure when the application starts up.

MSO Cable Connection

When the MSO cable is connected it must be oriented as shown on the label on the back of the oscilloscope (see the following figure). If the cable is upside-down, the pins may bend and cause a faulty connection. Make sure the cable is connected properly and that the pins remain straight.



MSO cable direction

Hardware Serial Trigger Assembly Troubleshooting

This section describes problems that may occur when an optional hardware serial trigger assembly is installed, and how to troubleshoot them.

If a signal appears on screen but the eye scan diagram consists of only a solid blue box, check the semi-rigid cable connections from the acquisition boards to the serial trigger assembly. Make sure the cables are seated securely.

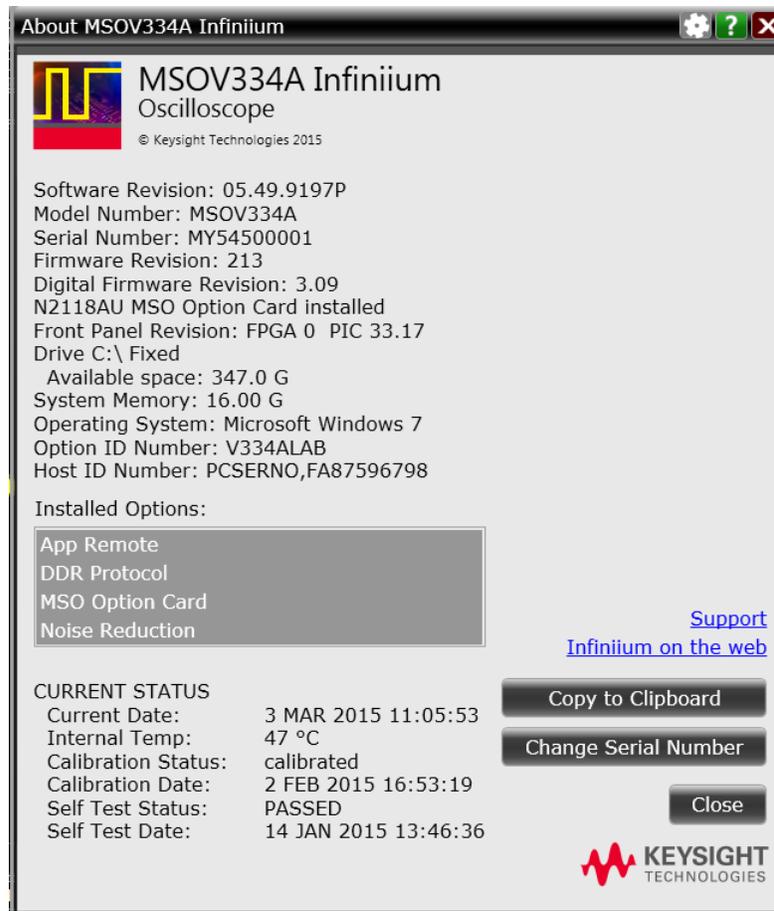
Before You Contact Keysight

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 Click **Help > About Infiniium...**

A dialog box similar to this one appears.



- 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.

5 Replacing Assemblies

Returning the oscilloscope to Keysight Technologies for service	86
Tools Required	87
Safety Precautions	88
CAUTION: Close SMA Cable Ports	89
Removing and replacing the top panel and bottom panel	90
Removing and replacing the front panel assembly	92
Removing and replacing front panel assembly parts	98
Removing and replacing the motherboard	103
Removing and replacing the acquisition boards/backplane/MSO assembly	109
Removing the backplane assembly from the acquisition assembly	117
Replacing the backplane board	122
Replacing an acquisition board	127
Setting the calibration factors after replacing an acquisition board	130
Removing and replacing the hard disk drive	131
Removing and replacing the power supply	132
Removing and replacing fans	134
Removing and replacing the optional GPIB port	136

Use the procedures in this chapter when removing and replacing assemblies and parts in the Infiniium V-Series oscilloscopes.

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

Returning the oscilloscope to Keysight Technologies for service

Before shipping the oscilloscope, contact Keysight Technologies 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.

Tools Required

The following tools are required for these procedures.

- Torx drivers: T10, T20
- Socket wrench: 5/8 inch
- Torque wrench: 5/16 inch (8 in-lbs)
- Flat-blade screwdriver: medium size (3/16 inch)
- Power driver vertical with T-20 bit (18 in-lbs)
- Power driver vertical with T-10 bit (5 in-lbs)
- Needle-nosed pliers

Safety 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

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

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

To avoid electric shock, adhere closely to the following procedures. Also, after disconnecting the power cable, wait at least 3 minutes for the capacitors on the power supply to discharge before servicing this oscilloscope.

WARNING

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

CAUTION: Close SMA Cable Ports

CAUTION

On the backplane and other boards inside the oscilloscope, there are locations with close SMA cable ports. It is easy to knock one SMA cable port off a board while torquing a cable connector to the port next to it.

In these cases, be careful with tightening order and the torque wrench orientation so that the wrench does not contact the nearby SMA cable port.

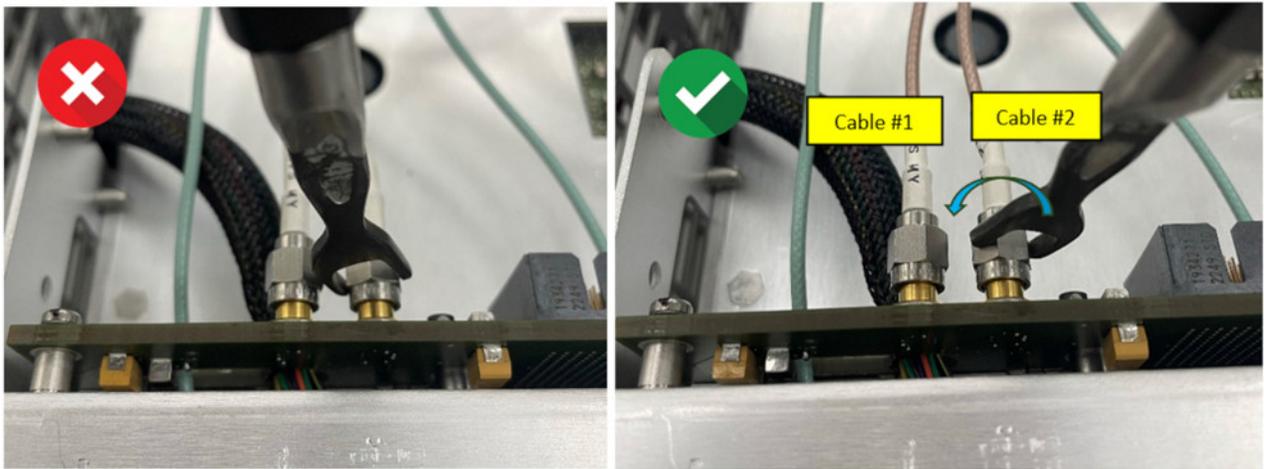


Figure 1

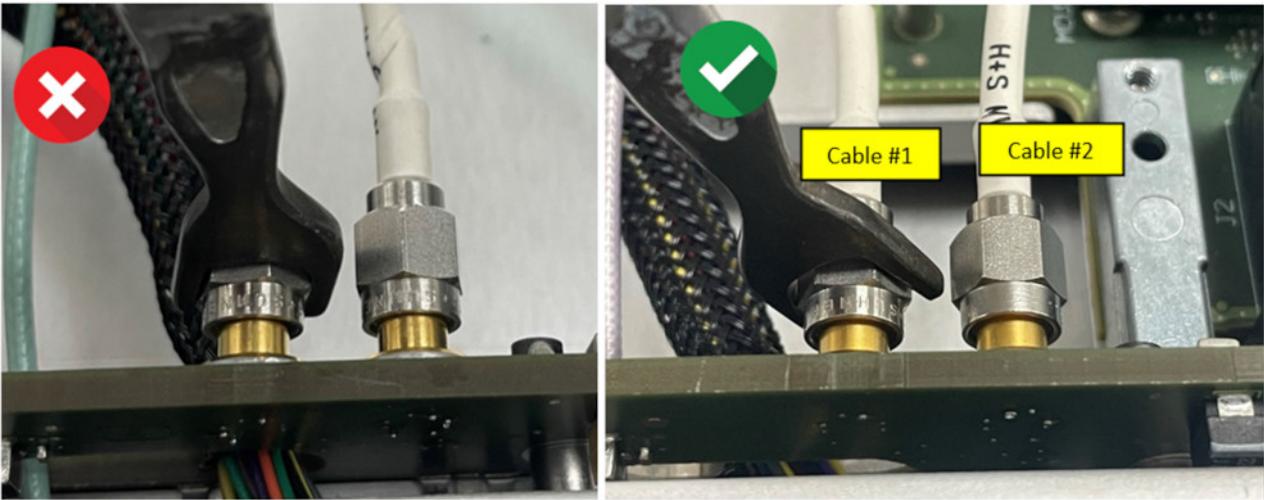


Figure 2

Removing and replacing the top panel and bottom panel

- 1 Disconnect the power cable, all probes and BNC input cables, and any other cables including those for a mouse, keyboard, printer, USB, and LAN.
- 2 Remove the four M3 screws from the rear edge of the top panel. When replacing, use a Torx T10 to torque to 5 in-lbs.



Figure 3

- 3 Slide the top panel back 1 to 2 inches and then lift it off.
- 4 To remove the bottom panel, flip the oscilloscope upside down and remove the three M3 screws from the rear of the bottom panel.

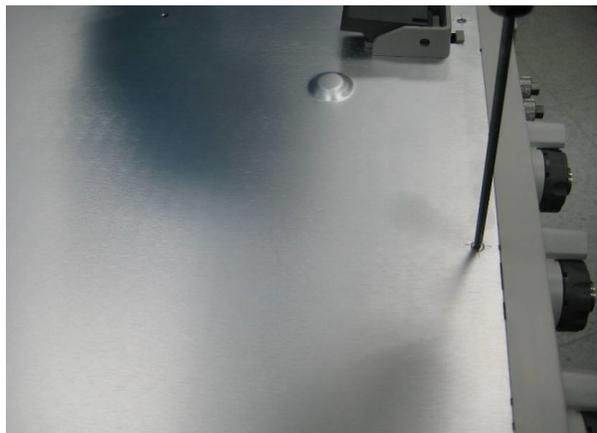


Figure 4

- 5 Remove the remaining 13 screws from the bottom panel and lift the bottom panel off the chassis.

To replace the top and bottom panels, reverse this procedure.

NOTE

All sheet metal holes that are supposed to have screws placed in them are marked by lines on four sides of the hole.



Figure 5

Removing and replacing the front panel assembly

- 1 Disconnect the power cable and remove the top panel as described earlier.
- 2 Disconnect the on/off cable and the display cable from the motherboard.

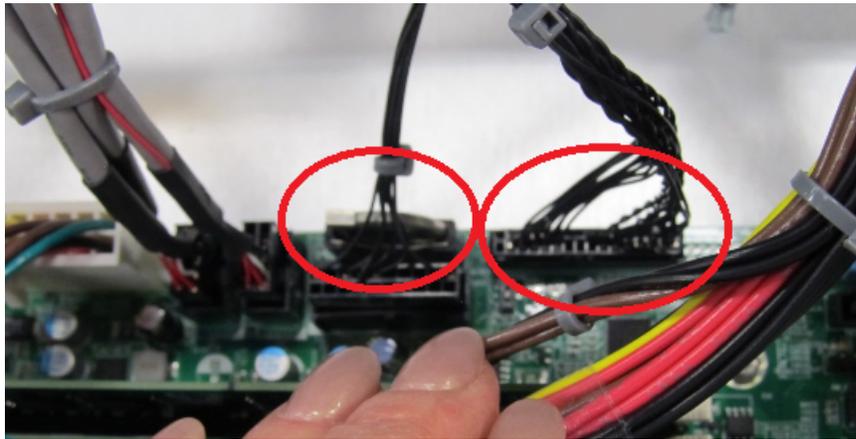


Figure 6

- 3 Disconnect the USB 3.0 cable from the motherboard.

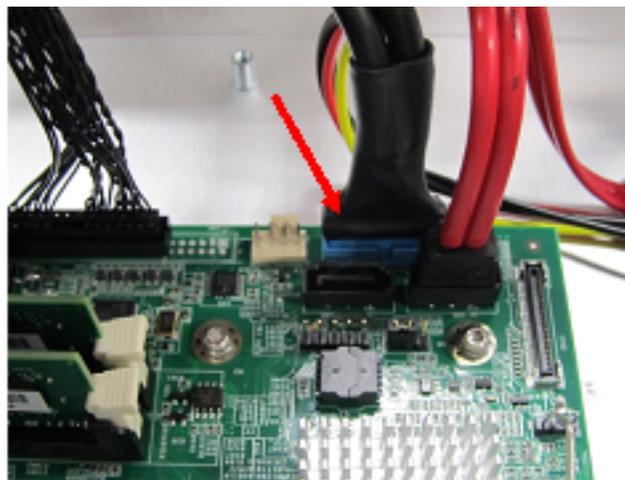


Figure 7

- 4 Disconnect the USB front touch screen cable from the USB connector on the motherboard.

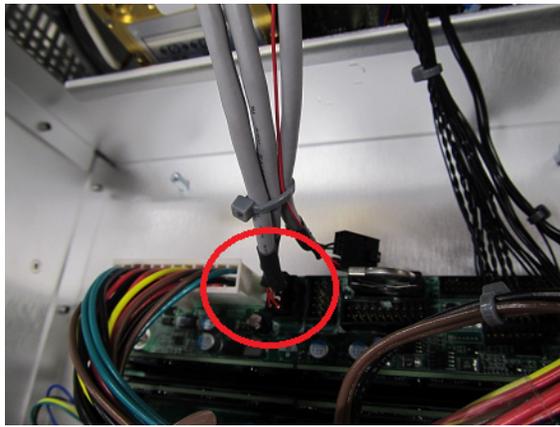


Figure 8

- 5 Disconnect the display cable's 4-pin connector from the connector on the rear of the front panel board.

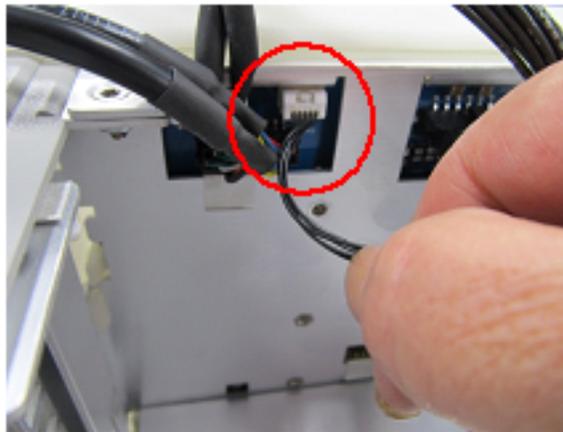


Figure 9

- 6 Remove the two screws from the front panel deck.

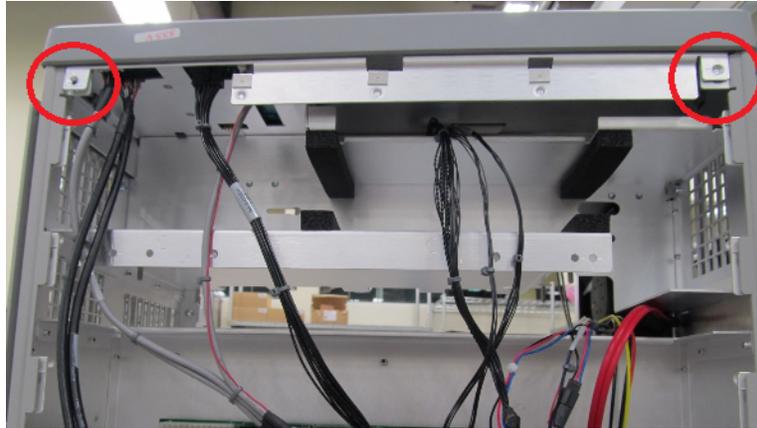


Figure 10

- 7 Turn the oscilloscope upside down and remove the three M3 screws from the rear of the bottom panel. Remove the remaining 13 screws from the bottom panel and lift the bottom panel off the chassis.
- 8 Disconnect the two Cal Out/Aux Out cables from the backplane board. Pull the cables straight back to remove them from the backplane board.

CAUTION

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

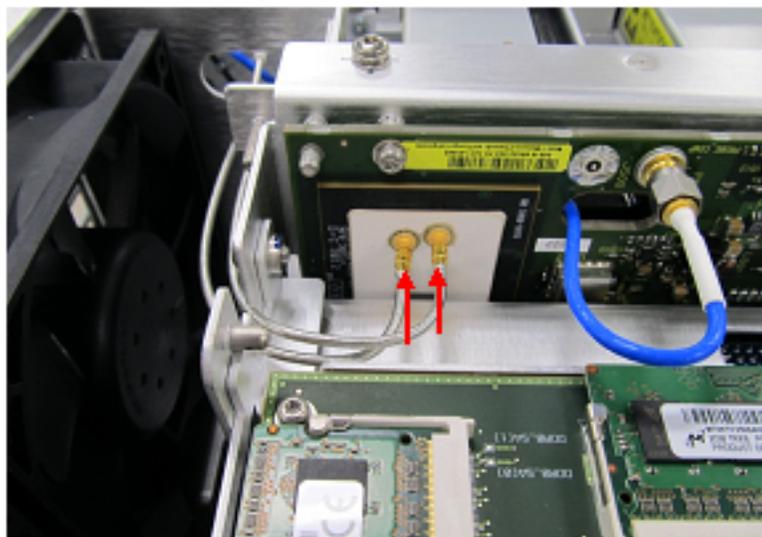


Figure 11

- 9 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.)

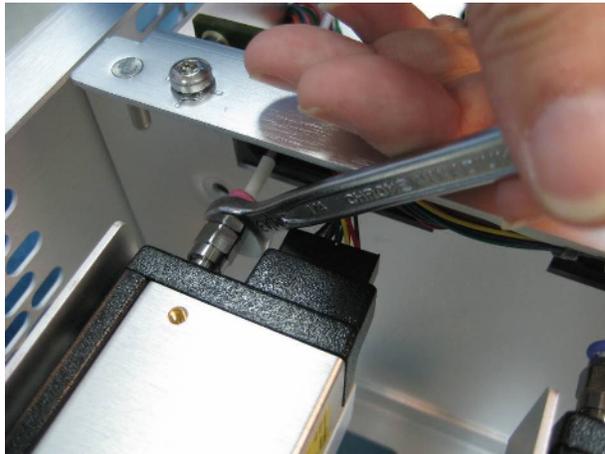
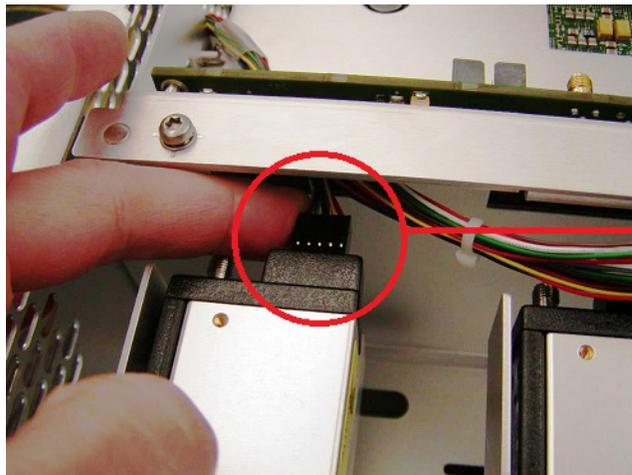


Figure 12

- 10 Remove the attenuator power cable from each input channel attenuator as shown below. Then route the entire cable through the backplane board. The attenuators are keyed to match the connectors.



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

Figure 13

- 11 Remove the probe comp cable from the backplane board.

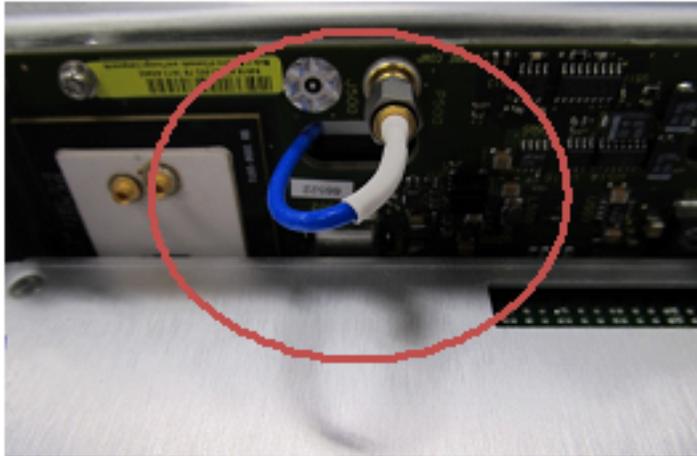


Figure 14

- 12 Remove the two M3 screws that attach the bottom of the chassis and the front panel assembly.

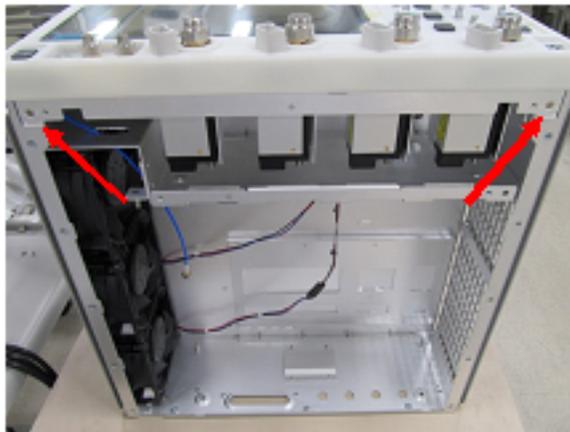


Figure 15

- 13 Pull up and tilt the front panel to see the cables connected to it. Route the display cable and on/off cable through the grommet on the chassis after disconnecting them from the other side of the connections.



Figure 16

- 14 Remove the front panel.

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.

To replace the front panel assembly, reverse this procedure.

Removing and replacing front panel assembly parts

To replace any of the front panel assembly parts, first remove the front panel assembly as described in the previous section.

Removing front panel clutches, bezel, and keyboard

WARNING

This step will ruin the clutches. You will need 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 the oscilloscope.
- 2 The front panel bezel has 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. When re-attaching the front panel bezel, carefully pull out the top and bottom tabs slightly to prevent damaging the tabs.



Figure 17

- 3 Disconnect the cables and remove the two screws shown below from the board.

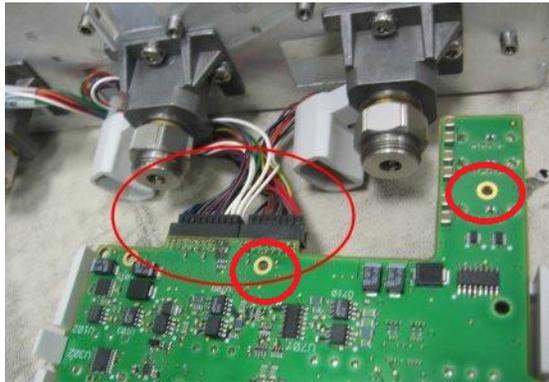


Figure 18

- 4 To remove the keyboard, unlatch the two clips from the back of the front panel deck and unsnap the board from the deck, pulling out the side closest to the display first, as shown below.

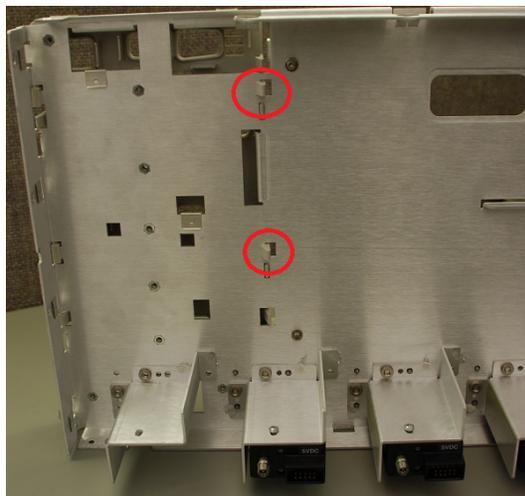


Figure 19

- 5 If you are replacing the keyboard or keypad, grasp and pull all of the knobs off of the front panel.



Figure 20

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

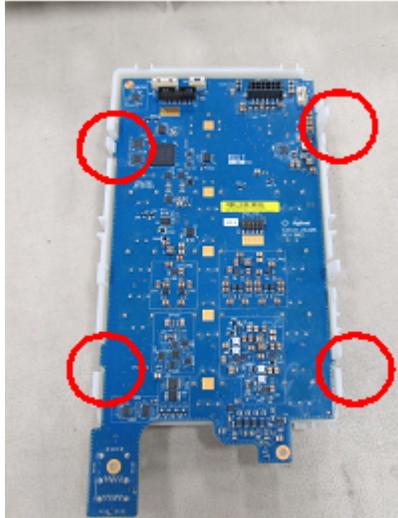


Figure 21

To reassemble the front panel board, reverse these steps.

Removing the display assembly

- 1 Remove the front panel assembly and front panel bezel as described previously.
- 2 Remove the four screws connecting the display to the deck.



Figure 22

- 3 Disconnect the backlight cable from the controller assembly.



Figure 23

- 4 Disconnect any cables connected to the display.

NOTE

If you are replacing the display, you may need to loosen the four screws in back to align the display with the bezel. Then tighten the screws.

Removing and replacing the motherboard

- 1 Disconnect the power cable and remove the top panel as described previously.
- 2 Disconnect the blue and red SATA cables from the PCIe-to-SATA adapter board. When replacing the motherboard, be careful to reconnect the blue SATA cable to the connector marked BLUE on the adapter board, and the red cable to the other SATA connector.

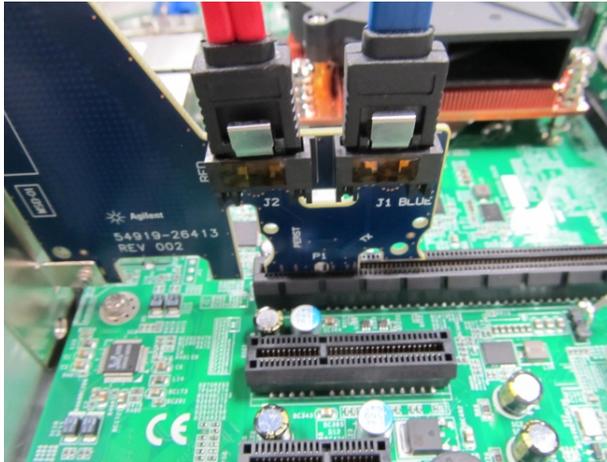


Figure 24

- 3 Disconnect the screw that connects the PCIe cover plate to the chassis and then remove the PCIe-to-SATA adapter board.



Figure 25

- 4 If the instrument has the optional GPIB board, remove it from the PCIe slot.



Figure 26

- 5 Disconnect the USB front touch screen cable from the USB connector on the motherboard.

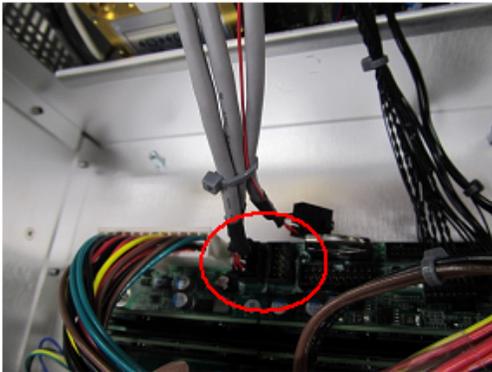


Figure 27

- 6 Disconnect the other connector (with the red wire) from the USB connector on the motherboard.

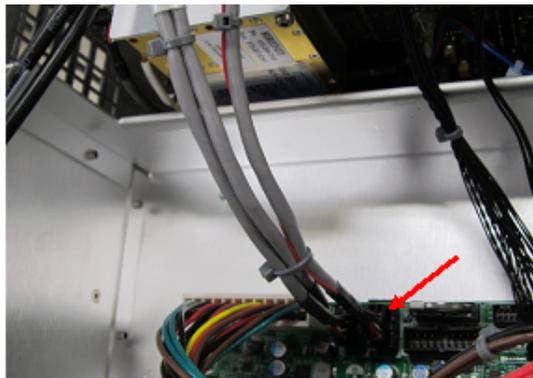


Figure 28

- 7 Disconnect the PC power cable 4-pin connector from the motherboard.



Figure 29

- 8 Disconnect the largest connector of the PC power cable from the connector on the motherboard.

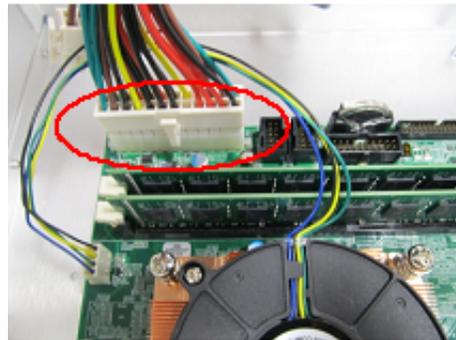


Figure 30

- 9 Disconnect the solid state drive SATA cable from the SATA connector on the motherboard.



Figure 31

10 Disconnect the on/off cable and the display cable from the motherboard.

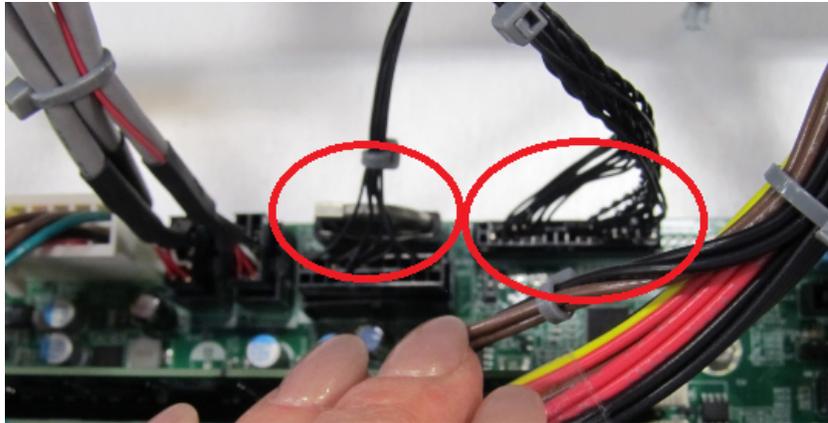


Figure 32

11 Disconnect the USB 3.0 cable from the motherboard.

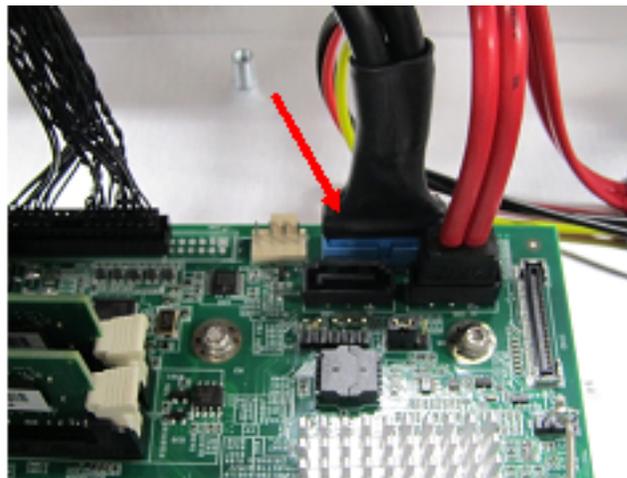


Figure 33

- 12 Remove the six screws from the motherboard. When replacing, torque the screws to 5 in-lbs using a power driver and T-10 bit.

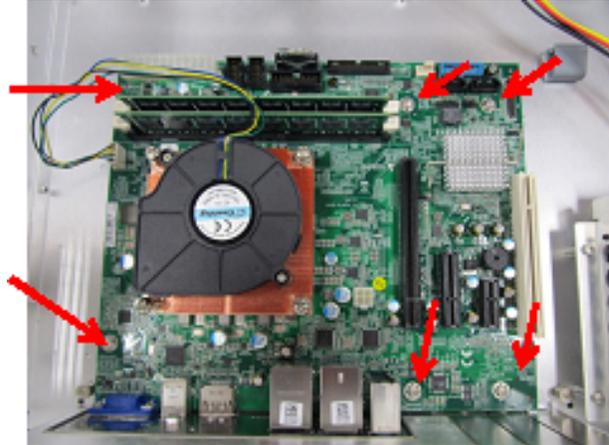


Figure 34

- 13 Slide the motherboard out, away from the chassis.
- 14 Remove the support bracket from the bottom of the motherboard.

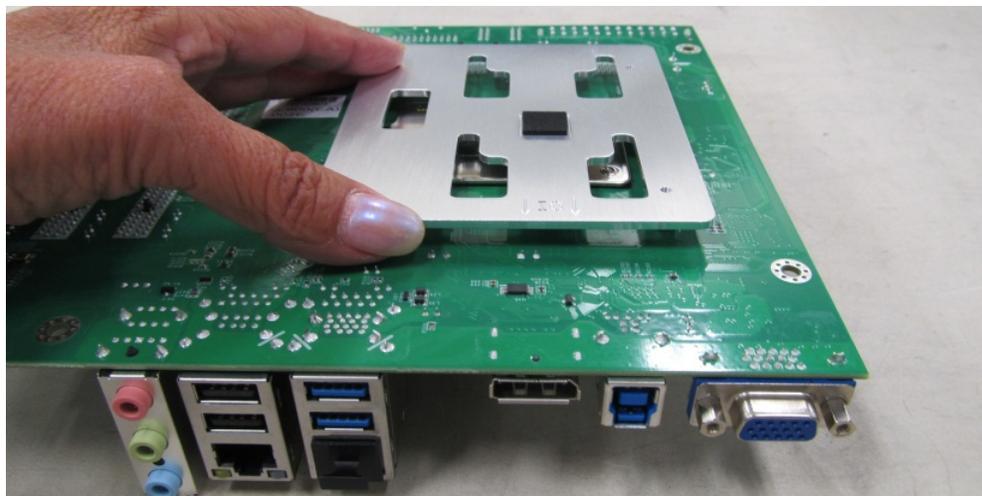


Figure 35

To replace the motherboard, reverse these procedures.

When the replacement motherboard has non-functional audio connectors, be sure to affix the motherboard I/O label and insert the audio connector port caps that come with the replacement motherboard kit.

WARNING

DANGER OF EXPLOSION

If you replace the ADLINK lithium battery on the motherboard, there is a danger of explosion if the battery is incorrectly replaced. Replacement with only with the same or equivalent type recommended (BR2023 3V lithium). Discard used batteries according to manufacturer's instructions.

Removing and replacing the acquisition boards/backplane/MSO assembly

- 1 Disconnect the power cable, top panel, and bottom panel 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 the photo below. It is toward the bottom of the backplane board, so look down the board to see it and then follow the cable up to where you can disconnect it.

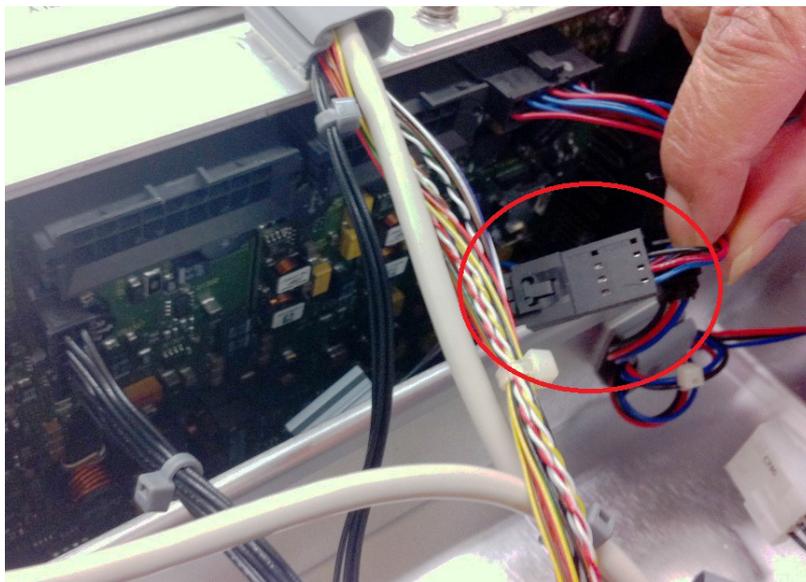


Figure 36

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

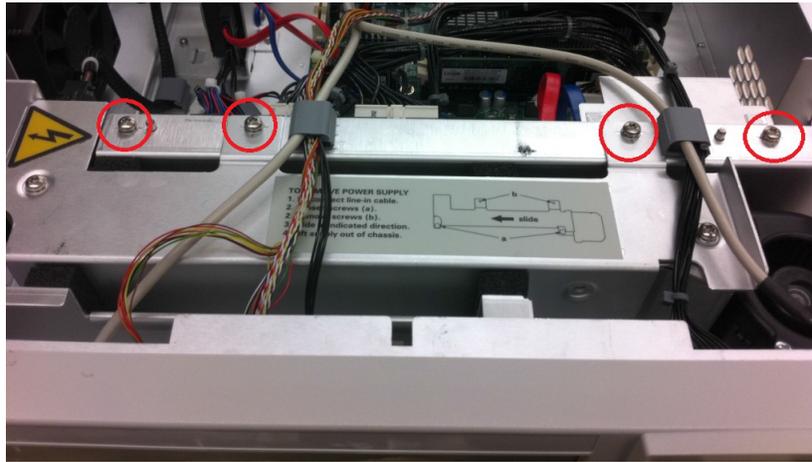


Figure 37

- 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.



The first screw to loosen

Figure 38

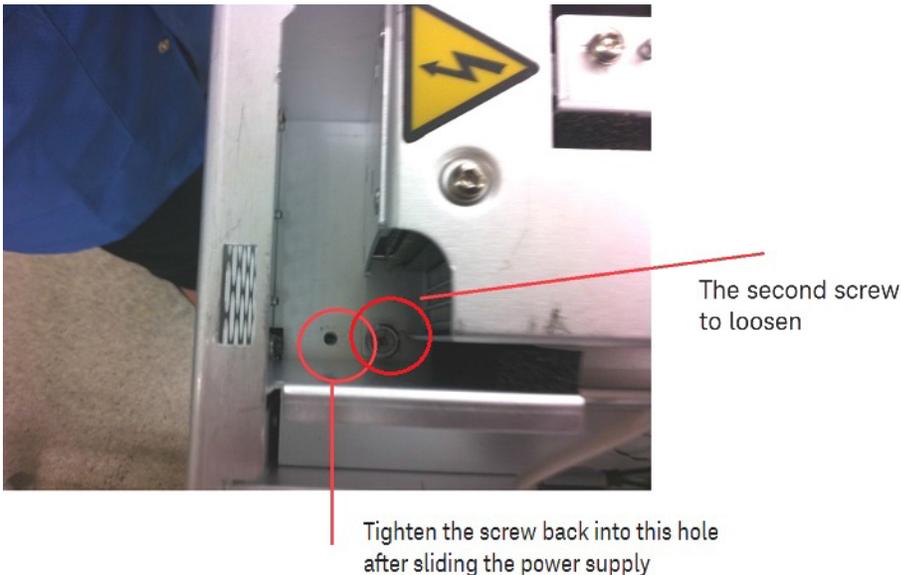


Figure 39

- 5 Loosen the two screws near the motherboard and rear panel. One of the screws is circled below.

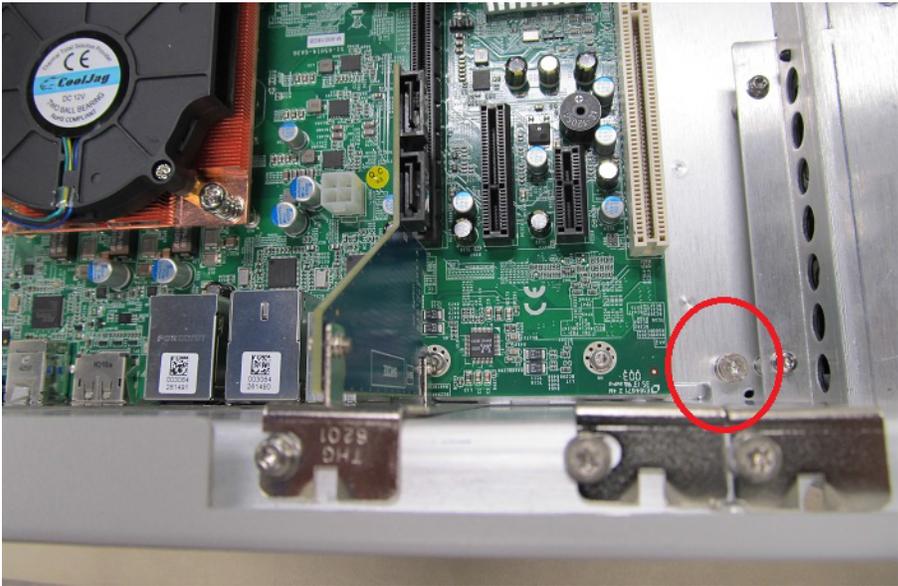


Figure 40

- 6 Turn the oscilloscope upside down and remove the SMA connections to the bottom of the backplane board. When reconnecting, route these cables

underneath the input cables. The cables and the connections on the backplane board are labeled to help in connecting each cable to its correct location.



Figure 41

- 7 Disconnect the two Cal Out / Aux Out cables from the backplane board. Pull the cables straight back to remove them from the backplane board.

CAUTION

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

When reconnecting these cables, you will hear two snap sounds when each cable is fully engaged.

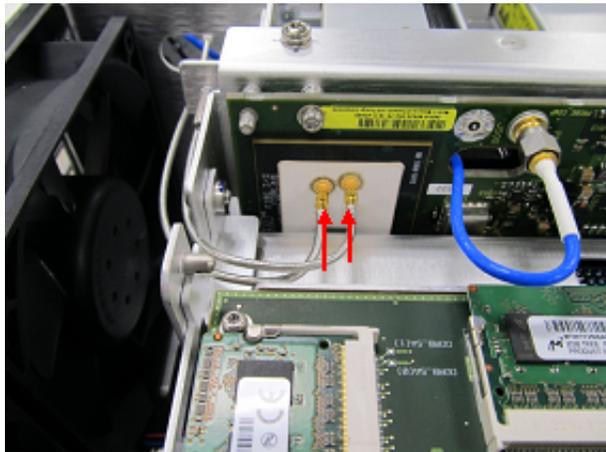


Figure 42

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

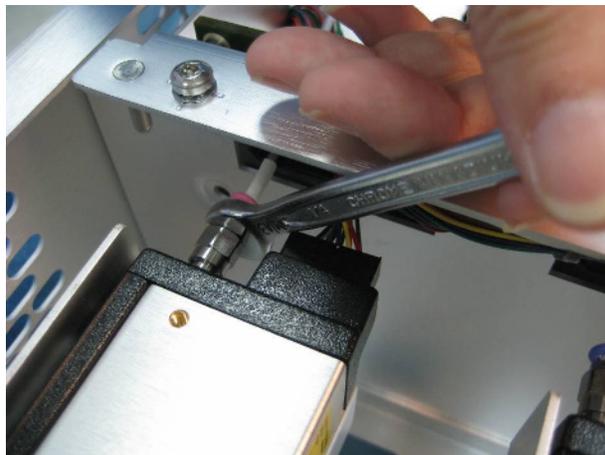
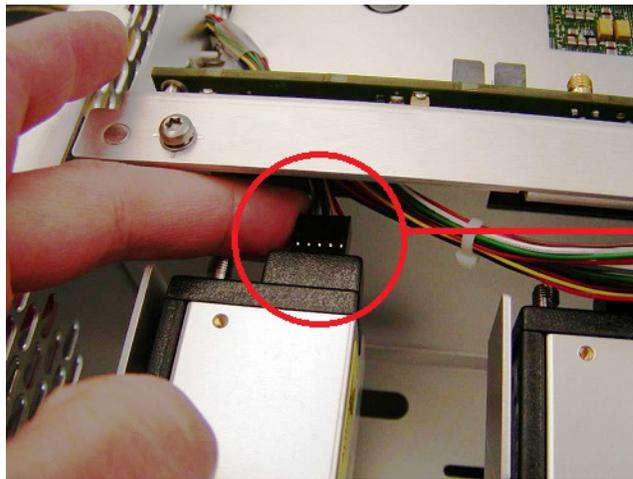


Figure 43

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



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

Figure 44

- 10 Remove the rear panel BNCs. The bottom figure shows the rear panel of a DSO/DSA model with the hardware serial trigger option.



Figure 45

- 11 Remove the two M4 screws from the top of the backplane board and two M4 screws from the rear of the oscilloscope.

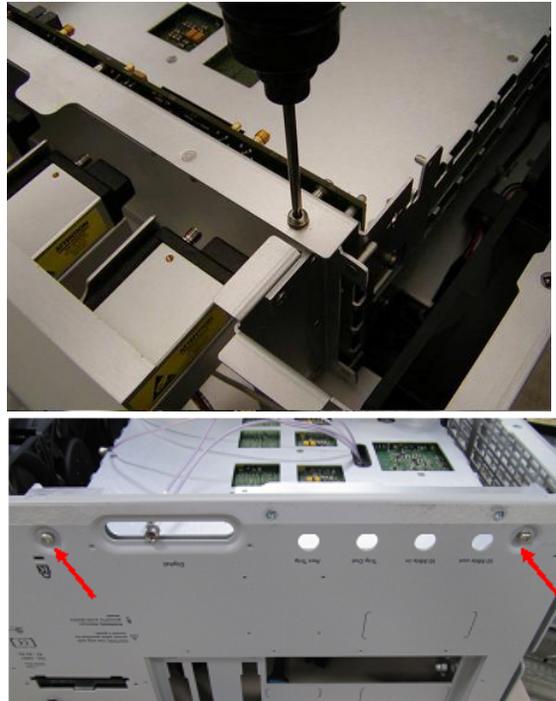


Figure 46

- 12 Ensure all cables are disconnected from the backplane board. Look from both the top and bottom of the oscilloscope to see and reach them all.
- 13 Lift the entire acquisition/backplane assembly out of the chassis.



Figure 47

The following figures show the removed assemblies in DSOV and DSAV models (first photo) and MSOV models (second photo).

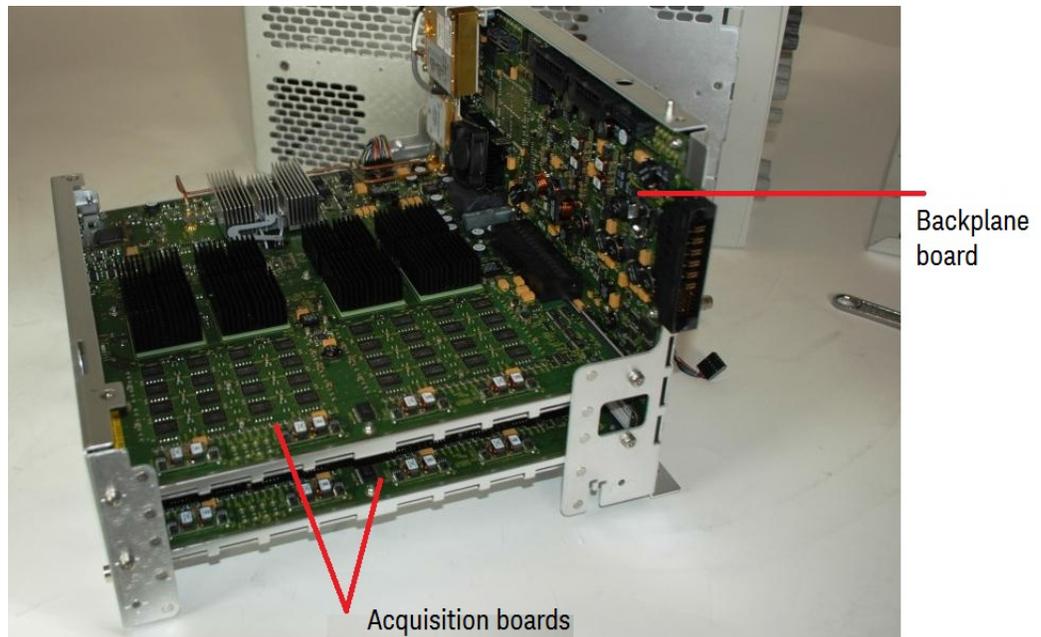


Figure 48

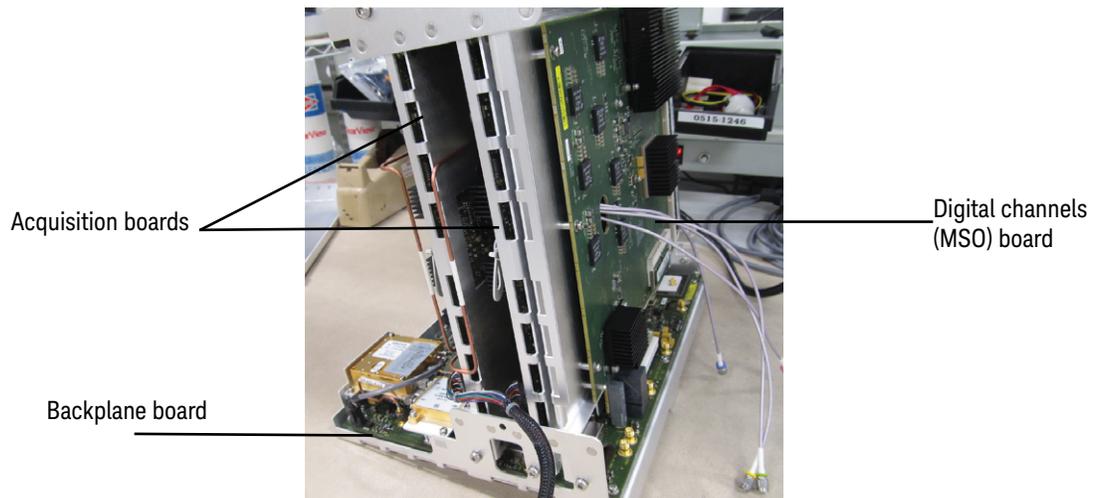


Figure 49

Removing the backplane assembly from the acquisition assembly

- 1 Remove the entire acquisition/backplane/MSO assembly as described in the previous section.
- 2 Remove the four M4 screws (two on each side) from the rear panel of the assembly (six M4 screws if the oscilloscope has the hardware serial trigger option or is an MSO model, as shown below). When replacing the screws, torque to 18 in-lbs.

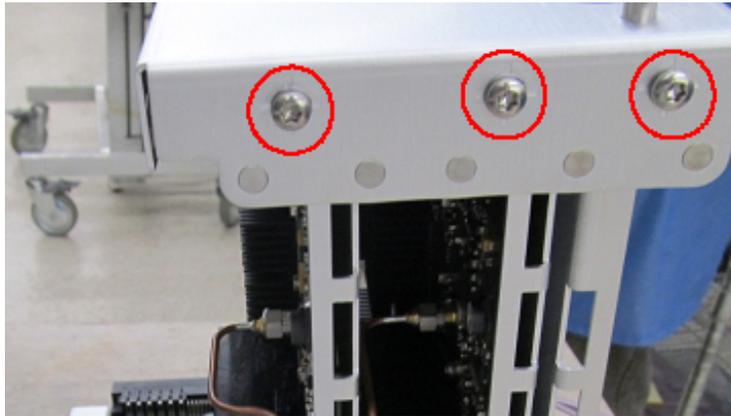


Figure 50

- 3 Remove the rear panel.
- 4 Loosen both ends of the two semi-rigid cables at the clock splitter. When tightening them, torque to 8 in-lbs.

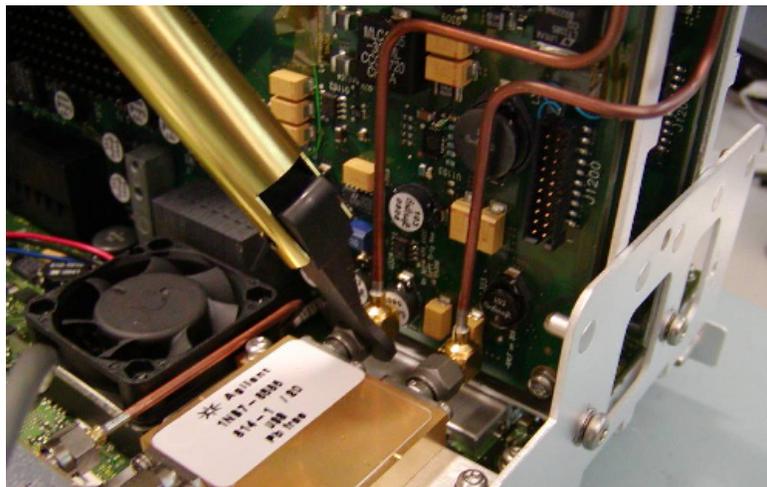


Figure 51

- 5 Disconnect the two attenuator cables shown below.

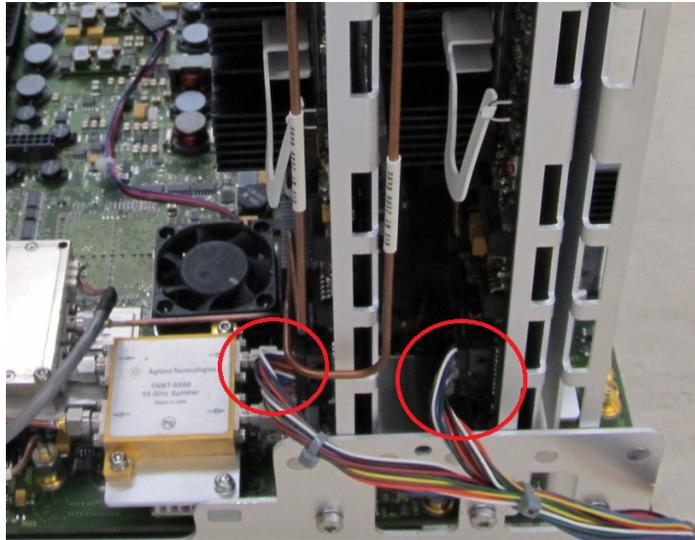


Figure 52

- 6 Disconnect the two semi-rigid cables from the acquisition boards, circled below.

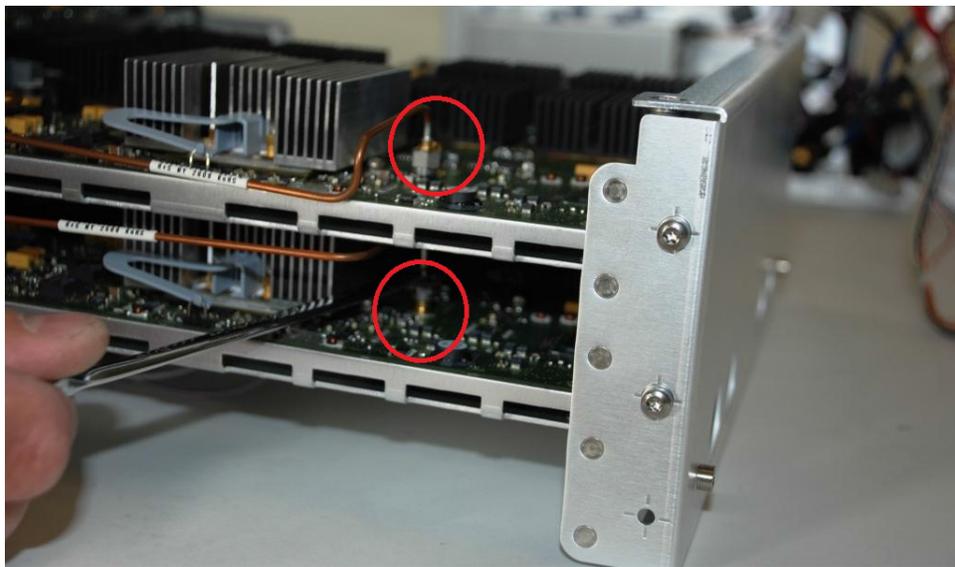


Figure 53

- 7 Remove the four M4 screws (two per acquisition assembly) on the side of the backplane assembly (six M4 screws if the oscilloscope has the hardware serial trigger option or is an MSO model, as shown below).

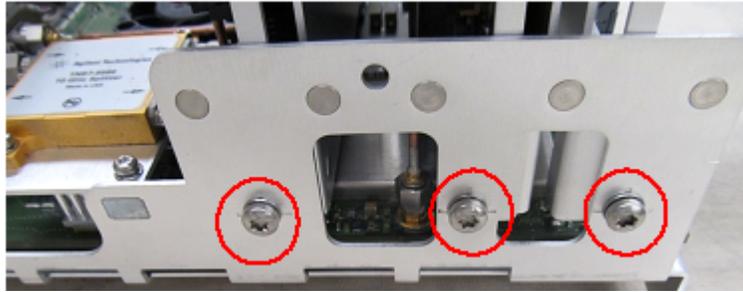


Figure 54

- 8 Remove the top acquisition board (channels 3 and 4) first, carefully guiding the input cables through the slots.

Use the handles on the acquisition tray to separate the backplane assembly from each of the acquisition assemblies. This step requires some force as the assemblies have numerous connections and pins.

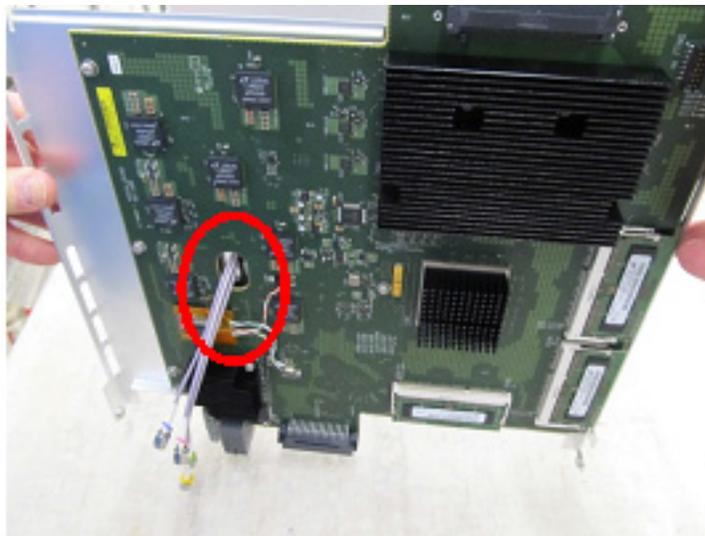


Figure 55

The following figure shows a DSO model with the top acquisition assembly removed.



Figure 56

- 9 For oscilloscopes with the hardware serial trigger option, disconnect both of the SMP/SMP cables from the connectors on the serial trigger board and the acquisition board. When reconnecting to the serial trigger board, you will hear a double click when the connectors are fully seated.

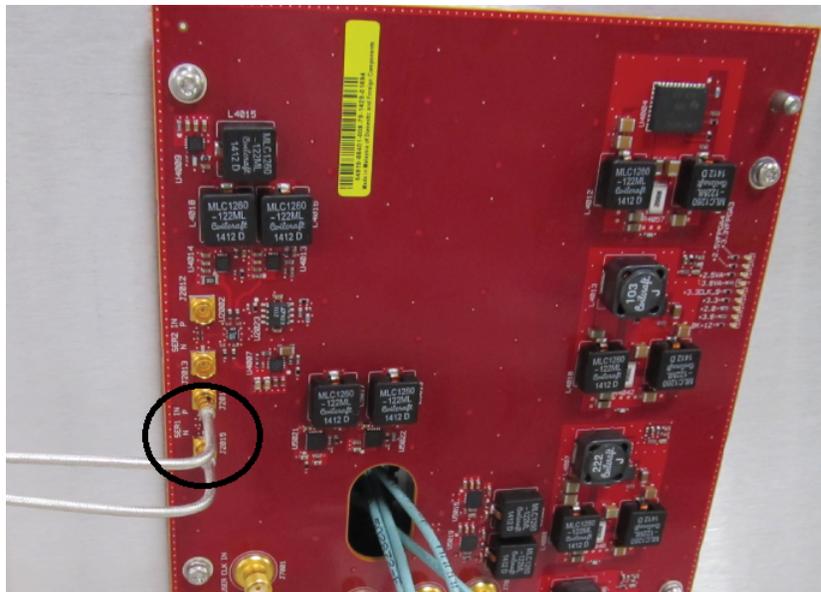


Figure 57



Figure 58

10 Remove the bottom acquisition board (channels 1 and 2) from the backplane frame assembly.

To reassemble the backplane/acquisition assembly, reverse this procedure.

Replacing the backplane board

The new backplane board does not come with an oscillator and splitter assembly or a backplane frame, so you will need to remove them from the old board and place them on the new board.

- 1** Remove the backplane assembly from the acquisition assembly as described in the previous section.
- 2** Remove the clock splitter/oscillator assembly bracket from the old backplane board.
- 3** Remove the 8 screws connecting the old backplane board to the bracket and use them to connect the new backplane board to the bracket. Torque to 5 in-lbs.

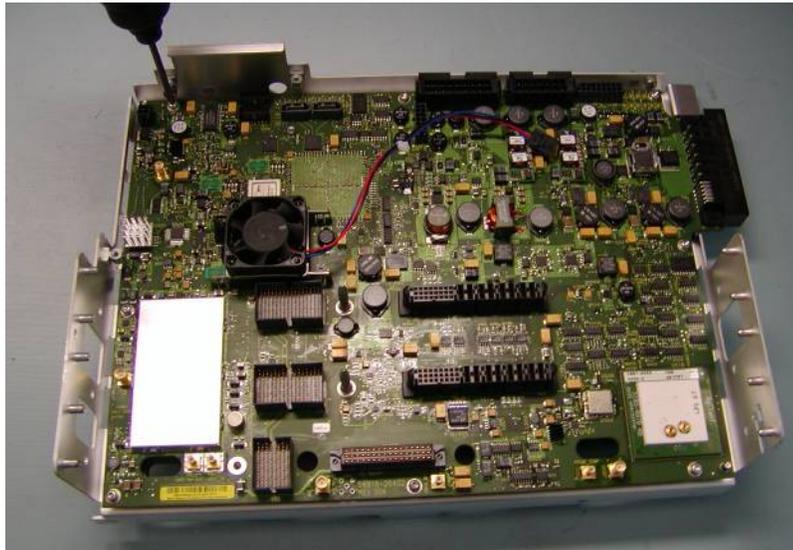


Figure 59

- 4 Remove the 2 or 3 guide posts (3 for MSO and serial trigger boards) from the old backplane board using an open-end wrench. Install them onto the new board and torque to 5 in-lbs.

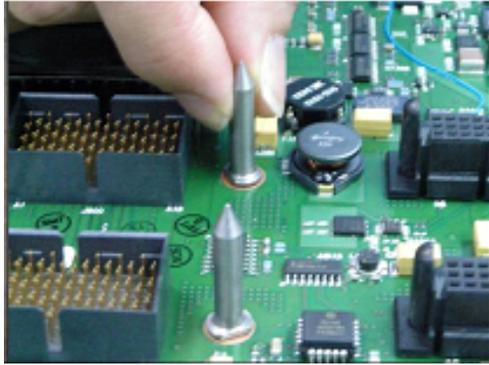


Figure 60

- 5 Install the oscillator assembly into the backplane board, using the bracket to guide the orientation. Start the 3 screws through the oscillator bracket and into the backplane bracket in the order shown below.

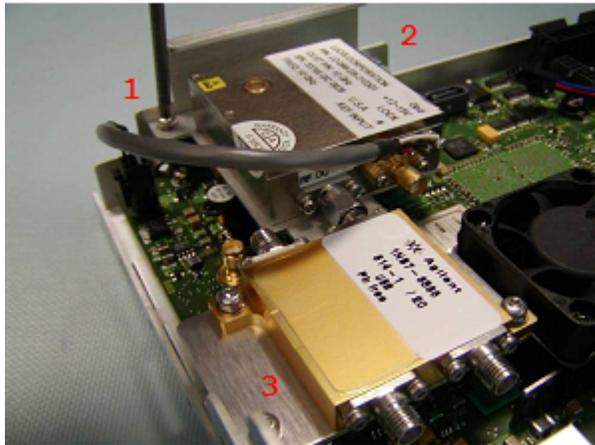


Figure 61

- 6 Connect the cable from the oscillator to connector J303 on the backplane board.



Figure 62

- 7 Connect the SR oscillator reference cable to its connector on the oscillator Reference IN connector. Torque to 8 in-lbs using a hand torque wrench.

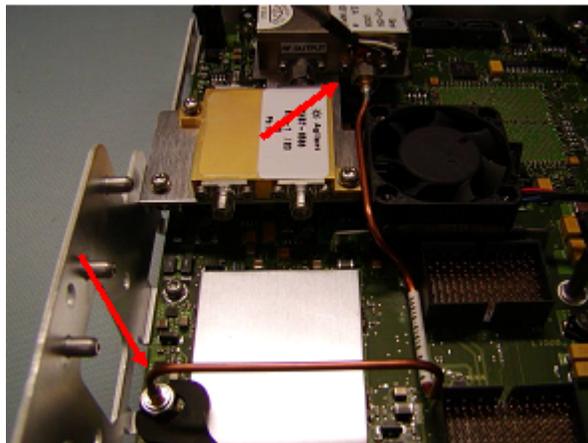


Figure 63

- 8 Connect one end of the semi-rigid SR Backplane Clock Out cable to connector J300 on the backplane board, and the other end to the clock splitter as shown. Torque both ends to 8 in-lbs. The semi-rigid cable must be installed correctly as shown below.

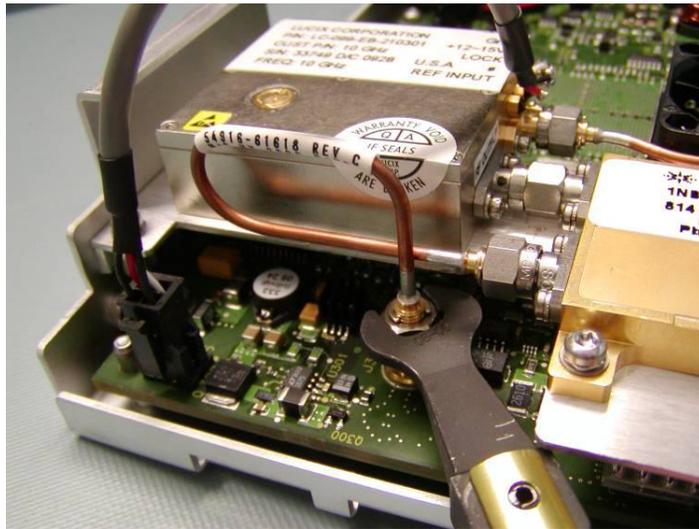


Figure 64



Figure 65

- 9 Connect the SR Clock CH1 + CH2 cable to its connector closest to the edge of the splitter. Finger tighten. Connect the SR Clock CH3 + CH4 cable to its connector on the splitter, closest to the fan. Finger tighten.

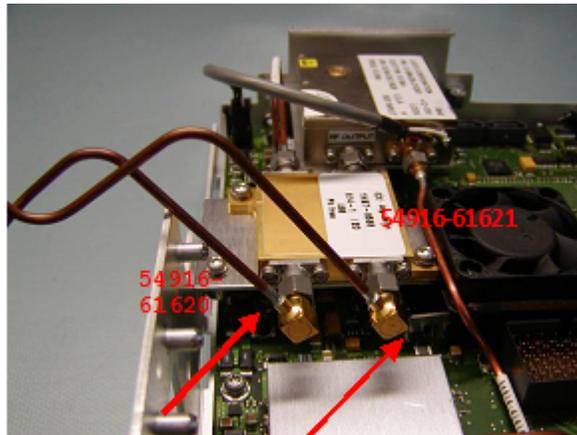


Figure 66

- 10 Dress both cables toward the outside edge.

Replacing an acquisition board

New acquisition boards do not come with input cables or an acquisition frame, so you will need to remove them from the old board and place them on the new one.

- 1 Remove the acquisition assembly from the backplane assembly as described earlier.
- 2 Remove the 9 screws from the old acquisition board and save them to attach the new board to the frame. Remove the board from the frame.
- 3 Place the new acquisition board onto the acquisition frame, ensuring that the board is seated into the guide pins.

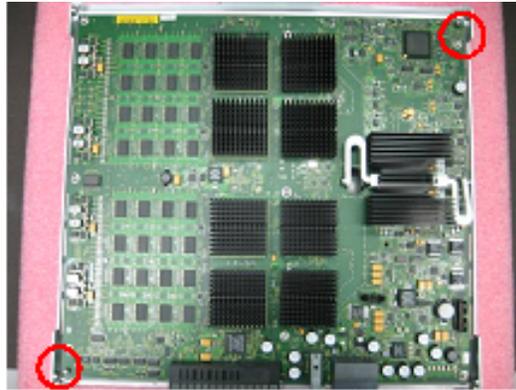


Figure 67

- 4 Replace the 9 screws.



Figure 68

- 5 Slide the heat shrink with the cable part number toward the SMPM connector as far as it will go for cable input.

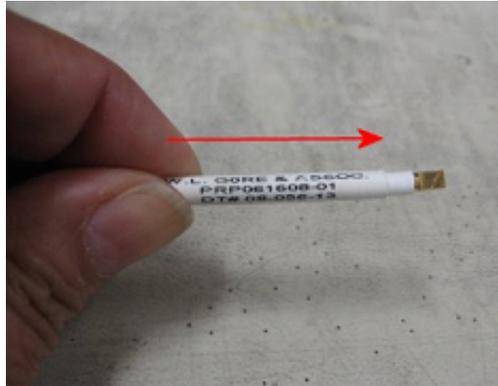


Figure 69

CAUTION

For the following steps, be careful not to crimp or pinch the input cables. Also, to ensure the weight of the assembly does not rest on the cables, support the tray from underneath.

- 6 Carefully remove the input cables from the old acquisition board.
- 7 Insert the right-angle SMPM end of the first input cable through the bottom of the acquisition tray assembly. The cables route through the plastic grommet and through the oval hole in the acquisition board as shown.

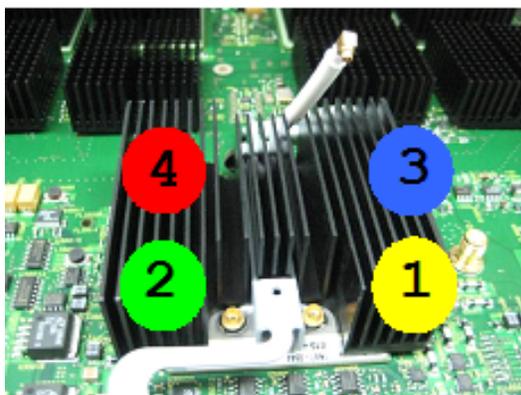


Figure 70

- 8 Snap the SMPM connector into its mating connector on the Oak module (U34000). Use needle-nosed pliers to guide the right-angle SMPM into place. You will hear a double-snap sound when the connector is properly seated.



Figure 71

- 9 Repeat the previous step for the second input cable.



Figure 72

- 10 Press the cables gently to relieve possible strain on the connections.

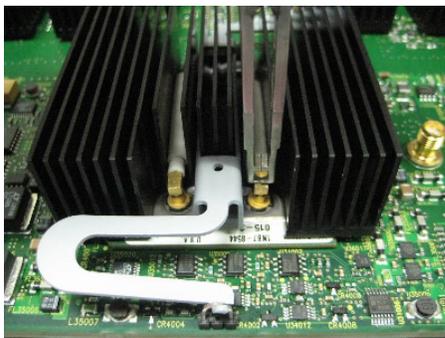


Figure 73

- 11 Repeat the previous steps for the second acquisition assembly.

Setting the calibration factors after replacing an acquisition board

After replacing an acquisition board you must perform a service calibration, including the interleave response correction, and then perform a self test procedure. Refer to Chapter 2, “Calibration”, for details.

NOTE

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.

Removing and replacing the hard disk drive

- 1 Loosen the two screws on back of the hard disk drive.



Figure 74

- 2 Pull the hard drive out.



Figure 75

- 3 Remove the four screws connecting the disk drive to the plate.

To replace the hard disk drive, reverse this procedure. Torque the four screws to 5 in-lbs.

Removing and replacing the power supply

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

- 1 Disconnect the power cable and remove the top panel as described previously.
- 2 Disconnect the AC power cable from the bulk 12 V power supply.



Figure 76

- 3 Follow the remaining instructions on the power supply to remove it.

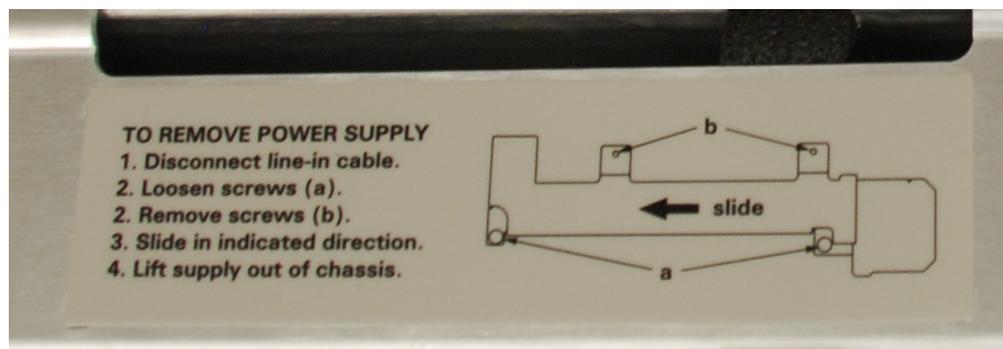


Figure 77

NOTE

There are no user-replaceable fuses in the oscilloscope.

Removing and replacing fans

WARNING

AVOID INJURY! The fan blades are exposed both inside and outside the chassis. Disconnect the power cable before working around the fan.

- 1 Remove the top panel, bottom panel, and front panel as described earlier.
- 2 Remove the four M3 screws (2 from each side) connected to the fan bracket.
- 3 Disconnect the fan harness cables from the fans you want to replace.

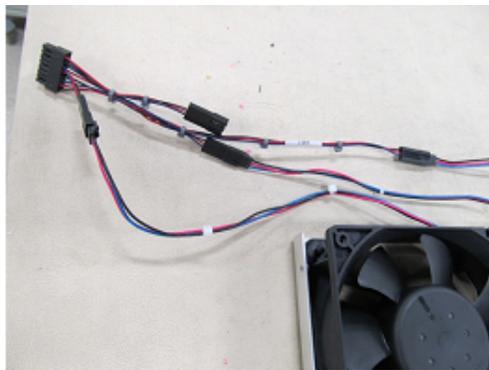


Figure 78

- 4 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 79

To replace a 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.

Removing and replacing the optional GPIB port

- 1 Disconnect the power cable and remove the top panel.
- 2 Remove the screw from the top edge of the chassis.
- 3 Pull the port out of the slot.

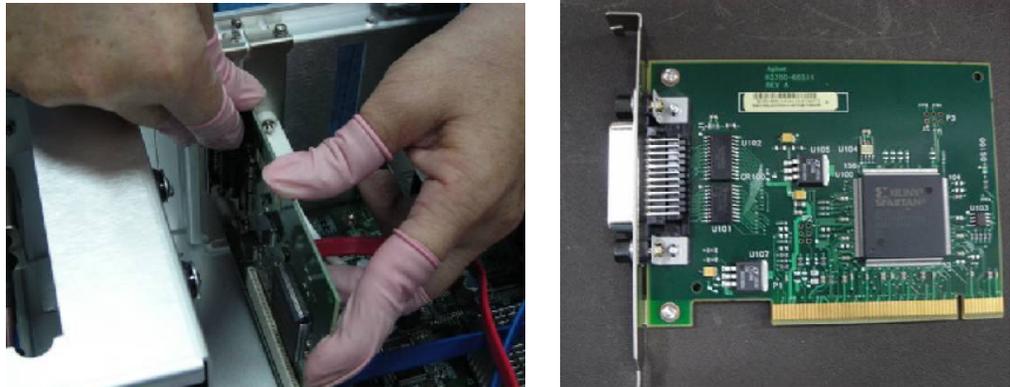


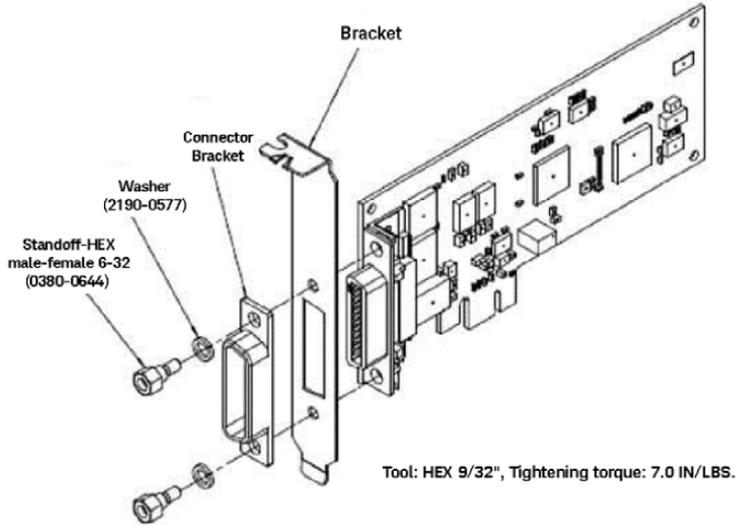
Figure 80

NOTE

If you are replacing the GPIB port with a new one (82351B or newer), you will need to use a V-Series Profile Bracket (54919-00105).

To replace the standard profile bracket with a V-Series Profile Bracket:

- 1 Remove the hex screws that hold the connector bracket and the standard profile bracket by using a hex 9/32", tightening torque 7.0 in/lbs screwdriver.
- 2 Replace the standard profile bracket with the V-Series Profile Bracket and replace the screws.



6 Replaceable Parts

Ordering Replaceable Parts **140**

Exploded Views **141**

Replaceable Parts List **145**

This chapter describes how to order replaceable assemblies and parts for the Infiniium V-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.

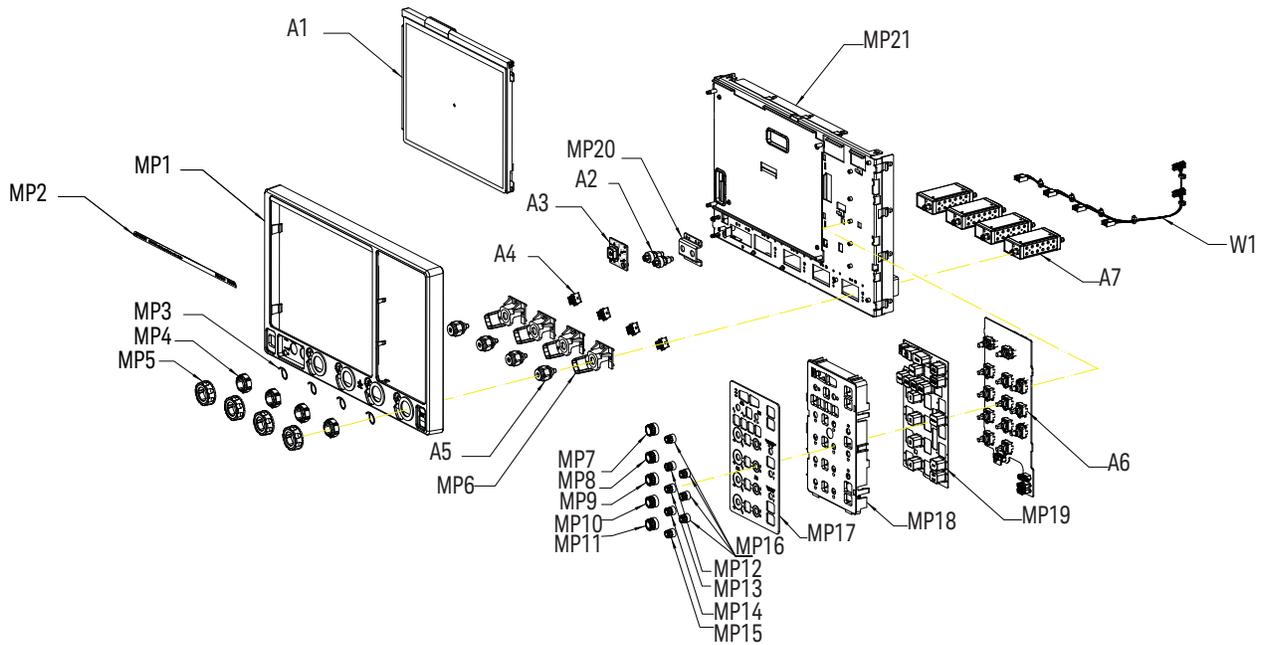
For Keysight Technologies to provide these advantages, please send a check or money order with each order.

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.

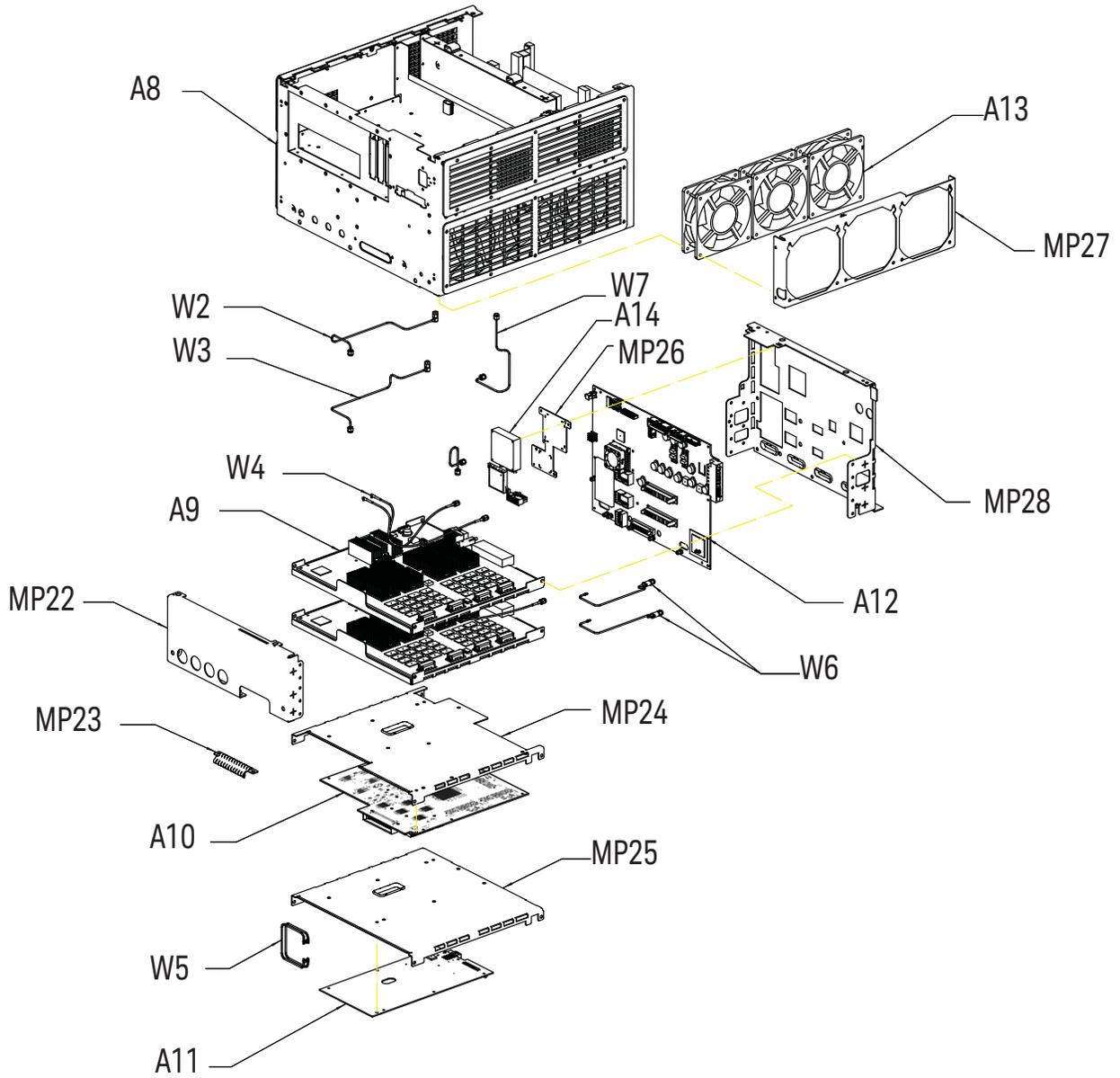
Exchange Assemblies

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

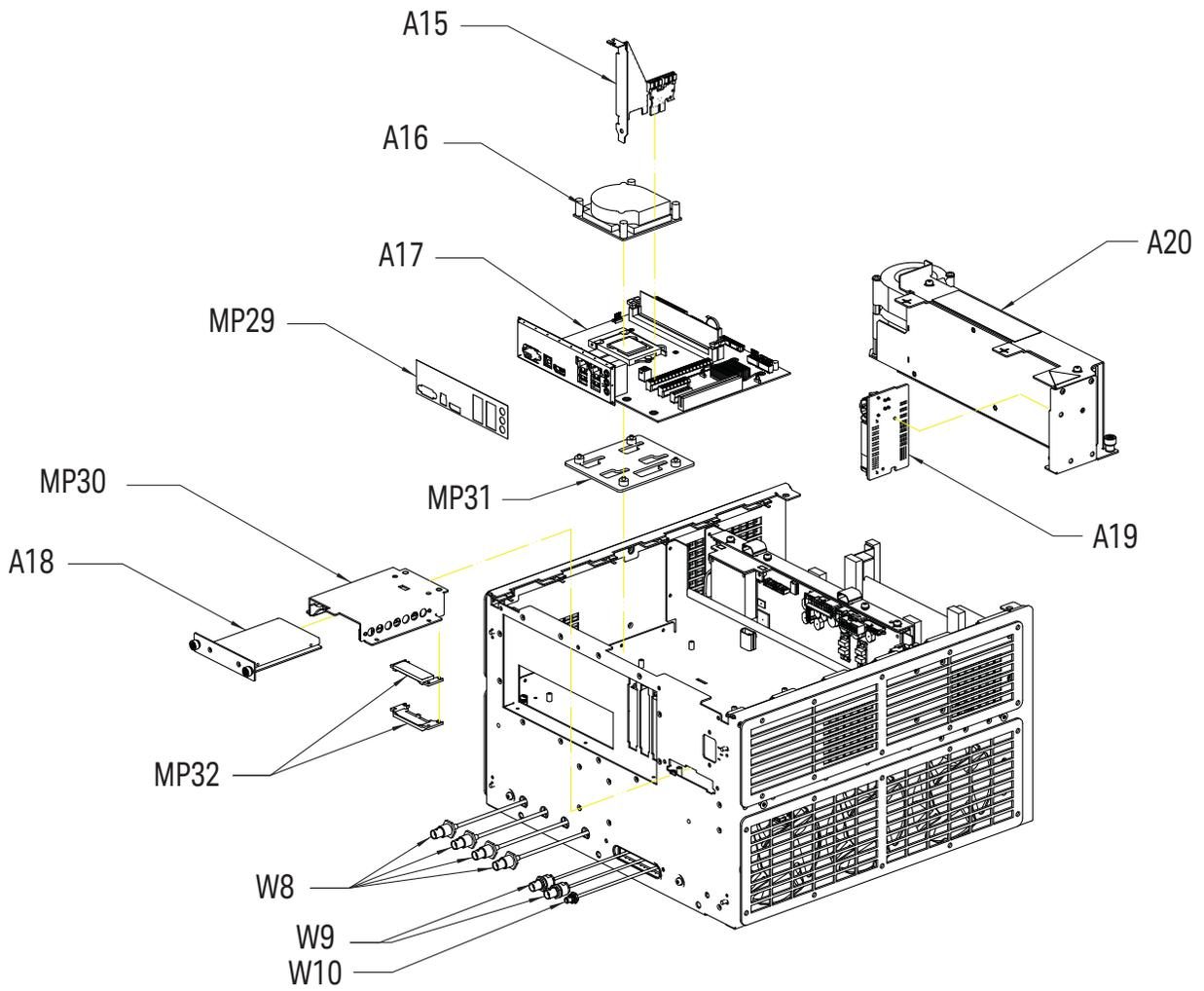
Exploded Views



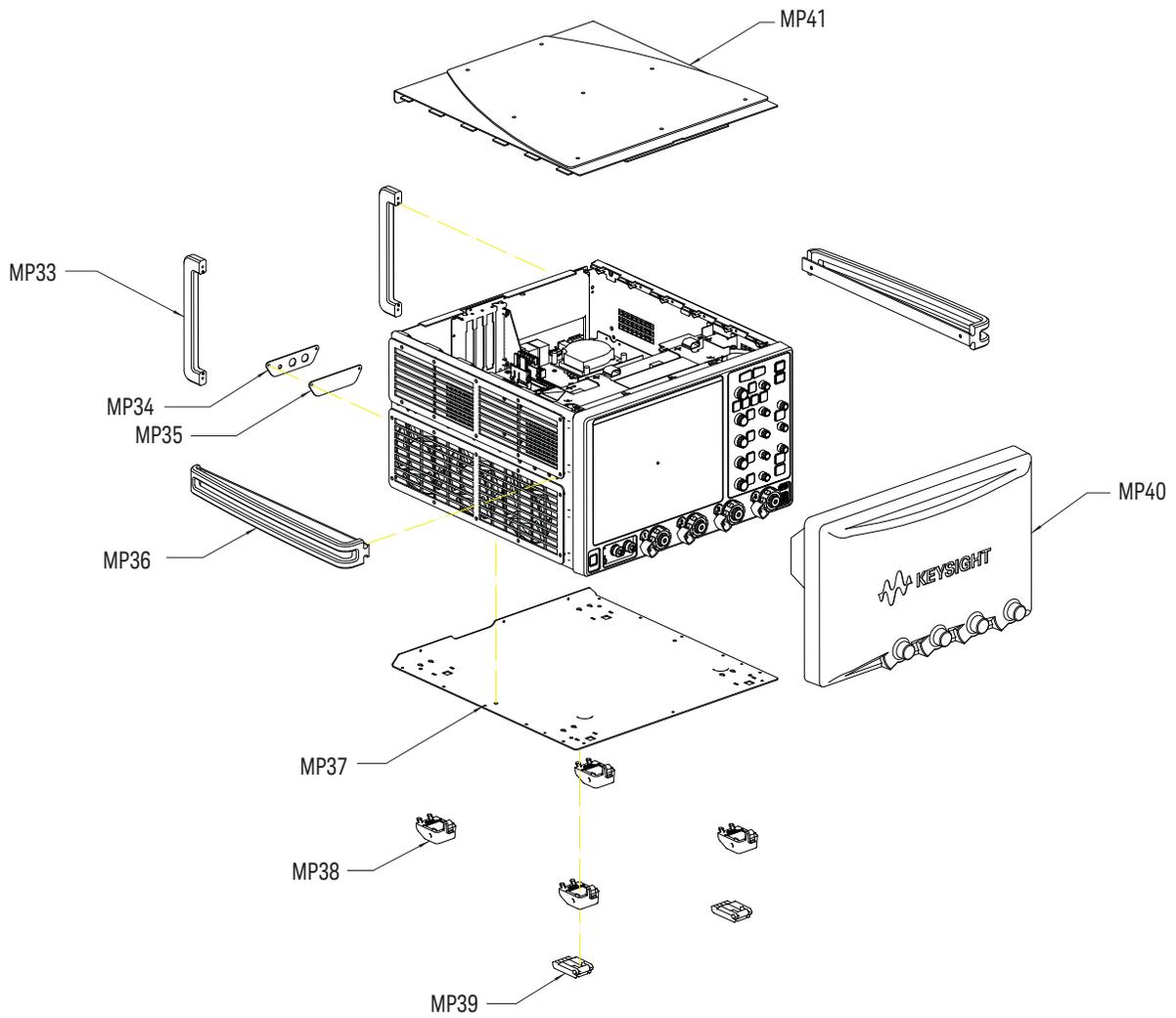
Front frame and front panel



Fan and acquisition assembly



Power supply and PC motherboard



External parts

Replaceable Parts List

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

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

Replaceable parts

Ref. Des	Part number	Qty	Description
A1	2090-1099	1	Display - LCD 12.1-in. backlit w/capacitive touch screen
A2	08673-67601	1	Connector assembly - output
A3	54919-66406	1	PCA - On/off board
A4	54916-66414	1	PCA - Autoprobe board
A5	5062-1247	1	Assembly - 3.5 mm connector
A6	54919-66405	1	PCA - keyboard
A7	33325-60024	1	Step attenuator - front panel (RoHS version of 33325-60013)
A8	54919-00104	1	Chassis
A9	54919-66721	2	Acquisition PCA, usable for up to and including 33 GHz - tested
A9	54919-69721	2	Acquisition PCA, usable for up to and including 33 GHz - exchange
A9	54919-66731	1	Tested acquisition board, usable for 25, 20, 16, 13, or 8 GHz
A9	54919-69731	1	Tested acquisition board, usable for 25, 20, 16, 13, or 8 GHz - exchange
A9	54916-00502	2	Frame for acquisition assembly
A10	N2834-66501	1	Printed circuit board for MSO models - loaded and tested
A10	N2834-69501	1	Printed circuit board for MSO models - exchange
A11	54919-66501	1	Hardware serial trigger PCA - tested
A11	54919-69501	1	Hardware serial trigger PCA - exchange
A12	54916-66533	1	Backplane PCA - tested
A12	54916-66733	1	Backplane PCA for MSO models - tested
A12	54916-69733	1	Backplane PCA for MSO models - exchange
A13	54913-68710	1	Fan replacement kit 120 mm

Replaceable parts (continued)

Ref. Des	Part number	Qty	Description
A14	1813-2449	1	Crystal - oscillator 10 GHz with cable
A15	54919-66413	1	PCA - PCIe to SATA paddle board
A16	3160-4454	1	Fan with heat sink, used with the M900 (54919-66515) motherboard
	3160-4588		Fan with heat sink, used with the M910 (54919-66516) motherboard
A17	54919-66515	1	Motherboard (M900) - 16 GB with modified BIOS bits (Without Audio). This motherboard must be replaced at the Keysight Service Center using upgrade kit 54919-68804 (see page 150).
	54919-66516		Motherboard (M910) - 16 GB with modified BIOS bits. Began shipping with serial number MY63330101 and higher.
A18	54964-83515	1	Imaged 480 GB SSD for M900 (54919-66515) motherboard
	54964-83516		Imaged 960 GB SSD for M900 (54919-66515) motherboard
	54964-83517		Imaged 480 GB SSD for M910 (54919-66516) motherboard
	54964-83518		Imaged 960 GB SSD for M910 (54919-66516) motherboard
A18	54904-04101	1	Plate - Removable hard disk drive (RHDD)
A19	54916-66403	1	PCA - Power supply bridge
A20	0950-5196	1	Power supply
MP1	54919-42201	1	Bezel
MP2	54919-94310	1	Label - DSOV084A
MP2	54919-94311	1	Label - DSOV134A
MP2	54919-94312	1	Label - DSOV164A
MP2	54919-94313	1	Label - DSOV204A
MP2	54919-94314	1	Label - DSOV254A
MP2	54919-94315	1	Label - DSOV334A
MP2	54919-94320	1	Label - DSAV084A
MP2	54919-94321	1	Label - DSAV134A
MP2	54919-94322	1	Label - DSAV164A
MP2	54919-94323	1	Label - DSAV204A
MP2	54919-94324	1	Label - DSAV254A
MP2	54919-94325	1	Label - DSAV334A
MP2	54919-94330	1	Label - MSOV084A

Replaceable parts (continued)

Ref. Des	Part number	Qty	Description
MP2	54919-94331	1	Label - MSOV134A
MP2	54919-94332	1	Label - MSOV164A
MP2	54919-94333	1	Label - MSOV204A
MP2	54919-94334	1	Label - MSOV254A
MP2	54919-94335	1	Label - MSOV334A
MP3	54916-07101	1	Input connector ground spring
MP4, MP5	54932-47400	1	Outer and Inner Clutch Assembly
MP6	54916-42001	1	Casting - probe mate
MP7	54932-47450	1	Knob - 18 mm slate plain
MP8	54932-47410	1	Knob - 18 mm slate yellow
MP9	54932-47420	1	Knob - 18 mm slate green
MP10	54932-47430	1	Knob - 18 mm slate blue
MP11	54932-47440	1	Knob - 18 mm slate red
MP12	54932-47411	1	Knob - 12 mm slate yellow
MP13	54932-47422	1	Knob - 12 mm slate green
MP14	54932-47403	1	Knob - 12 mm slate blue
MP15	54932-47404	1	Knob - 12 mm slate red
MP16	54932-47405	4	Knob - 12 mm slate plain
MP17	54919-48001	1	Label - control panel
MP18	54919-40201	1	Panel - control
MP19	54919-41901	1	Switch - control panel and on/off
MP20	54919-01206	1	Bracket - cal connectors
MP21	54919-00101	1	Deck - front panel
MP22	54919-00204	1	Panel - rear
MP23	54916-07102	1	MSO probe ground spring
MP24	54916-00506	1	Frame for MSO board
MP25	54919-00501	1	Tray - serial trigger
MP26	54916-01205	1	Bracket - oscillator
MP27	54919-21202	1	Bracket - fans
MP28	54916-00501	1	Backplane frame

Replaceable parts (continued)

Ref. Des	Part number	Qty	Description
MP29	54911-94339	1	Label - PC I/O. This label is for motherboards with functional audio connectors.
	54911-94339		Label - PCIO (With Disabled Audio) - Flint Gray. This label is included with the M900 (54919-66515) Motherboard 16GB (Without Audio) Kit.
	54964-94309		Label - PCIO - M910 - Phantom Grey. This label is included with the M910 (54919-66516) Motherboard 16GB Kit.
MP30	54904-01201	1	Bracket - RHDD
MP31	54932-21204	1	Bracket - motherboard
MP32	54904-41202	2	Clamp - SATA
MP33	54919-21002	2	Foot - rear
MP34	54919-04108	1	Cover - serial trigger
MP35	54916-04107	1	Cover - serial (blank)
MP36	54919-24902	1	Handle
MP37	54919-00206	1	Panel - bottom
MP38	54916-41001	4	Foot - tilt base
MP39	54916-41002	2	Foot - tilt lever
MP40	54919-44101	1	Cover - front
MP41	54919-00203	1	Panel - top
W1	54916-61615	1	Cable - attenuator
W2	54916-61621	1	Cable - SR Clock Ch3 + Ch4
W3	54916-61620	1	Cable - SR Clock Ch1 + Ch2
W4	54916-61601	1	Cable - input
W5	54919-61629	1	Cable - SMP/SMP
W6	54919-61624	1	Cable - Step/Aux Out
W7	54916-61619	1	Cable - oscillator reference
W8	54916-61622	4	Cable - Aux BNC/SMA
W9	54919-61631	2	Cable - SMA/BNC
W10	54919-61630	1	Cable - SMA/SMA
	54916-61637	1	Cable - Autoprobe
	54916-61618	1	Cable - SR backplane Clock Out

Replaceable parts (continued)

Ref. Des	Part number	Qty	Description
	54918-61603	1	Cable - PC power, used with the M900 (54919-66515) motherboard
	54919-61610		Cable - PC power, used with the M910 (54919-66516) motherboard
	54919-61604	1	Cable - on/off
	54919-61605	1	Cable - front power
	54919-61608	1	Cable - display
	54919-61606	1	Cable - USB front/touch screen
	54916-61626	1	Cable - calibration
	54919-61628	1	Cable - probe compensation, SMA to MCX
	54919-61611	1	Cable - fan
	54904-61614	1	Cable - hard disk power
	N2815-68701	1	Cable - serial card
	8121-2445	1	Cable - SATA straight to straight, red
	8121-2446	1	Cable - SATA straight to straight, blue
	54919-61607	1	Cable - USB 3.0
	54919-61609	1	Cable - backlight
	54919-61618	1	Cable - AC input
	54916-68716	5	Connector assembly - SMA female to female (kit of 5)
	54916-68717	5	Connector assembly - 3.5 mm female to female (kit of 5)
	54916-60003	10	Connector saver collars for 20, 25, and 33 GHz models
	54916-60004	10	Connector saver collars for 8, 13, and 16 GHz models
	1400-3191	1	Clip - latching, snap-in pressure sensitive
	N2834-68703	1	MSO calibrator board assembly
	54916-94337	1	Label - MSO cable direction
	54919-94340	1	Label - bandwidth upgrade, 13 GHz
	54919-94341	1	Label - bandwidth upgrade, 16 GHz
	54919-94342	1	Label - bandwidth upgrade, 20 GHz
	54919-94343	1	Label - bandwidth upgrade, 25 GHz
	54919-94344	1	Label - bandwidth upgrade, 33 GHz

Replaceable parts (continued)

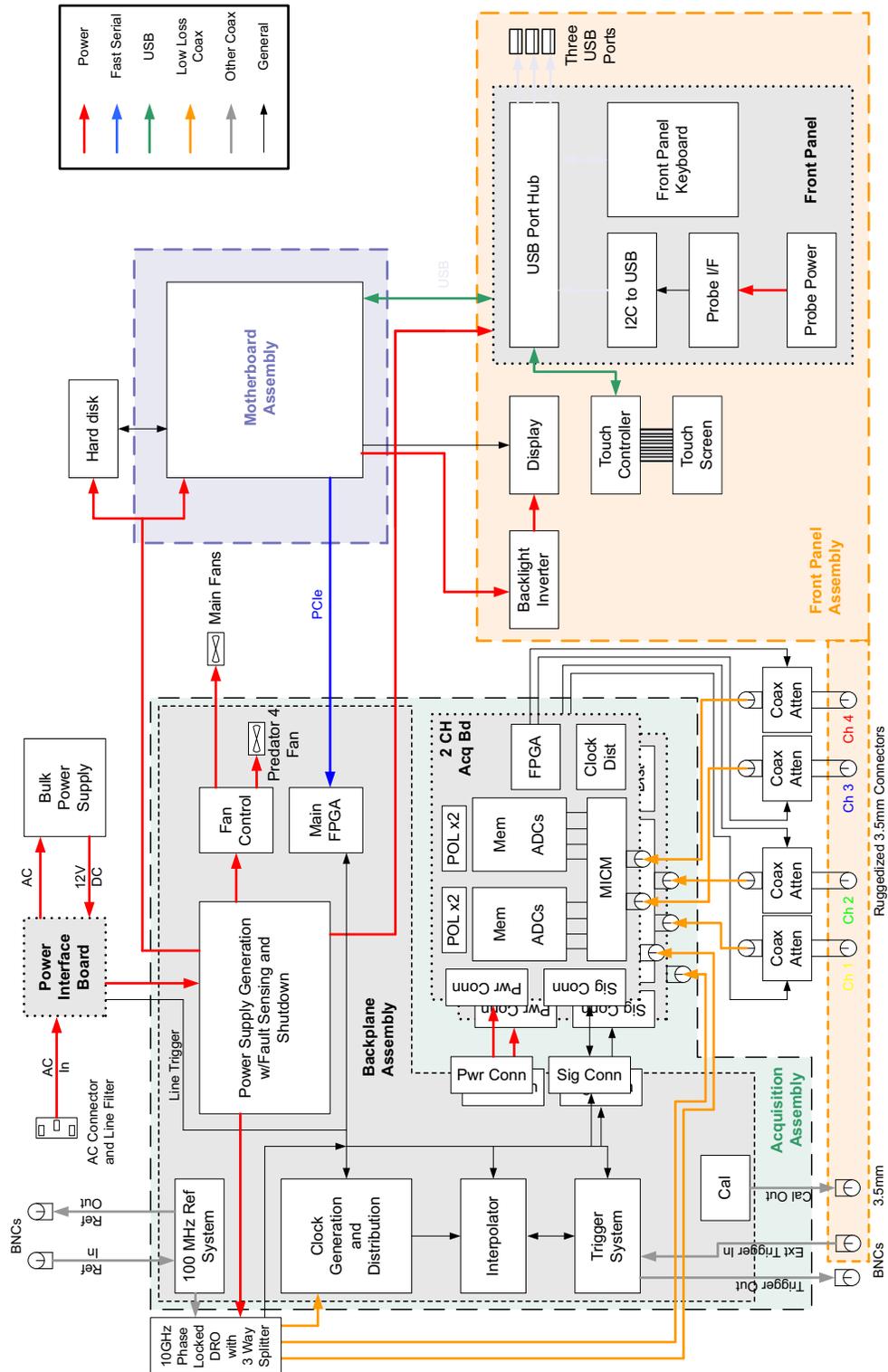
Ref. Des	Part number	Qty	Description
	54911-94307	1	Label -RHDD tray, for drives used with the M900 (54919-66515) motherboard
	54964-94364		Label -RHDD tray, for drives used with the M910 (54919-66516) motherboard
	8120-5392	1	Power cord - United Kingdom
	8120-5393	1	Power cord - Australia and New Zealand
	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 and South Africa
	8120-5400	1	Power cord - Japan
	8120-0955	1	Power cord - Israel
	8120-8390	1	Power cord - Argentina
	8120-8389	1	Power cord - Chile
	8120-1632	1	Power cord - China
	8121-1660	1	Power cord - Thailand
	8121-1858	1	Power cord- Brazil
	8121-1636	1	Power cord - Taiwan
	8121-1640	1	Power cord - Cambodia
	54919-00105	1	V-Series Profile Bracket

54919-68804 M910 motherboard upgrade kit parts

Part number	Qty	Description
3160-4588	1	Fan-Assembly w/heat-sink
54919-61610	1	Cable - PC Power
54919-66516	1	Motherboard Assembly
54919-68715	1	Removable hard drive assembly - Upgraded - Windows 10 for M910 motherboard
9010-0350	1	Win 10 Certificate of Authenticity (CoA)

7 Theory of Operation

Motherboard assembly	154
Acquisition assembly	155
Backplane assembly	157
Front Panel Assembly	163
Power Supply Assembly	164
MSO assembly	165
Hardware Serial Trigger Assembly	167



V-Series oscilloscope block diagram

Theory of Operation

This chapter describes the basic structure of the Infiniium V-Series oscilloscope and how the parts interact.

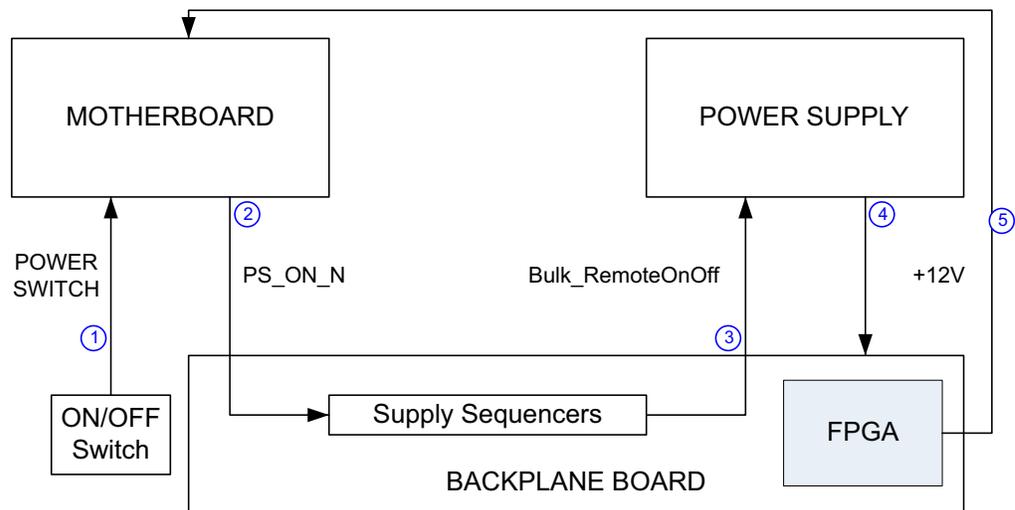
The oscilloscopes are comprised of five or six main assemblies, depending on the model: a motherboard assembly, an acquisition assembly, a backplane assembly, a front panel assembly, and a power supply assembly for all models, plus a Mixed Signal Oscilloscope (MSO) assembly for all MSO models. DSA and DSO models may also have the optional hardware serial trigger assembly.

The figure on the previous page shows a block diagram of the Infiniium V-Series oscilloscope.

Motherboard assembly

The motherboard assembly 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 and parallel 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 12 V power supply to turn on. When the power supply turns on, the remaining power supplies are enabled and powered on. Then the main FPGA (field-programmable gate array) on the backplane assembly gets self-configured from its PROM. Once it is configured, the main FPGA asserts a signal to tell the motherboard to power up and become fully functional. The following figure illustrates this system start-up process.



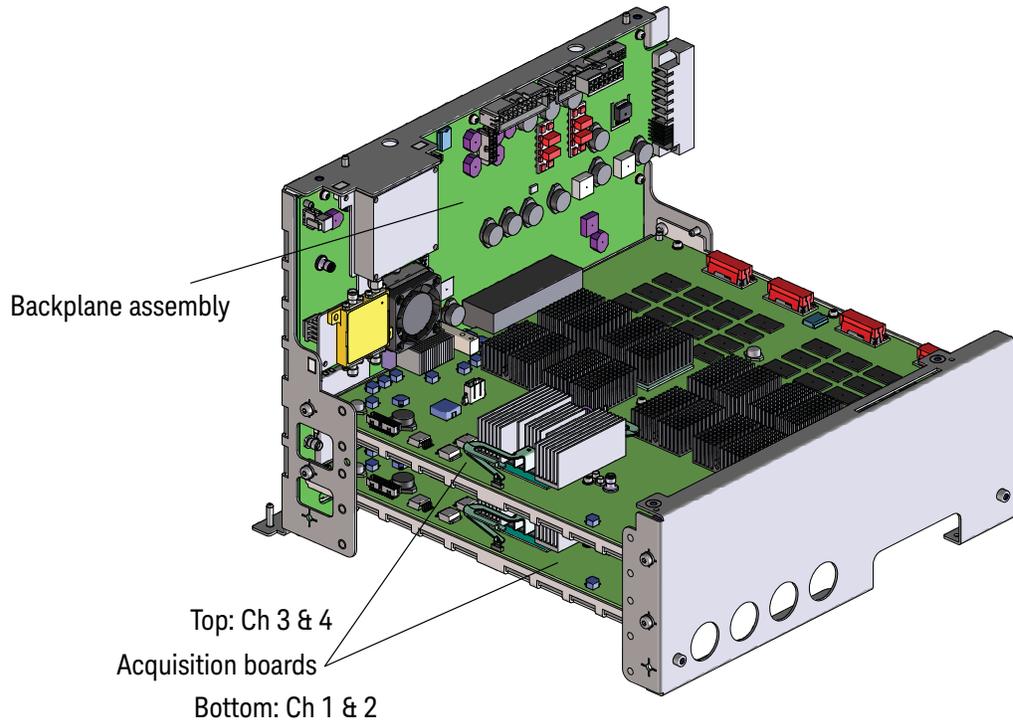
Power-up sequence

It is common for the motherboard to be revised during the life of the oscilloscope, so if a motherboard is replaced during a repair procedure, check to make sure it matches the image on the hard drive. 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.

The hard disk drive is a high-capacity (480 GB), removable, solid state, shock-resistant unit that stores the oscilloscope operating system, the oscilloscope application, compliance application information, calibration data, other data files, drivers for the boards and oscilloscope, and user data files. The hard disk drive can also be used to store and recall oscilloscope setups and waveforms.

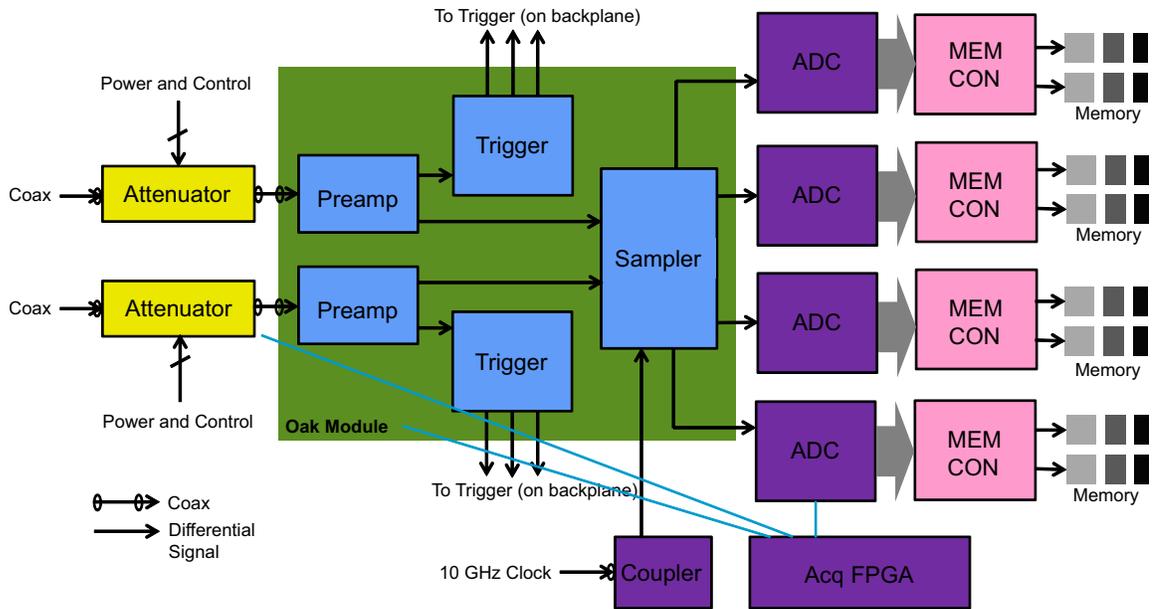
Acquisition assembly

The acquisition assembly consists of two identical acquisition boards. These two boards connect to the backplane board as shown below.



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 B 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. The following figure shows a block diagram of the acquisition boards including the Oak B module.

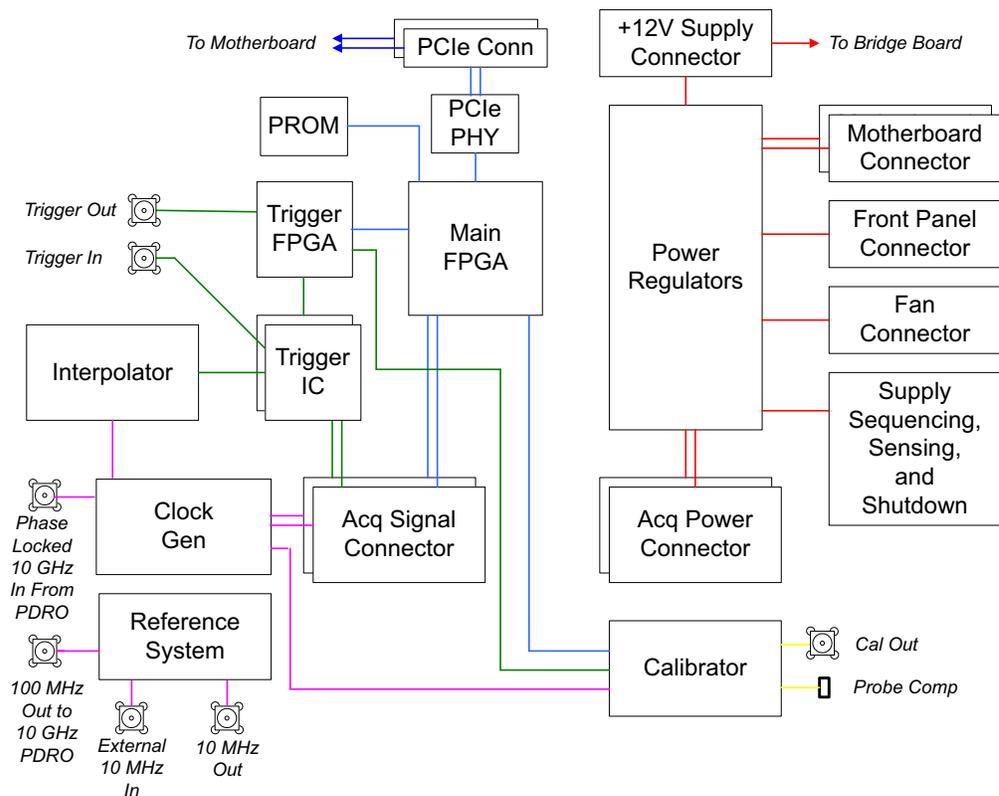


Oak B module and acquisition components

The acquisition front end starts at the front panel input connectors, then goes through the attenuators, cabling, and Oak B module. The differential outputs from Oak B 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 that connect to a PCIe-to SATA adapter board that is connected to the motherboard. The backplane assembly receives +12 V 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. The following figure shows a block diagram of the functions contained on the backplane assembly.

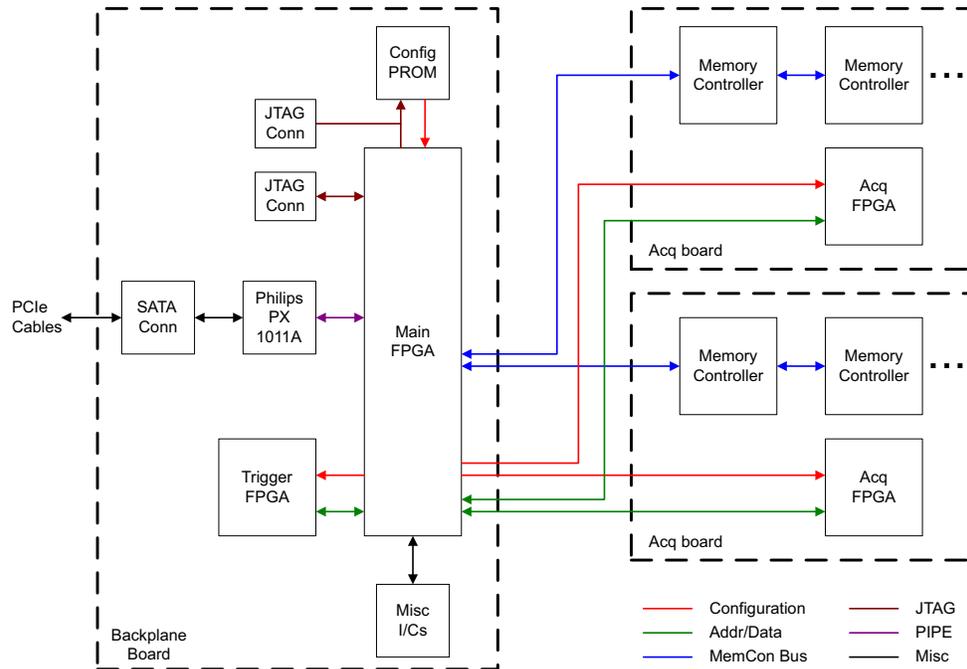


Backplane block diagram

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 is the only communication link from the oscilloscope hardware to the PC system. All system controls and data pass through the main FPGA. The following figure shows the connections to the main FPGA.



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, through a PCIe-to-SATA adapter board. 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 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 or a stopped cooling fan.

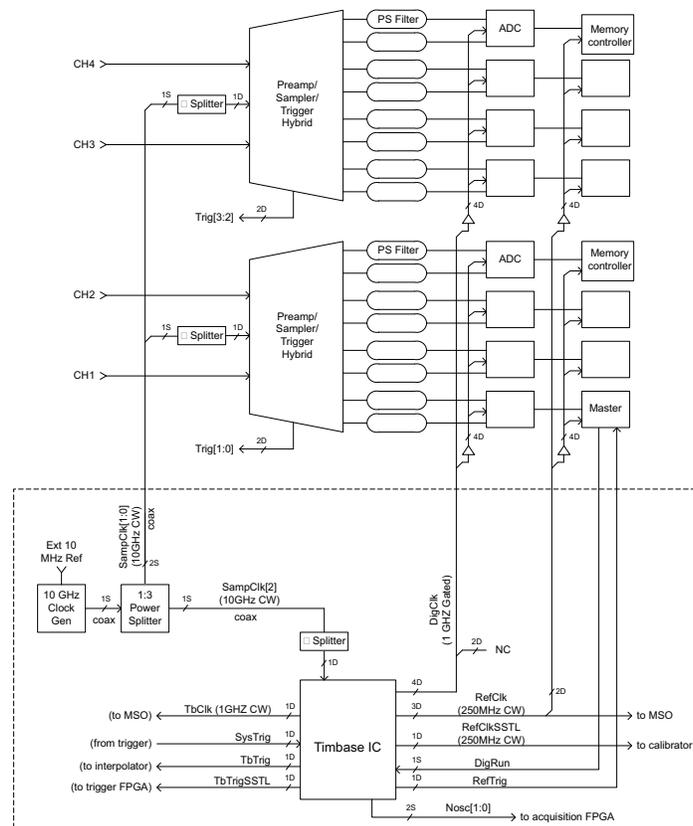
The main FPGA uses three identical buses to communicate with three different downstream FPGAs. The buses are 8-bit parallel buses with miscellaneous control signals. One bus is used to control the trigger functions in the backplane board and one bus connects to each of the two acquisition boards. A separate 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. The following figure shows the timebase system including its circuitry.

Time Base



Time base circuitry

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.

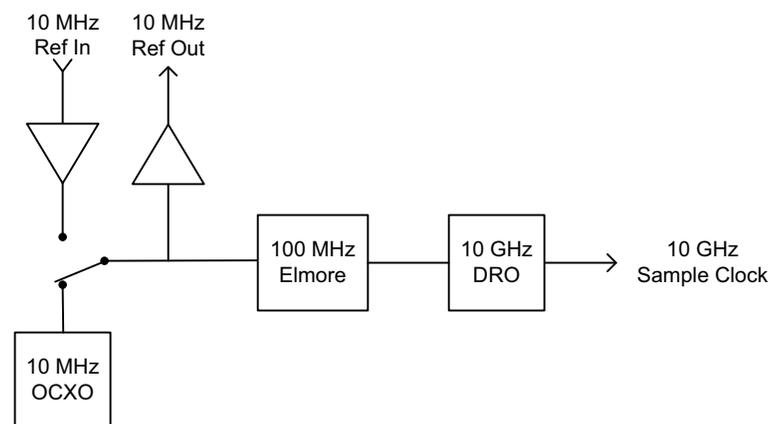
The Wahoo timebase IC divides the 10 GHz CW clock down into multiple 1 GHz and 250 MHz clocks. The 1 GHz DigClk clocks are gated by DigRun so that the ADCs can be synchronized with each other. Wahoo also performs some of the time interpolator functionality by synchronizing the system trigger to the 1 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. The following figure shows a block diagram showing clock generation.



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.

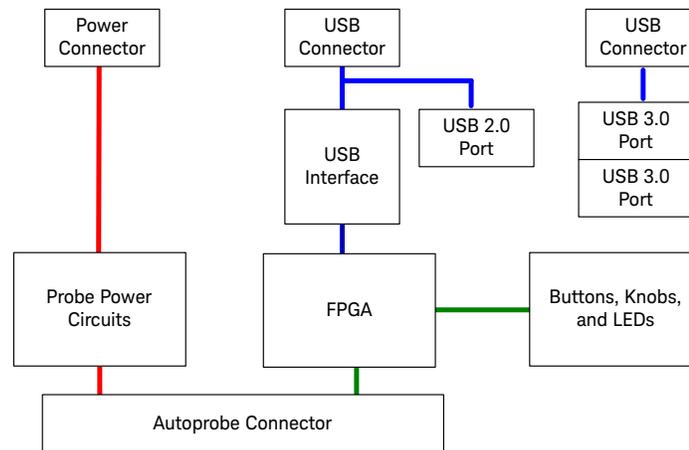
Front Panel Assembly

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 following figure shows a simplified block diagram of the oscilloscope front panel.



Front panel block diagram

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 on/off button stays yellow when the oscilloscope is in standby mode (plugged in but not powered on). 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.

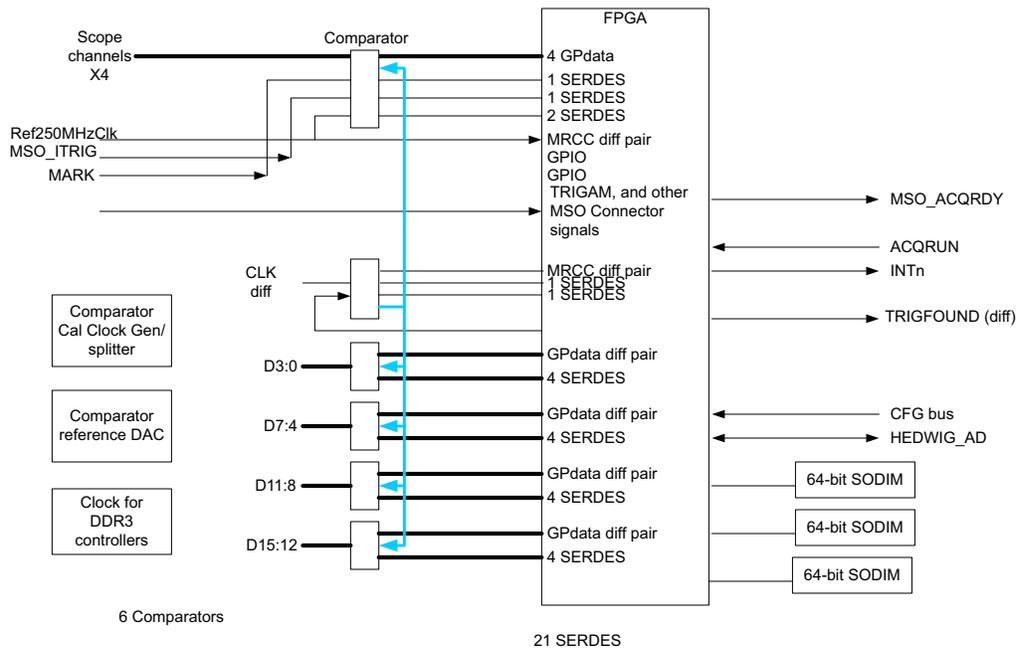
Power Supply Assembly

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

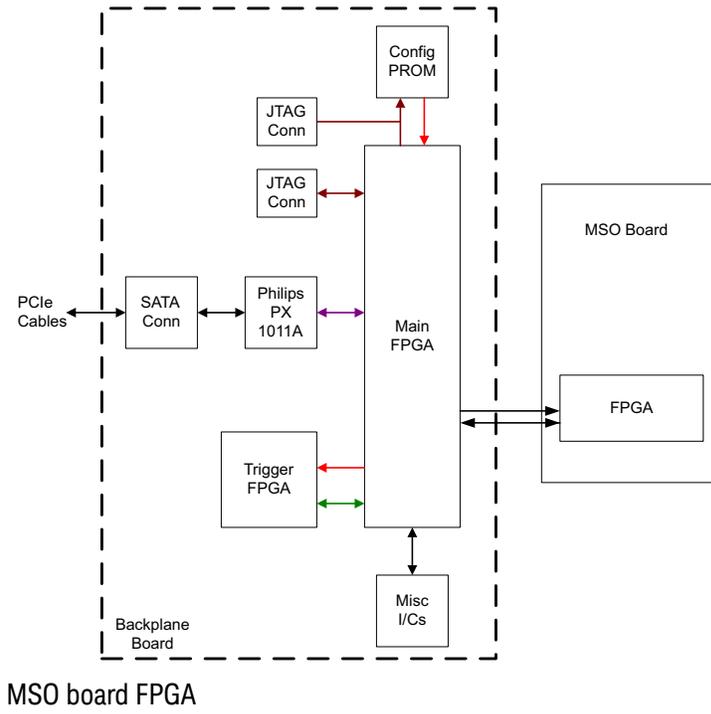
MSO assembly

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

The first figure below shows the circuitry of the MSO board. The second figure shows how the FPGA on the MSO board communicates with the Main FPGA on the backplane board.

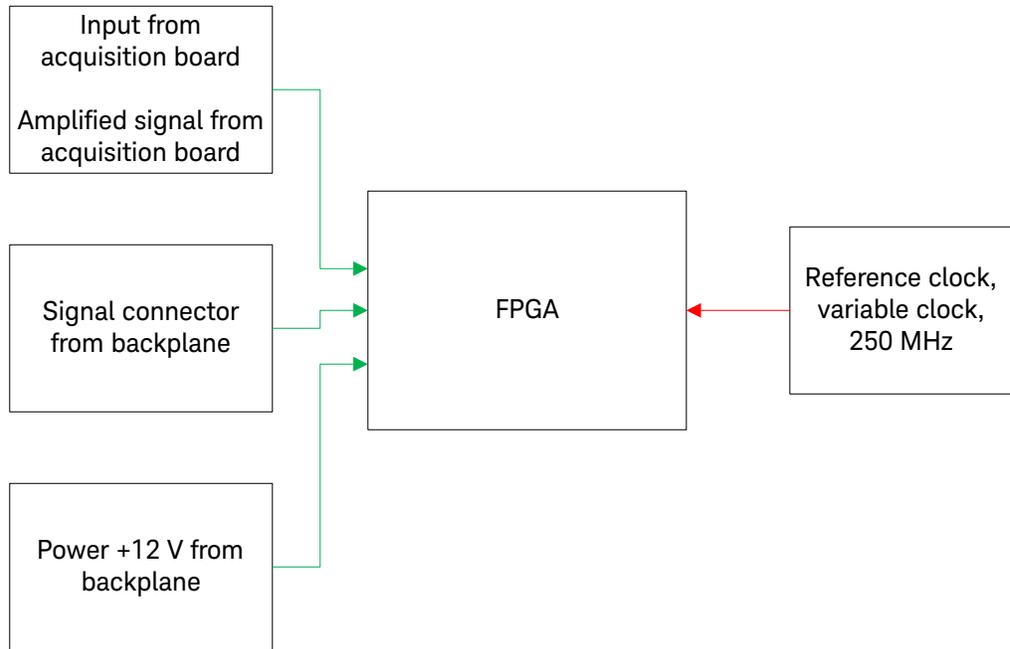


MSO printed circuit assembly



Hardware Serial Trigger Assembly

The optional hardware serial trigger assembly consists of a printed circuit assembly that fits below the lower acquisition board. Available for DSO and DSA models, it provides the capability for users to trigger on a specific portion of a serial stream of data at up to 12.5 Gbps.



Hardware serial trigger assembly block diagram



This information is subject to change without notice.

© Keysight Technologies, Inc.

2015-2017, 2021-2023

Ninth edition, September 2023



54919-97020

www.keysight.com