Keysight E6961A Automotive Ethernet Transmit Compliance Solution

User Guide and Method of Implementation

KEYSIGHT TECHNOLOGIES

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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.

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Introduction

BroadR-Reach specifications (see “Reference Documents” on page 47) defines the use of various test modes for testing compliance with the BroadR-Reach Physical Layer (PHY) transmitter. BroadR-Reach was developed by Broadcom Corporation specifically for automotive applications. OPEN (One Pair EtherNet) Alliance standardized the technology and established the standard. 100 Mbit/s Ethernet for automotive applications was standardized as IEEE 802.3bw with the terminology 100 Base-T1.

Keysight’s N6467B 100BaseT1-TX Compliance Application Software (provided as a software option to the E6961A Automotive Ethernet Solution) provides five test modes for the testing and validating the transmitter waveform, transmitter distortion, transmitted jitter, and transmitter droop. The test modes change only the data symbols provided to the transmitter circuitry and do not alter the electrical and jitter characteristics of the transmitter and receiver from those of normal operation.

Table 1-1 List of Test Modes available

Test Mode	Description
1	Transmit droop (positive and negative) test mode
2	Transmit jitter test in MASTER mode
3	Transmit jitter test in SLAVE mode
4	Transmitter distortion test
5	Power Spectral Density (PSD) mask and test.

NOTE This E6961A User Guide is written as a guide to using the N6467B BroadR-Reach TX Compliance Application software. For information on the N8847A BroadR-Reach Protocol Triggering and Decoder software, the E6960A 1000BaseT1 TX Compliance Application, or the E6964A BroadR-Reach MDI S-Parameter software, refer to their respective documentation.

Using the Keysight N6467B BroadR-Reach TX Compliance Application (100Base-T1 compliant) software along with an N5395C Ethernet Test Fixture greatly simplifies BroadR-Reach compliance testing. The software automatically configures all of the required test equipment reducing the overall test time.

The N6467B Software:

- Lets you select individual or multiple test to run.
- Lets you identify the device being tested and its configuration.
- Shows you how to make oscilloscope connections to the device under test.
- Automatically checks for proper oscilloscope configuration.
- Automatically sets up the oscilloscope for each test.
- Allows you to determine the number of trials for averaging in each test.
- Provides detailed information of each test that has been run. The result of maximum 64 worst trials can be displayed at any one time.
- Creates a printable HTML report of the tests that have been run. This report includes pass/fail limits, margin analysis, and screen captures.

Installing the Compliance Test Solution Software

1. Make sure you have the minimum version of Infiniium oscilloscope software (see the software release notes) by choosing **Help > About Infiniium...** from the main menu.
2. To obtain the N6467B BroadR-Reach Compliance Test Application, go to Keysight website: http://www.keysight.com/find/N6467B.
3. Click the **Trials & Licenses** tab.
4. Click the **Details & Download** button.
5. Read and verify the Prerequisites and installation information. Follow the instructions to download and install the application software. Click the red **Download** button.

Installing the License Key

1. Request a license code from Keysight by following the instructions on the Entitlement Certificate. You will need the oscilloscope's "Option ID Number", which you can find in the **Help > About Infiniium...** dialog box.
2. After you receive your license code from Keysight, choose **Utilities > License Manager > Legacy Licenses....** Depending on the license acquired, select either Local License or Server License.
3. In the Install Option License dialog box, enter your license code and click **Install License.** Additional information is required for server based licensing. Please refer to your entitlement.
4. Click **OK** in the dialog box that tells you to restart the Infiniium oscilloscope application software to complete the license installation.
5. Click **Close** to close the Install Option License dialog box.
6. Choose **File > Exit**.
7. Restart the Infiniium oscilloscope application software to complete the license installation.
8. You can also install the license using Keysight License Manager.

For detailed instructions, refer to the online help for the Keysight License Manager.

Preparing to Take Measurements

Before running the E6961 automated compliance tests, you should calibrate the oscilloscope and probe. After calibrating the oscilloscope and probe, you are ready to start the Compliance Test Application and perform the measurements.

Calibrate the Oscilloscope

For information on performing the internal diagnostic and calibration cycle for your Keysight Infiniium oscilloscope, refer to the "User Calibration" topic in your oscilloscope's online help.

NOTE If the ambient temperature changes more than 5 °C from the calibration temperature, internal calibration should be performed again. The delta between the calibration temperature and the present operating temperature is shown in the Utilities > Calibration menu.

NOTE If you switch cables between channels or other oscilloscopes, it is necessary to perform cable and probe calibration again. Keysight recommends that, once calibration is performed, you label the cables with the channel on which they were calibrated.

Probe Calibration

Before performing the automated tests, you should calibrate the probes. Calibration of the solder-in probe heads consists of a vertical calibration and a skew calibration. The vertical calibration should be performed before the skew calibration. Both calibrations should be performed for best probe measurement performance.

For information on performing probe vertical and skew calibration in your Keysight Infiniium oscilloscope, refer to the **"DC Attenuation/Offset Calibration"** and **"Skew Calibration"** topics in your oscilloscope's online help.

For more information on calibration/deskew procedures for your particular probe, refer to the probe's user's guide in the Keysight Probe Resource Center.

General Test Setup

Test Modes 1, 2, 3, and 5 require only the Infiniium oscilloscope and the device to be tested (Device Under Test or DUT). The test setup is described below. Differential Signal supplied to the Oscilloscope can be achieved either by using **Two Oscilloscope Channels** or a **Single Differential Probe**. The type of connection accepted can be selected in the **Setup** tab of the test application.

Two Oscilloscope Channels refers to connecting the differential automotive pair to the oscilloscope using only SMA cables. Refer to Figure 1-1 for more details

Single Differential Probe refers to connecting the differential automotive pair to the Oscilloscope using a single differential probe. Refer to Figure 1-2 for more details. The only variation would be the Power Spectral Density Level test that requires a balun.

Any variation from the above definition of differential signalling type is not recommended

Test Mode 4 requires the N5395C Ethernet Test Fixture and an Arbitrary Waveform Generator (AWG). Refer to "Test Mode 4. Transmitter Distortion and MDI Return Loss Tests" on page 34 for specific setup details.

Test Mode 4 also includes an MDI S-Parameter Test. This test is also available as E6964A BroadR-Reach MDI S-Parameter Software. The E6964A software does not require the Infiniium oscilloscope.

Test Mode 5 can also use the N9010B Signal Analyzer. Refer to "Test Mode 5. Transmitter Power Spectral Density (PSD) and Transmitter Peak Differential Output Tests" on page 42 for specific setup details.

Two Oscilloscope Channels Connection to Oscilloscope

Two SMA cables are needed to directly connect the output of the transmitter to the oscilloscope. The specific oscilloscope channel used can be selected in the **Configure** tab of the application.

An optional TX_TCLK may be supplied to the oscilloscope to run the tests.

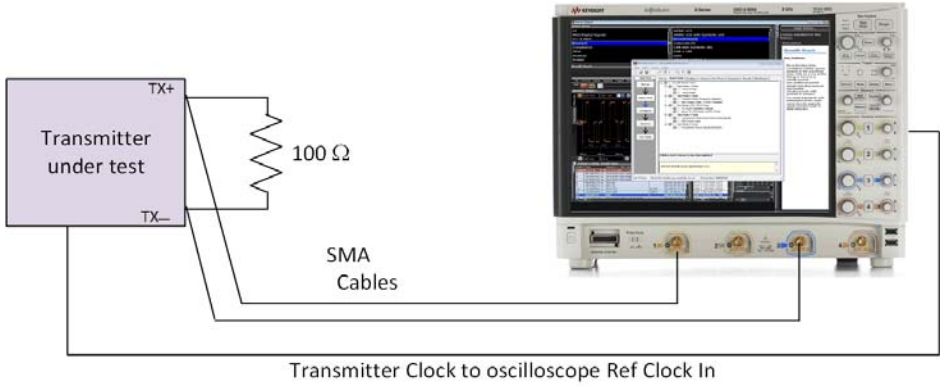


Figure 1-1 Connection to the Oscilloscope Using a Pair of SMA Cables

Single Differential Probe Connection to Oscilloscope

A differential probe is used to connect the output of the transmitter to the oscilloscope. The specific oscilloscope channel used can be selected in the **Configure** tab of the application.

An optional TX_TCLK may be supplied to the oscilloscope to run the tests.

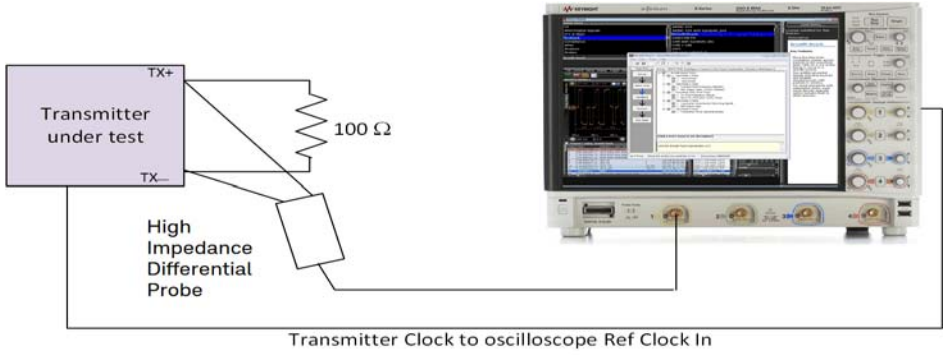


Figure 1-2 Connection to the Oscilloscope using a Differential Probe

Connection Using the N5395C Ethernet Transmitter Test Fixture

Alternately, you can use Section 1 of the N5395C Ethernet 10/100/1G Transmitter Electrical Test Fixture to make connections to the Transmitter under test. The SMA connections shown are for wire pair A (DA+ and DA–) in the RJ45 cable. This connection is only valid if the DUT has an RJ45 connector. To test to wire pair B, C, or D, connect the oscilloscope SMA cables to the appropriate Evaluation Board SMA connectors. In the event the DUT does not have a RJ45 connector, user will need to replace Section 1 with any adapter that converts the differential automotive pair to SMA.

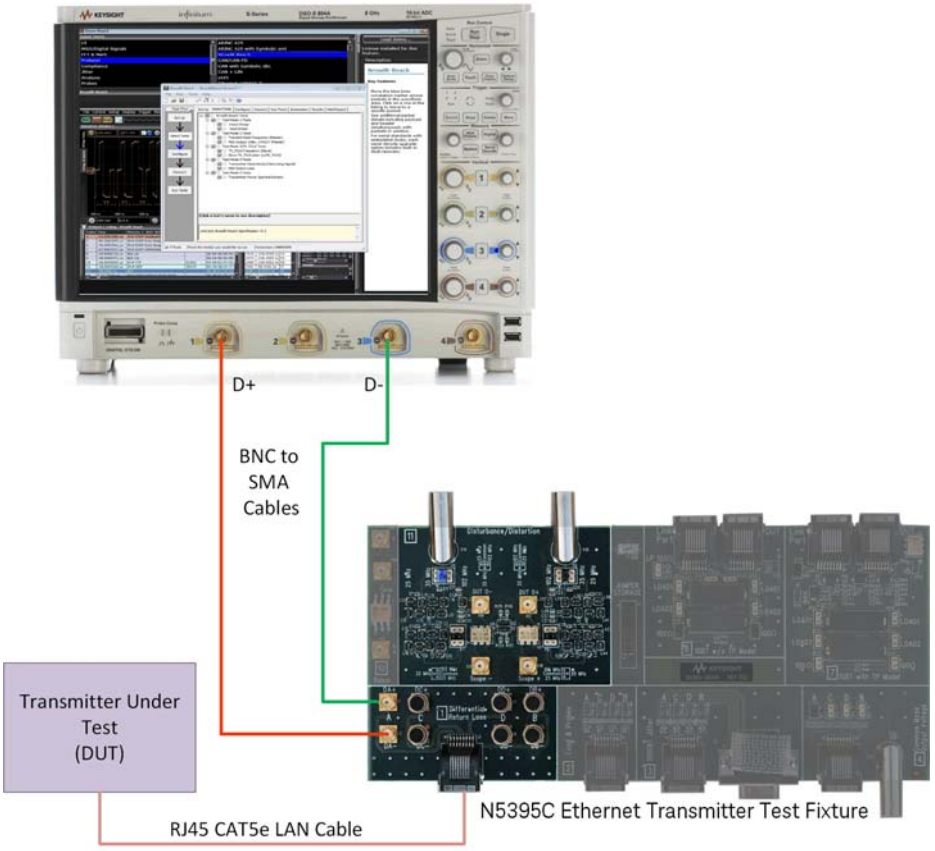


Figure 1-3 General Test Setup using the N5395C Evaluation Board

NOTE For all tests, use the software supplied with your transmitter PHY to control the Device Under Test.

Starting the Automotive Ethernet Compliance Test Solution Software

1. Ensure that the BroadR-Reach/100Base-T1 Device Under Test (DUT) transmitter is operating and set to desired test modes.
2. To start the Compliance Test Application from the Infiniium oscilloscope's main menu, select **Analyze > Automated Test Apps > N6467A/N6467B BroadR-Reach Test App**.

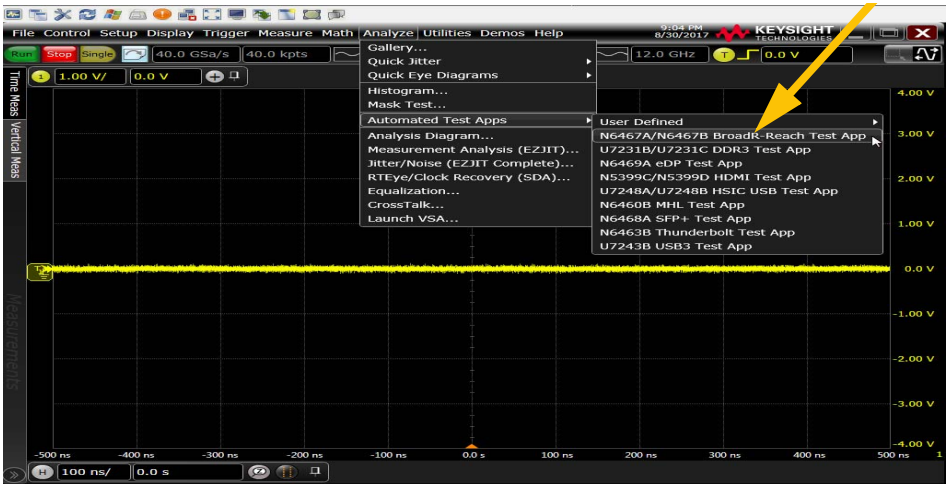


Figure 1-4 Launching the BroadR-Reach Compliance Test Application

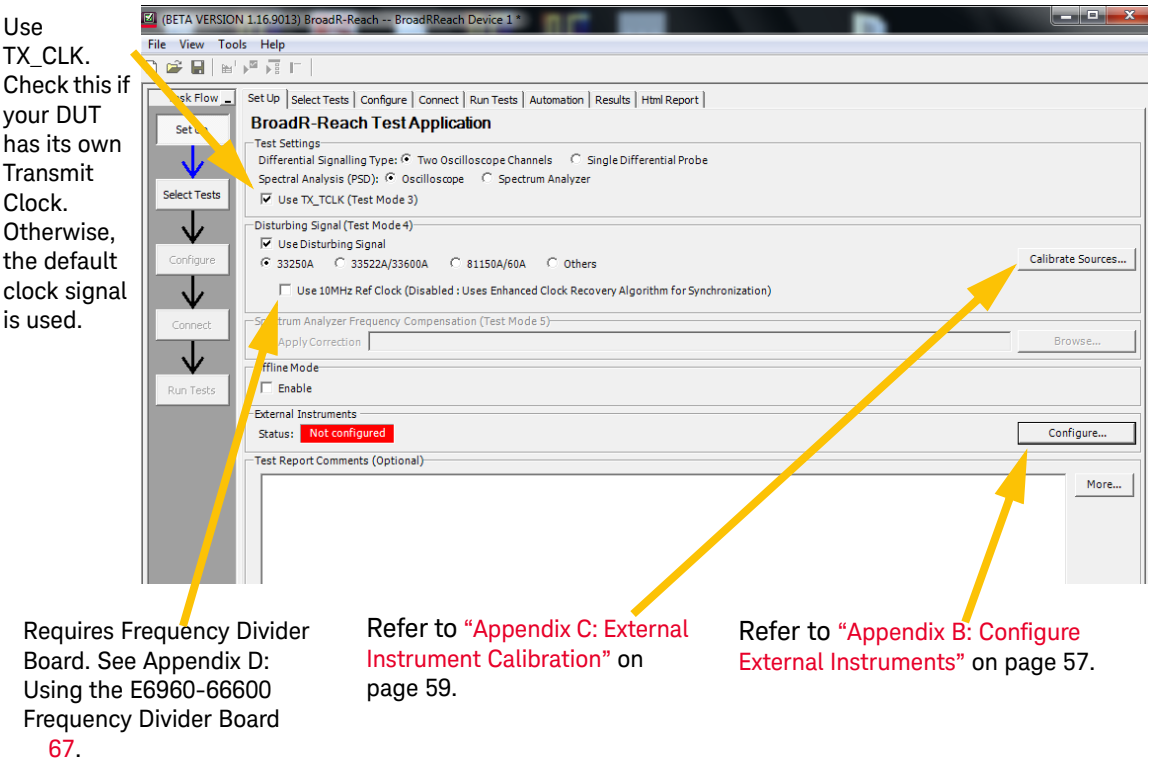


Figure 1-5 BroadR-Reach Compliance Test Application Main Window

The Compliance Application software automatically sets frequency, etc. of the external instruments (oscilloscope, ENA, generators, etc.) if they are properly configured. Refer to "Appendix D: Using the E6960-66600 Frequency Divider Board" on page 67.

The task flow pane, and the tabs in the main pane, show the steps you take in running the automated tests:

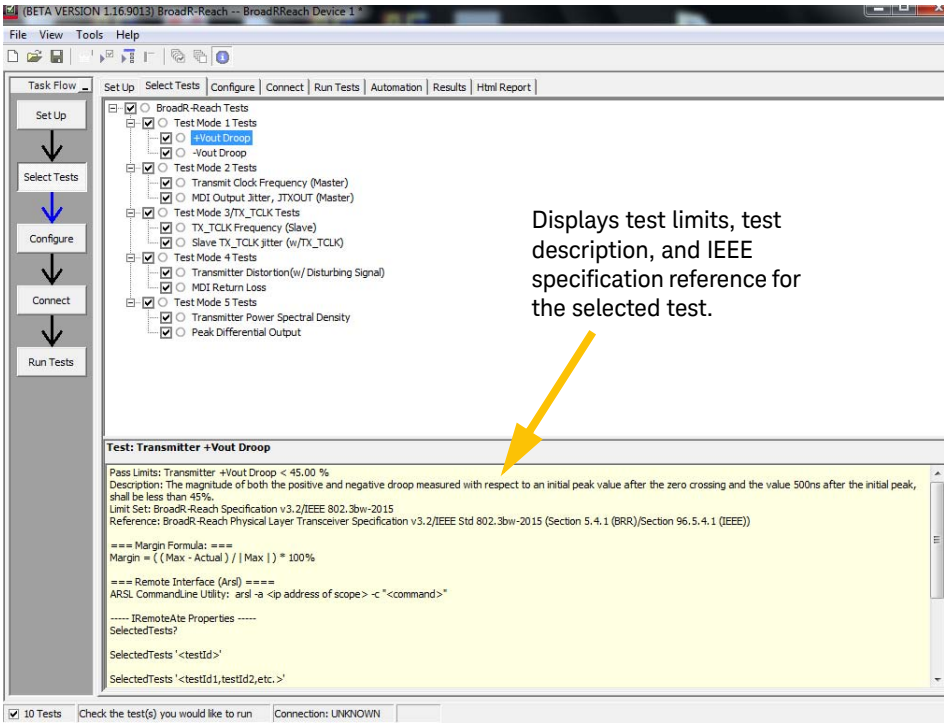


Figure 1-6 Select Tests Menu with all Tests Selected

Table 1-2 List of tabs available

Tab	Description
Set Up	Lets you identify and set up the test environment.
Select Tests	Lets you select the tests you want to run. After tests are run, status indicators show which tests have passed, failed, or have not run.
Configure	Lets you configure test parameters (for example, oscilloscope channels used in test, number of averages, etc.).
Connect	Shows you how to connect the oscilloscope to the device under test.
Run Tests	Starts the automated tests. If the connections to the device under test need to be changed, the test pauses, shows how change the connection, and waits for you to confirm that the changes were made before continuing.
Automation	Lets you construct scripts of commands to drive execution of the application.
Results	Contains more detailed information about the tests that have been run. You can change the thresholds at which marginal or critical warnings appear.
HTML Report	Report Shows a compliance test report that can be printed. See "Viewing the Test Report" on page 45

The Configure Tab allows you to select different oscilloscope channels and measurement attributes.

For example, the signal input can be changed from a differential probe to two SMA cables.

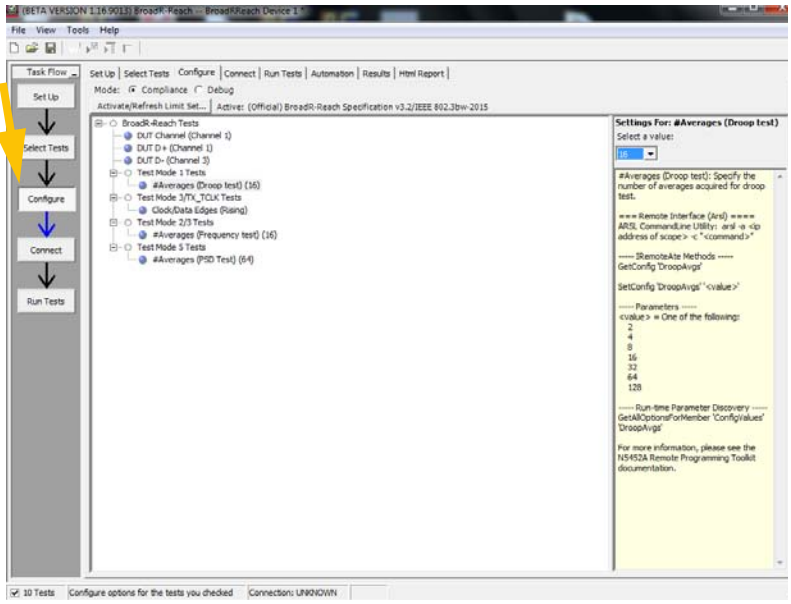
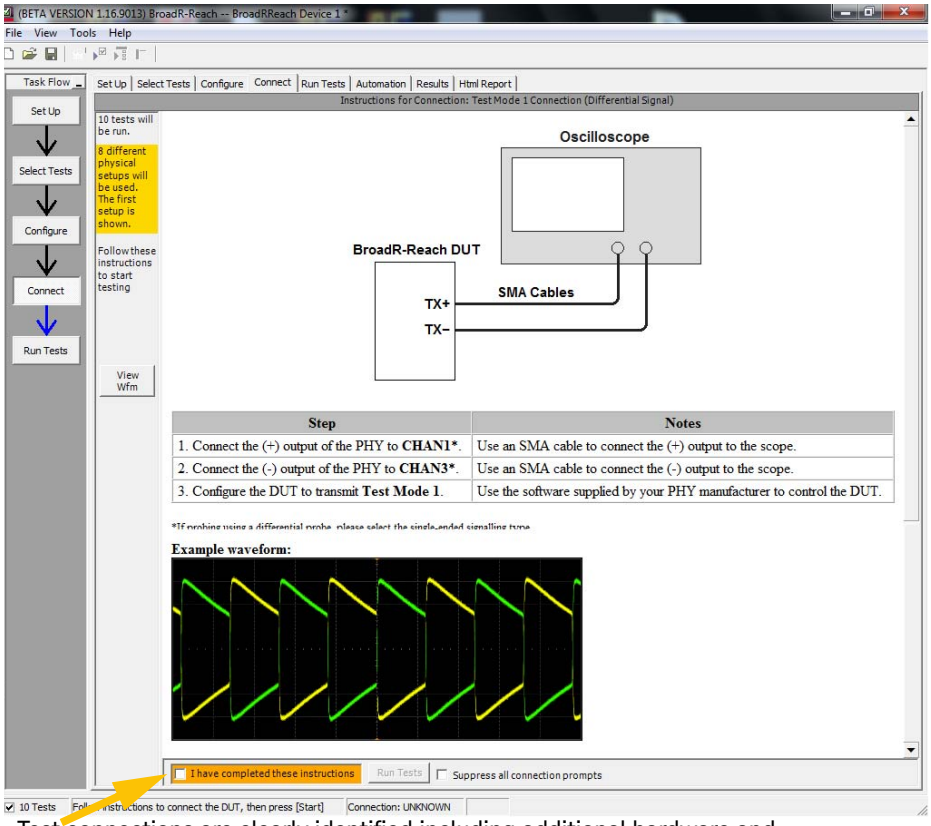


Figure 1-7 Configure Tab for Test Mode 1



Test connections are clearly identified including additional hardware and cables. When you make multiple tests where the connections must be changed, the software prompts you with appropriate connection diagrams.

Check the, “I have completed these instructions” box before clicking the Run Tests button.

Figure 1-8 Connect Tab for Test Mode 1

Top Menu Bar

The top menu bar of the compliance application offers several features:

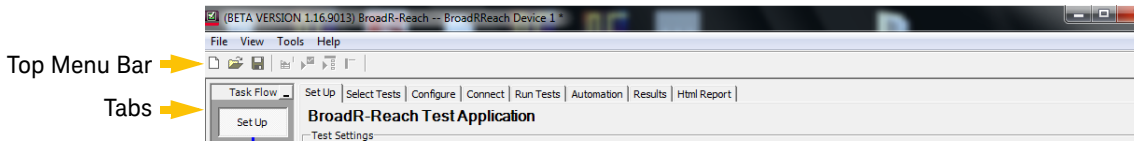


Figure 1-9 Navigation menus

Top Menu Bar icons from left to right:

Start a new project: Closes existing project and opens a new project.

Open an existing project: If you saved a previous project, this icon allows you to open it. You can load a sample project from: **C:\Users\Public\Documents\Infiniium\Apps\BroadR-ReachTest\ProjectSamples\BroadRReach Device 1.proj.**

Save the current project: Saves the current project in the following folder: **C:\Users\Public\Documents\Infiniium\Apps\BroadR-ReachTest\BroadRReach Device 1.**

Configure checked tests: Same as the **Configure** tab.

Run all checked tests: Runs all of the selected tests. Same as the **Run Tests** tab.

Run selected branch only: Runs only the selected test.

View results: Opens the HTML Report window. Same as the **Html Report** tab.

Tabs

The tabs across the top correspond to the Task Flow icons on the left side of the main display.

Test Mode 1. Output Droop Tests

Test Setup

This test may be run using either a two oscilloscope channels or a single differential probe from the transmitter (MDI). Refer to "General Test Setup" on page 14 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test.**

Specification References

[1] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.1.

Transmitter Output Droop Positive Test Information

This test measures the positive output droop of the transmitter.

Reference [1] specifies the positive output droop of a compliant PHY. The positive droop measured with respect to the initial peak value after the zero crossing and the value 500 ns after the initial peak, shall be less than 45%.

The application triggers the Test Mode 1 signal on the rising edge and determines the time the positive peak occurred and the voltage at that specific instance. The application then measures the voltage 500 ns after the peak. The Droop is calculated as:

Droop = 100 X (Vd/Vpk)%

Where:

- Vd is the magnitude of the droop.
- Vpk is the initial peak after the zero crossing.

Typical Waveform

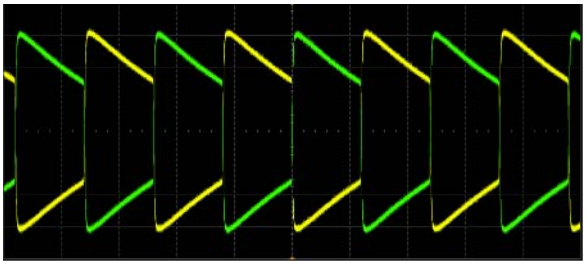


Figure 1-10 Typical Positive Droop Test Waveform (using a pair of SMA cables)

Transmitter Output Droop Negative Test Information

This test measures the negative output droop of the transmitter.

Reference [1] specifies the negative output droop of a compliant PHY. The negative droop measured with respect to the initial peak value after the zero crossing and the value 500 ns after the initial peak, shall be less than 45%.

The application triggers the Test Mode 1 signal on the falling edge and determines the time the negative peak occurred and the voltage at that specific instance. The application then measures the voltage 500 ns after the peak. The Droop is calculated as:

Droop = 100 X (Vd/Vpk) %

Where:

- Vd is the magnitude of the droop.
- Vpk is the initial peak after the zero crossing.

Typical Waveform

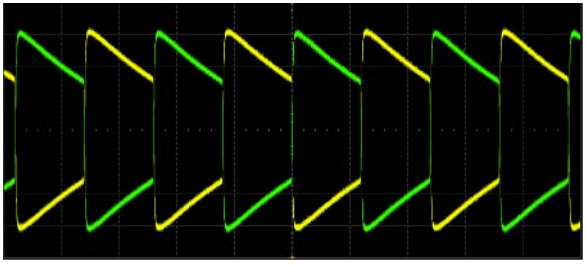


Figure 1-11 Typical Negative Droop Test Waveform (using a pair of SMA cables)

Test Mode 2. MASTER Clock Frequency and Jitter Tests

Test Setup

This test may be run using either a differential output or single-ended output from the transmitter (MDI). Refer to "General Test Setup" on page 14 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test.**

Specification References

[1] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.5.

[2] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.2.

[3] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.3.

Transmit Clock Frequency (MASTER) Test Information

This test measures the frequency of the transmitter clock when the PHY is operating in MASTER mode.

Reference [1] specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range if 66 2/3 MHz ±100 ppm.

The Reference [2] specifies that Test Mode 2 shall transmit the data symbol sequence {+1,-1} repeatedly on the channel. The transmitter shall time the transmitted symbols from a symbol rate clock in the MASTER timing mode. The measured data rate of the Test Mode 2 signal is thus equal to the MASTER Transmit Clock Frequency of the PHY.

Typical Waveform

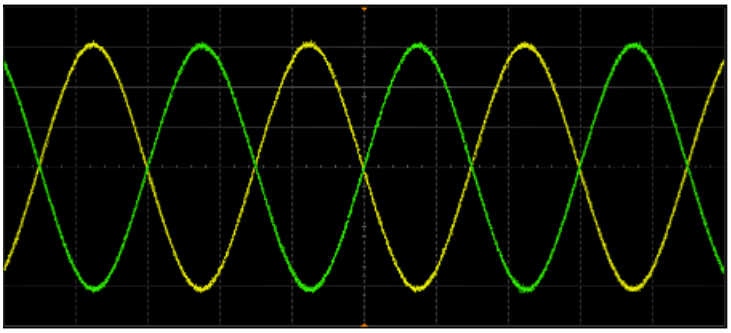


Figure 1-12 Typical MASTER Clock Test Waveform (using a pair of SMA cables)

MASTER TxOut Jitter Test Information

Reference [3] specifies that when in test mode 2, the RMS (Root Mean Square) value of the MDI output jitter, JTXOUT, relative to an unjittered reference shall be less than 50 ps.

This test measures the data time interval error of the test mode 2 signal at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Typical Waveform

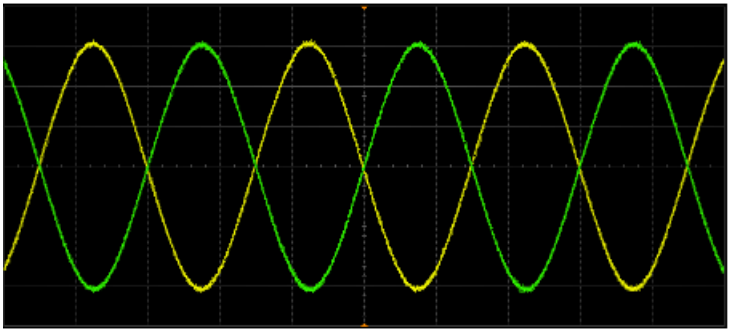


Figure 1-13 Typical MASTER TX Out Test Waveform (using a pair of SMA cables)

Test Mode 3. SLAVE Transmit Clock Frequency and Jitter Tests

Test Setup

This test may be run using either a differential output or single-ended output from the transmitter (MDI). Alternatively, this test can also be run using the TX_TCLK. Refer to "General Test Setup" on page 14 for connection details.

NOTE **Use the software supplied with your transmitter PHY to control the Device Under Test.**

Specification References

[1] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.5.

[2] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.2.

[3] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.3.

Transmit Clock Frequency (SLAVE) Test Information

Reference [1] specifies the symbol transmission rate of a compliant PHY. The symbol transmission rate of the MASTER PHY shall be within the range if 66 2/3 MHz ±100 ppm.

The specification does not specify the conformance limit for a PHY that is operating in SLAVE mode, but the SLAVE is supposed to have a symbol clock rate that is equal to the MASTER PHY.

Reference [2] specifies that Test Mode 3 shall transmit the data symbol sequence {+1,-1} repeatedly on the channel. The transmitter shall time the transmitted symbols from a symbol rate clock in the SLAVE timing mode.

Alternatively, an external TX_TCLK could be used to measure the frequency.

Typical Waveform

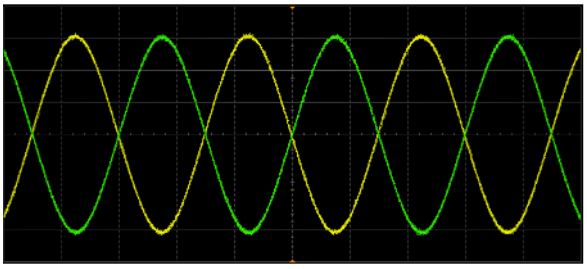


Figure 1-14 Typical TX Test Waveform (using a pair of SMA cables)

Slave TX_TCLK Jitter Test Information

Reference [3] specifies that the RMS value of the SLAVE TX_TCLK jitter relative to an unjittered reference shall be less than 0.01 UI (Unit Interval) after the receiver is properly receiving the data. This test measures the data time interval error at the MDI. The ideal reference data rate is selected automatically by the oscilloscope and compared to the original signal to determine the data time interval error.

Alternatively, an external TX_TCLK could be used to measure the jitter.

Typical Waveform

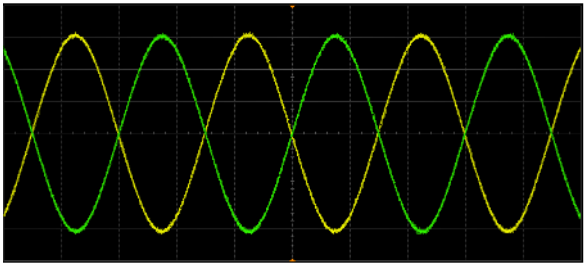


Figure 1-15 Typical TX-TCLK Test Waveform (using a pair of SMA cables)

Test Mode 4. Transmitter Distortion and MDI Return Loss Tests

Test Setup

Sections 1 and 11 of the N5395C Ethernet Test Fixture are used in this test.

A disturbing signal source is required to test for compliance. There is an option to test without a disturbing signal source, but the test result is not applicable for compliance. The test accepts only a differential signal.

When using a supported function generator, there is an automatic calibration process to calibrate the function generators. If an unsupported model is used, the user will have to manually calibrate the function generators.

Table 1-3 List of supported function generators

Supported Function Generators	Number Required	Notes
Keysight 33250A	2	Keysight 82357B USB/GPIB interface and one additional GPIB cable required.
Keysight 33612A	1	LAN Cable required.
Keysight 81150A	1	LAN Cable required. (2- Channel, orderable through E6961A Compliance Test Solution

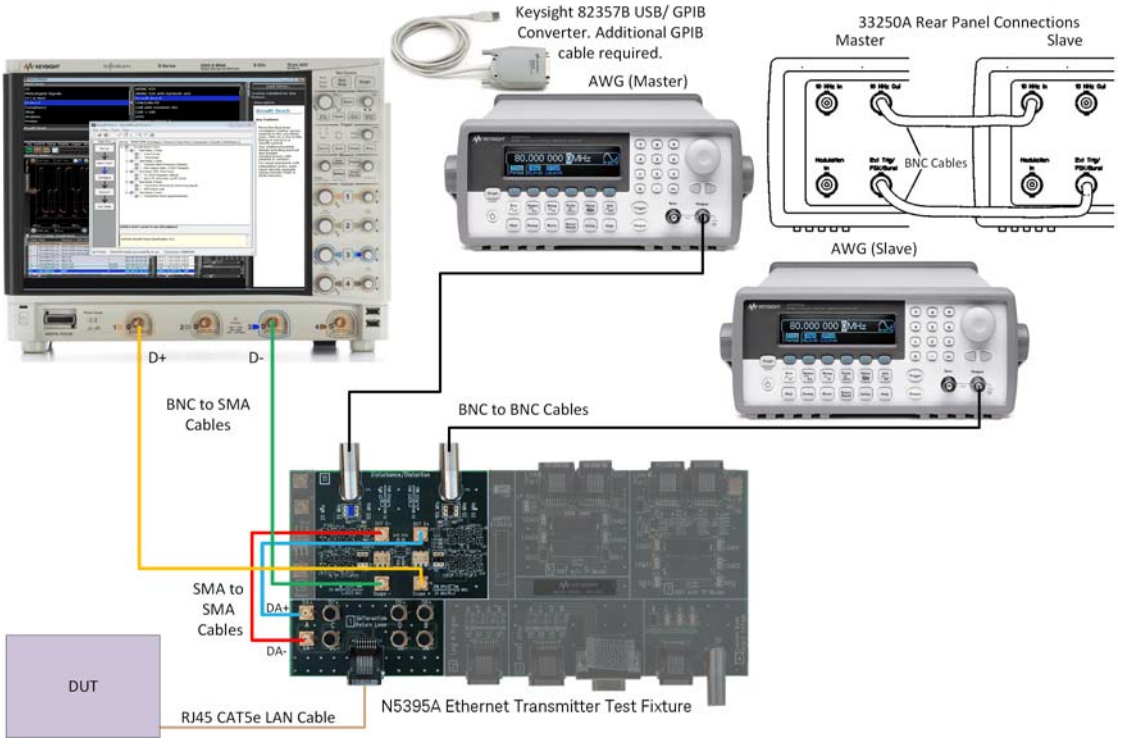


Figure 1-16 Transmitter Distortion Test Connection Using two Keysight 33250A Function Generators

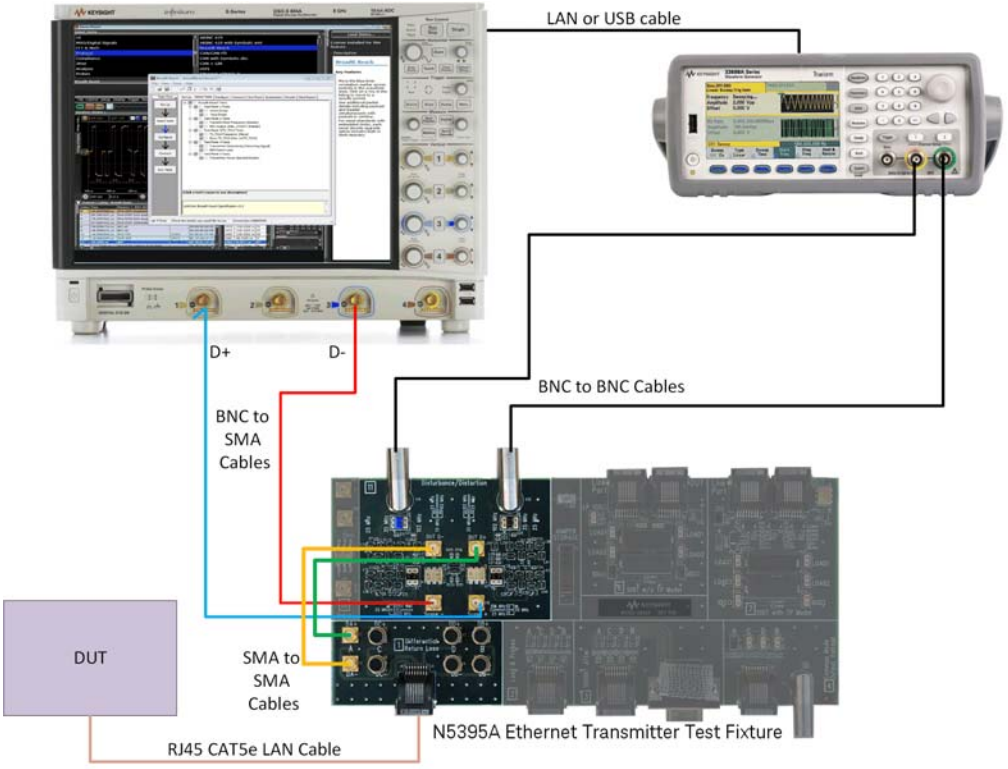


Figure 1-17 Connection for Transmitter Distortion Test Using Keysight 33612A Function Generator

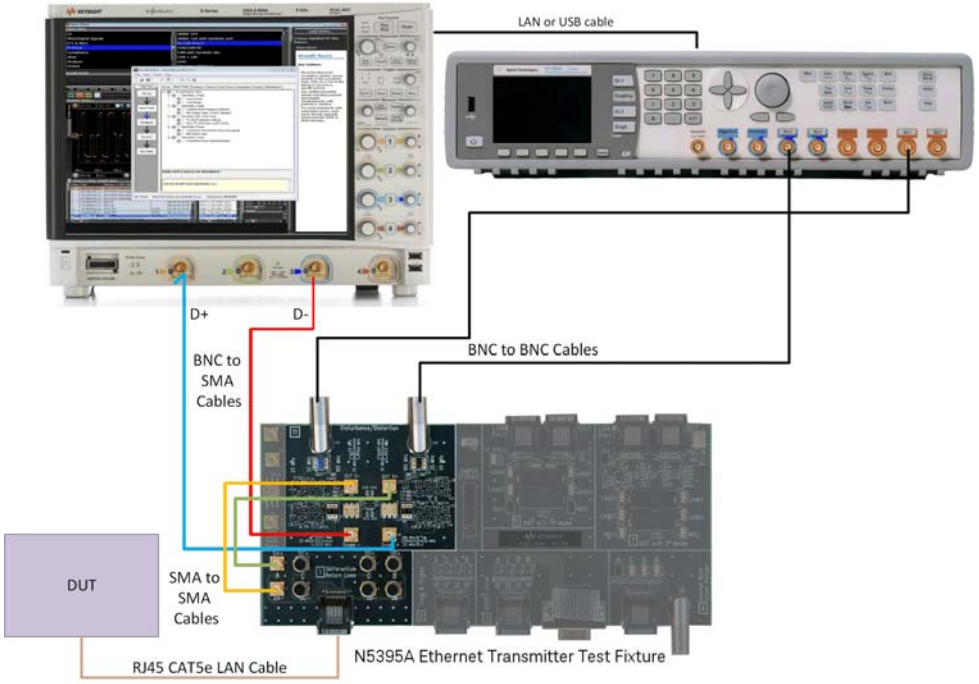


Figure 1-18 Connection for Transmitter Distortion Test Using Keysight 81150A Function Generator

Using the Optional E6961A Frequency Divider Board

If you want to use the optional E6961A Frequency Divider Board to provide a stable 10 MHz reference clock, refer to "Appendix D: Using the E6960-66600 Frequency Divider Board" on page 67 for detailed information.

Specification References

[1] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.2.

[2] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 8.2.2.

Transmitter Distortion Tests Information

When operating in Test Mode 4 and capturing the waveform using the Section 11 of the fixture, the peak distortion shall be less than 15 mV.

NOTE **If using the Frequency Divider, connect the 10 MHz output(s) of the divider to the 10 MHz Ref In Input of the oscilloscope and function generator for clock synchronization.**

Reference [1] specifies that the peak distortion is determined by sampling the differential signal output with the symbol rate clock at an arbitrary phase and processing a block of any 2047 consecutive samples with MATLAB code in reference [1].

A software high pass filter is applied to the sampled signal before post-processing.

Alternatively, this test can also be run without the disturbing signal, but the result cannot be used to determine compliance.

Transmitter Distortion Enhance Clock Recovery Algorithm

Keysight employs an enhanced clock recovery algorithm when the TX_TCLK is not available. The algorithm conditions the signal to the nominal bitrate. This is enabled by default when the **Use 10MHz Ref Clock** checkbox is disabled.

When the **Use 10MHz Ref Clock** checkbox is enabled, the E6960-66600 Frequency Divider board as well as access to TX_TCLK is required for synchronization.

NOTE **This test can only be run using a differential output from the transmitter (MDI). Refer to "General Test Setup" on page 14 for connection details. A differential probe cannot be used for this test.**

Typical Waveform

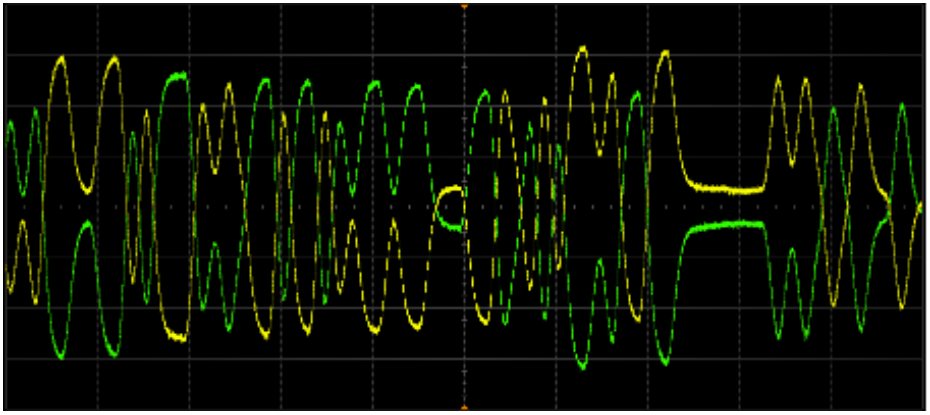


Figure 1-19 Typical Distortion Test Waveform (using a pair of SMA cables)

MDI Return Loss Test

Run the Management Data Input (MDI) Return Loss test with a vector network analyzer connected externally to the oscilloscope.

Test Setup

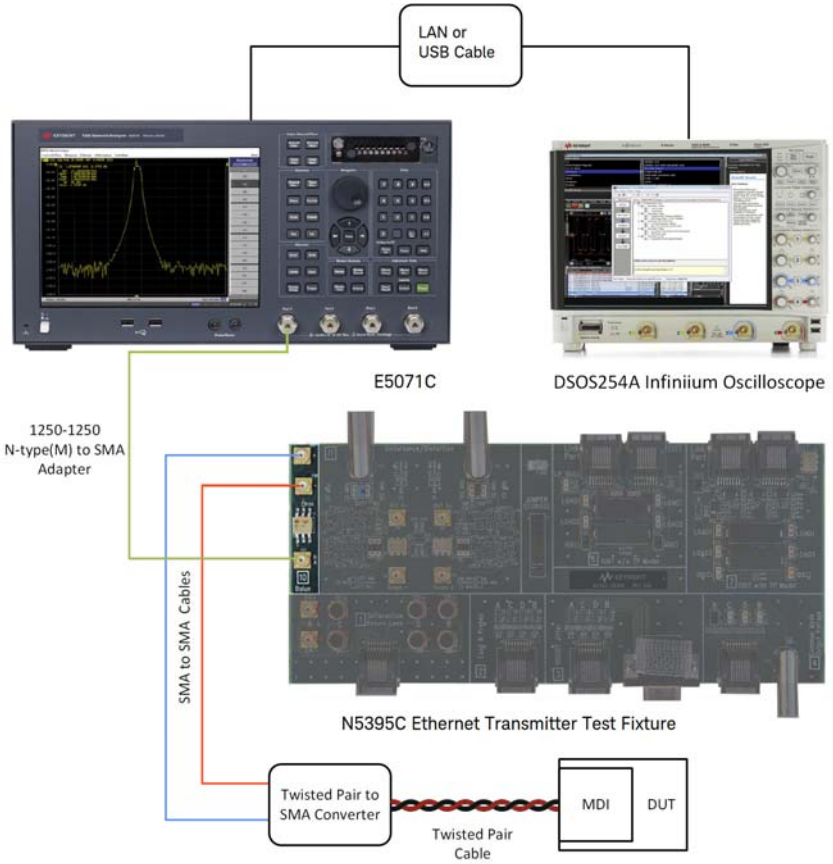


Figure 1-20 Connection Setup for MDI Return Loss test

MDI Return Loss Test Information

This test can run with an external vector network analyzer. However, an ENA exported data file in the Touchstone or CITI format can also be used in place of the external vector network analyzer.

NOTE

Calibrate the ENA prior to running the tests. Set the ENA as follows:

Measurement: Ref1 Fwd S11

Start Frequency: 1 MHz

Stop Frequency: 66 MHz

Turn Averaging On

Reference [2] specifies that the MDI return loss shall meet or exceed the following equation for all frequencies ranging from 1 MHz to 66 MHz (with 100 Ω reference impedance) at all times when the PHY is transmitting data or control symbols.

Table 1-4 Frequency and Return Loss

Frequency	Return Loss (dB)
1 - 30 MHz	20
30 - 66 MHz	20 - 20*log(f/30)

Test Mode 5. Transmitter Power Spectral Density (PSD) and Transmitter Peak Differential Output Tests

Test Setup

The Power Spectral Density (PSD) Test can be run using either a spectrum analyzer or an oscilloscope. When using the Oscilloscope, refer to "General Test Setup" on page 14 for testing using oscilloscope.

If you use the N9010B Signal Analyzer, convert the differential output to a single-ended output using a balun. Use the balun on the N5395C Ethernet Test Fixture as shown in Figure 1-19 on page 39.

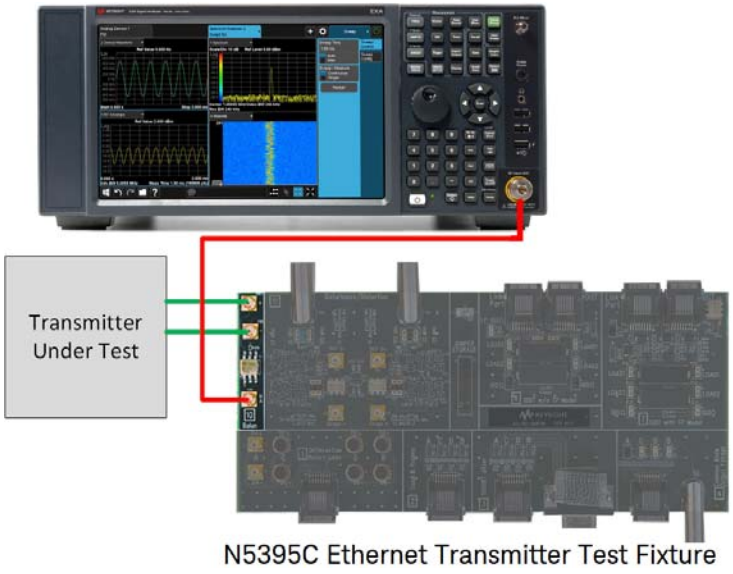


Figure 1-21 Power Spectral Density Test Using N9010B Signal Analyzer

NOTE Use the software supplied with your transmitter PHY to control the Device Under Test.

Specification References

[1] BroadR-Reach Physical Layer Transceiver Specification, v3.2, Section 5.4.4.

[2] 100Base-T1, IEEE Std. 802.3bw-2015, Section 96.5.6.

PSD Test Information

Reference [1] specifies that in Test Mode 5, the power spectral density (PSD) of the transmitter, shall be between the upper and lower bounds specified in the table below.

Table 1-5 PSD Test settings

Frequency	PSD Upper Bound (dBm) [a]	PSD Lower Bound (dBm) [1]
@1 MHz	-23.3	-30.7
@20 MHz	-24.8	-35.6
@40 MHz	-28.5	-49.0
57 MHz-200 MHz	-36.5	–

[a] Settings: RBW=10 kHz, VBW=30 kHz, sweep time >1 min, RMS detector, sweep time 3.275 seconds.

The upper and lower limits are piece-wise linear masks connecting points given in the table above. A lower PSD mask is provided to ensure the tolerances.

This test could be run using an external spectrum analyzer or the oscilloscope.

Typical Waveform

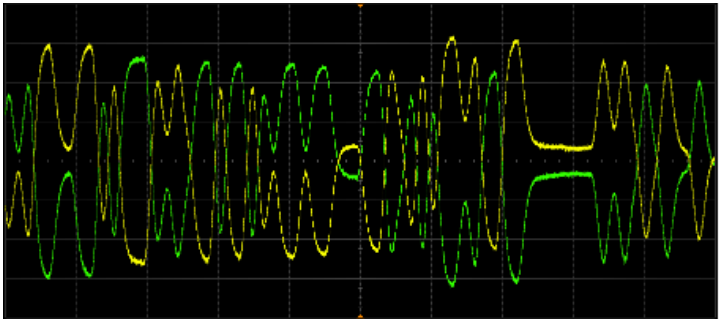


Figure 1-22 Typical Spectral Density Loss Test Waveform

Transmitter Peak Differential Output

Reference [2] specifies that in Test Mode 5, when measured with 100 Ω termination, the transmit differential signal at MDI shall be less than 2.2 Volt peak-to-peak.

Viewing the Test Report

After running any or all of the five Compliance tests, the **Results** tab shows which tests passed and details about the individual tests. For test result details, select any one of the tests form the top pane; the test details are shown below. In Figure 1-23 below, the Transmitter Power Spectral Density test is selected and the test results, with waveform, is shown below.

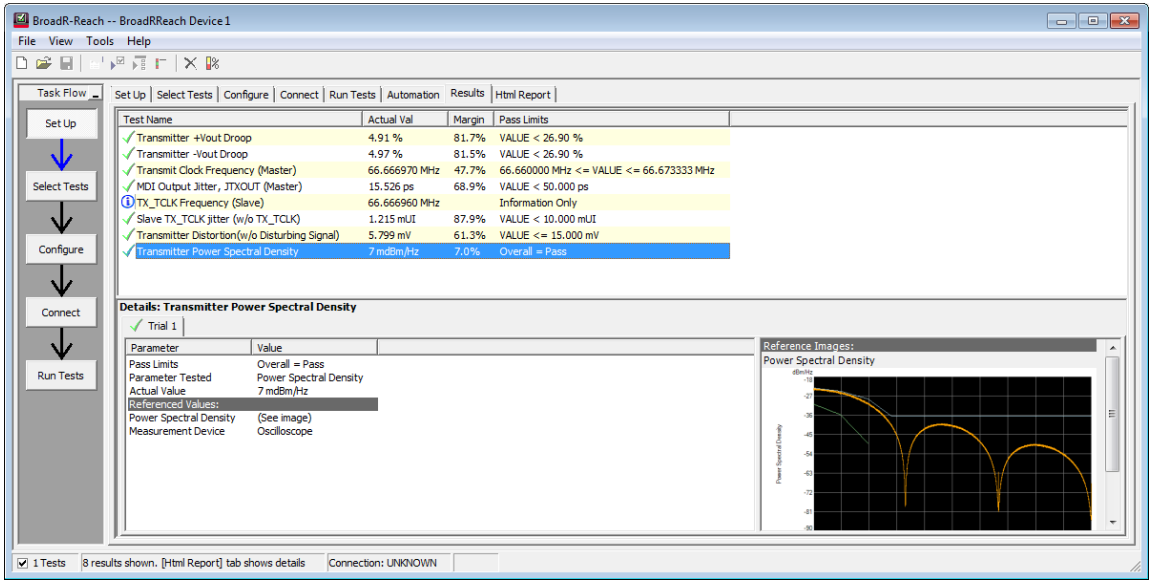


Figure 1-23 Typical Results Tab

Figure 1-24 below shows a portion of a typical **HTML Report**. Below this segment are waveforms and more test data.

KEYSIGHT TECHNOLOGIES

Test Report

Overall Result: PASS

Test Configuration Details	
Device Description	
Disturbing Signal Source	33250A
Spectral Analysis	Oscilloscope
Test Session Details	
Infiniium SW Version	05.50.0031
Infiniium Model Number	DSO50054A
Infiniium Serial Number	No Serial
Application SW Version	1.12
Debug Mode Used	No
Compliance Limits (official)	BroadR-Reach Specification v3.1
Last Test Date	2015-10-26 02:43:02 UTC -06:00

Summary of Results

Test Statistics	
Failed:	0
Passed:	8
Total:	8

Margin Thresholds	
Warning:	< 2 %
Error:	< 0 %

Pass	# Failed	# Trials	Test Name	Actual Value	Margin	Pass Limits
✓	0	1	Transmitter +Vout Droop	4.91 %	81.7 %	VALUE < 26.90 %
✓	0	1	Transmitter -Vout Droop	4.97 %	81.5 %	VALUE < 26.90 %
✓	0	1	Transmit Clock Frequency (Master)	66.666970 MHz	47.7 %	66.660000 MHz <= VALUE <= 66.673333 MHz
✓	0	1	MDI Output Jitter: jTXOUT (Master)	15.526 ps	68.9 %	VALUE < 50.000 ps
ⓘ		1	TX_TCLK Frequency (Slave)			Information Only
✓	0	1	Slave TX_TCLK Jitter (vs) TX_TCLK	1.215 mUI	87.8 %	VALUE < 10.000 mUI
✓	0	1	Transmitter Distortion (w/o Disturbing Signal)	5.799 mV	61.3 %	VALUE <= 15.000 mV
✓	0	1	Transmitter Power Spectral Density	7 mdBm/Hz	7.0 %	Overall = Pass

Report Detail

Next

✓ Transmitter +Vout Droop

Reference: BroadR-Reach Physical Layer Transceiver Specification v3.1 (Section 5.4.1)

Test Summary: Pass Test Description: The magnitude of both the positive and negative droop measured with respect to an initial peak value after the zero crossing and the value 500ns after the initial peak, shall be less than 45%.

Pass Limits: < 26.90 % Transmitter +Vout Droop: 4.91 %

Result Details

Vdf: 52 mV Vpk: 1.058 V

Trial 1

Trial 1: Transmitter +Vout Droop

Keysight Infiniium : Monday, October 26, 2015 4:33:12 PM

Scales

	Horiz Scale	Position	Vertical Scale	Offset
Function 1	100.0 ns/div	300.0 ns	310.7 mV/div	0.000V

Markers

	Source	X Position	Y Position
A	Function 1	41.490000000000 ns	1.05792V
B	Function 1	541.450000000000 ns	1.00596V

Top, Previous, Next

✓ Transmitter -Vout Droop

Reference: BroadR-Reach Physical Layer Transceiver Specification v3.1 (Section 5.4.1)

Test Summary: Pass Test Description: The magnitude of both the positive and negative droop measured with respect to an initial peak value after the zero crossing and the value 500ns after the initial peak, shall be less than 45%.

Pass Limits: < 26.90 % Transmitter -Vout Droop: 4.97 %

Figure 1-24 Top Portion of a Typical HTML Report

Reference Documents

OPEN Alliance / BroadR-Reach Specifications:
www.opensig.org or www.ieee802.org

Keysight's Automotive Ethernet Test Solutions Web Page:
www.keysight.com/find/BroadR-Reach

E6961A Automotive Ethernet TX Compliance Solution Web Page:
www.keysight.com/find/E6961A

Other Keysight Automotive Ethernet Applications and Software

- E6960A 1000Base-T1 TX Compliance Application: www.keysight.com/find/E6960A
- E6961A Automotive Ethernet TX Compliance Solution: www.keysight.com/find/E6961A
- E6962A Automotive Ethernet RX Compliance Solution – includes E6962A BroadR-Reach RX Compliance Application (100Base-T1 compliant) software : www.keysight.com/find/E6962A
- E6963A BroadR-Reach Automotive Ethernet Link Segment Compliance Solution – includes E6963A BroadR-Reach Link Segment Compliance Application (100Base-T1 compliant) software: www.keysight.com/find/E6963A
- N6467B BroadR-Reach Transmit Compliance Application Software (100Base-T1 compliant): www.keysight.com/find/N6467B
- N8847A Protocol Triggering and Decoder Software (100Base-T1 compliant) www.keysight.com/find/N8847A

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A Setting Up the N5395C Ethernet Transmitter Test Fixture

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Introduction

Keysight's N5395C Ethernet 10/100/1G Transmitter Electrical Test Fixture includes a main test fixture board (N5392-66402), a short RJ-45 interconnect cable (N5392-61601), and a small Return Loss impedance calibration board (N5392-66401).

Keysight's N5395C Ethernet Test Fixture is recommended for the Compliance Test Mode 4. A different, comparable fixture may be used, but is not guaranteed to produce the same result.

Notice that the main Test Fixture board is divided into eight sections plus an area to store jumpers. Not all sections are used in this demo/evaluation. Refer to Figure A-2 on page 51.

Table A-1 List of Compliance Test Board Sections

Compliance Test Board Section	Description	Compliance Test Mode Number
1	Differential Return Loss used for RJ45 devices	Test Mode 4, Transmitter Distortion Test
2	Load & Probes	Not Used
3	100BT Jitter	Not Used
4	Common Mode Output Voltage	Not Used
6	10BT w/o TP Model	Not Used
7	10BT with TP Model	Not Used
10	Balun used for Power Spectrum Density Test	Test Mode 4, MDI Return Loss Test
11	Disturbance/Distortion	Test Mode 4, Transmitter Distortion Test

The Return Loss impedance calibration board is Board Section 8. See Figure A-1 below. This board is used for calibrating the ENA. Refer to "Calibrating the ENA" on page 62. This board is only applicable if your DUT has a RJ45 connector. For other DUT's that do not have a RJ45 connector, user will need to fabricate a custom calibration kit.

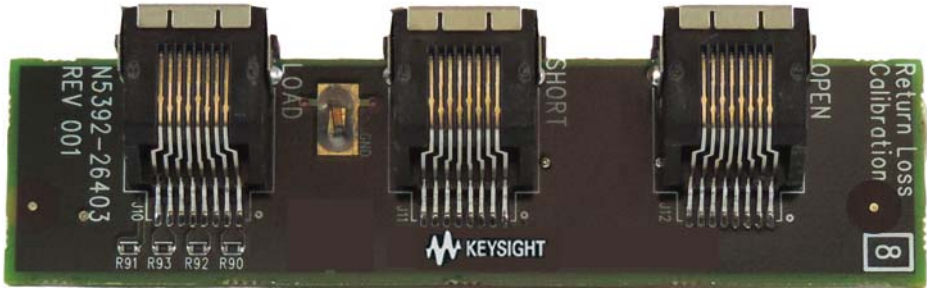


Figure A-1 Return Loss Impedance Calibration Board

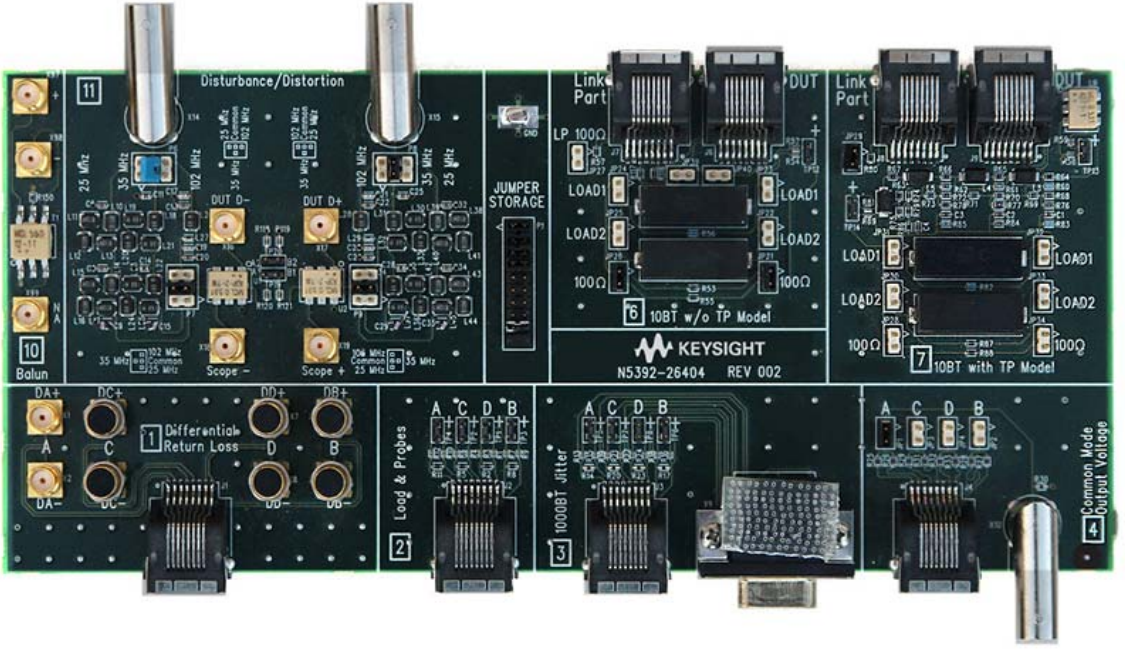


Figure A-2 N5395C Ethernet Electrical Transmitter Test Fixture

Jumper Settings

Figure A-3 and Table A-2 on page 53 show the jumper positions for the Ethernet Test Fixture Section 11 applicable for various frequencies.

Section 11 Jumpers. See Table A-2 (next page) for settings.

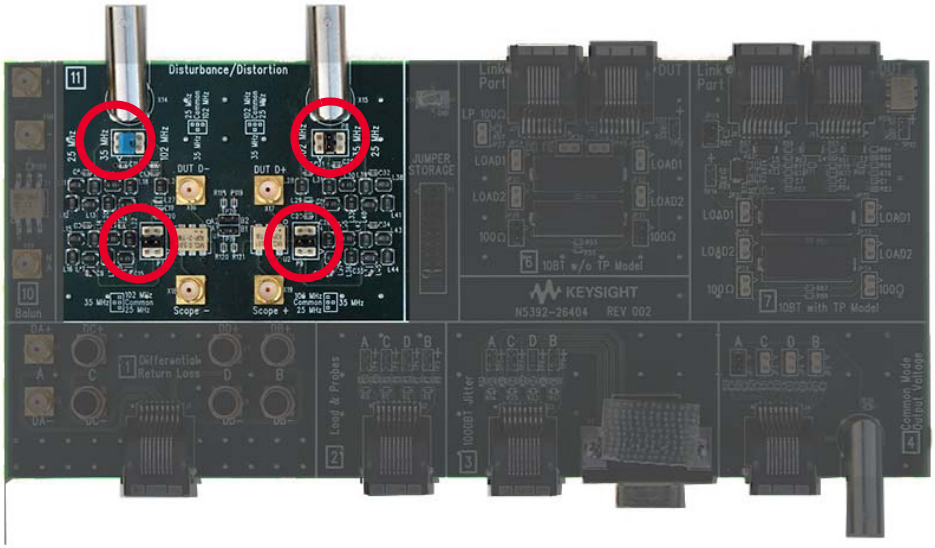
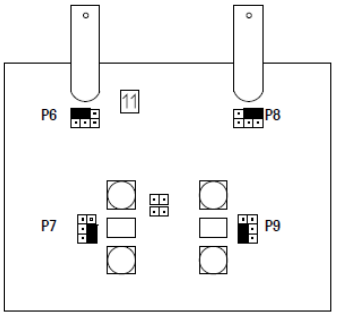
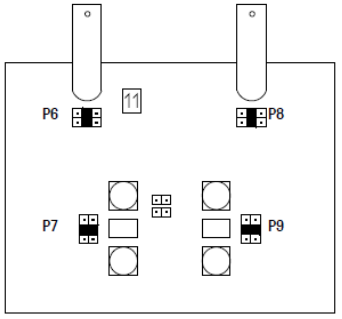
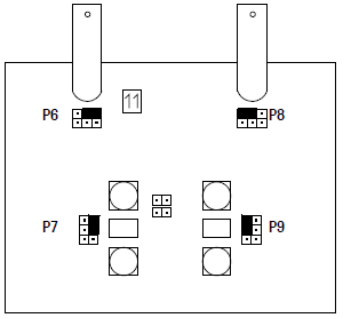


Figure A-3 Section 11 on the Ethernet Test Fixture. See Table 2 for Jumper Settings

Table A-2 Jumper Locations for Ethernet Test Fixture (Section 11 on Test Fixture)

Filter Bandwidth	Jumper Location
25 MHz	
35 MHz	
102 MHz	

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B Configure External Instruments

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Introduction

For each test, the DSOS254A Infiniium Oscilloscope automatically configures any external instruments (AWG, E5071C ENA, and E9010B EXA Signal Analyzer) as required for the test. In order to do this, however, the oscilloscope must know the SICL address of each instrument. The External Instruments **Status** indicator is red if the instruments are not properly configured.

NOTE

The instruments must be connected to the oscilloscope prior to configuring them. This is generally through a USB connection.

Note that the 33250A AWGs require an 82357B USB/GPIB interface. You must configure the Master and Slave 33250A AWGs separately.

1 From the BroadR-Reach Compliance Test Application Set Up tab, click the **Configure** button.

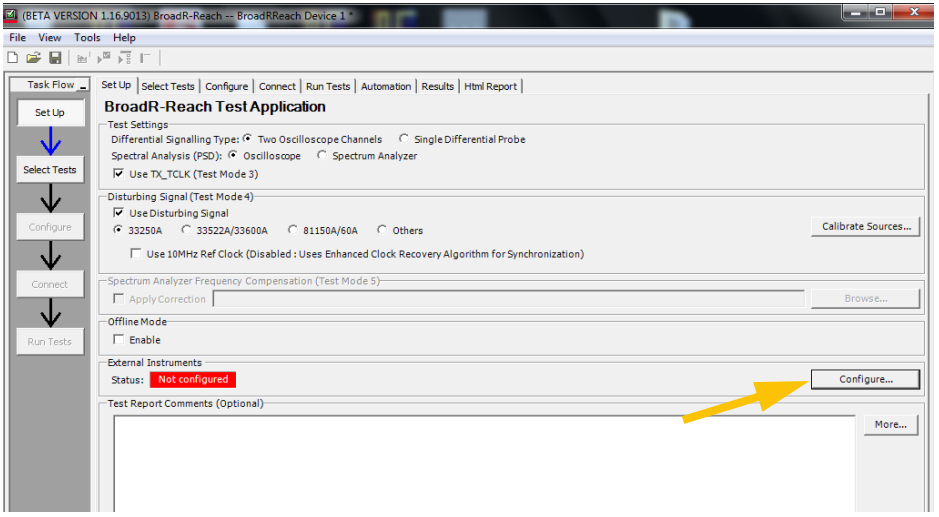

Figure B-1 BroadR-Reach Compliance Test Application Main Menu

2 This opens the **External Instruments List** dialog box.

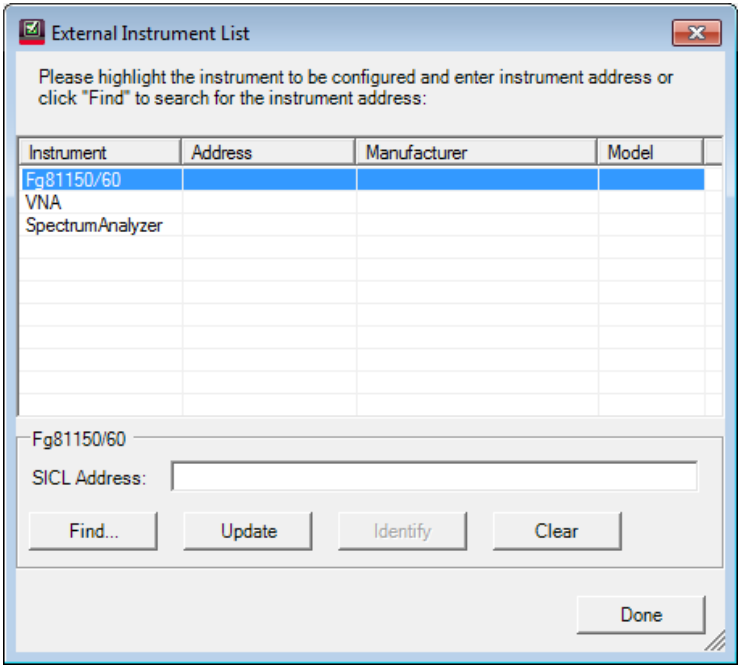

Figure B-2 BroadR-Reach Compliance Test Application External Instruments List

3 Select the AWG used in your system. For the E6961A Solution, this would be the **Fg81150/60**.

4 If you know the SICL address (you can use *Keysight IO Libraries Suite Connection Expert* utility to obtain the SICL address) enter it in the SICL Address field. If you do not know the SICL address, click the **Find** button and the Test Compliance Software will attempt to locate and identify the AWG.

5 Click the **Update** button.

6 Repeat steps 3, 4, and 5 for the E5071C ENA and the N9010B EXA Spectrum (or Signal) Analyzer.

7 When you are finished, click the **Done** button to return to the Main Menu.

8 The External Instruments **Status** indicator turns green to indicate that all external instruments have been properly configured.

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C External Instrument Calibration

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Introduction

All instruments must be calibrated prior to running the Compliance tests. The compliance application software guides you in calibrating the AWG and the ENA.

Calibrating the AWG

Before running disturbing signal tests, the AWG(s) must be calibrated. Connect the equipment as shown in Figure C-1 on page 61.

NOTE The AWG Disturbing Signal Source must be Configured before attempting to Calibrate it. If the system is not physically configured to perform the calibration, the application prompts you to change the physical configuration. Refer to "Appendix B: Configure External Instruments" on page 57

NOTE Instead of connecting SMA to SMA cables on the N5393C Evaluation Board, connect 50 Ω Terminators to the two DUT SMA Connectors on the Evaluation Board. This is shown in Figure C-1 below

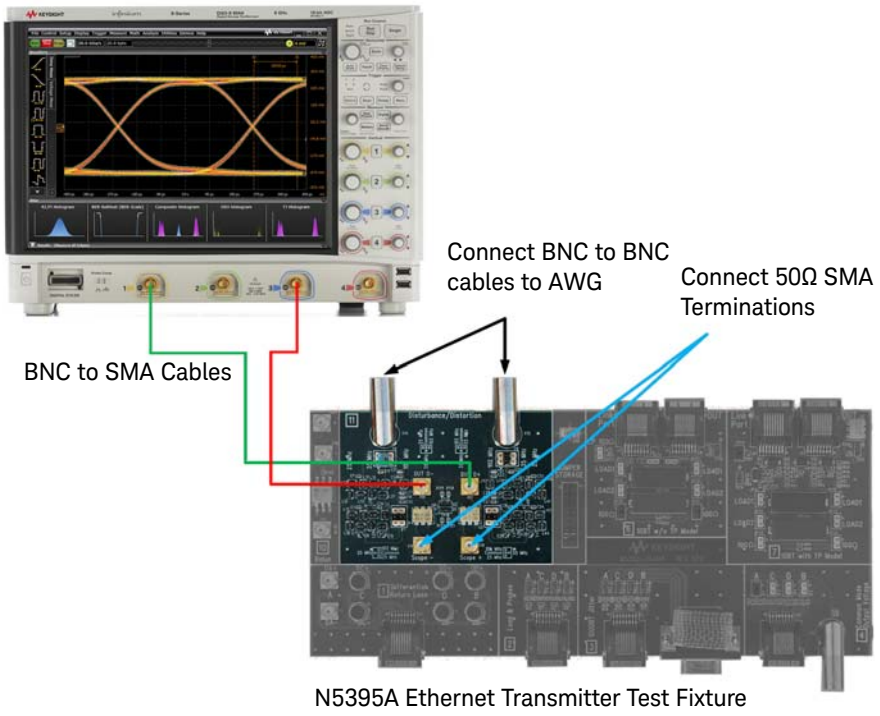

Figure C-1 AWG Calibration Setup for the Disturbing Signal Source

Performing the AWG Calibration for the Disturbing Signal Source

1 From the BroadR-Reach Compliance Test Application software main menu, click the **Calibrate Sources** button.

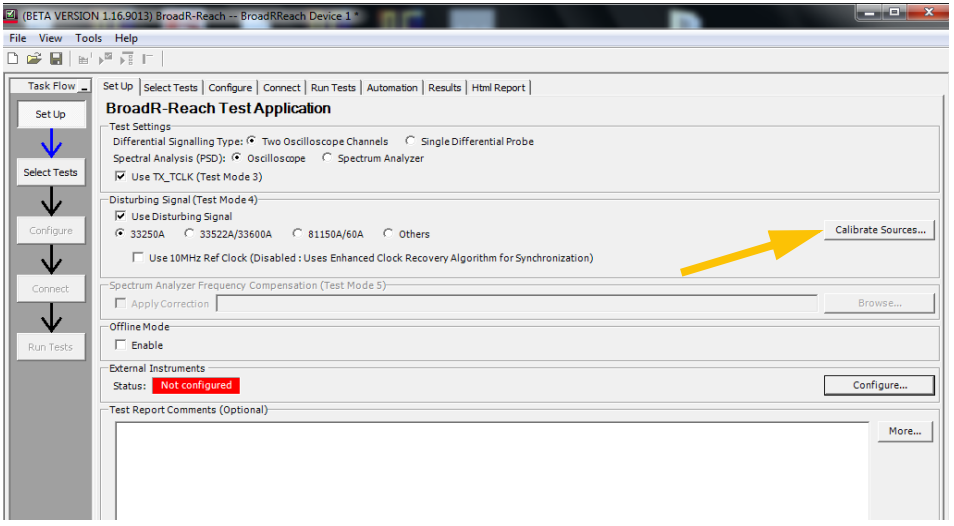

Figure C-2 BroadR-Reach Compliance Test Application Main Menu

2 This opens the **Calibrate Disturbing Signal** dialog box for the selected AWG.

3 With the appropriate AWG Address set and the correct oscilloscope channels selected, click the **Calibrate** button to start the calibration process.

4 When the software finishes the calibration, click the **Done** button to return to the Main Menu. Refer to the E6961A online help for a more detailed explanation.

Calibrating the ENA

Before using the ENA, it must be calibrated using the Return Loss Calibration board. See Figure C-3 below for the connection diagram. Calibrate the ENA using the instructions in the ENA's User's Guide.

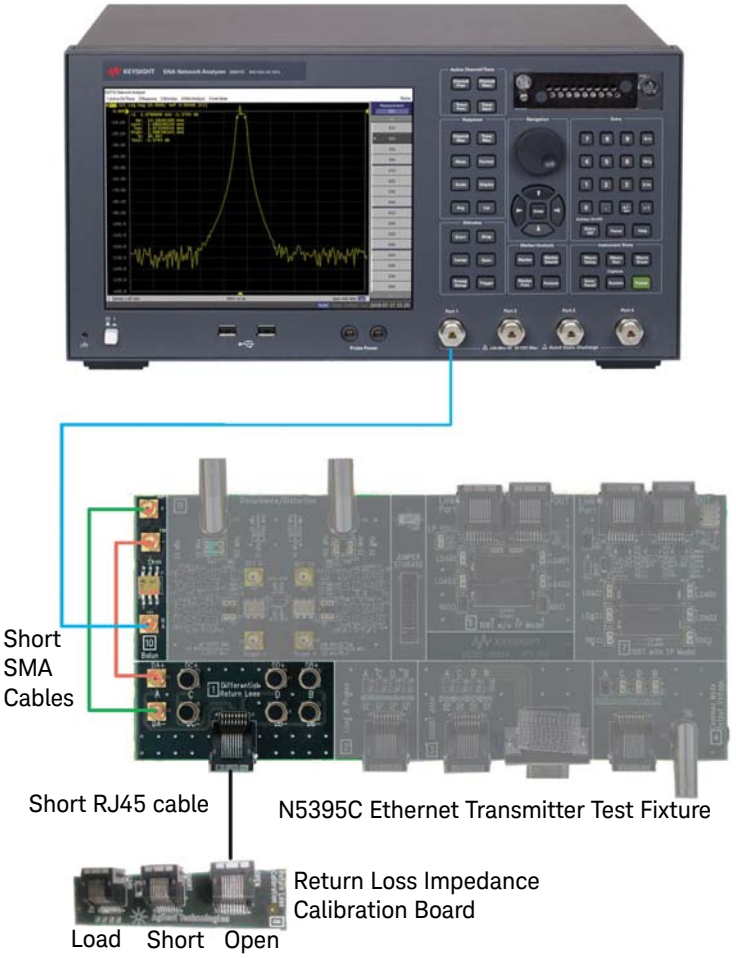

Figure C-3 ENA Calibration Setup

1 Connect the Return Loss Calibration board RJ45 connector labeled OPEN to the RJ45 connector on the main test fixture board using a short straight-through UTP cable.

2 Connect one end of two short SMA-to-SMA cables to the SMA test points for the pair you are testing (A, B, C, or D) on Section 1 of the test fixture. Connect the other end to the two SMA test points on Section 10 on the test fixture.

3 Connect a ENA input to the SMA test point on Section 10 on the test fixture.

4 Calibrate the ENA using the instructions in the ENA's User's Guide. The following is a list of setup requirements.

- Set Meas to Ref1 Fwd S11.
- Set Start to 1 MHz.
- Set Stop to 100 MHz.
- Set Format to Log Mag.
- Set Scale Div to 5.
- Set Scale Ref to reference line position 9.

5 5 Run the calibration for the OPEN, SHORT, and LOAD connections. For connectors other than RJ45, a custom calibration kit will need to be developed.

D Using the E6960-66600 Frequency Divider Board

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Introduction

Keysight's E6960-66600 Frequency Divider Board produces two identical clock signal outputs (10 MHz) that are phase locked to the input clock. This Frequency Divider Board is recommended for Compliance Test Mode 4, Transmitter Distortion Test.

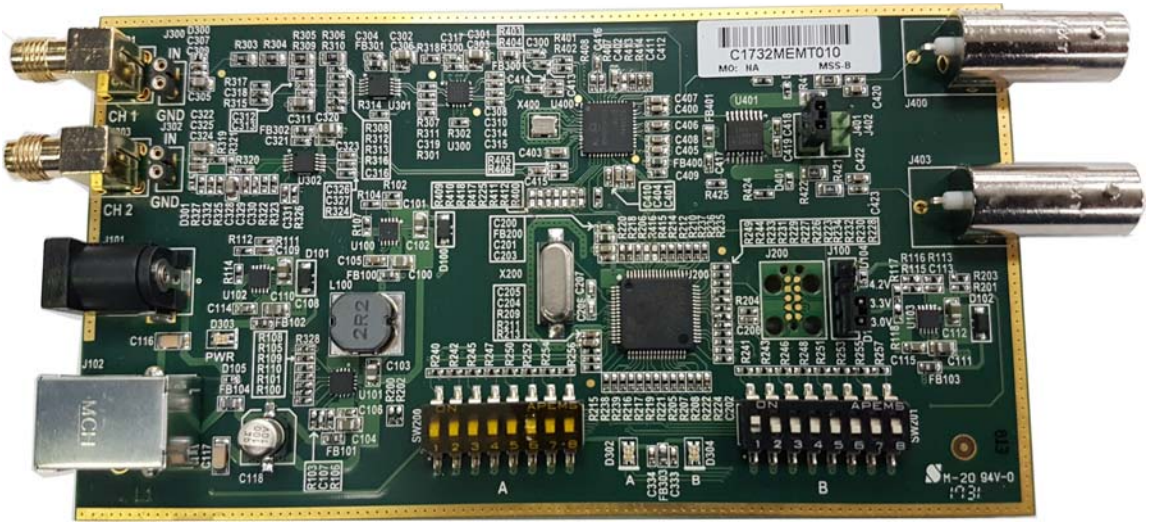
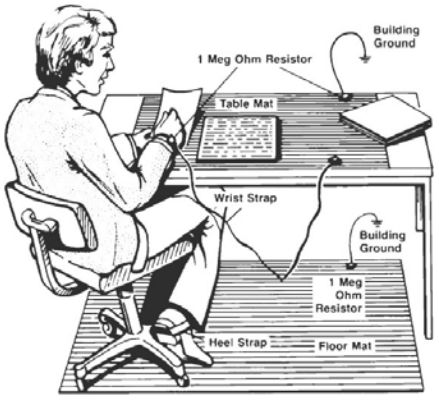


Figure D-1 Keysight's E6961A-FDB Frequency Divider Board

Static-safe Handling Procedures

Electrostatic discharge (ESD) can damage or destroy electronic components. Use a static-safe work station to perform at work on electronic assemblies. This figure shows a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination
- Conductive floor-mat and heel-strap combination



Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground.

Observe appropriate ESD precautions before connecting and disconnecting cables and changing the positions of jumpers ans switches.

To use the divider board, check the **Use 10MHz Ref Clock** on the BroadR-Reach Compliance Test Application Main Window.

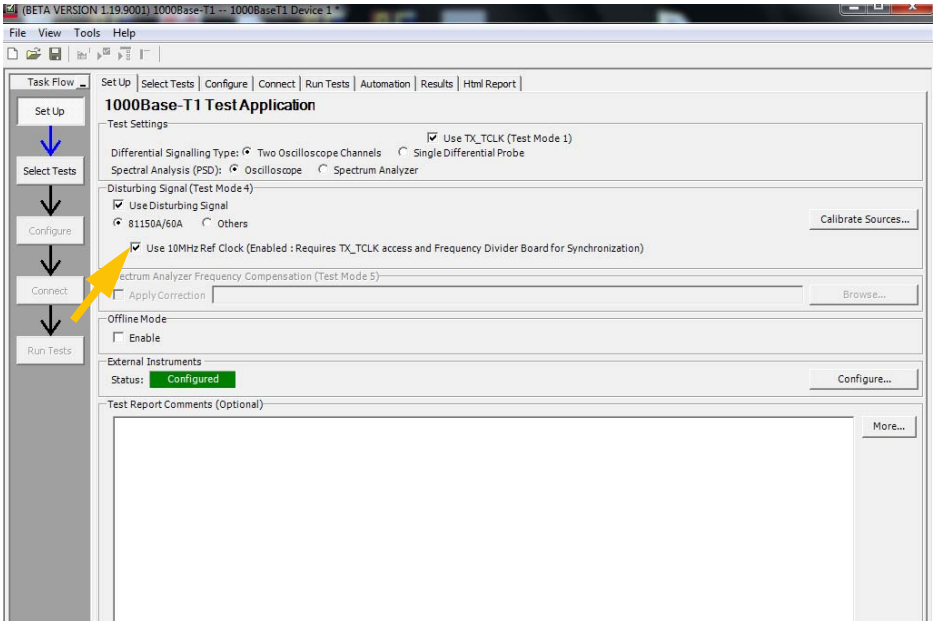


Figure D-2 Check the **Use 10MHz Ref Clock** on Main Application Window

Configure the test setup as shown below.

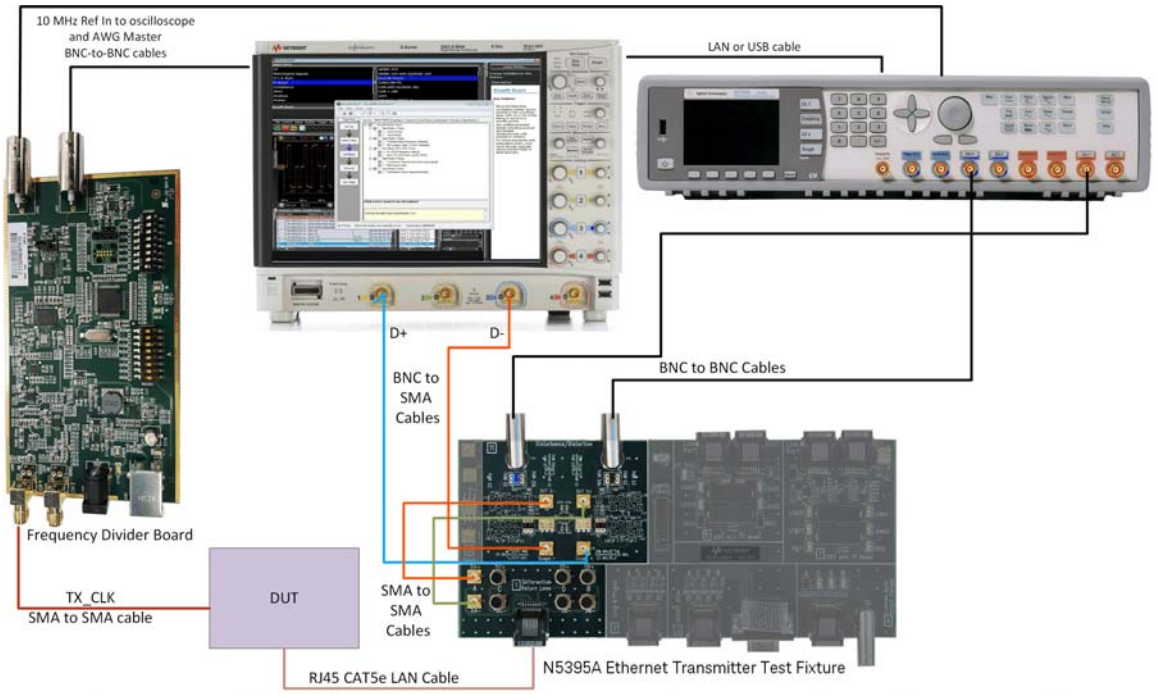


Figure D-3 Test Setup for 10 MHz Frequency Reference

Frequency Divider Board Test Setup

1. Connect CH1 SMA connector to the Device Under Test (DUT).
2. Use BNC to BNC cables to connect both J400 and J403 BNC connectors to the oscilloscope and the AWG 10 MHz In.
3. Select 4.2 Vpp output voltage by shorting Pin1 and Pin2 of J100 with jumper.
4. Select Normal Running mode by switching switch A1 to OFF.
5. Select Frequency Tracking mode by switching switch A2 to OFF.
6. Select CH1 as input by switching switch A6 to OFF.
7. Select Targeted 25 MHz input by switching switch B2 to ON.

8 Power on the board by connecting a power source to the USB connector or to the DC power jack. (4.5V to 5.5V @450mA).

At power on, the:

- Power LED PWR (D303) should light up as GREEN
- LED A (D302) should light up as GREEN
- LED B (D304) should light up as GREEN

Connector Description

This section describes the various user components on the E6960-26600.

USB type-B / DC Jack

Provides power to the fixture. Either the USB port or the 2.5 mm, center positive DC Power input jack may be used. The USB jack is not used for any other purpose. Input voltage is required to be within +4.5V to +5.5V @500mA. Any voltage that is out of specification will trigger a warning on the Power LED.

SMA

Provides an interface to feed the input signal into the test fixture. CH1 connector is 50 Ω terminated and CH2 connector is 10k Ω terminated.

BNC

Both J400 and J403 produce a separate output clock signal. The signals are back-terminated by 50 Ω.

Jumpers

Provides user the option to modify the test fixture circuitry.

J100

This jumper controls the output signal amplitude:

4.2Vpp: Connect pin 1 and pin 2

3.3Vpp: Connect pin 2 and pin 3

3.0Vpp: Connect pin 3 and pin 4

J300 & J302

This jumper allows user to probe the channel 1 and channel 2 inputs respectively

J401

This jumper shorts both outputs together.

J402

Parking location for unused jumpers.

DIP Switch Description

Switch A

Switch A sets the Fixture operating mode.

Table D-1 Switch Operating Modes

Switches	Position	Operating mode	Comment
A1	off	Normal running mode	Normal operating mode
	on	Sleep mode	Change made to any of the switches are ignored
A2	off	Frequency Tracking Mode	Output frequency track to input frequency
	on	Lock Frequency Mode	Output clock is phase lock to input clock
A3	off	NA	NA
	on	NA	NA
A4	off	NA	NA
	on	NA	NA
A5	off	NA	NA
	on	NA	NA
A6	off	Select CH1 as input	NA
	on	Select CH2 as input	NA
A7	off	NA	NA
	on	NA	NA

Table D-1 Switch Operating Modes

Switches	Position	Operating mode	Comment
A8	off	NA	NA
	on	NA	NA

Switch B

Switch B sets the frequency divider to the relevant setting.

Table D-2 Switch B Operating Modes

								Divider	Comment
B1	B2	B3	B4	B5	B6	B7	B8		To obtain 10 MHz output:
off	off	off	off	off	off	off	off	Not valid (def)	Free Run Mode
on	off	off	off	off	off	off	off	Div 1	Targeted 10MHz input clock
off	on	off	off	off	off	off	off	Div 5/2	Targeted 25MHz input clock
off	off	on	off	off	off	off	off	Div 20/3	Targeted 66.67MHz input clock
off	off	off	on	off	off	off	off	Div 25/2	Targeted 125MHz input clock
off	off	off	off	on	off	off	off	Div 75	Targeted 750MHz input clock

Note: Other combinations are not valid. if no valid switch setting is detected, LED will flash indicating invalid switch B configuration. After reset, if no valid position is detected, the board uses the “Free Run Mode” which generates an accurate 10 MHz signal.

LED Description

Power LED

Table D-3 LED Indicators

	Green	Red
Input voltage below 4.5V	ON	Flash 1 Hz
Input voltage below3.6V	ON	Flash 2 Hz
Input voltage above 5.5V	ON	ON

LED A

Table D-4 LED A Indicators

	Green	Red
Input signal locked (Normal condition)	ON	OFF
Lost of Lock	Flash 1 Hz	OFF
Lost of Signal	OFF	Flash 1 Hz
Lost of 48MHz reference	OFF	ON

LED B

Table D-5 LED B Indicators

	Green	Red
Valid switch B configuration (Normal condition)	ON	OFF
Invalid switch B configuration	Flash 1 Hz	OFF
Missing input signal/ input signal out of range/ Warning. See LED A for list of warning	N/A	ON

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