D90103BQC 25GBASE-T Ethernet Test Application

Notices

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Warranty

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CAUTION

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

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.

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1 Overview

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25GBASE-T Ethernet Automated Testing—At a Glance

The Keysight D90103BQC 25GBASE-T Ethernet Test Application helps you verify that the transmitter device under test (DUT) conforms to the specifications with the Keysight Infiniium MXR-Series (4/8 channels) and UXR-Series (4 channels) oscilloscope. The Keysight D90103BQC 25GBASE-T Ethernet Test Application:

·   Lets you select individual or multiple tests to run.

·   Lets you identify the device being tested and its configuration.

·   Shows you how to make oscilloscope, spectrum analyzer, and vector network analyzer connections to the device under test.

·   Automatically checks for proper oscilloscope configuration.

·   Automatically sets up the oscilloscope for each test.

·   Provides detailed information for each test that has been run and lets you specify the thresholds at which marginal or critical warnings appear.

·   Creates a printable HTML report of the tests that have been run.

| **NOTE** | The tests performed by the Keysight D90103BQC 25GBASE-T Ethernet Test Application are intended to provide a quick check of the electrical health of the DUT, which is designed based on the 10GBase-T, 25GBase-T, NBase-T (2.5G/5.0G) or MGBase-T (2.5G/5.0G) technology. This testing is not a replacement for an exhaustive test validation plan. |

Conformance testing measurements for devices using the 10GBase-T, 25GBase-T, NBase-T, and MGBase-T technologies are described in the *IEEE 802.3-2018 Standard*. For more information on 10GBase-T, 25GBase-T, NBase-T, and MGBase-T technology, see the IEEE 802 Standards web site at www.ieee802.org.

Required Equipment and Software

In order to run the 10GBase-T, 25GBase-T, NBase-T, and MGBase-T Ethernet automated tests, you need the following equipment and software:

Hardware

- Use one of the following oscilloscope models:
  - Keysight UXR Oscilloscopes (4 Channels): The bandwidth range and filter type in UXR is:
    - 13GHz bandwidth and brick wall filter for 25GBASE-T.
    - 4GHz bandwidth and brick wall filter for 10GBASE-T and below data rates.
  - Keysight MXR Oscilloscopes (4/8 Channels): The bandwidth range and filter type in MXR is:
    - Auto bandwidth limit for 25GBASE-T.
    - 4GHz bandwidth and brick wall filter for 10GBASE-T and below data rates.
- Spectrum Analyzer with the minimum frequency range upper limit of 3GHz (MXA, EXA, PSA or ESA series) for the 10G, 2.5G, and 5.0G data rates.
- Spectrum Analyzer with the minimum frequency range upper limit of 12GHz (MXA, EXA, PSA or ESA series) for the 25G data rate.
- Vector Network Analyzer with usable frequency range of 1 MHz to 500 MHz (E506x/7x, N5230A, and N5080B series) for the 10G, 2.5G, and 5.0G data rates.
- Vector Network Analyzer with usable frequency range of 1 MHz to 1250 MHz (E506x/7x, N5230A, and N5080B series) for the 25G data rate.
- Balun with 3GHz bandwidth for the 10G, 2.5G, and 5.0G data rates.
- Balun with 12GHz bandwidth for the 25G data rate.
- RJ-45 (8P8C) TPA Plug Test Adapter (ETH-TPA-RJ45) 25GBase-T Transmitter test fixture or U7237A 10GBase-T Transmitter test fixture (Note that in the 25GBASE-T Ethernet Test Application, the U7237A 10GBase-T Transmitter test fixture is replaced by the RJ-45 (8P8C) TPA Plug Test Adapter test fixture).
- SMA cable (24" or shorter).
- SMP to SMA cables (provided with U7237A 10GBase-T Transmitter test fixture).
- Keyboard, qty = 1, (provided with the Keysight Infiniium oscilloscope)
- Mouse, qty = 1, (provided with the Keysight Infiniium oscilloscope)
- Keysight also recommends using a second monitor to view the test application.

Software

- The minimum version of Infiniium oscilloscope software (see the Keysight D90103BQC 25GBASE-T Ethernet Test Application Release Notes).
- Keysight D90103BQC 25GBASE-T Ethernet Test Application software.

Licensing information

Refer to the *Data Sheet* pertaining to 25GBASE-T Ethernet Test Application to know about the licenses you must install along with other optional licenses. Visit "http://www.keysight.com/find/D90103BQC" and in the web page's **Resources** tab, you may view the associated Data Sheet.

The 25GBASE-T Ethernet Test Application supports the following licenses:
- D9010EBZC license: Allows you to access only 10G, 2.5G, and 5.0G data rates.
- D90103BQC license: Allows you to access 10G, 25G, 2.5G, and 5.0G data rates.

To procure a license, you require the Host ID information that is displayed in the Keysight License Manager application installed on the same machine where you wish to install the license.

The licensing format for Keysight License Manager 6 differs from its predecessors. See "Installing the License Key" on page 15 to see the difference in installing a license key using either of the applications on your machine.

In This Book

This manual describes the tests that are performed by the Keysight D90103BQC 25GBASE-T Ethernet Test Application in more detail; it contains information from (and refers to) the *IEEE 802.3-2018 Standard* for the 10GBase-T, 25GBase-T, NBase-T, and MGBase-T tests.

- Chapter 2, "Installing the Test Application and Licenses" shows how to install the automated test application software and licenses (if it was purchased separately).
- Chapter 3, "Preparing to Take Measurements" shows how to start the 25GBase-T Conformance Test Application and gives a brief overview of the required preparation and how the application is used.
- Chapter 4, "RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixtures" describes the RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T transmitter test fixture in detail.
- Chapter 5, "U7237A 10GBase-T Transmitter Test Fixtures" describes the U7237A 10GBase-T transmitter test fixture in detail.
- Chapter 6, "Transmitter Timing Jitter (MASTER) Test" contains information on the transmitter timing jitter MASTER test as specified in clause 55.5.3.3, 113.5.3.3, and 126.5.3.3 of the *IEEE 802.3-2018 Standard*.
- Chapter 7, "Transmit Clock Frequency Test" contains information on the transmit clock frequency test as specified in clause 55.5.3.5, 113.5.3.5, and 126.5.3.5 of the *IEEE 802.3-2018 Standard* and the Transmit Clock Frequency section of the *MGBase-T Ethernet Specification*.
- Chapter 8, "Maximum Output Droop Test" contains information on the positive and negative droop test as specified in clause 55.5.3.1, 113.5.3.1, and 126.5.3.1 of the *IEEE 802.3-2018 Standard*.
- Chapter 9, "Transmitter Power Spectral Density Test" contains information on the power spectral density test as specified in clause 55.5.3.4, 113.5.3.4, and 126.5.3.4 of the *IEEE 802.3-2018 Standard* and the Transmitter Power Spectral Density section of the *MGBase-T Ethernet Specification*.
- Chapter 10, "Power Level Test" contains information on the power level test as specified in clause 55.5.3.4, 113.5.3.4, and 126.5.3.4 of the *IEEE 802.3-2018 Standard*.
- Chapter 11, "Transmitter Linearity Tests" contains information on the transmitter linearity tests as specified in clause 55.5.3.2, 113.5.3.2, and 126.5.3.2 of the *IEEE 802.3-2018 Standard*.
- Chapter 12, "Transmitter Nonlinear Distortion Tests" contains information on the Transmitter Nonlinear Distortion tests as specified in clause 126.5.3.2 of the *IIEEE 802.3-2018 Standard*.
- Chapter 13, "MDI Return Loss Test" contains information on the MDI return loss test as specified in clauses 55.8.2.1, 113.8.2.1, and 126.8.2.2 of the *IEEE 802.3-2018 Standard*.
- Chapter 14, "MDI Impedance Balance Test" contains information on the MDI Impedance Balance loss test as specified in clauses 55.8.2.2, 113.8.2.2, and 126.8.2.3 of the *IEEE 802.3-2018 Standard*.
- Chapter 15, "Transmitter Timing Jitter (SLAVE) Test" contains information on the transmitter timing jitter SLAVE test as specified in clause 55.5.3.3, 113.5.3.3, and 126.5.3.3 of the *IEEE 802.3-2018 Standard*.

See Also

The Keysight D90103BQC 25GBASE-T Ethernet Test Application's Online Help, which describes:
- Starting the 25GBASE-T Ethernet Test Application
- Creating or Opening a Test Project
- Setting Up the Test Environment
- Selecting Tests
- Configuring Tests

- Verifying Physical Connections
- Running Tests
- Configuring Automation in the Test Application
- Viewing Results
- Viewing HTML Test Report
- Exiting the Test Application
- Additional Settings in the Test App

2 Installing the Test Application and Licenses

If you purchased the D90103BQC 25GBASE-T Ethernet Test Application separate from your Infiniium oscilloscope, you must install the software and license key.

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Installing the Test Application

1   Make sure you have the minimum version of Infiniium oscilloscope software (see the D90103BQC release notes). To ensure that you have the minimum version, select **Help > About Infiniium...** from the main menu.

2   To obtain the 25GBASE-T Ethernet Test Application, go to Keysight website: "http://www.keysight.com/find/D90103BQC".

3   In the web page's **Free Trials** tab, click the **Request Free Trial** button to view instructions for downloading and installing the application software.

Installing the License Key

To procure a license, you require the Host ID information that is displayed in the Keysight License Manager application installed on the same machine where you wish to install the license.

Using Keysight License Manager 5

To view and copy the Host ID from Keysight License Manager 5:

1   Launch Keysight License Manager on your machine, where you wish to run the Test Application and its features.
2   Copy the Host ID that appears on the top pane of the application. Note that x indicates numeric values.
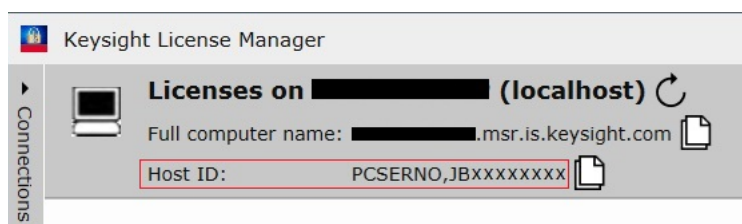
Figure 1   Viewing the Host ID information in Keysight License Manager 5

To install one of the procured licenses using Keysight License Manager 5 application,

1   Save the license files on the machine, where you wish to run the Test Application and its features.
2   Launch Keysight License Manager.
3   From the configuration menu, use one of the options to install each license file.
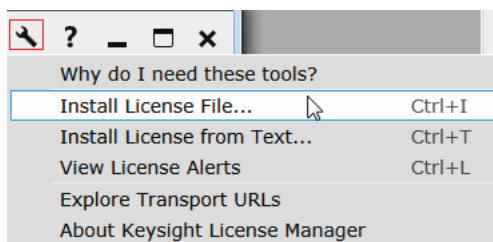
Figure 2   Configuration menu options to install licenses on Keysight License Manager 5

For more information regarding installation of procured licenses on Keysight License Manager 5, refer to Keysight License Manager 5 Supporting Documentation.

Using Keysight License Manager 6

To view and copy the Host ID from Keysight License Manager 6:

1   Launch Keysight License Manager 6 on your machine, where you wish to run the Test Application and its features.

2   Copy the Host ID, which is the first set of alphanumeric value (as highlighted in Figure 3) that appears in the Environment tab of the application. Note that x indicates numeric values.
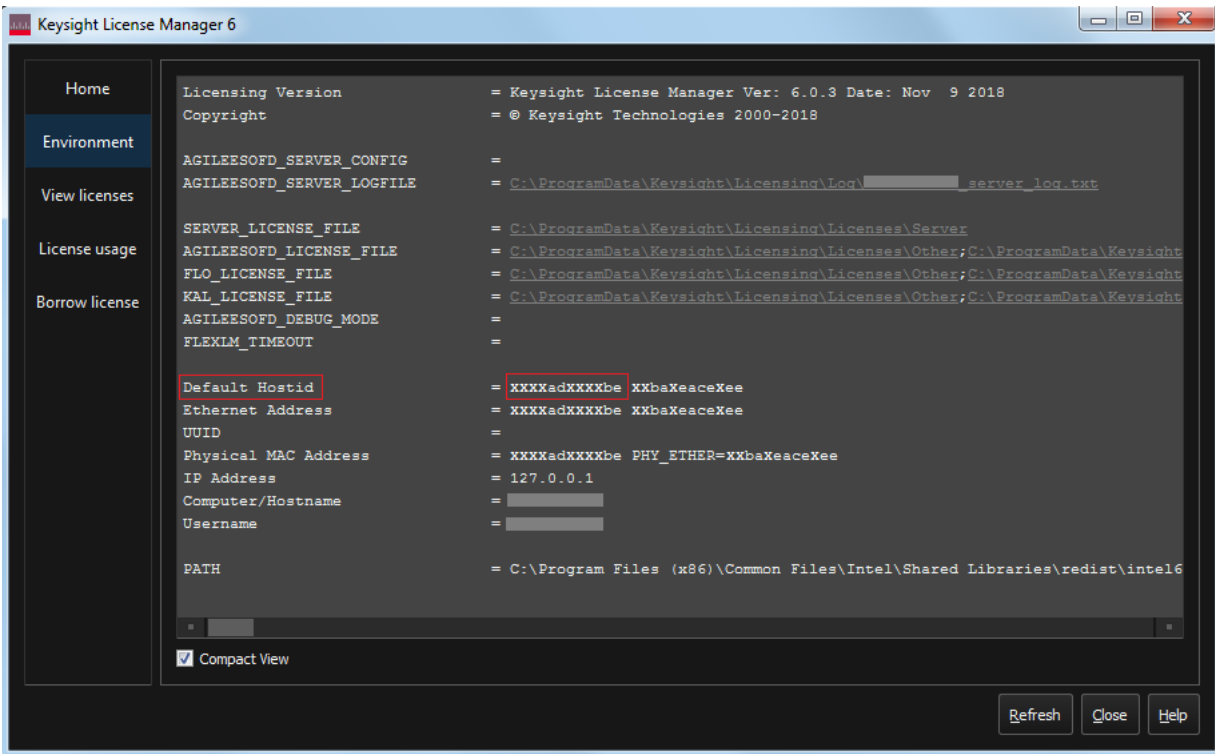
Figure 3   Viewing the Host ID information in Keysight License Manager 6

To install one of the procured licenses using Keysight License Manager 6 application:

1   Save the license files on the machine, where you wish to run the Test Application and its features.

2   Launch Keysight License Manager 6.

3   From the **Home** tab, use one of the options to install each license file.
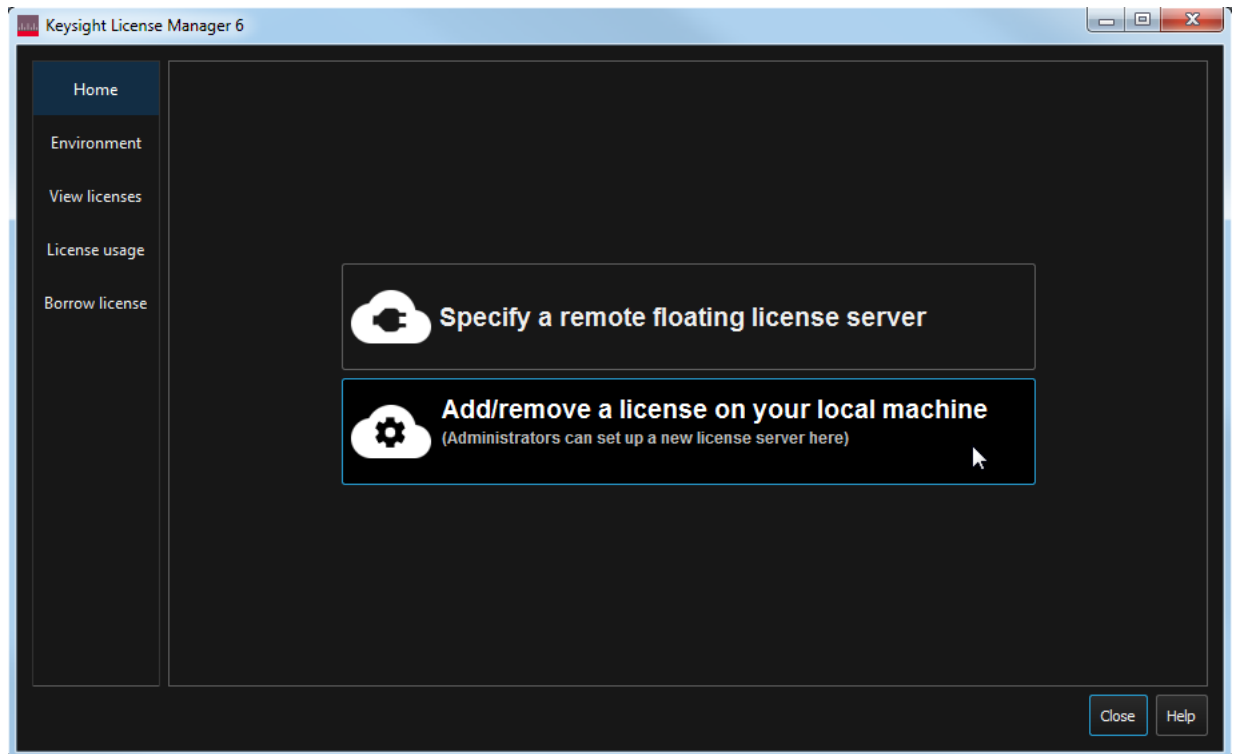
Figure 4   Home menu options to install licenses on Keysight License Manager 6

For more information regarding installation of procured licenses on Keysight License Manager 6, refer to Keysight License Manager 6 Supporting Documentation.

3 Preparing to Take Measurements

Before running the automated tests, you should calibrate the oscilloscope and probe. No test fixture is required for the calibration but is required for the test measurements. After the oscilloscope and probe have been calibrated, you are ready to start the 25GBASE-T Ethernet Test Application and perform the measurements.

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Calibrating the Oscilloscope

If you have not already calibrated the oscilloscope, refer to the *User Guide* for the respective oscilloscope you are using.

NOTE	If the ambient temperature changes more than 5 degrees Celsius 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.

Starting the 25GBASE-T Ethernet Test Application

1   Ensure that the 25GBASE-T Ethernet Device Under Test (DUT) is operating and set to desired test modes. To start the 25GBASE-T Ethernet Test Application: From the Infiniium oscilloscope's main menu, select **Analyze > Automated Test Apps > D90103BQC 25GBASE-T Ethernet Test App**.
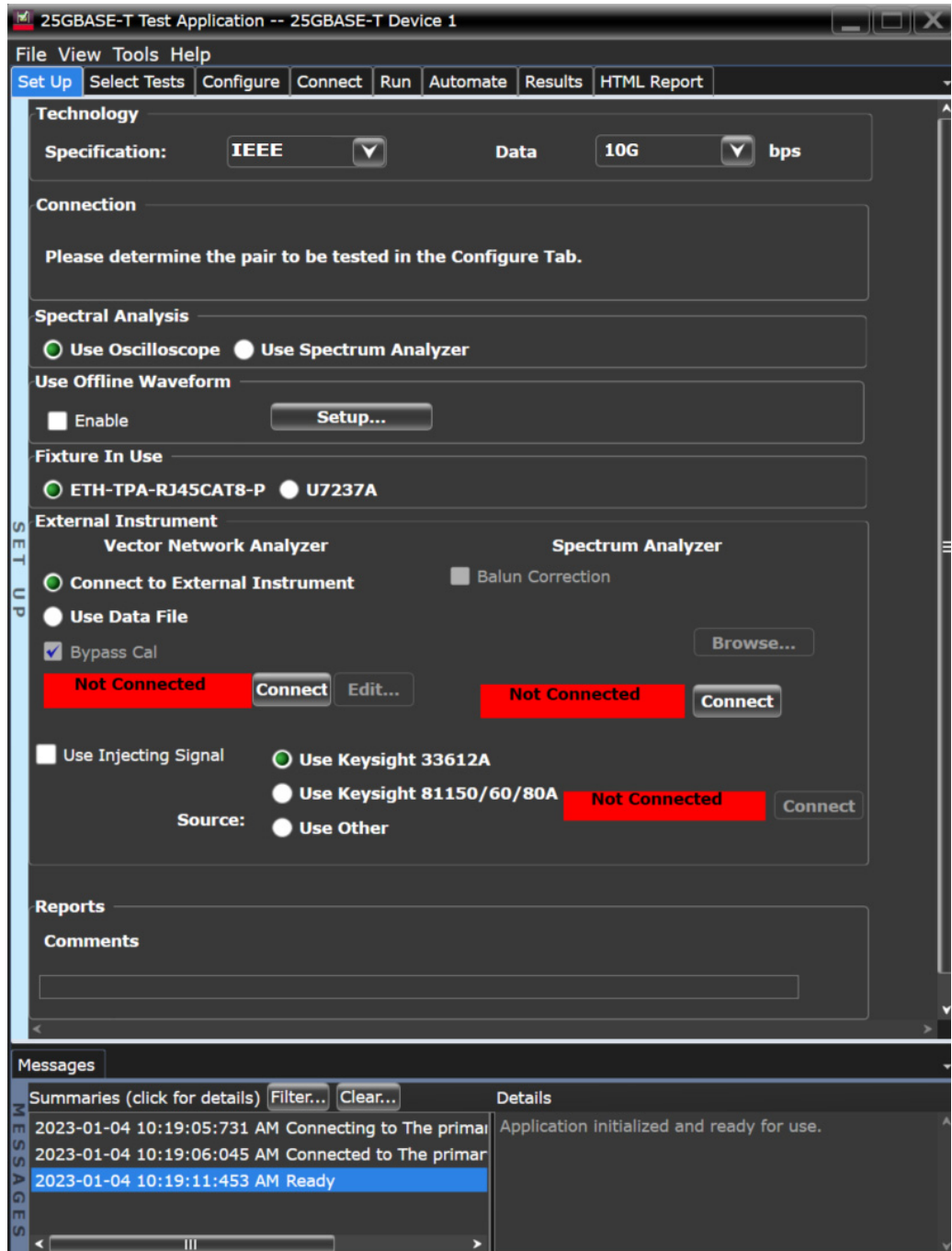
Figure 5   25GBASE-T Ethernet Test Application main window

To understand the functionality of the various features in the user interface of the Test Application, refer to the *Keysight D90103BQC 25GBASE-T Ethernet Test Application Online Help* available in the Help menu.

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

Tab	Description
Set Up	Lets you identify and set up the test environment, including information about the device under test. The Test App includes relevant information in the final HTML report.
Select Tests	Lets you select the tests you want to run. The tests are organized hierarchically so you can select all tests in a group. After tests are run, status indicators show which tests have passed, failed, or not been run, and there are indicators for the test groups.
Configure	Lets you configure test parameters (for example, channels used in test, voltage levels, etc.).
Connect	Shows you how to connect the oscilloscope to the device under test for the tests that are to be run.
Run	Starts the automated tests. If the connections to the device under test need to be changed while multiple tests are running, the tests pause, show you how to change the connection, and wait for you to confirm that the connections have been changed before continuing.
Automate	Lets you construct scripts of commands that 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	Shows a conformance test report that can be printed.

NOTE   In the **Configure** tab, the values for all such Configuration parameters that are oscilloscope-dependent, will correspond to the oscilloscope Model (MXRs or UXRs), where you are running the Test Application.

Connections for Conformance Tests

To run tests using the 25GBASE-T Ethernet Test Application, you must make proper connections between the oscilloscope, DUT and if needed, any external device (such as Vector Network Analyzer or Spectrum Analyzer). Once you select the tests that you want to run, refer to the **Connect** tab in the 25GBASE-T Ethernet Test Application for connection instructions and the connection diagram, similar to one shown in Figure 6.
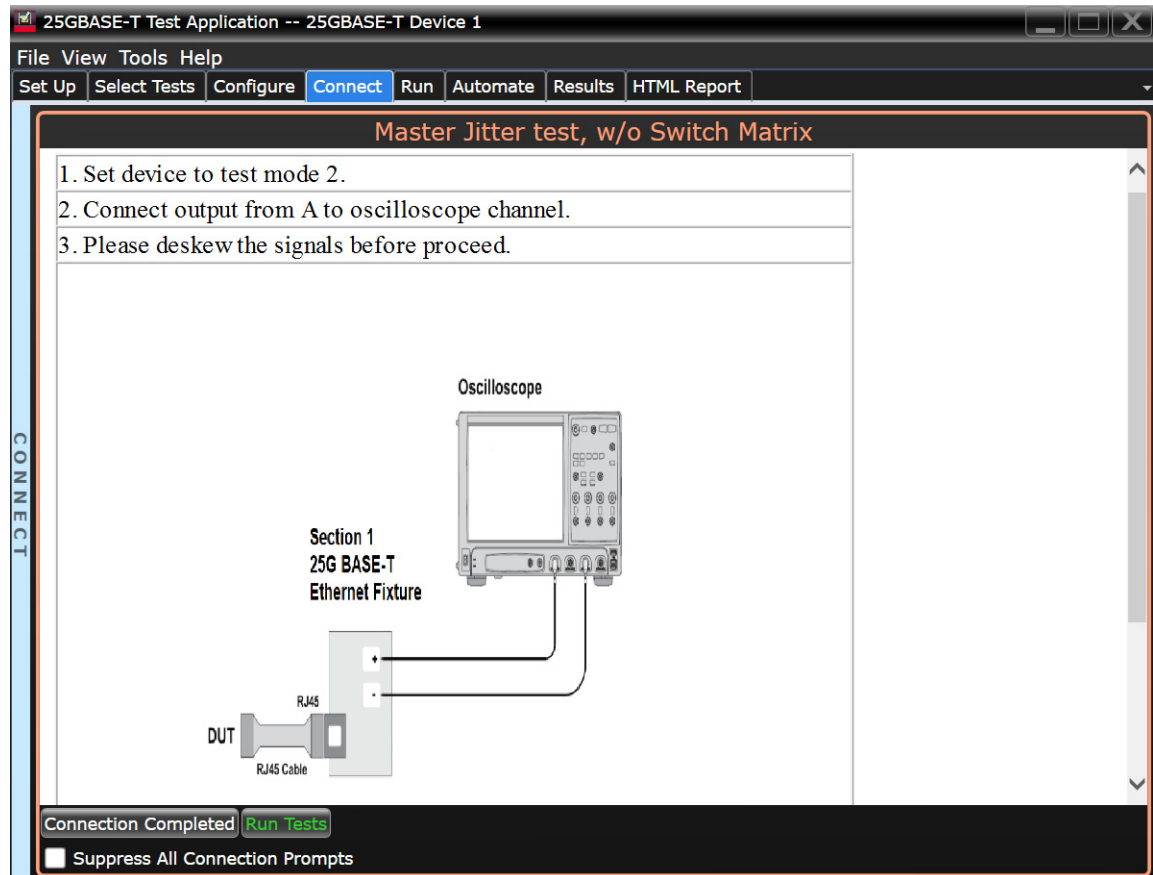
Figure 6   Physical connection diagram and instructions for conformance tests

The 25GBASE-T Ethernet Test Application also supports the Parallel Analysis signal type in the **Configure** tab (as shown in Figure 7). The Parallel Analysis signal type is available for all the data rates (10G, 25G, 5.0G, 2.5G) and allows you to perform parallel test measurements of the test pairs for a DUT in less time without connecting to the switch matrix.

If you are using MXR oscilloscope (8 channels), then selecting Parallel Analysis signal type connects all the test pairs for a DUT to the scope's 8 channels (as shown in Figure 8) and allows to test all the test pairs at once in less time.

If you are using MXR/UXR oscilloscope (4 channels), then selecting Parallel Analysis signal type connects two test pairs for DUT to the scope's 4 channels (as shown in Figure 9) and allows to test only two test pairs at a time.

<table>
<tr><td>NOTE</td><td>The Parallel Analysis of test pairs (Pair A, Pair B, Pair C, and Pair D) is not supported by Network Analyzer and Spectrum Analyzer.</td></tr>
</table>
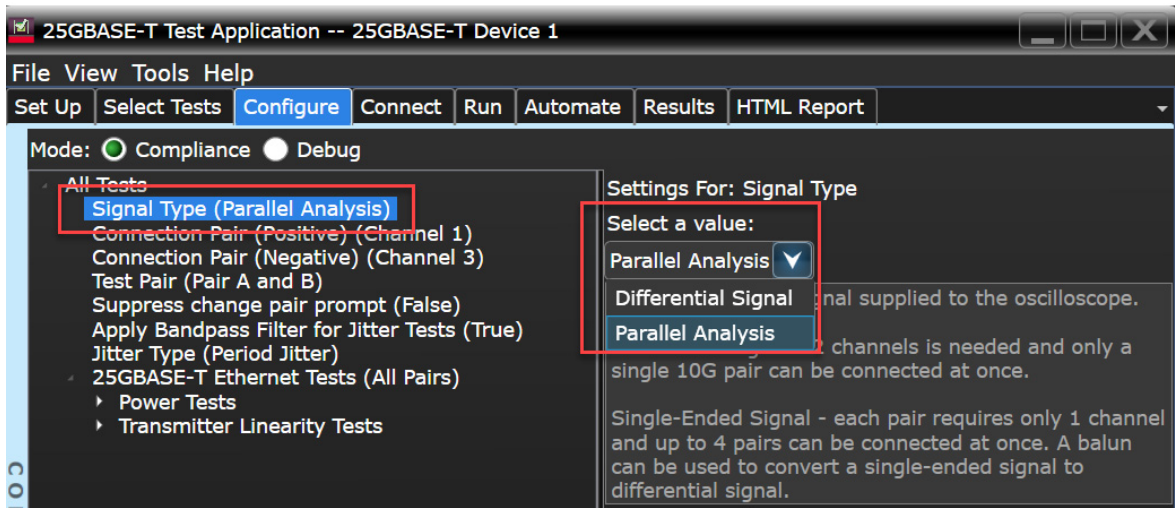
Figure 7   Parallel Analysis signal type selected in the Configure tab
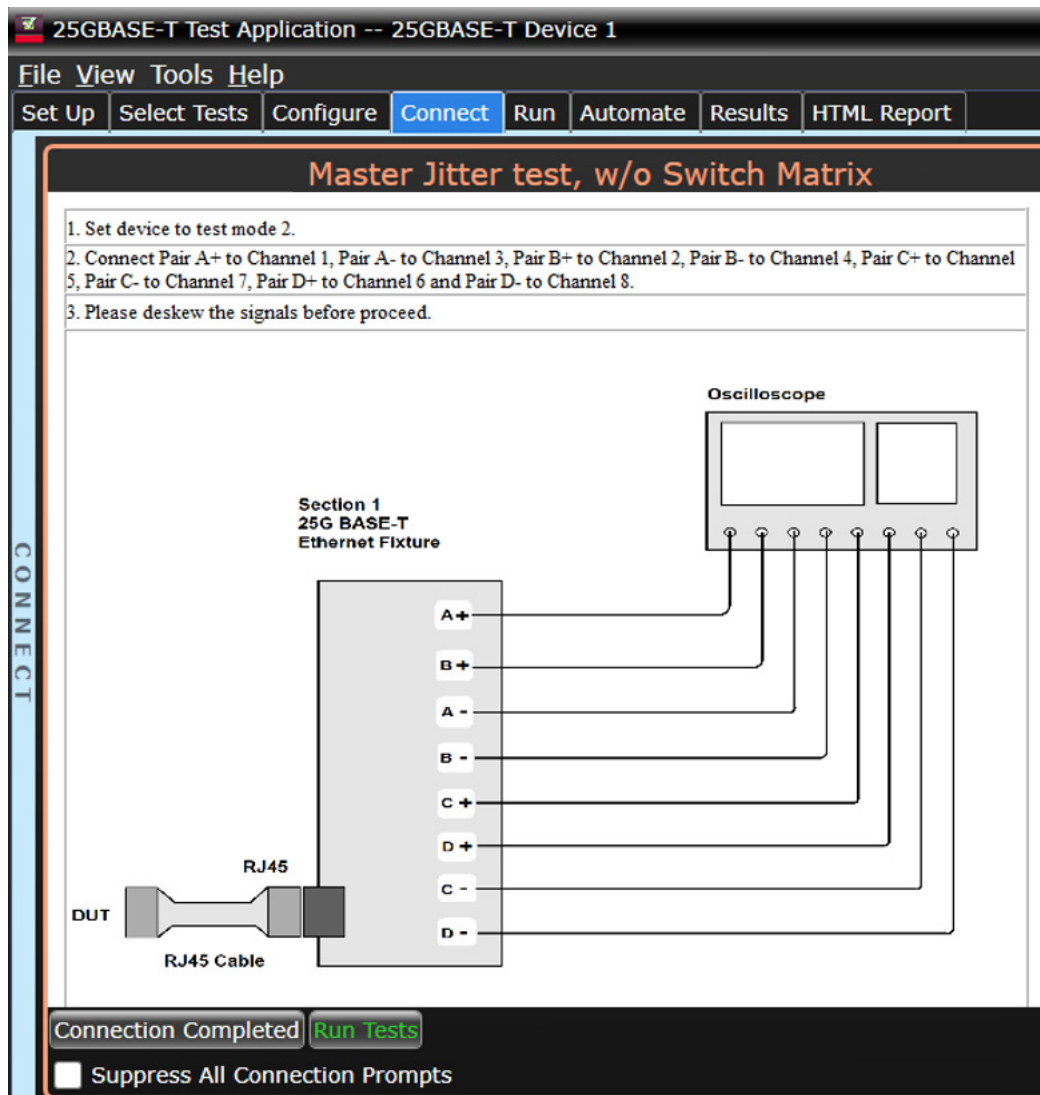
Figure 8   Physical connection diagram and instructions for conformance tests in MXR (8 channels) oscilloscope
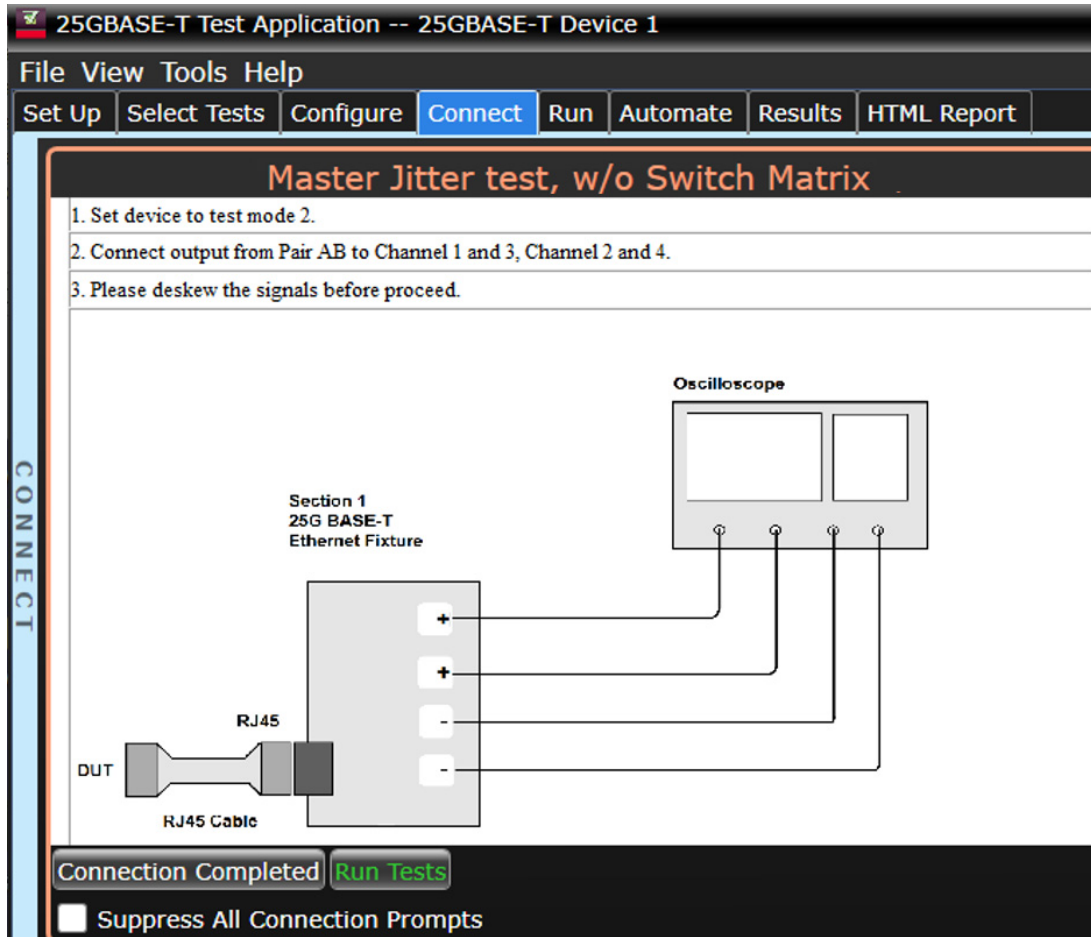
Figure 9   Physical connection diagram and instructions for conformance tests in MXR/UXR (4 channels) oscilloscope

4 RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixtures

The RJ-45 (8P8C) TPA Plug Test Adapter (ETH-TPA-RJ45) 25GBase-T transmitter test fixtures are required to perform the 25GBase-T Conformance test measurements. Note that, the U7237A 10GBase-T Transmitter Test Fixtures can only be used for data rates lower than 25G.

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RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture Description

The RJ-45 (8P8C) TPA Plug Test Adapter (ETH-TPA-RJ45) transmitter test fixture is required to perform the measurement with the Keysight D90103BQC 25GBASE-T Ethernet Test Application. The fixture helps you to easily access the 10GBase-T, 25GBase-T, NBase-T (2.5G), NBase-T (5.0G) test signals or MGBase-T test signals.

The RJ-45 (8P8C) TPA Plug Test Adapter fixture (shown in Figure 10) measures or inject data signals via SMA connections.
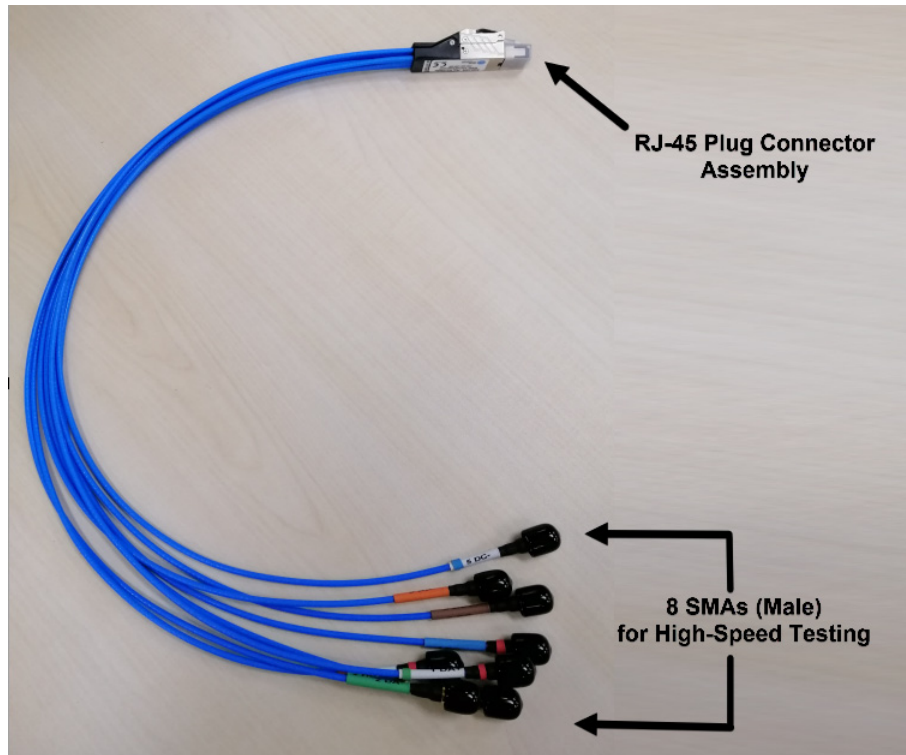
Figure 10   RJ-45 TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture

The fixture has one section: Section 1

Section 1 of the RJ-45 (8P8C) TPA Plug Test Adapter (ETH-TPA-RJ45) transmitter test fixture is required for the following tests:
- Transmitter Timing Jitter (MASTER) Test
- Transmit Clock Frequency Test
- Maximum Output Droop Test
- Transmitter Power Spectral Density Test
- Power Level Test
- Transmitter Linearity Tests
- MDI Return Loss Test
- MDI Impedance Balance Test
- Transmitter Timing Jitter (Slave)

Test Modes

The test modes are required for testing the transmitter waveform, transmitter distortion, transmitter jitter, transmitter droop, and BER testing:

· Test Mode 1 is a mode provided to enable the timing jitter testing on a SLAVE transmitter.
· Test Mode 2 is for transmitter jitter testing when the transmitter is in the MASTER timing mode and for transmit clock frequency testing.
· Test Mode 3 is for transmitter jitter testing in the SLAVE mode.
· Test Mode 4 is for transmitter distortion testing.
· Test Mode 5 is used to verify whether the transmitter is compliant with the transmit PSD mask, power level test, MDI return loss test, and MDI Impedance Balance test.
· Test Mode 6 is for testing the transmitter droop.
· Test Mode 7 is used to enable the measurement of the bit error ratio of the link.

For more information on RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T transmitter test fixture, refer to RJ-45 (8P8C) TPA Plug Test Adapter User Manual.

5 U7237A 10GBase-T Transmitter Test Fixtures

If you have a D9010EBZC license, then you can access only 10G, 5.0G, and 2.5G data rates in the test application. The U7237A 10GBase-T transmitter test fixture or RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T transmitter test fixture can be used to perform the 10G, 2.5G, and 5G test measurements. For the 25G test measurements, you must use RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T transmitter test fixture.

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U7237A 10GBase-T Transmitter Test Fixture Description

The U7237A 10GBase-T Transmitter Test Fixture can be used to perform the 10G, 2.5G, and 5G test measurements. The fixture helps you to easily access the 10GBase-T test signals or MGBase-T test signals.

The fixture has three sections: Section 1, Section 2 and Section 3.

Section 1 of the U7237A 10GBase-T transmitter test fixture is required for the following tests:
- Transmitter Timing Jitter (MASTER) Test
- Transmit Clock Frequency Test
- Maximum Output Droop Test
- Transmitter Power Spectral Density Test
- Power Level Test
- Transmitter Linearity Tests
- MDI Return Loss Test

Section 2 of the fixture is required for the following test:
- Transmitter Timing Jitter (SLAVE) Test

Section 3 of the fixture is required for calibration during the MDI Return Loss Test.

Figure 11, Figure 12 and Figure 13 shows the U7237A 10GBase-T Transmitter Test Fixtures. The U7237A 10GBase-T transmitter test fixture is shipped to you as one piece of board with 3 sections, as shown in Figure 11. The board has a V-cut break-out tab that allows you to easily separate the board into two pieces.
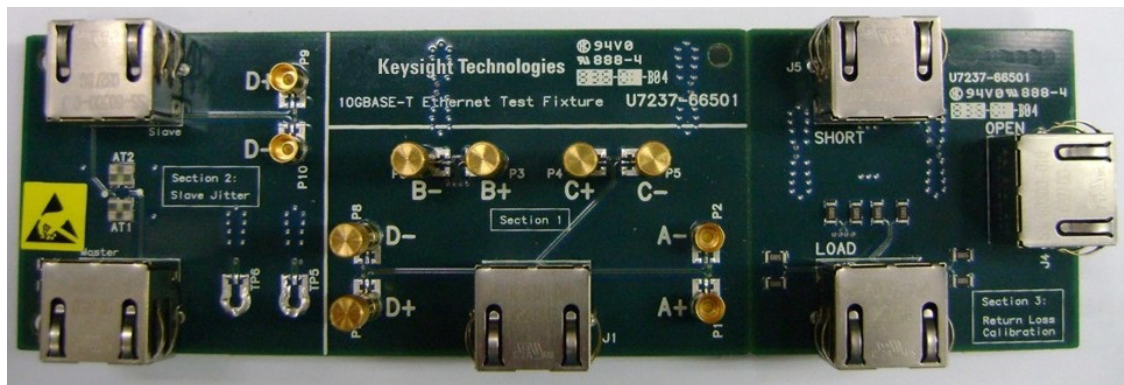
Figure 11   Complete U7237A 10GBase-T Transmitter Test Fixture Board

The bigger piece of board, as shown in Figure 12 has Section 1 and Section 2. This sections are required to perform the conformance tests. Whereas, the smaller board which has Section 3, as shown in Figure 13 is required to calibrate the Vector Network Analyzer.
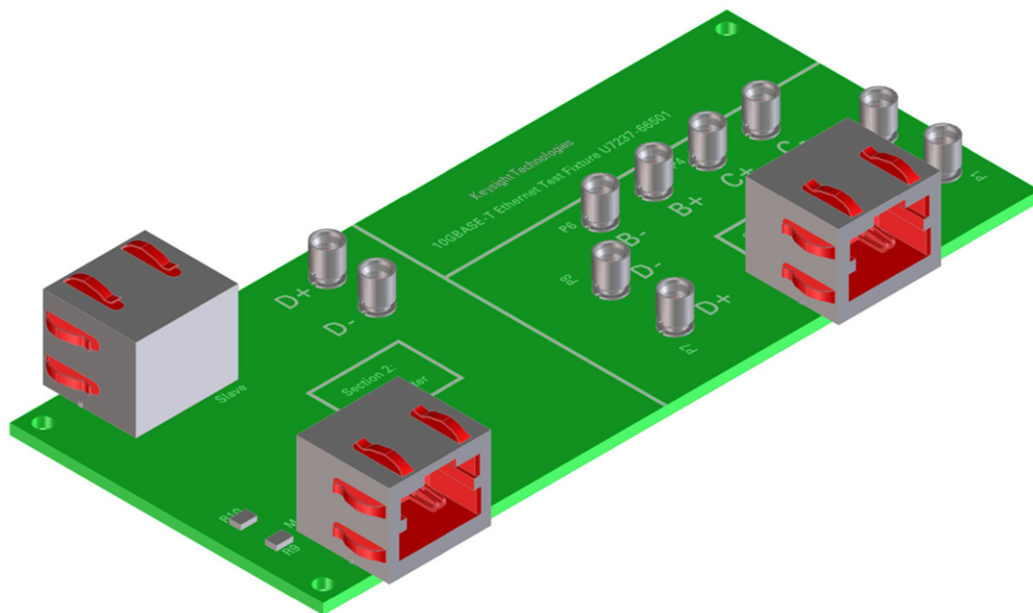
Figure 12   Section 1 and Section 2 of the U7237A 10GBase-T Transmitter Test Fixture
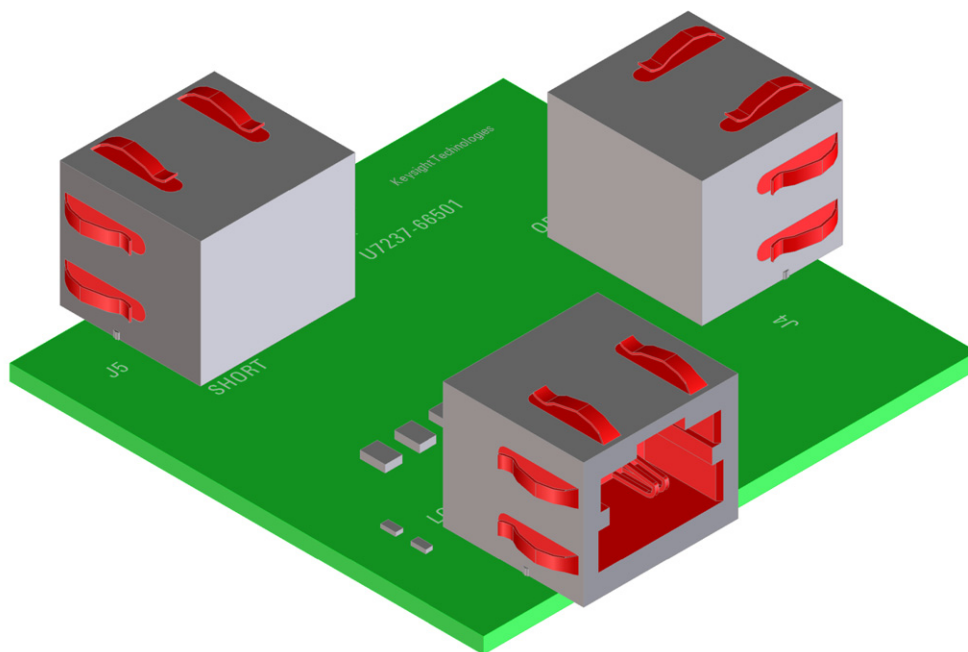
Figure 13   Section 3 of the U7237A 10GBase-T Transmitter Test Fixture

Fixture and Accessories

The complete set of 10GBase-T Transmitter Test Fixture contains the following items:

Part Number	Description	Quantity
U7237-66501	10GBase-T Test Fixture	1 unit
1250-3553*	50 ohm RF SMP female straight connector	6 units
N4235-61602	16 inches phase matched SMP female/SMA male cable pair	2 units
U7237-61601	8 inches 10GBase-T shielded patch cord	2 units
0955-2095	Precision instrumentation Balun 300 KHz to 3 GHz	1 unit

* It is always recommended to mate and de-mate connectors straight up. However, this connector is capable of mating at a +/- 0.020" radial tolerance. In handling this connector, one should not hold or squeeze it on the interface side. Always hold it on the knurled end.

Dimension

The dimension of the U7237A test fixture board is as follows:

PCB board height = 1.89 inches

PCB board width = 6.30 inches

PCB board thickness = 0.063 inches

Test Modes

The test modes are required for testing the transmitter waveform, transmitter distortion, transmitter jitter, transmitter droop and BER testing:

· Test Mode 1 is a mode provided to enable the timing jitter testing on a SLAVE transmitter.

· Test Mode 2 is for transmitter jitter testing when the transmitter is in the MASTER timing mode and for transmit clock frequency testing.

· Test Mode 3 is for transmitter jitter testing in the SLAVE mode if the loop timing is supported.

· Test Mode 4 is for the transmitter linearity testing.

· Test Mode 5 is used to verify whether the transmitter is compliant with the transmit PSD mask, the power level test and MDI return loss test.

· Test Mode 6 is for testing the transmitter droop.

· Test Mode 7 is used to enable the measurement of the bit error rate of the link.

Characteristics, Regulatory and Safety Information

Electrical Characteristics

The following electrical characteristics are the specification of the U7237A 10GBase-T Transmitter Test Fixture:

Description	Specification	
Bandwidth	3 GHz	
Attenuation between the master & slave in Section 2 (3 GHz bandwidth)	15 dB + 1 dB (including transmission line)	
Isolation (between transmitter & Pair D)	> 30 dB	
Insertion loss	**Frequency Range**	**Max Insertion Loss**
	0- 500 MHz	< 0.5 dB
	500 MHz - 1 GHz	< 1.5 dB
	1 GHz - 2 GHz	< 3.2 dB
	2 GHz - 3 GHz	< 4.5 dB
Ethernet shielded patch cord	CAT6A	
Balun bandwidth	300 KHz to 3 GHz	

Operating and Non-operating Environmental Characteristics

The following are the environmental characteristics of the U7237A 10GBase-T Transmitter Test Fixture:

Description	Minimum Requirement
Ambient temperature	Operating = 0℃ to 40℃ Non-operating = - 51℃) to 71℃
Humidity	Operating = 95% RH at 40℃ for 24 hours
Altitude	Operating = 4,570m (15,000 ft) Non-operating = 15,244m (50,000 ft)
Indoor use	This fixture is rated for indoor use only
Random vibration	HP/Keysight class B1 and MIL-PRF-2880 OF Class 3 random
Mechanical shock	HP/Keysight class B1 and MIL-PRF-2880 OF (operating 30g, 1/2 sine, 11-ms duration, 3 shocks/axis along major axis. Total of 18 shocks)

Safety Information

The U7237A 10GBase-T Transmitter Test Fixture herewith complies with the essential requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly. The product was tested in a typical configuration with HP/Keysight test systems.

The following are the safety regulatory information of the U7237A 10GBase-T Transmitter Test Fixture:

Minimum Requirement:

IEC 61010-1: Second edition 2001-2

EN 61010-1:2001

UL3111-1 or UL 6101B-1:2003 (must be a Keysight ID)

Canada: CSA-C22.2 No. 1010.1:1992

6 Transmitter Timing Jitter (MASTER) Test

This section provides the Methods of Implementation (MOIs) for Transmitter Timing Jitter (MASTER) test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; 25GBase-T Transmitter Test Fixture and the Keysight D90103BQC 25GBASE-T Ethernet Test Application.

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Procedure for Transmitter Timing Jitter (MASTER) Test

Running the Transmitter Timing Jitter (MASTER) Test using the 25GBase-T Test Application

1   Start the 25GBase-T Conformance Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Transmitter Timing Jitter (MASTER) test, refer to "Connections for Conformance Tests" on page 23.

3   Based on the transmitter text fixture in use, make one of the following connections:

- **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

- **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the any two of the oscilloscope channels by using the cables.

5   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

6   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

- **Specification: IEEE** and **Data Rate: 10G** or **25G**,

- **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

- **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

7   Based on the test requirements, select the appropriate options and perform connections in the **Spectral Analysis** and **External Instruments** areas.

8   Enter your comments in the **Comments** text box.

9   Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

Figure 14   Selecting Transmitter Timing Jitter (MASTER) test

10 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 1), run the test, and view the test results.

Table 1   Test Configuration Options

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Signal Type	Type of signal generated on the Oscilloscope.
Sampling Rate [Debug mode]	Sampling Rate configured on the Oscilloscope.
Apply Band Pass Filter for Jitter Tests	Apply a a bandpass filter to the input of the jitter tests.
Band Pass Filter Center Frequency [Debug mode]	Center Frequency of the Band Pass Filter.
Band Pass Filter Bandwidth [Debug mode]	Bandwidth of the Band Pass Filter.
Jitter Type (Period Jitter)	The type of jitter for Transmitter Timing Jitter Test.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Transmitter Timing Jitter (MASTER) Test—Implementation Methodology

The purpose of the Transmitter Timing Jitter (MASTER) test is to verify that the MASTER transmitter timing jitter of the device under test (DUT) is within the conformance limits specified in:

· Clause 55.5.3.3 of *IEEE 802.3-2018* for the 10GBase-T DUT

· Clause 113.5.3.3 of *IEEE 802.3-2018* for the 25GBase-T DUT

· Clause 126.5.3.3 of *IEEE 802.3-2018* for the MGBase-T DUT and NBase-T DUT

For the 10GBase-T, the obtained timing jitter must be less than 5.5 ps over a sample size of 200000 $\pm$ 20000. This jitter value is to be verified for each of the four pairs of the 10GBase-T test mode 2 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

For the 25GBase-T, the obtained timing jitter must be less than 2.1 ps over a sample size of 200000 $\pm$ 20000. This jitter value is to be verified for each of the four pairs of the 25G test mode 2 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

For the NBase-T (5.0G) and MGBase-T (5.0G), the obtained timing jitter must be less than 7.2 ps and must be less than 10 ps for the NBase-T (2.5G) and MGBase-T (2.5G) over a sample size of 200000 $\pm$ 20000. This jitter value is to be verified for each of the four pairs of the 2.5G/5G test mode 2 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018 Clause 55.5.3.3 Transmitter Timing Jitter

RMS period jitter over an integration time interval of 1 ms $\pm$ 10% is defined as the root mean square period difference from the average period $(T - T_{avg})$ accumulated over a sample size of 200000 $\pm$ 20000.

$$RMS\ period\ jitter < \sqrt{\frac{\left(\sum [(T - Tavg)^2]\right)}{Sample\ Size}}$$

25GBase-T, Spec IEEE 802.3—2018 Clause 113.5.3.3 Transmitter Timing Jitter

RMS period jitter over an integration time interval of 1 ms $\pm$ 10% is defined as the root mean square period difference from the average period $(T - T_{avg})$ accumulated over a sample size of 200000 $\pm$ 20000.

$$RMS\ period\ jitter < \sqrt{\frac{\left(\sum [(T - Tavg)^2]\right)}{Sample\ Size}}$$

MGBase-T and NBASE-T, Spec IEEE 802.3—2018 Clause 126.5.3.3 Transmitter Timing Jitter

RMS period jitter over an integration time interval of 2ms $\pm$ 10% for 5.0G and 4ms $\pm$ 10% for 2.5G is defined as the root mean square period difference from the average period $(T - T_{avg})$ accumulated over a sample size of 200000 $\pm$ 20000.

$$RMS\ period\ jitter < \sqrt{\frac{\sum [(T - Tavg)^2]}{Sample\ Size}}$$

Pass Condition

The RMS period jitter measured at the MDI must be:

- Less than 5.5 ps for all the test pairs of 10GBase-T tests.
- Less than 10 ps for all the test pairs of MGBase-T (2.5G) and NBase-T (2.5G) tests.
- Less than 7.2 ps for all the test pairs of MGBase-T (5.0G) and NBase-T (5.0G) tests.
- Less than 2.1 ps for all the test pairs of 25GBase-T test.

Measurement Algorithm

1   Configure the MASTER DUT to produce Test Mode 2 signal.
2   On the Infiniium Oscilloscope,
    a   Convert the single ended signal to differential signal:
    FUNC2 = Positive Connection Pair (default Channel1) subtract Negative Connection Pair (default Channel3) to get the differential signal.
    b   Trigger on the rising edge of Positive Connection Pair. Set the trigger level to offset voltage of Positive Connection Pair.
    c   In the **Configure** tab of the Conformance Test Application, set the sampling rate:
    - On the UXR Oscilloscopes, set the value as 32 GSa/s.
    - On the MXR oscilloscopes, set the value as 16 GSa/s.
3   On the 25GBASE-T Ethernet Test Application, apply a Bandpass filter of 2 MHz bandwidth in the following manner:
    - 200 MHz center frequency for **Specification: IEEE** and **Data Rate: 10G**,
    - 500 MHz center frequency for **Specification: IEEE** and **Data Rate: 25G**,
    - 100 MHz center frequency for **Specification: MGBASE-T** or **NBASE-T** and **Data Rate: 5.0G**,
    - 50 MHz center frequency for **Specification: MGBASE-T** or **NBASE-T** and **Data Rate: 2.5G**.
4   On the Infiniium oscilloscope,
    a   The number of acquisitions to be taken depends on the time range and the memory depth selected by the user:
    Number of Acq = Time Range / (Memory Depth * 1/Sampling Rate)
    b   Enable the histogram and measure the period to the acquired waveform.
    c   Take the standard deviation from the histogram statistics.
    d   Compare the test result with the conformance test limit.

Test References

- See Clause 55.5.3.3 Transmitter Timing Jitter in the *IEEE 802.3-2018 Standard* for the 10GBase-T.
- See Clause 113.5.3.3 Transmitter Timing Jitter in the *IEEE 802.3-2018 Standard* for the 25GBase-T.
- See Clause 126.5.3.3 Transmitter Timing Jitter in the *IEEE 802.3-2018 Standard* for the MGBase-T and NBase-T.

7 Transmit Clock Frequency Test

This section provides the Methods of Implementation (MOIs) for Transmit Clock Frequency test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; 25GBase-T Transmitter Test Fixture and the Keysight D90103BQC 25GBASE-T Ethernet Test Application.

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Procedure for Transmit Clock Frequency Test

Running the Transmit Clock Frequency Test using the 25GBase-T Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Transmit Clock Frequency test, refer to "Connections for Conformance Tests" on page 23.

3   Based on the transmitter text fixture in use, make one of the following connections:

   · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

   · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the any two of the oscilloscope channels by using the cables.

5   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

6   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

   · **Specification: IEEE** and **Data Rate: 10G** or **25G**,

   · **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

   · **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

7   Based on the test requirements, select the appropriate options and perform connections in the **Spectral Analysis** and **External Instruments** areas.

8   Enter your comments in the **Comments** text box.

9   Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
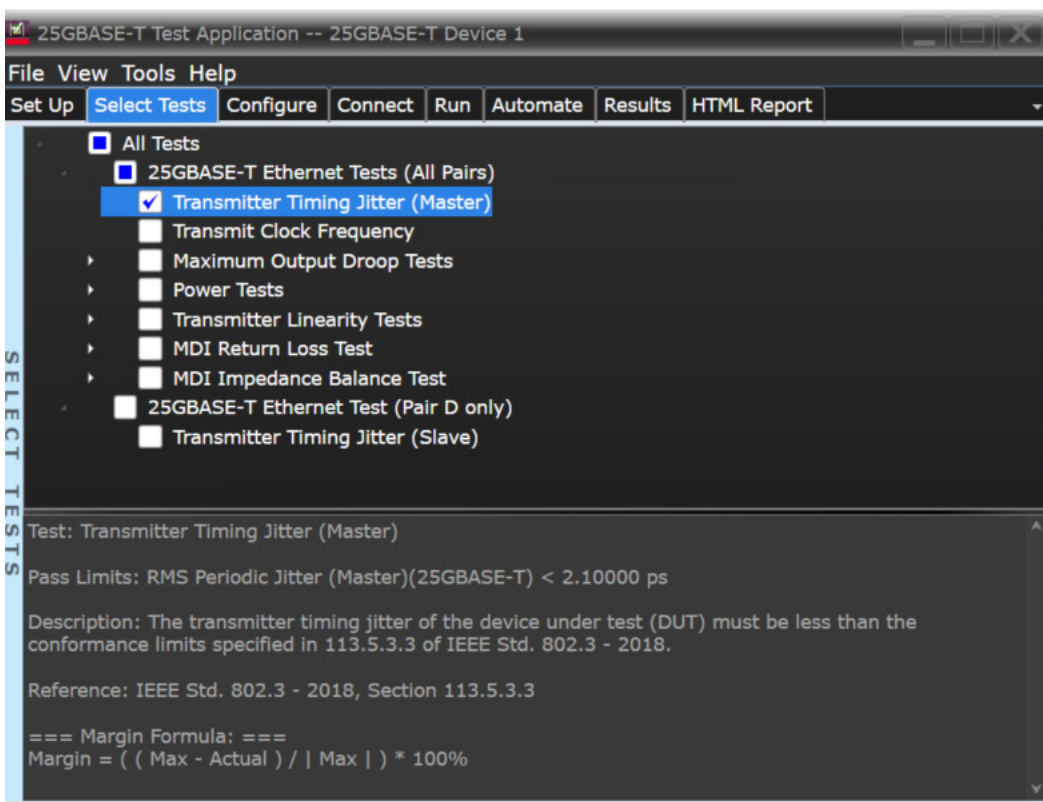
Figure 15   Selecting Transmitter Clock Frequency test

10 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options
(see Table 2), run the test, and view the test results.

Table 2   Test Configuration Options

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Signal Type	Type of signal generated on the Oscilloscope.
Sampling Rate [Debug Mode]	Sampling Rate configured on the Oscilloscope.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to
the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Transmit Clock Frequency Test—Implementation Methodology

The purpose of the Transmit Clock Frequency test is to verify that the device under test (DUT) meets the requirements as specified in:

- Clause 113.5.3.5 of *IEEE 802.3-2018* for the 25GBase-T DUT
- Clause 55.5.3.5 of *IEEE 802.3-2018* for the 10GBase-T DUT
- Clause 126.5.3.5 of *IEEE 802.3-2018* for the NBase-T and MGBase-T DUT

For this test, the Transmit Clock, which is recovered from the transmitted Quinary symbol sequence, must have a symbol rate of 2000 MBd ± 50 ppm for the 25GBase-T DUT, 800 MHz ± 50 ppm for the 10GBase-T DUT, 400 MHz ± 50 ppm for the MGBase-T (5.0G) DUT, 200 MHz ± 50 ppm for the MGBase-T (2.5G) DUT, 400MHz ± 50ppm for the NBase-T (5G) DUT, and 200 MHz ± 50 ppm for the NBase-T (2.5G) DUT. This is verified for each of the four pairs of the Test Mode 2 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018, Clause 55.5.3.5 Transmit Clock Frequency

The symbol transmission rate on each pair of the MASTER PHY shall be within the range 800 MHz ± 50 ppm.

25GBase-T, Spec IEEE 802.3—2018, Clause 113.5.3.5 Transmit Clock Frequency

The symbol transmission rate on each pair of the MASTER PHY shall be within the range 2000 MBd ± 50 ppm.

MGBase-T and NBase-T, Spec IEEE 802.3—2018, Clause 126.5.3.5 Transmit Clock Frequency

The symbol transmission rate on each pair of the MASTER PHY shall be within the range 400 MHz ± 50 ppm and 200 MHz ± 50 ppm for the 5.0G and 2.5G modes, respectively.

Pass Condition

The Transmit Clock, which is recovered from the transmitted Quinary symbol sequence, must have a symbol rate of 2000 MBd ± 50 ppm for the 25GBase-T DUT, 800 MHz ± 50 ppm for the 10GBase-T DUT, 400 MHz ± 50 ppm for the MGBase-T (5.0G) DUT, 200 MHz ± 50 ppm for the MGBase-T (2.5G) DUT, 400MHz ± 50ppm for the NBase-T (5.0G) DUT, and 200 MHz ± 50 ppm for the NBase-T (2.5G) DUT; depending on the data.

Measurement Algorithm

1 Configure the DUT to produce Test Mode 2 signal.
2 On the Infiniium oscilloscope,
   a Convert the single ended signal to differential signal:
   FUNC2 = Positive Connection Pair (default Channel1) subtract Negative Connection Pair (default Channel3) to get the differential signal.
   b Trigger on the rising edge of Positive Connection Pair. Set the trigger level to offset voltage of Positive Connection Pair.
   c In the **Configure** tab of the 25GBASE-T Ethernet Test Application, set the sampling rate:
   - On the UXR Oscilloscopes, set the value as 32 GSa/s.

- On the MXR oscilloscopes, set the value as 16 GSa/s.

d Measure the clock data rate of the FUNC2 signal with the clock recovery option as Semi-Automatic.

e Compare the test result with the conformance test limit.

Test References

- See Clause 55.5.3.5 Transmit Clock Frequency in the *IEEE 802.3-2018 Standard* for the 10GBase-T.
- See Clause 113.5.3.5 Transmit Clock Frequency in the *IEEE 802.3-2018 Standard* for the 25GBase-T.
- See Clause 126.5.3.5 Transmit Clock Frequency in the *IEEE 802.3-2018 Standard* for the MGBase-T and NBase-T.

8 Maximum Output Droop Test

This section provides the Methods of Implementation (MOIs) for Maximum Output Droop test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; 25GBase-T Transmitter Test Fixture and the 25GBASE-T Ethernet Test Application.

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Procedure for Maximum Output Droop Test

Running the Maximum Output Droop Test using the 25GBase-T Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Maximum Output Droop test, refer to "Connections for Conformance Tests" on page 23.

3   Based on the transmitter text fixture in use, make one of the following connections:

   · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

   · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the any two of the oscilloscope channels by using the cables.

5   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

6   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

   · **Specification: IEEE** and **Data Rate: 10G** or **25G**,

   · **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

   · **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

7   Based on the test requirements, select the appropriate options and perform connections in the **Spectral Analysis** and **External Instruments** areas.

8   Enter your comments in the **Comments** text box.

9   Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
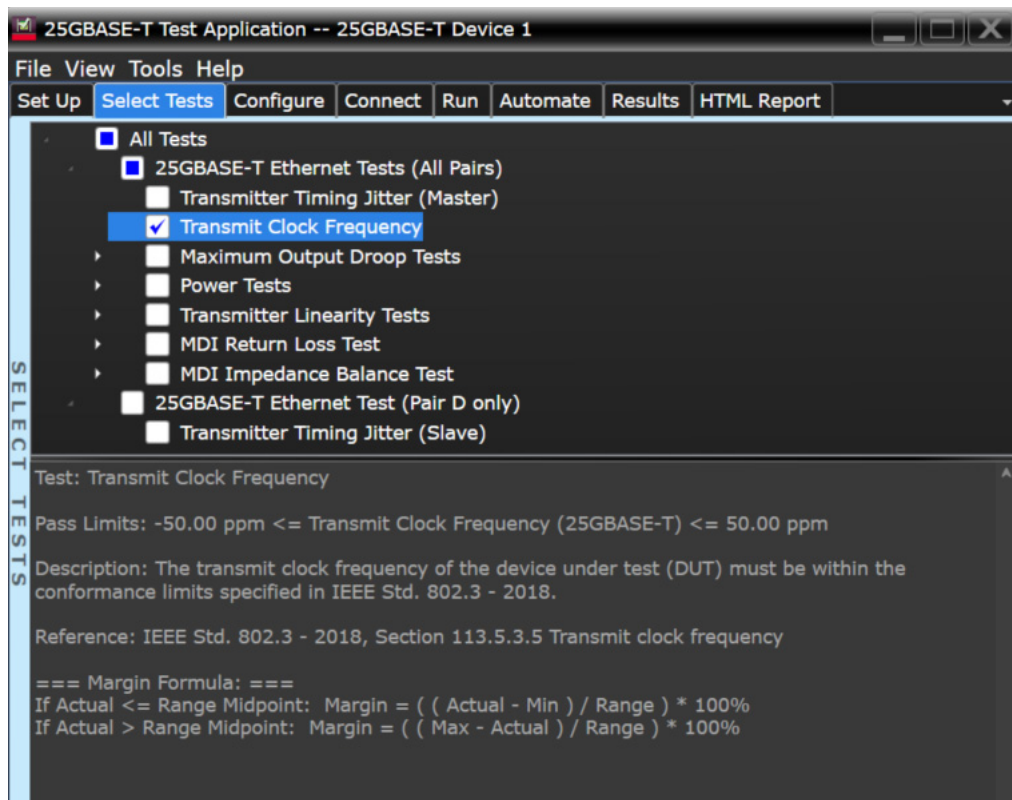
Figure 16   Selecting Maximum Output Droop test

10 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options
    (see Table 3), run the test, and view the test results.

Table 3   Test Configuration Options

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Signal Type	Type of signal generated on the Oscilloscope.
Sampling Rate [Debug Mode]	Sampling Rate configured on the Oscilloscope.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to
    the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Maximum Output Droop Test—Implementation Methodology

The purpose of the Maximum Output Droop test is to verify that the positive and negative droop of the device under test (DUT) is within the conformance limits specified in:

- Clause 113.5.3.1 of *IEEE 802.3-2018* for the 25GBase-T DUT
- Clause 55.5.3.1 of *IEEE 802.3-2018* for the 10GBase-T DUT
- Clause 126.5.3.1 of *IEEE 802.3-2018* for the MGBase-T and NBase-T DUT

For the 10GBase-T DUT, the magnitude of both the positive and negative droop must be less than 10%, measured at initial value of 10 ns after the zero cross point and final value at 90 ns after the zero cross point. This droop will be verified for each of the four pairs of the 10G Test Mode 6 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

For the 25Base-T DUT, the amplitude of both the positive and negative droop must be less than 10%, measured at initial value of 4 ns after the zero cross point and final value at 36 ns after the zero cross point. This droop will be verified for each of the four pairs of the 25G Test Mode 6 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

For the MGBASE-T (5.0G) and NBASE-T (5.0G) DUT, the amplitude of both the positive and negative droop must be less than 12.5%, measured at initial value of 10 ns after the zero crossing and a final value at 170 ns after the zero crossing.

For the MGBASE-T (2.5G) and NBASE-T (2.5G) DUT, the amplitude of both the positive and negative droop must be less than 17.5%, measured at initial value of 10ns after the zero crossing and a final value at 330ns after the zero crossing.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018, Clause 55.5.3.1 Maximum Output Droop

With the transmitter in Test Mode 6 and using the transmitter test fixture 1, the magnitude of both the positive and negative droop shall be less than 10%, measured with respect to an initial value at 10 ns after the zero crossing and final value at 90 ns after the zero crossing.

25GBase-T, Spec IEEE 802.3—2018, Clause 113.5.3.1 Maximum Output Droop

With the transmitter in Test Mode 6 and using the transmitter test fixture 1, the magnitude of both the positive and negative droop shall be less than 10%, measured with respect to an initial value at 4ns after the zero crossing and final value at 36 ns after the zero crossing.

MGBase-T (5.0G) and NBASE-T (5.0G), Spec IEEE 802.3—2018, Clause 126.5.3.1 Maximum Output Droop

With the transmitter in test mode 6 and using the transmitter test fixture 1, the magnitude of both the positive and negative droop shall be less than 12.5%, measured with respect to an initial value at 10 ns after the zero crossing and final value at 170 ns after the zero crossing.

MGBase-T (2.5 G) and NBASE-T (2.5G), Spec IEEE 802.3—2018, Clause 126.5.3.1 Maximum Output Droop

With the transmitter in test mode 6 and using the transmitter test fixture 1, the magnitude of both the positive and negative droop shall be less than 17.5%, measured with respect to an initial value at 10 ns after the zero crossing and a final value at 330 ns after the zero crossing.

Pass Condition

The average droop over all acquisitions in a given lane must be less than 10% for the 25GBase-T DUT, 10GBase-T DUT, and MGBase-T DUT. It should be less than 12.5% for the NBase-T (5.0G) DUT and 17.5% for the NBase-T (2.5G) DUT.

Measurement Algorithm

1   Configure the DUT to produce Test Mode 6 signal.
2   On the Infiniium oscilloscope,
    a   Convert the single ended signal to differential signal:
    FUNC2 = Positive Connection Pair (default Channel1) subtract Negative Connection Pair (default Channel3) to get the differential signal.
    b   Trigger on the rising edge of Positive Connection Pair. Set the trigger level to offset voltage of Positive Connection Pair.
    c   In the **Configure** tab of the Conformance Test Application, set the sampling rate:
    ·   On the UXR Oscilloscopes, set the value as 32 GSa/s.
    ·   On the MXR oscilloscopes, set the value as 16 GSa/s.
    d   Measure the amplitude at 4 ns reference from the trigger point for 25GBase-T and 10 ns for 10GBase-T.
    e   Measure the amplitude at 36 ns reference from the trigger point for 25GBASE-T, 90 ns for the 10GBase-T and MGBASE-T, 170ns for NBASE-T (5.0G), and 330ns NBASE-T (2.5G).
    f   Calculate the droop:
    % droop for 25GBase-T= (4 ns amplitude) - (36 ns amplitude)/(4 ns amplitude)
    or
    % droop= (10ns amplitude) - (90/170/330 ns amplitude)/(10ns amplitude)
    g   Compare the test result with the conformance test limits.

Test References

·   See Clause 113.5.3.1 Maximum Output Droop in the *IEEE 802.3-2018* for the 25GBase-T DUT.
·   See Clause 55.5.3.1 Maximum Output Droop in the *IEEE 802.3-2018* for the 10GBase-T DUT.
·   See Clause 126.5.3.1 Maximum Output Droop in the *IEEE 802.3-2018* for the MGBase-T and NBase-T DUT.

9 Transmitter Power Spectral Density Test

This section provides the Methods of Implementation (MOIs) for Transmitter Power Spectral Density test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; Spectrum Analyzer, 25GBase-T Transmitter Test Fixture, and the 25GBASE-T Ethernet Test Application.

There are two methods of running the Transmitter Power Spectral Density test:

- Using an External Spectrum Analyzer.
- Using the Oscilloscope.

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Procedure for Transmitter Power Spectral Density Test Using an External Spectrum Analyzer

Running the Transmitter Power Spectral Density Test using the 25GBASE–T Ethernet Test Application

1 Start the 25GBASE–T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2 To make connections for the Transmitter Power Spectral Density test, refer to "Connections for Conformance Tests" on page 23.

3 Based on the transmitter text fixture in use, make one of the following connections:

- **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase–T Transmitter Test Fixture.

- **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase–T Transmitter Test Fixture.

4 Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the Balun by using the cables.

5 Connect the Balun to the Spectrum Analyzer by using the SMA cable.

6 Use a LAN or GPIB to USB cable to connect the Spectrum Analyzer to the Oscilloscope.

7 In the 25GBASE–T Ethernet Test Application, click the **Set Up** tab.

8 Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

- **Specification: IEEE** and **Data Rate: 10G** or **25G**,

- **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

- **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

9 In the **Spectral Analysis** area, select **Use Spectrum Analyzer**.

10 Ensure that the application detects the Spectrum Analyzer connection to the Oscilloscope. If the status indicates **Not Connected**, click the **Connect...** button in the **Spectrum Analyzer** area of the **External Instruments** section of the 25GBASE–T Ethernet Test Application.

11 A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 17.

Figure 17   Checking VISA/SICL address for Spectrum Analyzer in the Keysight Connection Expert

12 Once the 25GBASE-T Ethernet Test Application detects the Spectrum Analyzer, it is indicated on the **Set Up** tab as shown in Figure 18.
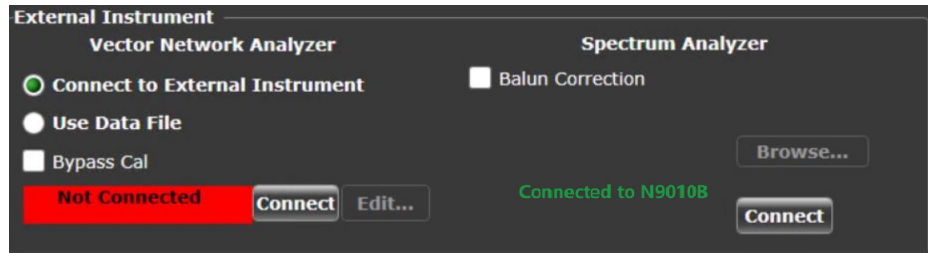
Figure 18   Connection status after the Test App detects the Spectrum Analyzer

13 Enter your comments in the **Comments** text box.

14 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

15 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 4), run the test, and view the test results.

Table 4   Test Configuration Options Using Spectrum Analyzer

Configuration Option	Description
Power Test	
Start Frequency	The start frequency for the Spectrum Analyzer.
Stop Frequency	The stop frequency for the Spectrum Analyzer.
Resolution Bandwidth	The resolution bandwidth for the Spectrum Analyzer.
Test Type [Debug Mode]	The test type for the Power Spectral Density test.
Command File [Debug Mode]	The command file for the Spectrum Analyzer.
Reference Level	The reference level for the Spectrum Analyzer.
Frequency Resolution Step	The frequency resolution step use in plotting the graph for the external Spectrum Analyzer.
#Averages	The number of averages for Power Spectral Density test using the Spectrum Analyzer.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Procedure for Transmitter Power Spectral Density Test Using the Oscilloscope

Running the Transmitter Power Spectral Density Test using the 25GBASE-T Ethernet Test Application

1. Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.
2. To make connections for the Transmitter Power Spectral Density test, refer to "Connections for Conformance Tests" on page 23.
3. Based on the transmitter text fixture in use, make one of the following connections:
   - **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.
   - **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.
4. Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the oscilloscope.
5. In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.
6. Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.
   - **Specification: IEEE** and **Data Rate: 10G** or **25G**,
   - **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,
   - **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**
7. In the **Spectral Analysis** area, select **Use Oscilloscope**.
8. Enter your comments in the **Comments** text box.
9. Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
10. Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 5), run the test, and view the results.

Table 5   Test Configuration Options Using Oscilloscope

Configuration Option	Description
Signal Type	Type of signal supplied to the Oscilloscope.
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Sampling Rate [Debug Mode]	Sampling Rate configured on the Oscilloscope.
Power Test	
Spectral Windowing [Debug Mode]	The windowing function applied to the input data segment before implement FFT using Oscilloscope.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Selecting Transmitter Power Spectral Density Test

Figure 19 shows the tests available under the **Power Tests** group of the **Select Tests** tab.
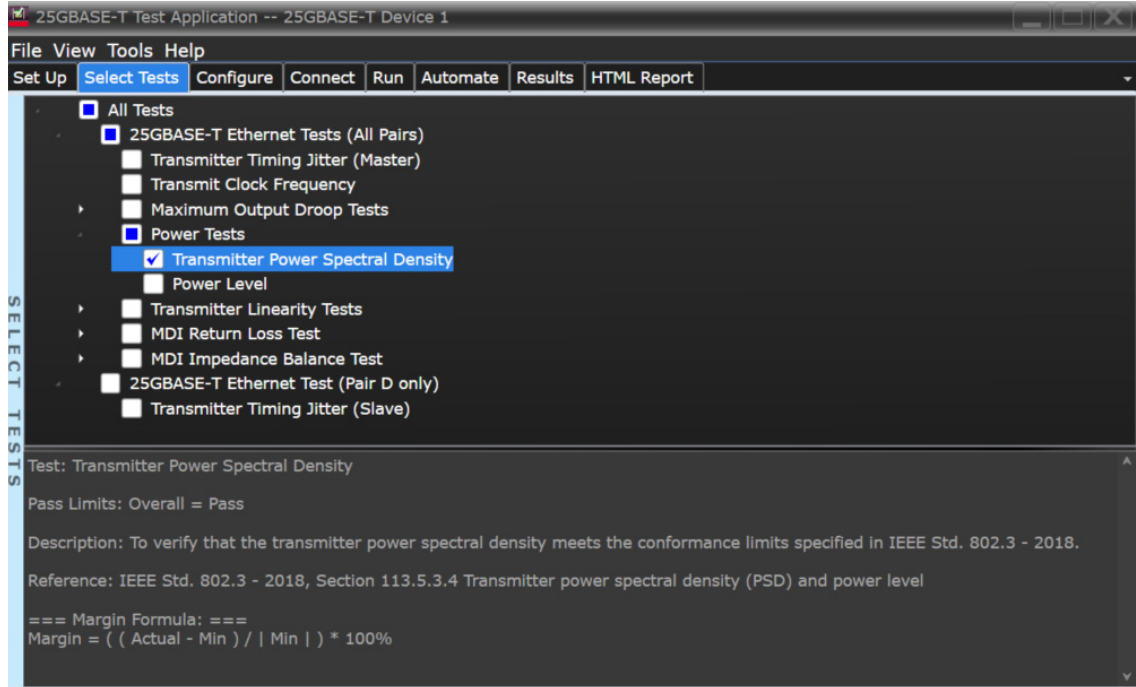
Figure 19   Selecting Power Spectral Density test

Transmitter Power Spectral Density Test—Implementation Methodology

The purpose of the Transmitter Power Density test is to verify that the power spectral density (PSD) of the device under test (DUT) is within the conformance limits specified in:

- Clause 55.5.3.4 of *IEEE 802.3-2018* for the 10GBase-T DUT
- Clause 113.5.3.4 of *IEEE 802.3-2018* for the 25GBase-T DUT
- Clause 126.5.3.4 of *IEEE 802.3-2018* for the NBase-T and MGBase-T DUT

The PSD of the 10GBase-T, 25GBase-T, and MGBase-T / NBase-T (2.5G / 5.0G) must be within the upper and lower masks as shown in Figure 20, Figure 21, and Figure 22 respectively below. PSD of the DUT is verified for each of the four lanes of Test Mode 5 signal. These pairs are identified as Pair A, Pair B, Pair C and Pair D.
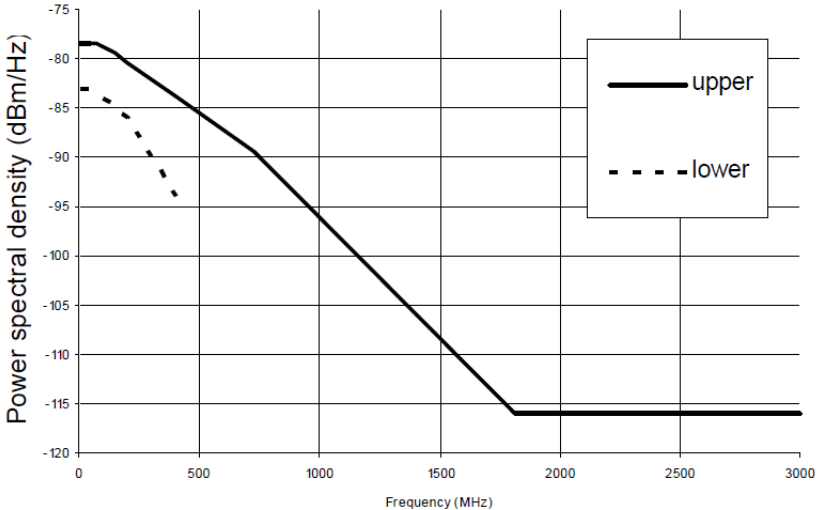
Figure 20   PSD vs. Frequency for a 10GBase-T DUT
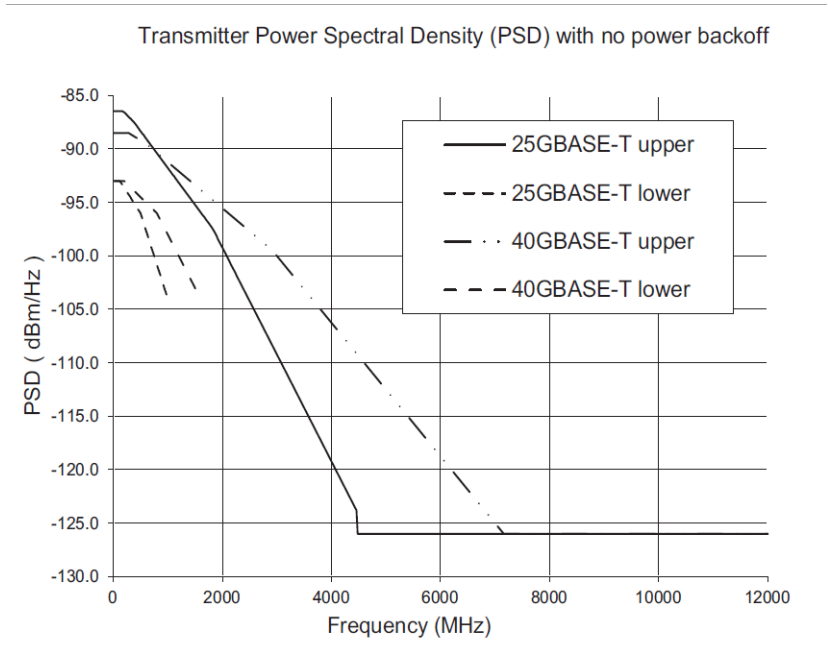
Figure 21   PSD vs. Frequency for a 25GBase-T DUT
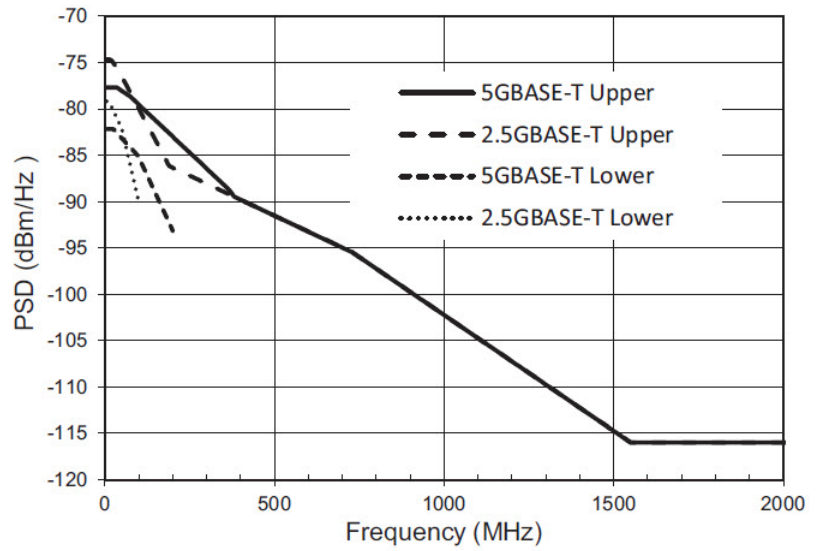
Figure 22   PSD vs. Frequency for MGBase-T / NBase-T DUT (2.5G & 5G)

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3–2018, Clause 55.5.3.4 Power Spectral Density

The power spectral density of the transmitter, measured into a 100 Ω load using the test fixture for a 10GBase-T DUT, shall be between the upper and lower masks specified in the equations shown in Figure 23. The masks are shown graphically in Figure 20.

$$\text{Upper PSD } (f) \le \begin{cases} -78.5 \ \text{dBm/Hz} & 0 < f \le 70 \\ -78.5 - \left(\dfrac{f-70}{80}\right) \text{dBm/Hz} & 70 < f \le 150 \\ -79.5 - \left(\dfrac{f-150}{58}\right) \text{dBm/Hz} & 150 < f \le 730 \\ -79.5 - \left(\dfrac{f-330}{40}\right) \text{dBm/Hz} & 730 < f \le 1790 \\ -116 \ \text{dBm/Hz} & 1790 < f \le 3000 \end{cases} \qquad (55\text{–}9)$$

$$\text{Lower PSD } (f) \ge \begin{cases} -83 \ \text{dBm/Hz} & 5 \le f \le 50 \\ -83 - \left(\dfrac{f-50}{50}\right) \text{dBm/Hz} & 50 < f \le 200 \\ -86 - \left(\dfrac{f-200}{25}\right) \text{dBm/Hz} & 200 < f \le 400 \end{cases} \qquad (55\text{–}10)$$

Figure 23   Equations for PSD Masks applicable to 10GBase-T DUT

25GBase-T, Spec IEEE 802.3–2018, Clause 113.5.3.4 Power Spectral Density

The power spectral density of the transmitter, measured into a 100 Ω load using the test fixture for a 25GBase-T DUT, shall be between the upper and lower masks specified in the equations shown in Figure 24. The masks are shown graphically in Figure 21.

$$
\text{Upper PSD }(f) \leq
\begin{cases}
-88.5 - 10\log_{10} S \ \text{dBm/Hz} & 0 < \dfrac{f}{S} \leq 280 \\[2ex]
-88.5 - 10\log_{10} S - \left(\dfrac{\frac{f}{S} - 280}{320}\right) \text{dBm/Hz} & 280 < \dfrac{f}{S} \leq 600 \\[2ex]
-89.5 - 10\log_{10} S - \left(\dfrac{\frac{f}{S} - 600}{232}\right) \text{dBm/Hz} & 600 < \dfrac{f}{S} \leq 2920 \\[2ex]
-89.5 - 10\log_{10} S - \left(\dfrac{\frac{f}{S} - 1320}{160}\right) \text{dBm/Hz} & 2920 < \dfrac{f}{S} \leq 7160 \\[2ex]
-126 \ \text{dBm/Hz} & 7160 < \dfrac{f}{S} \leq \dfrac{12000}{S}
\end{cases}
\qquad (113\text{–}11)
$$

$$
\text{Lower PSD }(f) \geq
\begin{cases}
-93 \ \text{dBm/Hz} & 20 \leq f \leq 200 \\[2ex]
-93 - \left(\dfrac{\frac{f}{S} - 200}{200}\right) \text{dBm/Hz} & 200 < \dfrac{f}{S} \leq 800 \\[2ex]
-96 - \left(\dfrac{\frac{f}{S} - 800}{100}\right) \text{dBm/Hz} & 800 < \dfrac{f}{S} \leq \dfrac{1600}{S}
\end{cases}
\qquad (113\text{–}12)
$$

Figure 24   Equations for PSD Masks Applicable to 25GBase-T DUT

Note: For Lower PSD (f), the equation followed by application differs from the equation mentioned in specification (as shown in Figure 24). With reference to formula 113-12, the application follows the below equation.

$$
\text{Lower PSD }(f) \geq
\begin{cases}
-93 \ \text{dBm/Hz} & 20 \leq \dfrac{f}{S} \leq 200 \\[2ex]
-93 - \left(\dfrac{\frac{f}{S} - 200}{200}\right) \text{dBm/Hz} & 200 < \dfrac{f}{S} \leq 800 \\[2ex]
-96 - \left(\dfrac{\frac{f}{S} - 800}{100}\right) \text{dBm/Hz} & 800 < \dfrac{f}{S} \leq 1600
\end{cases}
$$

MGBase-T and NBase-T, Spec IEEE 802.3–2018, Clause 126.5.3.4 Transmit Power Spectral Density (PSD)

The power spectral density of the transmitter measured into a 100 Ω load using the test fixture for the NBase-T / MGBase-T (2.5G) and NBase-T / MGBase-T (5.0G) DUT shall be between the upper and lower masks specified in the respective equations shown in Figure 25. The masks are shown graphically in Figure 22.

$$PSD1(f) \leq \begin{cases} -77.7 - 10 \times \log_{10}(S) & \text{dBm/Hz} \quad 0 < 2\frac{f}{S} \leq 70 \\[2mm] -77.7 - 10 \times \log_{10}S - \dfrac{\left(2\frac{f}{S} - 70\right)}{80} & \text{dBm/Hz} \quad 70 < 2\frac{f}{S} \leq 150 \\[2mm] -78.7 - 10 \times \log_{10}S - \dfrac{\left(2\frac{f}{S} - 150\right)}{58} & \text{dBm/Hz} \quad 150 < 2\frac{f}{S} \leq 730 \\[2mm] -78.7 - 10 \times \log_{10}S - \dfrac{\left(2\frac{f}{S} - 330\right)}{40} & \text{dBm/Hz} \quad 730 < 2\frac{f}{S} \leq 1822 - 400 \times \log_{10}(S) \\[2mm] -116 & \text{dBm/Hz} \quad S \times (911 - 200 \times \log_{10}(S)) < f \leq 3000 \end{cases}$$

$$UpperPSD(f) \leq \max(PSD1(f), (\text{Equation 55-9}) - 6 \text{ dB})$$

(126–9)

and

$$\text{Lower PSD } (f) \geq \begin{cases} -82.2 - 10 \times \log_{10}(S) & \text{dBm/Hz} \quad 5 < 2\frac{f}{S} \leq 50 \\[2mm] -82.2 - 10 \times \log_{10}S - \dfrac{\left(2\frac{f}{S} - 50\right)}{50} & \text{dBm/Hz} \quad 50 < 2\frac{f}{S} \leq 200 \\[2mm] -85.2 - 10 \times \log_{10}S - \dfrac{\left(2\frac{f}{S} - 200\right)}{25} & \text{dBm/Hz} \quad 200 < 2\frac{f}{S} \leq 400 \end{cases}$$

(126–10)

Figure 25   Equations for PSD Masks applicable to MGBase-T and NBase-T (2.5G & 5.0G) DUT

Pass Condition

The signal obtained from the Test Mode 5 must fit within the PSD mask shown in Figure 20, Figure 21, or Figure 22.

Measurement Algorithm When Using an External Spectrum Analyzer

1 Configure the DUT to produce Test Mode 5 signal.

2 Configure the following parameters in the **Configure** tab of the 25GBASE-T Ethernet Test Application to set up the External Spectrum Analyzer:

   a For the 10Base-T/NBase-T/MGBase-T, the Start frequency is 0 MHz and the Stop frequency is 3 GHz. For the 25GBase-T, the Start frequency is 0 MHz and the Stop frequency is 12 GHz.

   b Resolution bandwidth = 3 MHz (MXR Oscilloscopes and UXR Oscilloscopes).

   c Averaging (default value is 50).

3 Configure the following parameters on the Spectrum Analyzer:

   a Noise marker function

   b DC coupling (not applicable for the Economic Spectrum Analyzers)

4 Collect the data from the Spectrum Analyzer to the 25GBASE-T Ethernet Test Application and plot the graph.

5 Set the Spectrum Analyzer to AC coupling mode.

6 Compare each point of the graph with the upper and lower limits with respective to the frequency.

Measurement Algorithm When Using the Oscilloscope

1 Configure the DUT to produce Test Mode 5 signal.

2 On the Infiniium oscilloscope,

   a Trigger and collect the waveform from the oscilloscope.

   b Apply the selected windowing function to the sampled waveform.

   c Compute the power spectra as:

$$\text{power spectra } = \ \frac{1}{N} \ \sum_{i=0}^{N-1} \ \left| \text{FFT amplitude[i]} \right|^2$$

Where N = number of segments or cycles to compute.

   d Apply a correction factor to the signal to compensate windowing losses:

$$\text{Correction factor } = \ \frac{\text{nfft}}{\left\{ \sum (\text{window function})^2 \right\}}$$

   e Normalize the power spectra to get the power spectral density:

$$\text{power spectral density } (V^2/\text{Hz}) \ = \ \text{Power spectra } /F_s$$

   f Convert the amplitude of the power spectral density from Vp^2 to Vrms^2.

   g Compare each point of the result to the upper and lower limits with respect to the frequency.

Test References

- See Clause 55.5.3.4 Transmitter Power Spectral Density (PSD) and Power Level in the *IEEE 802.3-2018 Standard* for the 10GBase-T DUT.
- See Clause 113.5.3.4 Transmitter Power Spectral Density (PSD) and Power Level in the *IEEE 802.3-2018 Standard* for the 25GBase-T DUT.
- See Clause 126.5.3.4 Transmitter Power Spectral Density (PSD) and Power Level in the *IEEE 802.3-2018 Standard* for the MGBase-T and NBASE-T DUT.

10 Power Level Test

This section provides the Methods of Implementation (MOIs) for Power Level test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; Spectrum Analyzer, 25GBase-T Transmitter Test Fixture and the 25GBASE-T Ethernet Test Application.

There are two methods of running the Power Level test:

· Using an External Spectrum Analyzer.

· Using the Oscilloscope.

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Procedure for Power Level Test Using an External Spectrum Analyzer

Running the Power Level Test using the 25GBASE-T Ethernet Test Application

1 Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2 To make connections for the Power Level test, refer to "Connections for Conformance Tests" on page 23.

3 Based on the transmitter text fixture in use, make one of the following connections:

   · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Ethernet Fixture.

   · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4 Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the Balun by using the cables.

5 Connect the Balun to the Spectrum Analyzer by using the SMA cable.

6 Use a LAN or GPIB to USB cable to connect the Spectrum Analyzer to the oscilloscope.

7 In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

8 Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

   · **Specification: IEEE** and **Data Rate: 10G** or **25G**,

   · **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

   · **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

9 In the **Spectral Analysis** area, select **Use Spectrum Analyzer**.

10 Ensure that the application detects the Spectrum Analyzer connection to the Oscilloscope. If the status indicates **Not Connected**, click the **Connect...** button in the **Spectrum Analyzer** area of the **External Instruments** section of the 25GBASE-T Ethernet Test Application.

11 A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 26.

Figure 26   Checking VISA/SICL address for Spectrum Analyzer in the Keysight Connection Expert

12 Once the 25GBASE-T Ethernet Test Application detects the Spectrum Analyzer, it is indicated on the **Set Up** tab as shown in Figure 27.
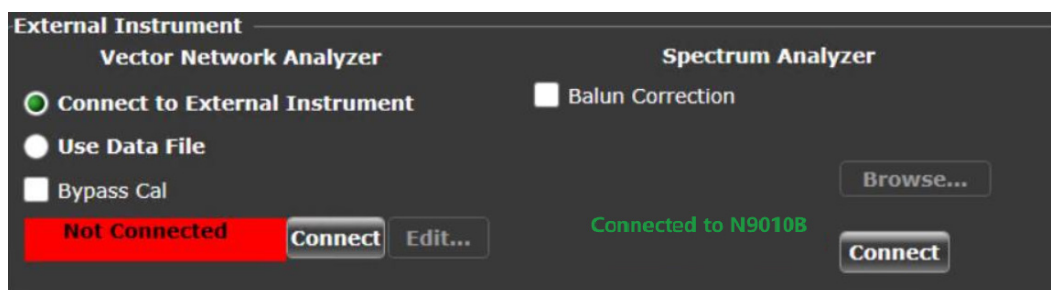
Figure 27   Connection Status after the Test App detects the Spectrum Analyzer

13 Enter your comments in the **Comments** text box.

14 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

15 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 6), run the test, and view the test results.

Table 6   Test Configuration Options Using Spectrum Analyzer

Configuration Option	Description
Power Test	
Start Frequency	The start frequency for the Spectrum Analyzer.
Stop Frequency	The stop frequency for the Spectrum Analyzer.
Input Impedance	The input impedance for the power level test.
Resolution Bandwidth	The resolution bandwidth for the Spectrum Analyzer.
Test Type [Debug Mode]	The test type for the Power Level test.
Command File [Debug Mode]	The command file for the Spectrum Analyzer.
Reference Level	The reference level for the Spectrum Analyzer.
#Averages	The number of averages for Power Level test using the Spectrum Analyzer.
Timeout	The timeout for the power level test.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Procedure for Power Level Test Using the Oscilloscope

Running the Power Level Test using the 25GBASE-T Ethernet Test Application

1   Start the 25GBase-T Conformance Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Power Level test, refer to "Connections for Conformance Tests" on page 23.

3   Based on the transmitter text fixture in use, make one of the following connections:

- **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

- **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the oscilloscope.

5   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

6   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

- **Specification: IEEE** and **Data Rate: 10G** or **25G**,

- **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

- **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

7   In the **Spectral Analysis** area, select **Use Oscilloscope**.

8   Enter your comments in the **Comments** text box.

9   Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

10 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 7), run the test, and view the results.

Table 7   Test Configuration Options Using Oscilloscope

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Signal Type	Type of signal supplied to the Oscilloscope.
Sampling Rate [Debug Mode]	Sampling Rate configured on the Oscilloscope.
Power Test	
Input Impedance	The Input Impedance configured on the Oscilloscope.
Memory Depth	Memory Depth configured on the Oscilloscope.
Spectral Windowing	Windowing function applied to the input data segment before implement FFT using Oscilloscope.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Selecting Transmitter Power Level Test

Figure 28 shows the tests available under the **Power Tests** group of the **Select Tests** tab.
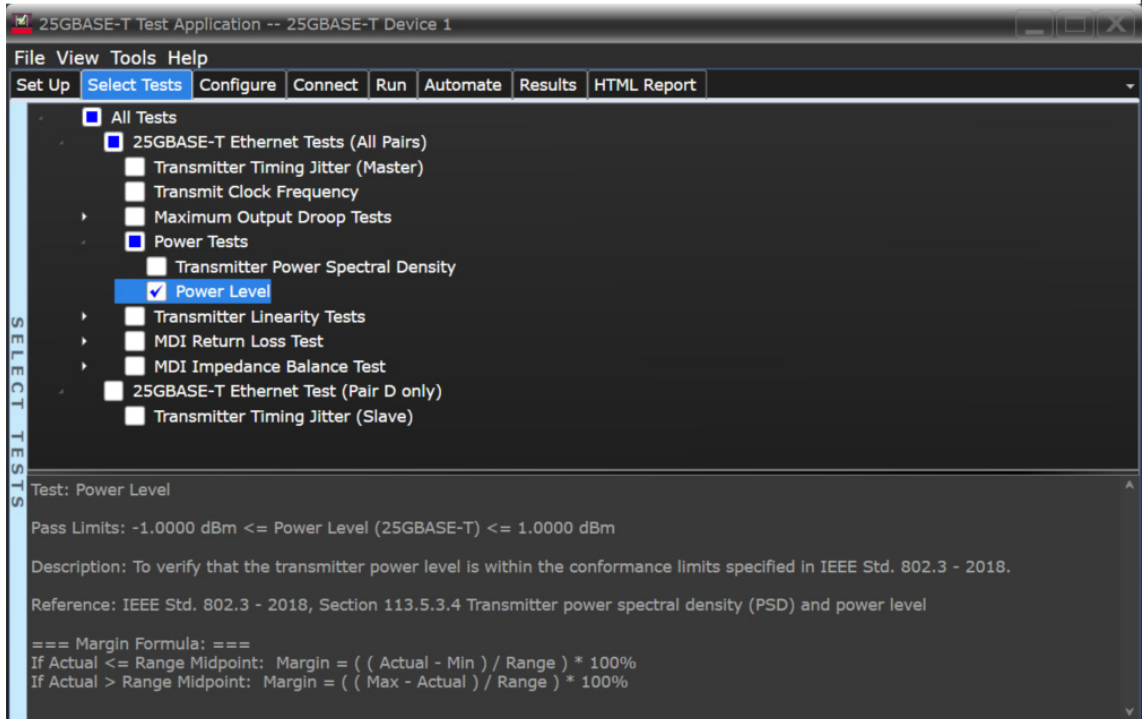
Figure 28   Selecting Power Level test

Power Level Test—Implementation Methodology

The purpose of the Power Level test is to verify that the power level of the device under test (DUT) meets the specification requirement as specified in:

- Clause 55.5.3.4 of *IEEE 802.3-2018* for the 10GBase-T DUT
- Clause 113.5.3.4 of *IEEE 802.3-2018* for the 25GBase-T DUT
- Clause 126.5.3.4 of *IEEE 802.3-2018* for the MGBase-T *and* NBase-T DUT

For 10GBase-T DUT, the obtained power level must be between 3.2 dBm to 5.2 dBm. This value is verified for each of the four pairs of the Test Mode 5 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

For 25GBASE-T DUT, the obtained power level must be between -1.0 dBm to 1.0 dBm. This value is verified for each of the four pairs of the Test Mode 5 signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

For MGBase-T (2.5G/5.0G) and NBASE-T (2.5G/5.0G) DUT, the obtained power level must be between 1.0 dBm and 3.0 dBm. This is 2.2 dBm below 10BASE-T bounds to limit emission on CAT5e, while still allows reasonable signal-to-noise ratio (SNR).

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018 Clause 55.5.3.4 Transmitter Power Spectral Density (PSD) and Power Level

In Test Mode 5 (normal operation with no power backoff), the transmit power shall be in the range 3.2 dBm to 5.2 dBm.

25GBase-T, Spec IEEE 802.3—2018 Clause 113.5.3.4 Transmitter Power Spectral Density (PSD) and Power Level

In Test Mode 5 (normal operation with no power backoff), the transmit power shall be in the range -1.0 dBm to 1.0 dBm.

MGBase-T and NBASE-T, Spec IEEE 802.3—2018 Section 126.5.3.4, Transmit Power Spectral Density (PSD) and Power Level

In Test Mode 5 (normal operation with no power backoff), the transmit power shall be in the range 1.0 to 3.0 dBm.

Pass Condition

For the 10GBase-T, the obtained Power Level must be between 3.2 dBm and 5.2 dBm from the frequency range of 3 MHz to 400 MHz.

For the 25GBase-T, the obtained Power Level must be between -1 dBm and 1 dBm from the frequency range of 3 MHz to 400 MHz.

For the MGBASE-T (2.5/5.0G) and NBASE-T (2.5/5.0G), the obtained Power Level must be between 1 dBm and 3 dBm from the frequency range of 3 MHz to 400 MHz.

Measurement Algorithm Using an External Spectrum Analyzer

1   Configure the DUT to produce Test Mode 5 signal.

2   Configure the following parameters in the **Configure** tab of the 25GBase-T Conformance Test Application:

   a   Start frequency = 3 MHz, Stop frequency = 400 MHz

   b   Resolution bandwidth = 3 MHz (for MXR oscilloscopes and UXR oscilloscopes)

   c   Averaging (default value is 50)

3   Configure the following parameters on the Spectrum Analyzer:

   a   Band/Interval Power marker function

   b   DC coupling (not applicable for the Economy Spectrum Analyzers)

   c   Measure the Power Level within range of 3 MHz to 400 MHz

4   Collect the data from the Spectrum Analyzer to the 25GBASE-T Ethernet Test Application and plot the graph.

5   Set the Spectrum Analyzer to AC coupling mode.

6   Compare the test result with the conformance test limit.

Measurement Algorithm Using the Oscilloscope

1   Configure the DUT to produce Test Mode 5 signal.

2   On the Infiniium oscilloscope,

   a   Trigger and collect the waveform from the oscilloscope.

   b   Apply the selected windowing function to the sampled waveform.

   c   Compute the amplitude spectra as:

$$\text{Amplitude spectra(f)} \ = \ \frac{1}{N} \ \sum_{i\,=\,0}^{N-1} \text{FFT amplitude[i]}$$

   Where N = number of segments or cycles to compute.

   d   Apply a correction factor to the signal to compensate windowing losses:

$$\text{Correction factor} \ = \ \frac{n}{\left\{ \sum (\text{window function}) \right\}}$$

   e   Convert the amplitude to dBm.

   f   Calculate the band power:

$$\text{BP} \ = \ (\text{Bs}\,/\text{Bp}) \ \cdot \ \frac{1}{n2 - n1 + 1} \ \cdot \ \sum 10^{P\,[i]\,/10}$$

   Where:

   · Bs = specified bandwidth

      ·   For data rates lower than 25G, the Bs range is 400 MHz - 3 MHz.

      ·   For 25G data rate, the Bs range is 7.5 MHz - 1 GHz.

   · Bn = equivalent noise bandwidth of frequency resolution

   · n1 = index of first point

   · n2 = index of last point

- P = power in Watts

g Compare the result to the conformance limit.

Test References

- See Clause 55.5.3.4 Power Level in the *IEEE 802.3-2018 Standard* for the 10GBase-T DUT.
- See Clause 113.5.3.4 Power Level in the *IEEE 802.3-2018 Standard* for the 25GBase-T DUT.
- See Clause 126.5.3.4 Power Level in the *IEEE 802.3-2018 Standard* for the MGBase-T and NBASE-T DUT.

11 Transmitter Linearity Tests

This section provides the Methods of Implementation (MOIs) for Transmitter Linearity tests using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; Spectrum Analyzer, 25GBase-T Transmitter Test Fixture and the 25GBASE-T Ethernet Test Application.

There are two methods of running the Transmitter Linearity tests:

· Using an External Spectrum Analyzer.

· Using the Oscilloscope.

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Procedure for Transmitter Linearity Tests Using an External Spectrum Analyzer

Running the Transmitter Linearity Tests using the 25GBASE-T Ethernet Test Application

1 Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2 To make connections for the Transmitter Linearity tests, refer to "Connections for Conformance Tests" on page 23.

3 Based on the transmitter text fixture in use, make one of the following connections:

   · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

   · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4 Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the Balun by using the cables.

5 Connect the Balun to the Spectrum Analyzer by using the SMA cable.

6 Use a LAN or GPIB to USB cable to connect the Spectrum Analyzer to the oscilloscope.

7 In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

8 Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

   · **Specification: IEEE** and **Data Rate: 10G** or **25G**,

   · **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

   · **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**,

9 In the **Spectral Analysis** area, select **Use Spectrum Analyzer**.

10 Ensure that the application detects the Spectrum Analyzer connection to the oscilloscope. If the status indicates **Not Connected**, click the **Connect...** button in the **Spectrum Analyzer** area of the **External Instruments** section of the 25GBASE-T Ethernet Test Application.

11 A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 29.

Figure 29   Checking VISA/SICL address for Spectrum Analyzer in the Keysight Connection Expert

12 Once the 25GBASE-T Ethernet Test Application detects the Spectrum Analyzer, it is indicated on the **Set Up** tab as shown in Figure 30.
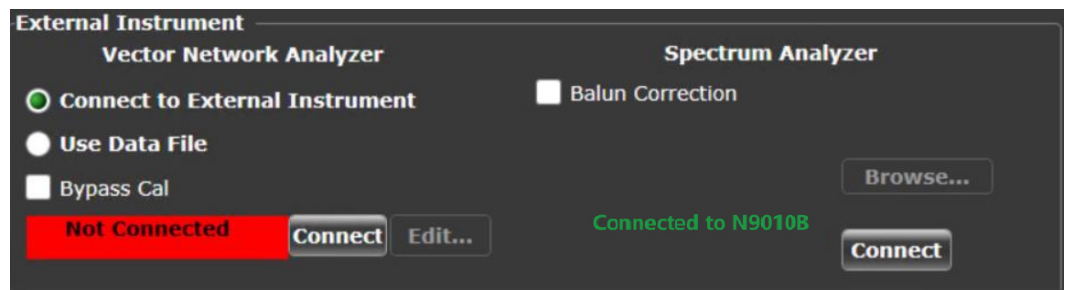
Figure 30   Connection status after the Test App detects the Spectrum Analyzer

13 Enter your comments in the **Comments** text box.

14 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

15 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 8), run the test, and view the test results.

Table 8   Test Configuration Options Using Spectrum Analyzer

Configuration Option	Description
Transmitter Linearity Tests	
Start Frequency	The start frequency for the Spectrum Analyzer.
Stop Frequency	The stop frequency for the Spectrum Analyzer.
Resolution Bandwidth	The resolution bandwidth for the Spectrum Analyzer.
Reference Level	The reference level for the Spectrum Analyzer.
Intermodulation Tolerance	The tolerance for intermodulation.
Test Type [Debug Mode]	The test type for Transmitter Linearity tests.
Command File [Debug Mode]	The command file for the Spectrum Analyzer.
Timeout	The timeout configured for the Spectrum Analyzer.
#Averages	The number of averages for Power Level test using the Spectrum Analyzer.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Procedure for Transmitter Linearity Tests Using the Oscilloscope

Running the Transmitter Linearity Tests using the 25GBase-T Test Application

1 Start the 25GBase-T Conformance Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2 To make connections for the Power Level test, refer to "Connections for Conformance Tests" on page 23.

3 Based on the transmitter text fixture in use, make one of the following connections:

- **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

- **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4 Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the oscilloscope.

> **NOTE** To view test instructions on the connection diagram to perform the connection changes, it is recommended not to select the "Suppress All Connection Prompts" check box in the Connect tab.

5 In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

6 Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

- **Specification: IEEE** and **Data Rate: 10G** or **25G**,

- **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

- **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**,

7 In the **Spectral Analysis** area, select **Use Oscilloscope**.

8 Enter your comments in the **Comments** text box.

9 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

10 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 9), run the test, and view the results.

Table 9   Test Configuration Options Using Oscilloscope

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Signal Type	Type of signal supplied to the Oscilloscope.
Sampling Rate (Debug Mode)	Sampling Rate configured on the Oscilloscope.
Transmitter Linearity Tests	
Memory Depth	Memory Depth configured on the Oscilloscope.
Spectral Windowing [Debug Mode]	Windowing function applied to the input data segment before implement FFT using Oscilloscope.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

List of Transmitter Linearity Tests

Figure 31 shows the tests available under the **Transmitter Linearity Tests** group of the **Select Tests** tab.
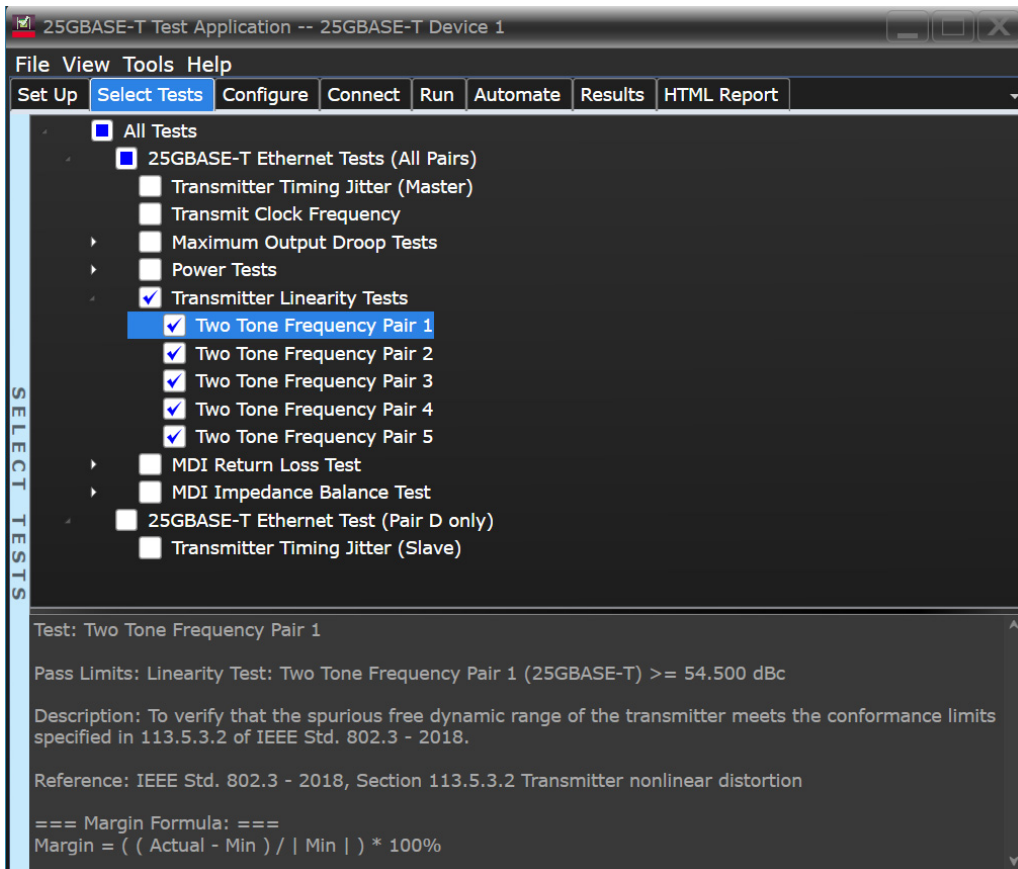

Figure 31   Selecting Transmitter Linearity Tests

Transmitter Linearity Tests—Implementation Methodology

The purpose of the Transmitter Linearity tests is to verify that the device under test (DUT) conforms to the Spurious Free Dynamic Range (SFDR) requirements specified in:

- Clause 55.5.3.2 of *IEEE 802.3-2018* for the 10GBase-T DUT
- Clause 113.5.3.2 of *IEEE 802.3-2018* for the 25GBase-T DUT
- Clause 126.5.3.2 of *IEEE 802.3-2018* for the MGBase-T DUT and NBase-T DUT

This SFDR will be verified for each of the four pairs of 10G/25G/NBase-T/MGBase-T Test Mode 4 with dual tone input signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018 Clause 55.5.3.2 Transmitter Linearity

When in Test Mode 4 and observing the spectrum of the differential signal output at the MDI using transmitter test fixture 2, for each pair, with no intervening cable, the transmitter linearity mask is defined as follows:

The SFDR of the transmitter, with dual tone inputs as specified in Test Mode 4, shall meet the requirement that:

$$SFDR \geq 2.5 + \min\{52,58 - 20 \times \log_{10}(f/25)\} \quad (55\text{-}7)$$

where f is the maximum frequency of the two test tones in MHz and SFDR is the ratio in dB of the minimum RMS value of either input tone to the RMS value of the worst inter-modulation product in the frequency range of 1 MHz to 400 MHz.

This specification on transmit linearity is derived from the requirement for interoperability with the far-end device.

25GBase-T, Spec IEEE 802.3—2018 Clause 113.5.3.2 Transmitter Linearity

When in Test Mode 4 and observing the spectrum of the differential signal output at the MDI using transmitter test fixture 2, for each pair, with no intervening cable, the transmitter linearity mask is defined as follows:

The SFDR of the transmitter, with dual tone inputs as specified in Test Mode 4, shall meet the requirement that:

$$SFDR \geq 2.5 + \min\{52,58 - 20 \times \log_{10}(f/(100 \times 0.625))\} \quad (113\text{-}9)$$

where f is the maximum frequency of the two test tones in MHz and SFDR is the ratio in dB of the minimum RMS value of either input tone to the RMS value of the worst inter-modulation product in the frequency range of 1 MHz to 1000 MHz.

This specification on transmit linearity is derived from the requirement for interoperability with the far-end device.

MGBase-T and NBase-T, Spec IEEE 802.3—2018 Clause 126.5.3.2 Transmitter Linearity

When in Test Mode 4 and observing the spectrum of the differential signal output at the MDI using transmitter test fixture 2, for each pair, with no intervening cable, the transmitter linearity mask is defined as follows:

The SFDR of the transmitter, with dual tone inputs as specified in Test Mode 4, shall meet the requirement that:

SFDR $\geq$ 2.5 + min{52,58 - 20 X $\log_{10}$(f/25)} (126-6)

where f is the maximum frequency of the two test tones in MHz and SFDR is the ratio in dB of the minimum RMS value of either input tone to the RMS value of the worst inter-modulation product in the frequency range of 1 MHz to 200 MHz and 1 MHz to 100 MHz for the 5G and 2.5G modes, respectively.

This specification on transmit linearity is derived from the requirement for interoperability with the far-end device.

Pass Condition

1   The SFDR of the transmitter for each Lane should meet the below requirement:
   · **10GBase-T**: SFDR $\geq$ 2.5 + min {52, 58 - 20$\log_{10}$(f/25)}
   · **25GBase-T**: SFDR $\geq$ 2.5 + min{52,58 - 20 X $\log_{10}$(f/(100 x 0.625))}
   · **MGBase-T** and **NBase-T**: SFDR $\geq$ 2.5 + min{52,58 - 20 X $\log_{10}$(f/25)}
   Where, f = maximum frequency of the two test tones
   SFDR = Ratio of the minimum RMS value between two input tone and worst intermodulation product of RMS.
2   The test limit of SFDR for each Lane should be different for different transmit frequency.

Table 10   Test Limit of SFDR for 10GBase-T

Transmit Frequency	Frequency Pair (MHz)	Test Limit (dBc)
1	36.718 & 41.406	$\geq$ 54.5
2	78.906 & 80.469	$\geq$ 50.346
3	139.844 & 141.406	$\geq$ 45.449
4	216.406 & 219.531	$\geq$ 41.629
5	310.156 & 313.281	$\geq$ 38.540

Table 11   Test Limit of SFDR for 25GBase-T

Transmit Frequency	Frequency Pair (MHz)	Test Limit (dBc)
1	91.796 & 103.515	$\geq$ 54.5
2	197.265 & 201.171	$\geq$ 50.346
3	349.609 & 353.515	$\geq$ 45.449
4	541.015 & 548.828	$\geq$ 41.629
5	775.390 & 783.203	$\geq$ 38.540

Table 12   Test Limit of SFDR for MGBase-T and NBase-T

Transmit Frequency	Frequency Pair for 2.5G (MHz)	Test Limit for 2.5G(dBc)	Frequency Pair for 5.0G (MHz)	Test Limit for 5.0G(dBc)
Dual Tone 1	9.1796 & 10.3515	≥ 54.5	18.359 & 20.703	≥ 54.5
Dual Tone 2	19.7265 & 20.11725	≥ 54.5	39.453 & 40.2343	≥ 54.5
Dual Tone 3	34.961 & 35.3515	≥ 54.5	69.922 & 70.703	≥ 51.47
Dual Tone 4	54.1015 & 54.88281	≥ 53.67	108.203 & 109.7656	≥ 47.649
Dual Tone 5	77.539 & 78.32031	≥ 50.581	155.078 & 156.6406	≥ 44.561

Measurement Algorithm When Using the External Spectrum Analyzer

1   Configure the DUT to produce Test Mode 4 signal and set the test frequency.

2   Configure the following parameters in the **Configure** tab of the 25GBASE-T Ethernet Test Application:

   a   Start frequency = 1 MHz

   b   Stop frequency = 400 MHz

   c   Resolution bandwidth:

   ·   200 kHz for 10G, 2.5G, and 5.0G data rates

   ·   200 kHz for 25G data rate if using SA

> **NOTE**   When using an external spectrum analyzer, the resolution bandwidth configuration shares the same variable as in oscilloscope usage.

   d   Averaging (default value is 50)

3   Configure the following parameter on the Spectrum Analyzer:

   a   DC coupling (not applicable for the Economic Spectrum Analyzers)

4   Collect the data from the Spectrum Analyzer to the 25GBASE-T Ethernet Test Application and plot the graph.

5   Calculate the Intermodulation Product Frequency with the below equation:

   Even Order = n(A+B), n(A-B)

   where, n = 2,4,6,8,10......120

   Odd Order = N(A)+/- (N-1)(B), N(B)+/- (N-1)(A)

   where,

   N = n - ((n/2)-0.5) and n = 3,5,7,9....119

   A, B = Two frequency components

6   Keep the list of the calculated frequency, L1.

7   Get the peak product frequency from the Spectrum Analyzer and keep it in another list, L2.

8   Compare L1 with L2 and keep the list of the peak value (obtained from the Spectrum Analyzer), L3 with the condition:

   ·   Frequency values that are close to the frequency (with default tolerance of 500 kHz) in L1.

9   SFDR = Highest Peak (L3) - Third Highest Peak (L3)

10 Set the Spectrum Analyzer to AC coupling mode.

11 Compare the test result with the conformance test limit.

Measurement Algorithm When Using the Oscilloscope

1   Configure the DUT to produce Test Mode 4 signal and set the test frequency.
2   Configure the following parameters in the **Configure** tab of the 25GBASE-T Ethernet Test Application:
   a   Start frequency = 1 MHz
   b   Stop frequency = 400 MHz
   c   Resolution bandwidth:
   ·   200 kHz for 10G, 2.5G, and 5.0G data rates (MXR and UXR oscilloscopes)
   ·   400 kHz for 25G data rate (UXR oscilloscopes)
   d   Averaging (default value is 50)
3   On the Infiniium oscilloscope,
   a   Trigger and collect the waveform from the oscilloscope.
   b   Apply the selected windowing function to the sampled waveform.
   c   Compute the amplitude spectra as:

$$\text{amplitude spectra} = \frac{1}{N} \sum_{i=0}^{N-1} |\text{FFT amplitude[i]}|$$

   Where N = number of segments or cycles to compute.
   d   Apply a correction factor to the signal to compensate windowing losses:

$$\text{Correction factor} = \frac{n}{\left\{ \sum (\text{window function}) \right\}}$$

   e   Convert the amplitude to dBm.
   f   Calculate the Intermodulation Product Frequency with the equation:
   Even Order = n(A+B), n(A-B)
   where, n = 2,4,6,8,10......120
   Odd Order = N(A)+/- (N-1)(B), N(B)+/- (N-1)(A)
   where,
   N = n - ((n/2)-0.5) and n = 3,5,7,9....119
   A, B = Two frequency components
4   Keep the list of the calculated frequency, L1.
5   Get the peak product frequency from the amplitude spectra (calculated in step 3c above) and keep it in another list, L2.
6   Compare L1 with L2 and keep the list of the peak value, L3, which is obtained from the amplitude spectra (calculated in step 3c above), with the condition:
   ·   Frequency values close to the frequency (with default tolerance of 500 kHz) in L1.
7   SFDR = Highest Peak (L3) - Third Highest Peak (L3)
8   Compare the test result with the conformance test limit.

Test References

- See Clause 55.5.3.2 Transmitter Linearity in the *IEEE 802.3-2018 Standard* for the 10GBase-T.
- See Clause 113.5.3.2 Transmitter Linearity in the *IEEE 802.3-2018 Standard* for the 25GBase-T.
- See Clause 126.5.3.2 Transmitter Linearity in the *IEEE 802.3-2018 Standard* for the MGBase-T and NBase-T.

12 Transmitter Nonlinear Distortion Tests

This section provides the Methods of Implementation (MOIs) for Transmitter Nonlinear Distortion tests using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; Spectrum Analyzer, 25GBase-T Transmitter Test Fixture and the 25GBASE-T Ethernet Test Application.

There are two methods of running the Transmitter Nonlinear Distortion tests:

- Using an External Spectrum Analyzer.
- Using the Oscilloscope.

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Procedure for Transmitter Nonlinear Distortion Tests Using an External Spectrum Analyzer

Running the Transmitter Nonlinear Distortion tests using the 25GBASE-T Ethernet Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Transmitter Nonlinear Distortion tests, refer to "Connection Diagram using Spectrum Analyzer" on page 102.

3   Based on the transmitter text fixture in use, make one of the following connections:
    · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.
    · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the Balun by using the cables.

5   Connect the Balun to the port S of the power splitter using an SMA cable.

6   Connect the output of the AWG to Port 1 of the power splitter using an SMA cable.

7   Connect Port 2 of the Power Splitter to the Spectrum Analyzer using an SMA cable.

8   Use a LAN or GPIB to USB cable to connect the Spectrum Analyzer to the oscilloscope.

9   In the 25GBase-T Conformance Test Application, click the **Set Up** tab.

10 Select **NBASE-T / MGBASE-T** and **2.5G** under **Technology** to run tests on the DUT based on the respective technology standards.

11 In the **Spectral Analysis** area, select **Use Spectrum Analyzer**.
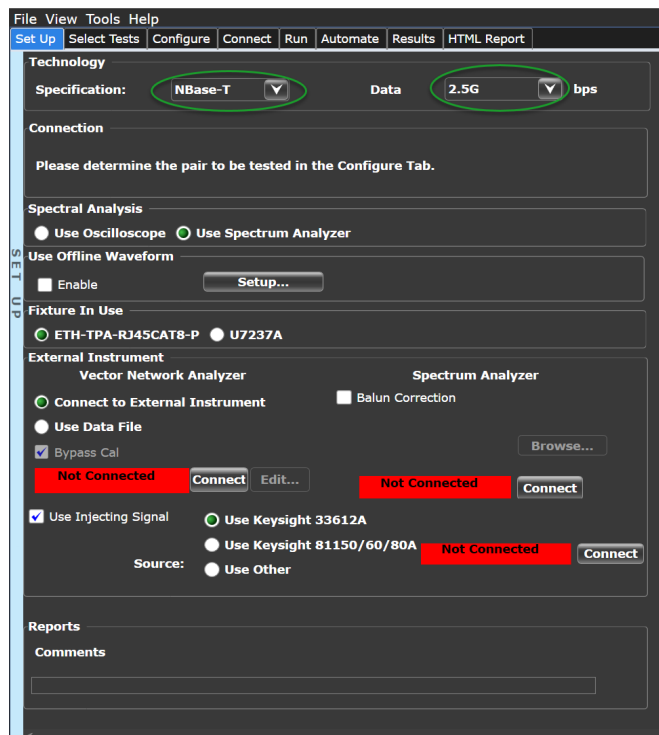
Figure 32   Set Up tab settings for Transmitter Nonlinear Distortion tests using Spectrum Analyzer

12 Ensure that the application detects the Spectrum Analyzer connection to the oscilloscope. If the status indicates **Not Connected**, click the **Connect** button in the **Spectrum Analyzer** area of the **External Instruments** section of the 25GBASE–T Ethernet Test Application.

13 A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 34.

Figure 33   Checking VISA/SICL address for Spectrum Analyzer in the Keysight Connection Expert

14 Select the **Use Injecting Signal** check box, as shown in Figure 32, so that the Test Application is able to connect to the waveform generator to run the Transmitter Nonlinear Distortion tests.

15 Select one of the Waveform Generator device names displayed in the **Source:** area.

16 Click the **Connect** button. A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 34.
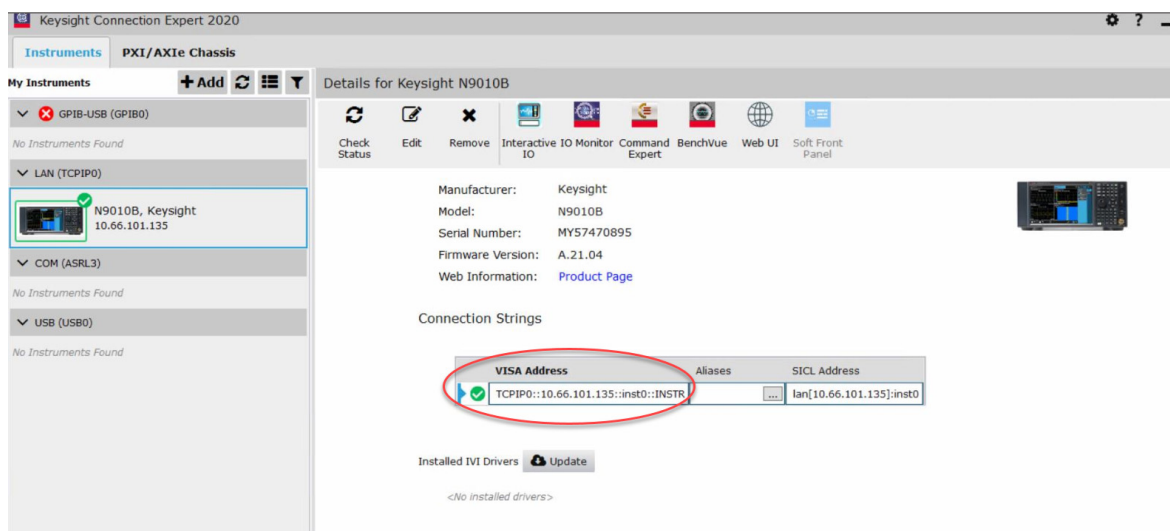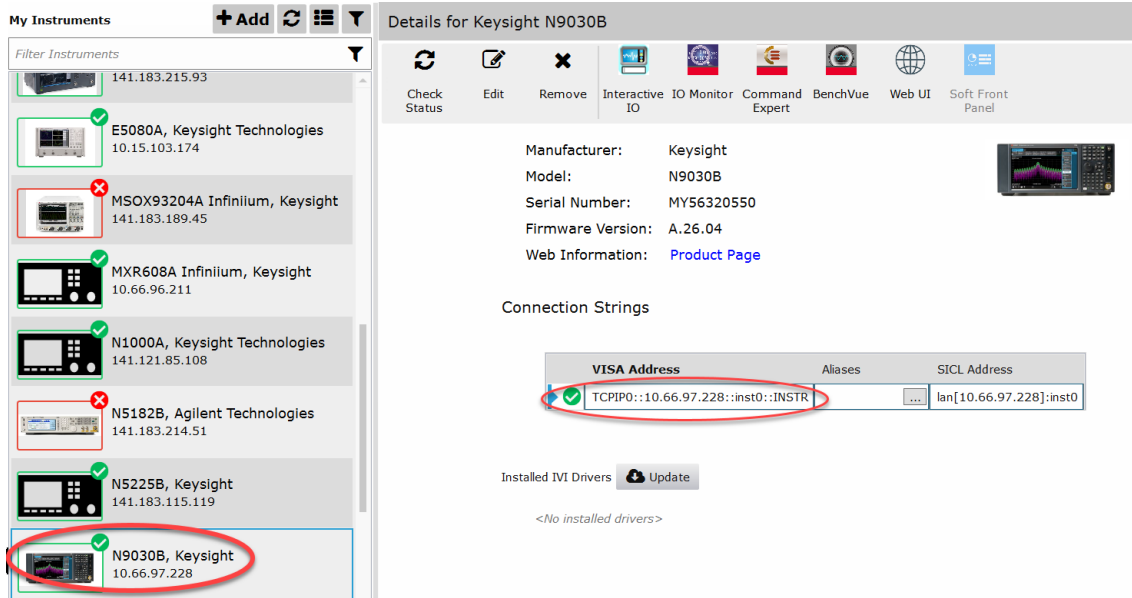

Figure 34   Checking VISA/SICL address for Injecting Signal Source in the Keysight Connection Expert

17 Once the 25GBASE-T Ethernet Test Application detects the Spectrum Analyzer and Injecting Signal source, it is indicated on the **Set Up** tab as shown in Figure 35.
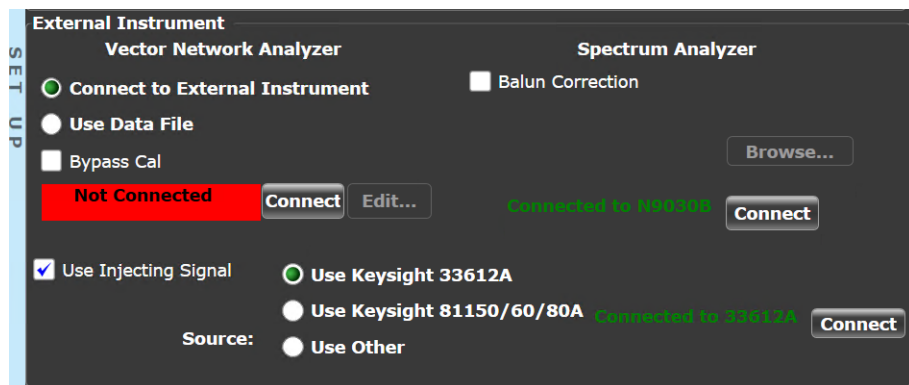

Figure 35   Connected status for Spectrum Analyzer & for Keysight 33612A as Injecting Signal Source

Figure 36   Connected status for Keysight 81160A as Injecting Signal Source

If you are using an external (non-Keysight) function generator, such as a 2-Channel signal generator that can output 45MHz Sine wave, select the **Use Other** option as the Injecting Signal Source. However, notice that the **Connect** button is grayed out because the 25GBASE-T Ethernet Test Application does not control the connectivity to the external device. You must manually set up the frequency and amplitude along with other settings on the external device.
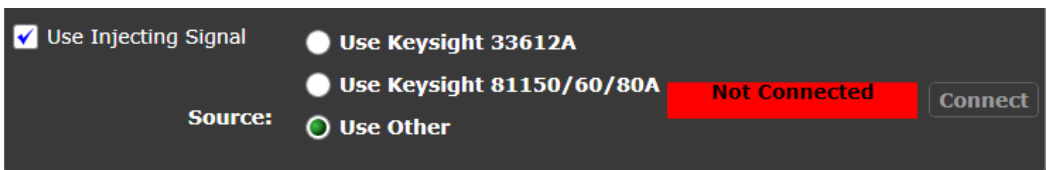

Figure 37   Connect button's unavailability for an External (non-Keysight) Injecting Signal Source

18 Enter your comments in the **Comments** text box.

19 Click the **Select Tests** tab and check the tests you want to run, as shown in Figure 40. Check the parent node or group to check all the available tests within the group.

20 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 13), run the test, and view the test results.

Table 13   Test Configuration Options Using Spectrum Analyzer

Configuration Option	Description
Transmitter Nonlinear Distortion tests	
Start Frequency	The start frequency for the Spectrum Analyzer.
Stop Frequency	The stop frequency for the Spectrum Analyzer.
Resolution Bandwidth	The resolution bandwidth for the Spectrum Analyzer.
Reference Level	The reference level for the Spectrum Analyzer.
Intermodulation Tolerance	The tolerance for intermodulation.
Test Type [Debug Mode]	The test type for Transmitter Linearity tests.
Command File [Debug Mode]	The command file for the Spectrum Analyzer.
Timeout	The timeout configured for the Spectrum Analyzer.
#Averages	The number of averages for Transmitter Linearity test using the Spectrum Analyzer.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

Procedure for Transmitter Nonlinear Distortion Tests Using the Oscilloscope

Running the Transmitter Nonlinear Distortion tests using the 25GBASE-T Ethernet Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Transmitter Nonlinear Distortion tests, refer to "Connection Diagram using Oscilloscope" on page 103.

3   Based on the transmitter text fixture in use, make one of the following connections:

   · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

   · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect Channel 1 of the AWG to Port 1 of the first Power Splitter.

5   Connect Channel 2 of the AWG to Port 1 of the second Power Splitter.

6   Connect the SMP/SMA connector pairs, for example A+, to Port S of the first Power Splitter and A- to Port S of the second Power Splitter.

7   Connect Port 2 of each Power Splitter to the oscilloscope.

8   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

9   Select **MGBase-T / NBASE-T** and **2.5G** under **Technology** to run tests on the DUT based on the respective technology standards.

10 In the **Spectral Analysis** area, select **Use Oscilloscope**.
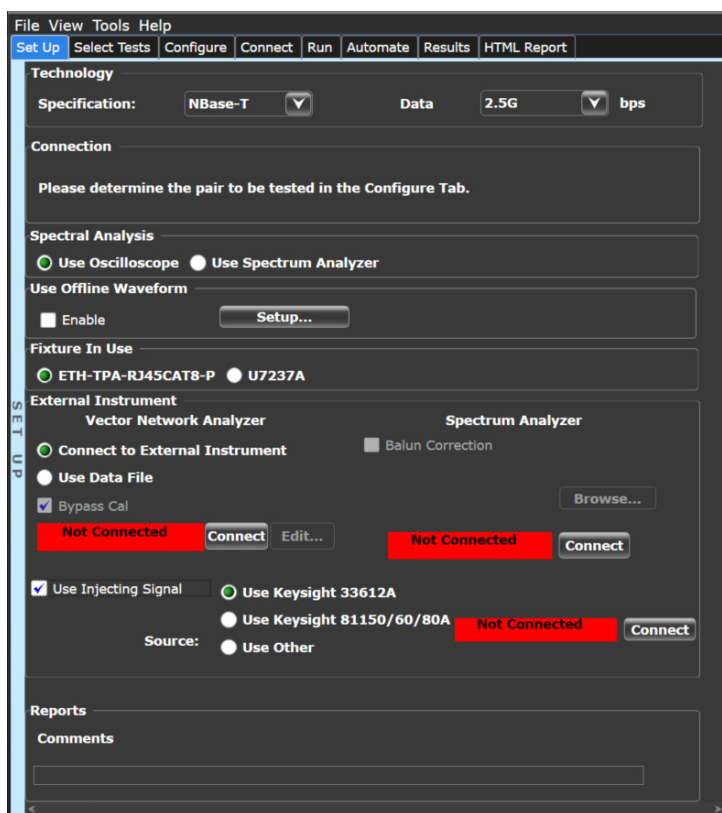
Figure 38   Set Up tab settings for Transmitter Nonlinear Distortion tests using oscilloscope

11 Select the **Use Injecting Signal** check-box, as shown in Figure 38, so that the Test Application is able to connect to the waveform generator to run the Transmitter Nonlinear Distortion tests.

12 Select one of the Waveform Generator device names displayed in the **Source:** area.

13 Click the **Connect** button. A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 34.

NOTE   As described earlier, the **Connect** button is unavailable when **Use Other** is selected as **Source** from the **Use Injecting Signal** options.

14 Once the 25GBASE-T Ethernet Test Application detects the Injecting Signal source, it is indicated on the **Set Up** tab as shown in Figure 39.
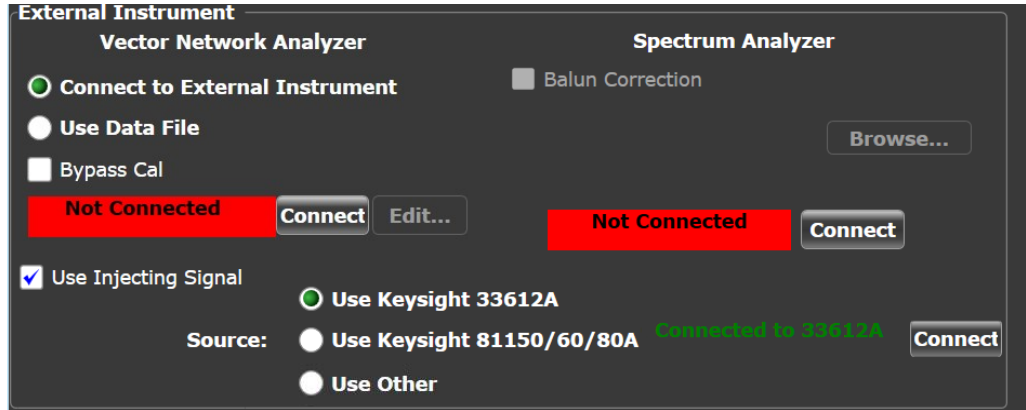

Figure 39   Connection status after the application detects the Injecting Signal Source

15 Enter your comments in the **Comments** text box.

16 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group, as shown in Figure 40.

17 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 14), run the test, and view the results.

Table 14   Test Configuration Options Using Oscilloscope

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Transmitter Nonlinear Distortion tests	
Memory Depth	Memory Depth configured on the Oscilloscope.
Spectral Windowing (Debug Mode)	Windowing function applied to the input data segment before implement FFT using Oscilloscope.

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

List of Transmitter Nonlinear Distortion tests

Figure 40 shows the tests available under the **Transmitter Nonlinear Distortion tests** group of the **Select Tests** tab.

NOTE	The Transmitter Nonlinear Distortion Tests will not appear under the **Select Tests** tab if the Parallel analysis signal type is selected under the **Configure** tab.

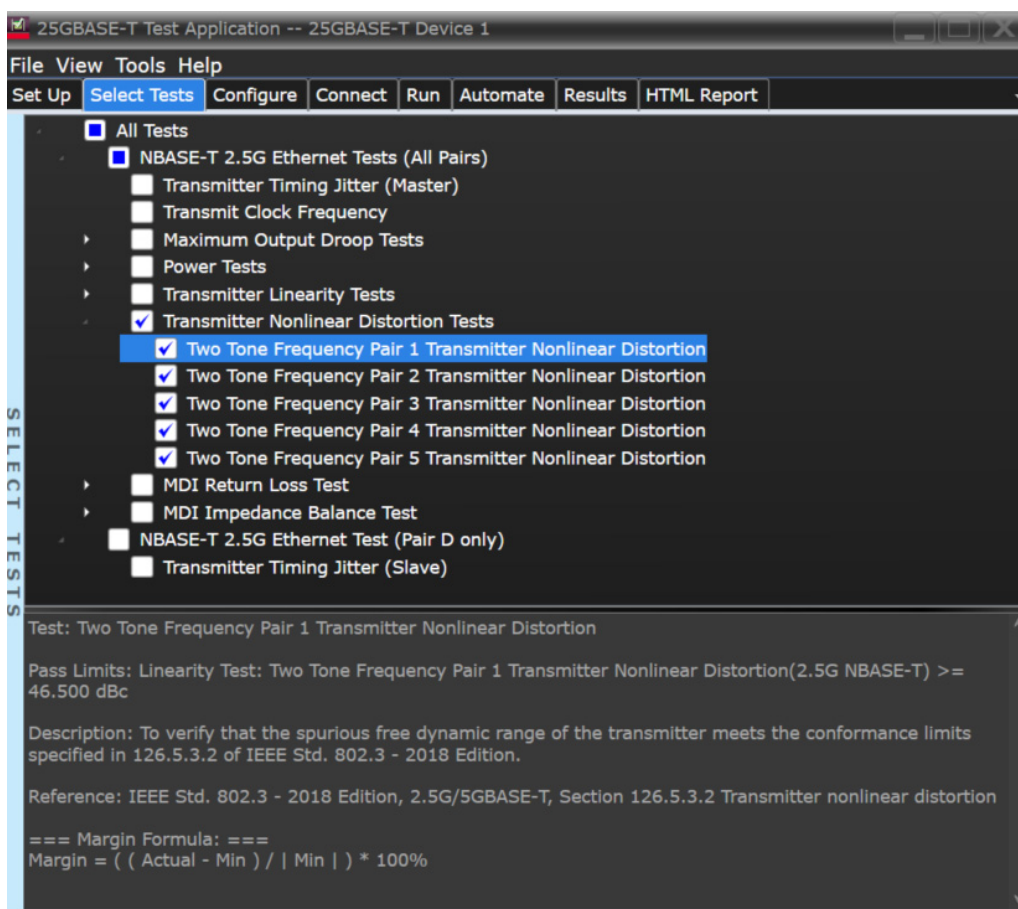Figure 40   Selecting Transmitter Nonlinear Distortion tests

Connection Diagrams for Transmitter Nonlinear Distortion tests

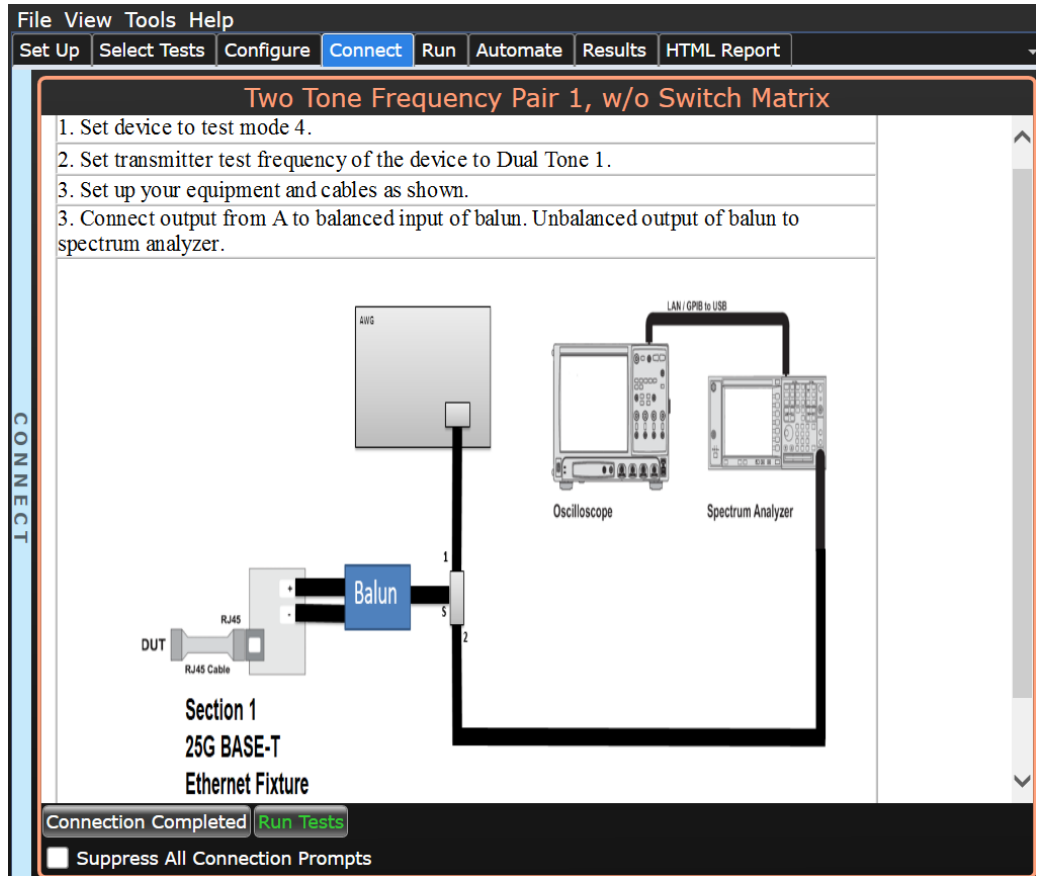Connection Diagram using Spectrum Analyzer

Figure 41   Connection diagram for Transmitter Nonlinear Distortion tests with a Spectrum Analyzer
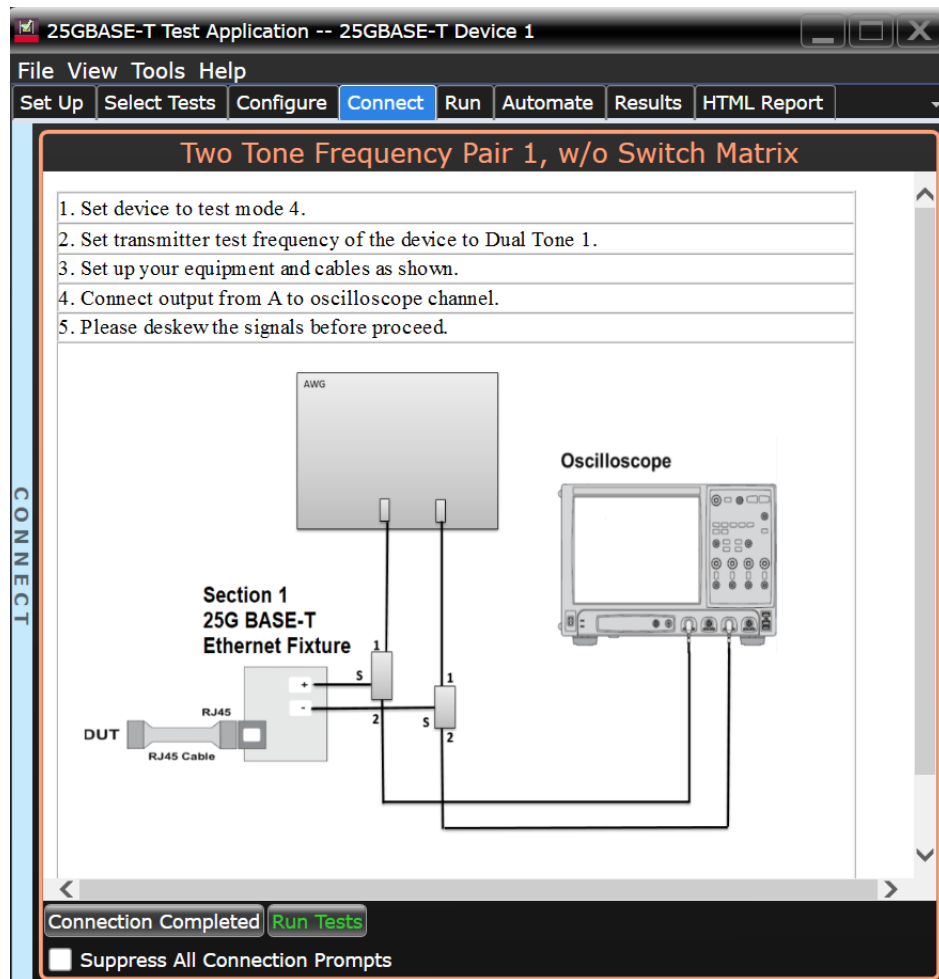
Connection Diagram using Oscilloscope

Figure 42   Connection diagram for Transmitter Nonlinear Distortion tests with an Oscilloscope

Transmitter Nonlinear Distortion Tests—Implementation Methodology

The purpose of the Transmitter Nonlinear Distortion tests is to verify that the device under test (DUT) conforms to the Spurious Free Dynamic Range (SFDR) requirements specified in clause 126.5.3.2 of *IEEE 802.3-2018*.

This SFDR will be verified for each of the four pairs of NBase-T (2.5G) and MGBase-T (2.5G) Test Mode 4 with dual tone input signaling for a particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

Test Definition Notes from the Specification

MGBase-T (2.5G) and NBase-T (2.5G), Spec IEEE 802.3—2018 Clause 126.5.3.2 Transmitter Nonlinear Distortion

In Test Mode 4 at 0dB PBO along with observing the spectrum of the differential signal output at the MDI using transmitter test fixture 4, while injecting a 45 MHz sine wave from the signal generator so that it has an amplitude 7 dB below the peak of the transmitter at the MDI, with no intervening cable, the transmitter nonlinear distortion mask for each pair is defined as follows:

The SFDR of the transmitter, with dual tone inputs as specified in Test Mode 4, shall meet the requirement that:

$\text{SFDR} \geq -5.5 + \min\{52, 58 - 20\log_{10}(f/25)\}$ (126-7)

where, *f* is the maximum frequency of the two test tones in MHz and SFDR is the ratio in dB of the minimum RMS value of either input tones to the RMS value of the worst inter-modulation product in the frequency range of 1 MHz to 100 MHz.

This specification on transmitter nonlinear distortion is derived from the requirement for interoperability with the far-end device.

Pass Condition

Both NBase-T (2.5G) and MGBase-T (2.5G) use the following pass conditions:

1 The SFDR of the transmitter for each Lane should meet the following requirement:

   $\text{SFDR} \geq -5.5 + \min\{52, 58 - 20\log_{10}(f/25)\}$

Where, *f* = maximum frequency of the two test tones

   SFDR = Ratio of the minimum RMS value between two input tone and worst intermodulation product of RMS.

2 The test limit of SFDR for each Lane should be different for different transmit frequency.

Table 15   Test Limit of SFDR for NBase-T (2.5G) and MGBase-T (2.5G)

Transmit Frequency	Frequency Pair for 2.5G (MHz)	Test Limit for 2.5G(dBc)
Dual Tone 1	9.1796 & 10.3515	$\geq$ 46.500
Dual Tone 2	19.7265 & 20.11725	$\geq$ 46.500
Dual Tone 3	34.961 & 35.3515	$\geq$ 46.500
Dual Tone 4	54.1015 & 54.88275	$\geq$ 45.670
Dual Tone 5	77.539 & 78.32031	$\geq$ 42.580

Measurement Algorithm When Using the External Spectrum Analyzer

1　Configure the DUT to produce Test Mode 4 signal and set the test frequency.

2　Configure the following parameters in the **Configure** tab of the 25GBase-T Conformance Test Application:

　　a　Start frequency = 1 MHz

　　b　Stop frequency = 400 MHz

　　c　Resolution bandwidth:

　　・　200 kHz

　　d　Averaging (default value is 50)

3　Configure the following parameter on the Spectrum Analyzer:

　　a　DC coupling (not applicable for the Economic Spectrum Analyzers)

4　Collect data from the Spectrum Analyzer to the 25GBASE-T Ethernet Test Application and plot the graph.

5　Calculate the Intermodulation Product Frequency with the following equation:

　　Even Order = n(A+B), n(A-B)

　　where, n = 2,4,6,8,10......120

　　Odd Order = N(A)+/- (N-1)(B), N(B)+/- (N-1)(A)

　　where,

　　N = n - ((n/2)-0.5) and n = 3,5,7,9....119

　　A, B = Two frequency components

6　Keep the list of the calculated frequency, L1.

7　Get the peak product frequency from the Spectrum Analyzer and keep it in another list, L2.

8　Compare L1 with L2 and keep the list of the peak values (obtained from the Spectrum Analyzer), L3 with the condition:

　　・　Frequency values that are close to the frequency (with default tolerance of 500 kHz) in L1.

9　SFDR = Highest Peak (L3) - Third Highest Peak (L3)

10　Set the Spectrum Analyzer to AC coupling mode.

11　Compare the test result with the conformance test limit.

Measurement Algorithm When Using the Oscilloscope

1　Configure the DUT to produce Test Mode 4 signal and set the test frequency.

2　On the Infiniium oscilloscope,

　　a　Trigger and collect the waveform from the oscilloscope.

　　b　Apply the selected windowing function to the sampled waveform.

　　c　Compute the amplitude spectra as:

$$\text{amplitude spectra} = \frac{1}{N} \sum_{i=0}^{N-1} |\text{FFT amplitude[i]}|$$

Where N = number of segments or cycles to compute.

　　d　Apply a correction factor to the signal to compensate windowing losses:

$$\text{Correction factor} = \frac{n}{\left\{\sum (\text{window function})\right\}}$$

    e Convert the amplitude to dBm.

    f Calculate the Intermodulation Product Frequency with the equation:

     Even Order = n(A+B), n(A-B)

     where, n = 2,4,6,8,10......120

     Odd Order = N(A)+/- (N-1)(B), N(B)+/- (N-1)(A)

     where,

     N = n - ((n/2)-0.5) and n = 3,5,7,9....119

     A, B = Two frequency components

3   Keep the list of the calculated frequency, L1.

4   Get the peak product frequency from the amplitude spectra (calculated in step 2c above) and keep it in another list, L2.

5   Compare L1 with L2 and keep the list of the peak values, L3, which is obtained from the amplitude spectra (calculated in step 2c above), with the condition:

    · Frequency values that are close to the frequency (with default tolerance of 500 kHz) in L1.

6   SFDR = Highest Peak (L3) - Third Highest Peak (L3)

7   Compare the test result with the conformance test limit.

Test References

See Clause 126.5.3.2 Transmitter Nonlinear Distortion in the *IEEE 802.3-2018 Standard* for the NBase-T (2.5G) and MGBase-T (2.5G) DUT.

13 MDI Return Loss Test

This section provides the Methods of Implementation (MOIs) for MDI Return Loss test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; Vector Network Analyzer, 25GBase-T Transmitter Test Fixture and the 25GBASE-T Ethernet Test Application.

There are two methods of running the MDI Return Loss test:

· Using an External Vector Network Analyzer.

· Using the Oscilloscope.

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Procedure for MDI Return Loss Test

Running the MDI Return Loss Test using the 25GBASE-T Ethernet Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the MDI Return Loss test, refer to "Connections for Conformance Tests" on page 23.

3   Based on the transmitter text fixture in use, make one of the following connections:

    · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

    · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the Balun by using the cables.

5   Connect the Balun to the Vector Network Analyzer by using the SMA cable.

6   Use a LAN or GPIB to USB cable to connect the Vector Network Analyzer to the oscilloscope.

7   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

8   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

    · **Specification: IEEE** and **Data Rate: 10G** or **25G**,

    · **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

    · **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

9   Based on the test requirements, select the appropriate options and perform connections in the **Spectral Analysis** area.

10 Ensure that the application detects the Vector Network Analyzer connection to the oscilloscope. If the status in the **Vector Network Analyzer** area of the **External Instruments** section of the 25GBASE-T Ethernet Test Application indicates **Not Connected**,

 a With the default option **Connect to External Instrument** selected, click the **Connect...** button.

 b A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 43.
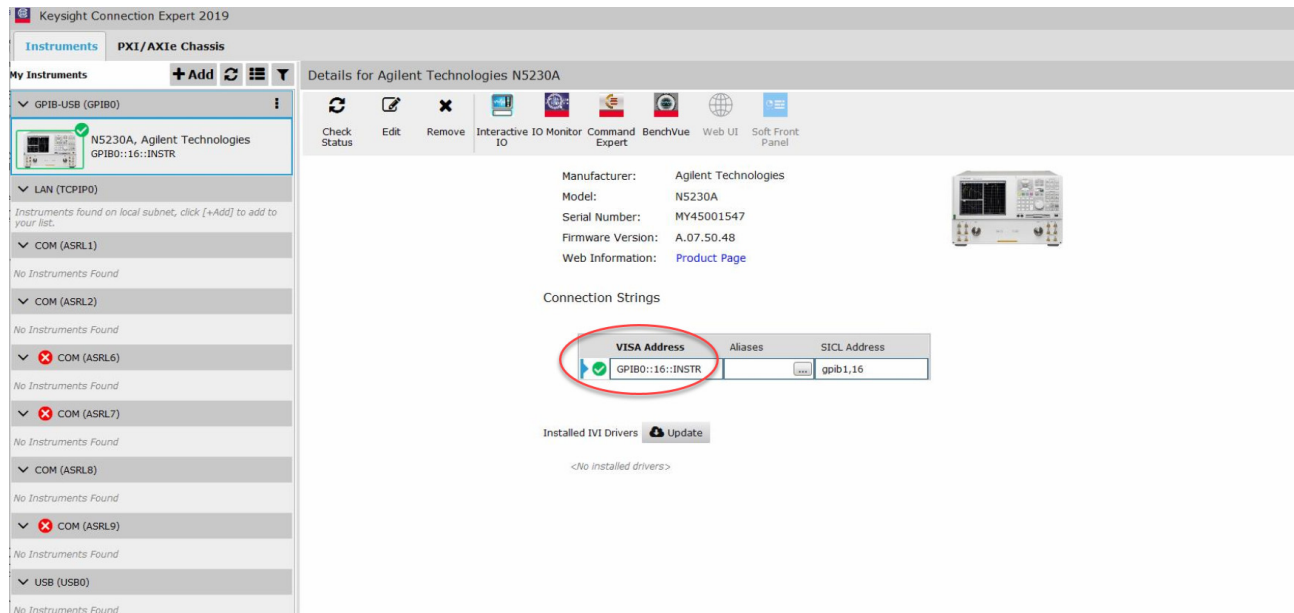

Figure 43   Checking VISA/SICL address for Vector Network Analyzer in the Keysight Connection Expert

11 Once the 25GBASE-T Ethernet Test Application detects the Vector Network Analyzer, it is indicated on the **Set Up** tab as shown in Figure 44.
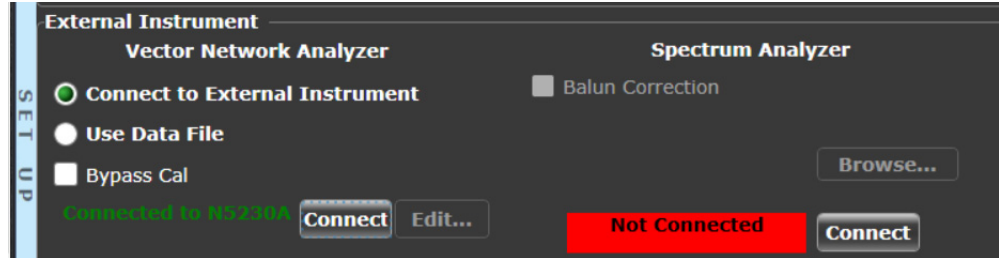

Figure 44   Connection status after the test application detects the Vector Network Analyzer

12 Instead of connecting to the Vector Network Analyzer, you can also use the data file. Select the **Use Data File** check-box and the **Edit...** button appears, as shown in Figure 45.
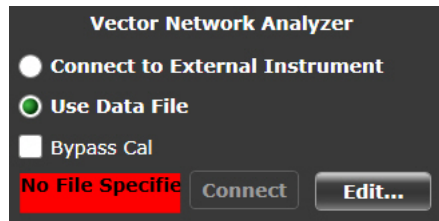

Figure 45   Use Data File option for Vector Network Analyzer

13 Click the **Edit...** button to access the **Return Loss Data Files** dialog and select the data file for each pair, as shown in Figure 46.
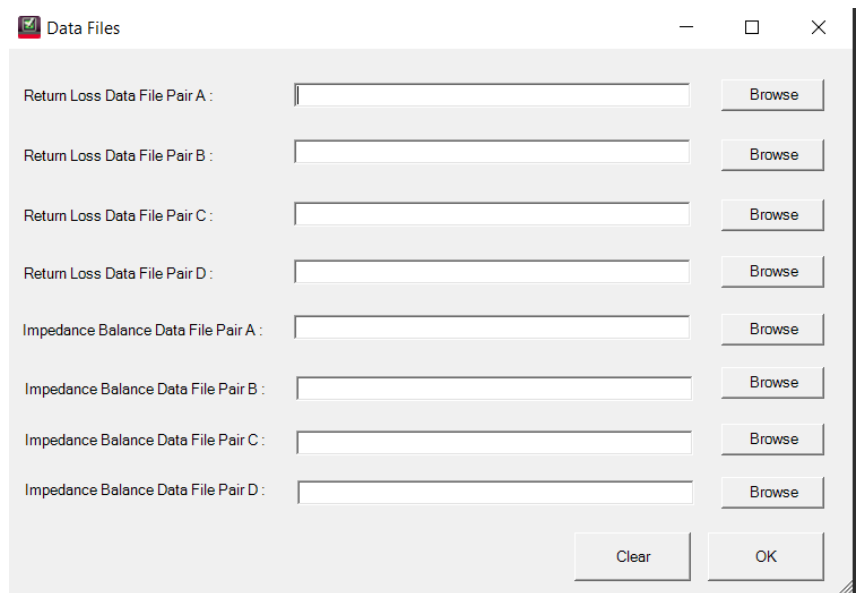

Figure 46   Data File selection pop-up box

14 Click **Browse** to access the data file on the local disk and assign it to each pair under test. Once you have selected the data files, click **OK**.

15 Once the 25GBASE-T Ethernet Test Application detects the user file, it is indicated on the **Set Up** tab as shown in Figure 47.

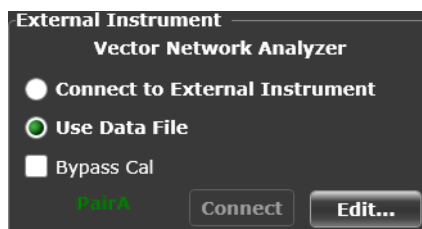Figure 47   VNA pair information after the test application detects the data file

16 Enter your comments in the **Comments** text box.

17 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
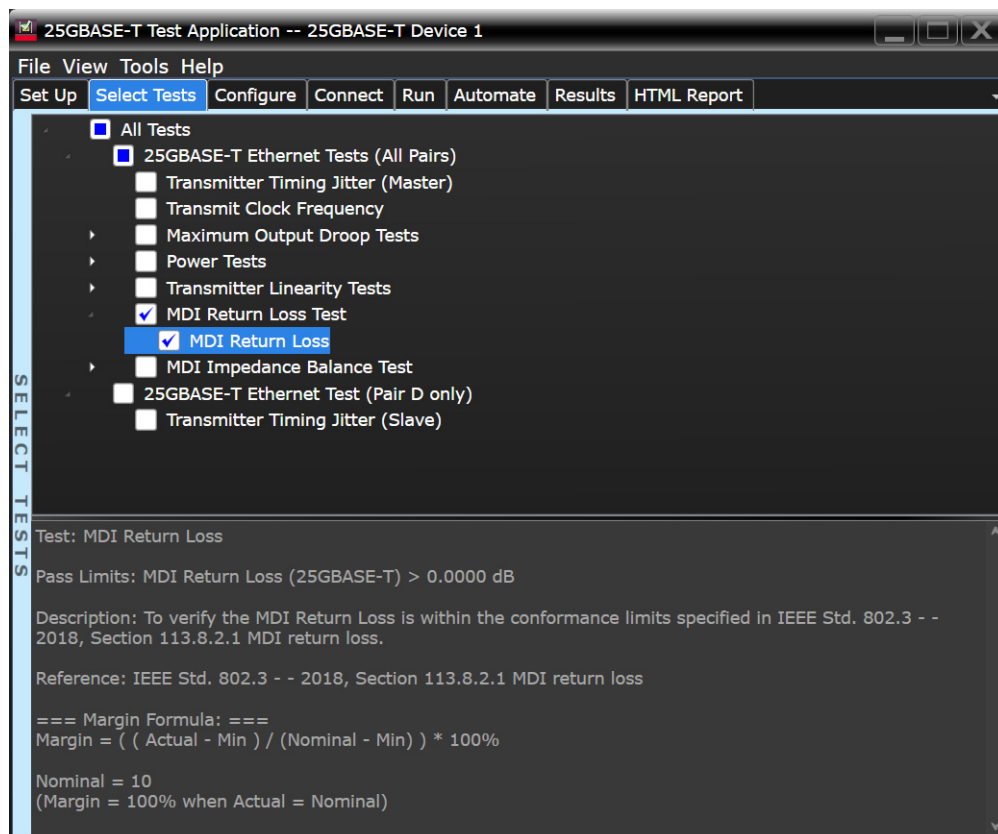

Figure 48   Selecting MDI Return Loss test

18 Follow the 25GBASE-T Ethernet Test Application's task flow and run the test.

Note that if you are using the 10GBase-T Ethernet Fixture, then:

• Before running the test, the application prompts you to calibrate the test setup. Connect the other end of RJ45 cable to Section 3 of the test fixture to calibrate the test setup. Test setup refers to the setup from the RJ45 cable connection point at Section 3 test fixture to the point where SMA cables are connected to the connector pairs.

• A pop-up message box will prompt you to connect the cal fixture to OPEN, SHORT, and LOAD port respectively. When this message is prompt, connect the mentioned port of Section 3 to another end of the RJ45 cable and click OK.

19 Once the calibration is done, the application continues to run the tests.

NOTE   Test Configuration Options are not applicable for the oscilloscope as the MDI Return Loss test uses the Vector Network Analyzer.

MDI Return Loss Test—Implementation Methodology

The purpose of the MDI Return Loss test is to verify that the MDI return loss of the device under test (DUT) meets the specified eye template requirement as specified in:

· Clause 55.8.2.1 of *IEEE 802.3-2018* for the 10GBase-T DUT

· Clause 113.8.2.1 of *IEEE 802.3-2018* for the 25GBase-T DUT

· Clause 126.8.2.2 of *IEEE 802.3-2018* for the MGBase-T (2.5G/5G) and NBase-T (2.5G/5G) DUT.

MDI Return loss of the DUT is verified for each of the four lanes of the Test Mode 5 signaling for that particular DUT. These pairs are identified as Pair A, Pair B, Pair C, and Pair D.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018 Clause 55.8.2.1 MDI Return Loss

The differential impedance at the MDI for each transmitter/receive channel shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having a nominal differential characteristic impedance of 100 Ω is attenuated, relative to the incident signal as per the relationship shown below for 10GBase-T:

$$\text{Return loss} \geq \begin{cases} 16 & 1 \leq f \leq 40 & \text{(dB)} \\ 16 - 10\log_{10}(f/40) & 40 < f \leq 400 & \text{(dB)} \\ 6 - 30\log_{10}(f/400) & 400 < f \leq 500 & \text{(dB)} \end{cases}$$

where f is in MHz.

25GBase-T, Spec IEEE 802.3—2018 Clause 113.8.2.1 MDI Return Loss

The differential impedance at the MDI for each duplex channel shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having a nominal differential characteristic impedance of 100 Ω is attenuated, relative to the incident signal as per the relationship shown below for 25GBase-T:

$$\text{Return loss} \geq \begin{cases} 16 & 1 \leq f \leq 40 & \text{(dB)} \\ 16 - 10\log_{10}(f/40) & 40 < f \leq 400 & \text{(dB)} \\ 6 & 400 < f \leq 2000 \times S & \text{(dB)} \end{cases} \qquad (113\text{–}39)$$

where f is in MHz.

MGBase-T and NBase-T, IEEE 802.3—2018 Clause 126.8.2.2 MDI Return Loss

The differential impedance at the MDI for each transmit/receive channel shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having a nominal differential characteristic impedance of 100 Ω is attenuated, relative to the incident signal as per the relationship shown below for MGBase-T and NBase-T:

$$\text{Return loss} \geq \begin{cases} 16 & 1 \leq f \leq 40 & \text{(dB)} \\ 16 - 10\log_{10}(f/40) & 40 < f \leq f_{max} & \text{(dB)} \end{cases} \qquad (126\text{–}38)$$

where

f is in MHz
f_{max} is 125 MHz for 2.5GBASE-T and 250 MHz for 5GBASE-T

Pass Condition

- The return loss obtained for 10GBase-T must be at least 16 dB from 1 MHz to 40 MHz, at least 16-10log$_{10}$(f/40) from 40 MHz to 400 MHz, and at least 6-30log$_{10}$(f/400) from 400 MHz to 500 MHz.
- The return loss obtained for 25GBase-T must be at least 16 dB from 1 MHz to 40 MHz, at least 16-10log$_{10}$(f/40) from 40 MHz to 400 MHz, and at least 6 dB from 400 MHz to 1250 MHz.
- The return loss obtained for MGBase-T and NBase-T must be at least 16dB from 1 MHz to 40 MHz (for both 2.5G and 5.0G modes) and at least 16-10log$_{10}$(f/40) from 40 MHz to either 125 MHz (for 2.5G mode) or 250 MHz (for 5.0G mode).

Measurement Algorithm

1 Configure the DUT to produce Test Mode 5 signal.
2 Calibrate the Vector Network Analyzer with the calibration fixture (load, open and short).
3 Configure the following parameters in the **Configure** tab of the 25GBASE-T Ethernet Test Application:
   - Start frequency = 1 MHz and Stop frequency = 1250 MHz
   - Averaging on.
4 Collect the data from the Vector Network Analyzer to the 25GBASE-T Ethernet Test Application and plot the graph.
5 Analyze the collected data by using a MATLAB script and compute the return loss for the Zs of 100Ω.
6 Compare the test result with the conformance test limit.

Test References

- See Clause 55.8.2.1 of *IEEE 802.3-2018* for the 10GBase-T DUT.
- See Clause 113.8.2.1 of *IEEE 802.3-2018* for the 25GBase-T DUT.
- See Clause 126.8.2.2 of *IEEE 802.3-2018* for the MGBase-T and NBase-T DUT.

14 MDI Impedance Balance Test

This section provides the Methods of Implementation (MOIs) for MDI Impedance Balance test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; Vector Network Analyzer, 25GBase-T Transmitter Test Fixture and the 25GBASE-T Ethernet Test Application.

There are two methods of running the MDI Impedance Balance test:

· Using an External Vector Network Analyzer.
· Using the Oscilloscope.

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Procedure for MDI Impedance Balance Test

Running the MDI Impedance Balance Test using the 25GBASE-T Ethernet Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the MDI Return Loss test, refer to "Connections for Conformance Tests" on page 23.

3   Based on the transmitter text fixture in use, make one of the following connections:

    · **RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture**: Connect one end of the RJ45 cable to the DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

    · **U7237A 10GBase-T Transmitter Test Fixture:** Connect one end of the RJ45 cable to the DUT and another end to J1 connector on the Section 1 of the 10GBase-T Transmitter Test Fixture.

4   Connect the SMP/SMA connector pairs, for example A+ and A- SMP/SMA connectors to the Vector Network Analyzer by using the SMA cables.

5   Use a LAN or GPIB to USB cable to connect the Vector Network Analyzer to the oscilloscope.

6   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

7   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

    · **Specification: IEEE** and **Data Rate: 10G** or **25G**,

    · **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

    · **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

8   Based on the test requirements, select the appropriate options and perform connections in the **Spectral Analysis** area.

9   Ensure that the application detects the Vector Network Analyzer connection to the oscilloscope. If the status in the **Vector Network Analyzer** area of the **External Instruments** section of the 25GBASE-T Ethernet Test Application indicates **Not Connected**,

  a   With the default option **Connect to External Instrument** selected, click the **Connect...** button.

  b   A pop-up box appears where you can enter either the VISA/SICL address or the IP address. Enter the information and click the **Verify** button, followed by the **Done** button to close this box. The VISA/SICL address or the IP address can be obtained from the Keysight Connection Expert application, as shown in Figure 49.
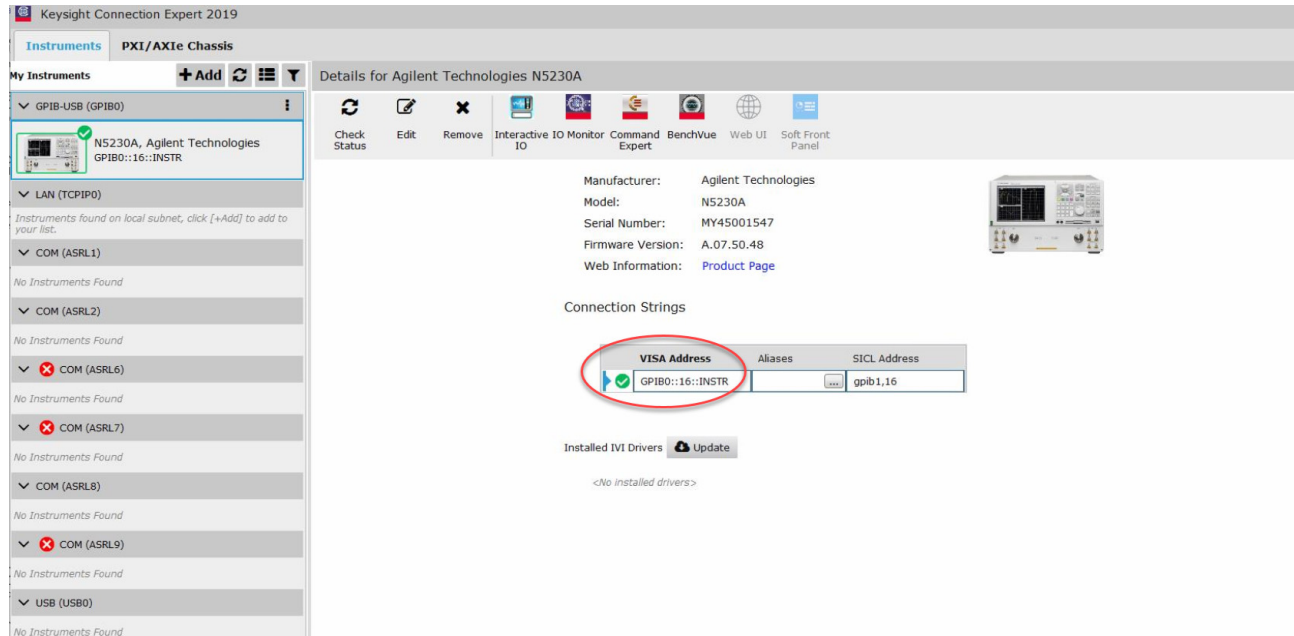

Figure 49   Checking VISA/SICL address for Vector Network Analyzer in the Keysight Connection Expert

10 Once the 25GBASE-T Ethernet Test Application detects the Vector Network Analyzer, it is indicated on the **Set Up** tab as shown in Figure 50.
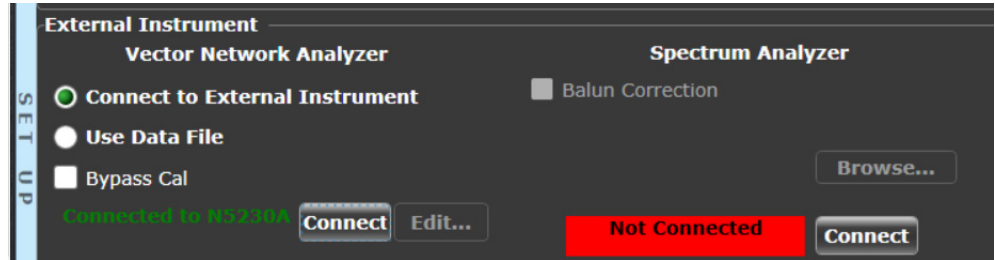

Figure 50   Connection status after the test application detects the Vector Network Analyzer

11 Instead of connecting to the Vector Network Analyzer, you can also use the data file. Select the **Use Data File** check-box and the **Edit...** button appears, as shown in Figure 51.
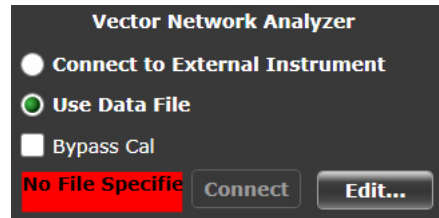

Figure 51   Use Data File Option for Vector Network Analyzer

12 Click the **Edit...** button to access the **Return Loss Data Files** dialog and select the data file for each pair, as shown in Figure 52.
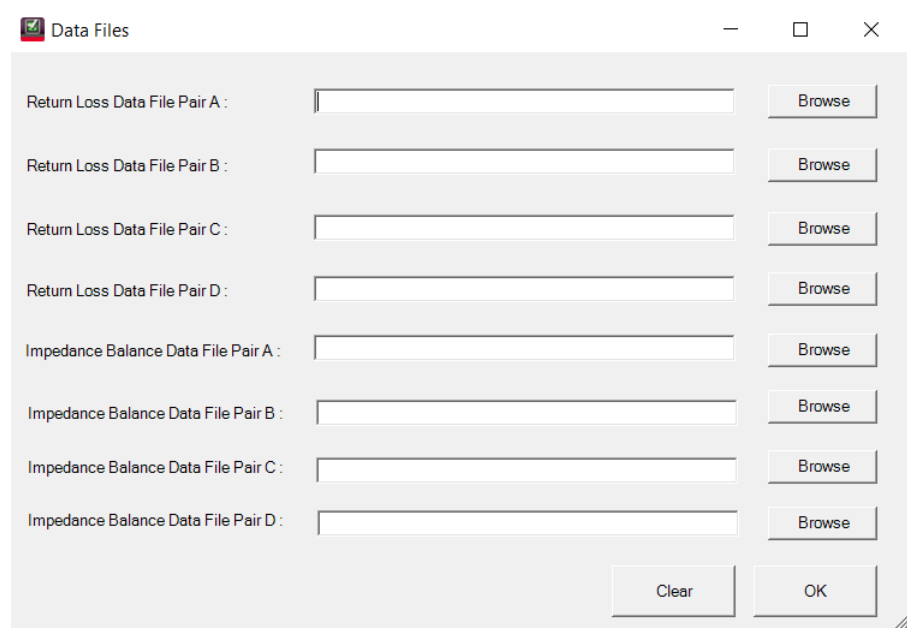

Figure 52   Data File selection pop-up box

13 Click **Browse** to access the data file on the local disk and assign it to each pair under test. Once you have selected the data files, click **OK**.

14 Once the 25GBASE-T Ethernet Test Application detects the user file, it is indicated on the **Set Up** tab as shown in Figure 53.
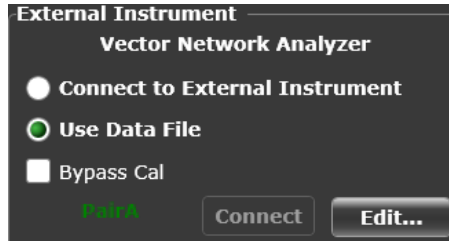

Figure 53   VNA pair information after the test application detects the data file

15 Enter your comments in the **Comments** text box.

16 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
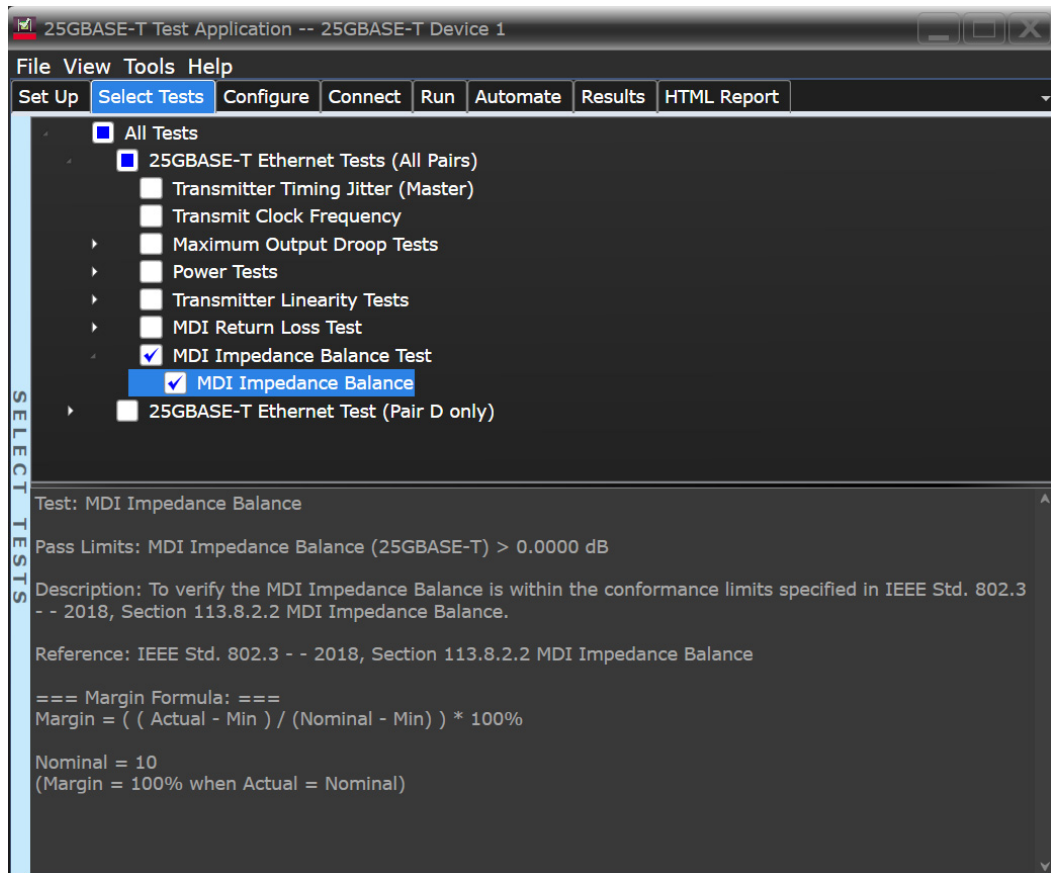

Figure 54   Selecting MDI Impedance Balance test

17 Follow the 25GBASE-T Ethernet Test Application's task flow and run the test.

Note that if you are using the 10GBase-T Ethernet Fixture, then:

· Before running the test, the application prompts you to calibrate the test setup. Connect the other end of RJ45 cable to Section 3 of the test fixture to calibrate the test setup. Test setup refers to the setup from the RJ45 cable connection point at Section 3 test fixture to the point where SMA cables are connected to the connector pairs.

· A pop-up message box will prompt you to connect the cal fixture to OPEN, SHORT, and LOAD port respectively. When this message is prompt, connect the mentioned port of Section 3 to another end of the RJ45 cable and click OK.

18 Once the calibration is done, the application continues to run the tests.

NOTE	Test Configuration Options are not applicable for the oscilloscope as the MDI Impedance Balance test uses the Vector Network Analyzer.

MDI Impedance Balance Test—Implementation Methodology

The purpose of the MDI Impedance Balance test is to verify that the MDI Impedance Balance of the device under test (DUT) meets the specification requirement specified in:

- Clause 55.8.2.2 of *IEEE 802.3-2018* for the 10GBase-T DUT.
- Clause 113.8.2.2 of *IEEE 802.3-2018* for the 25GBase-T DUT.
- Clause 126.8.2.3 of *IEEE 802.3-2018* for the MGBase-T (2.5G/5.0G) and NBase-T (2.5G/5.0G) DUT.

MDI Impedance Balance of the DUT is verified for each of the four lanes of the Test Mode 5 signaling for that particular DUT. These pairs are identified as Pair A, Pair B, Pair C and Pair D.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018 Clause 55.8.2.2 MDI Impedance Balance

Impedance balance is a measure of the impedance-to-ground difference between the two MDI contacts used by a duplex link channel and is referred to as *common-mode-to-differential-mode impedance balance*. The common-mode-to-differential-mode impedance balance, *Bal(f),* of each channel of the MDI shall meet the below relationship:

$$Bal(f) \geq \begin{cases} 48 & 1 \leq f < 30 \quad \text{(dB)} \\ 44 - 19.2\log_{10}\left(\dfrac{f}{50}\right) & 30 \leq f \leq 500 \quad \text{(dB)} \end{cases} \qquad (55\text{--}55)$$

Where *f* is the frequency in MHz when the transmitter is transmitting random or pseudo random data.

25GBase-T, Spec IEEE 802.3—2018 Clause 113.8.2.2 MDI Impedance Balance

Impedance balance is a measure of the impedance-to-ground difference between the two MDI contacts used by a duplex link channel and is referred to as *common-mode-to-differential-mode impedance balance*. The common-mode-to-differential-mode impedance balance, *Bal(f),* of each duplex channel of the MDI shall meet the below relationship:

$$Bal(f) \geq \begin{cases} 48 & 1 \leq f \leq 40 & \text{(dB)} \\ 44 - 19.2\log_{10}(f/40) & 40 < f \leq 2000 \times S & \text{(dB)} \end{cases} \qquad (113\text{--}40)$$

Where *f* is the frequency in MHz.

MGBase-T and NBase-T, Spec IEEE 802.3—2018 Clause 126.8.2.3 MDI Impedance Balance

Impedance balance is a measure of the impedance-to-ground difference between the two MDI contacts used by a duplex link channel and is referred to as *common-mode-to-differential-mode impedance balance*. MDI impedance balance is specified beyond the Nyquist frequency of the PHY

to account for system performance variation. When the transmitter is transmitting random or pseudo-random data, the common mode-to-differential-mode impedance balance, Bal(f), of each channel of the MDI shall meet the below relationship:

For 2.5GBASE-T: (126–39)

$$Bal(f) \geq \begin{cases} 48 & 1 \leq f < 10 & \text{(dB)} \\ 48 - 20\log_{10}(f/10) & 10 \leq f < 20 & \text{(dB)} \\ 42 - 15\log_{10}(f/20) & 20 \leq f \leq 125 & \text{(dB)} \end{cases}$$

For 5GBASE-T:

$$Bal(f) \geq \begin{cases} 48 & 1 \leq f \leq 30 & \text{(dB)} \\ 44 - 19.2\log_{10}(f/50) & 30 < f \leq 250 & \text{(dB)} \end{cases}$$

where

f is the frequency in MHz

Pass Condition

- The return loss obtained for 10GBase-T must be at least 48 dB from 1 MHz to 30 MHz and at least 44-19.2$\log_{10}(f/50)$ from 30 MHz to 500 MHz.
- The return loss obtained for 25GBase-T must be at least 48 dB from 1 MHz to 40 MHz and at least 44-19.2$\log_{10}(f/40)$ from 40 MHz to 1250 MHz.
- The return loss obtained for MGBase-T and NBase-T (2.5G mode) must be at least 48 dB from 1 MHz to 10 MHz, at least 48-20$\log_{10}(f/10)$ from 10 MHz to 20 MHz, and at least 42-15$\log_{10}(f/20)$ from 20 MHz to 125 MHz.
- The return loss obtained for MGBase-T and NBase-T (5G mode) must be at least 48 dB from 1 MHz to 30 MHz and at least 44-19.2$\log_{10}(f/50)$ from 30 MHz to 250 MHz.

Measurement Algorithm

1 Configure the DUT to produce Test Mode 5 signal.
2 Calibrate the Vector Network Analyzer with the calibration fixture (load, open and short).
3 Configure the following parameters in the **Configure** tab of the 25GBASE-T Ethernet Test Application:
   - Start frequency = 1 MHz and Stop frequency = 1250 MHz
   - Averaging on.
4 Collect the data from the Vector Network Analyzer to the 25GBASE-T Ethernet Test Application and plot the graph.
5 Analyze the collected data by using a MATLAB script and compute the return loss for the Zs of 100Ω.
6 Compare the test result with the conformance test limit.

Test References

- See Clause 55.8.2.2 of *IEEE 802.3-2018* for the 10GBase-T DUT.
- See Clause 113.8.2.2 of *IEEE 802.3-2018* for the 25GBase-T DUT.
- See Clause 126.8.2.3 of *IEEE 802.3-2018* for the MGBASE-T *and* NBase-T DUT.

15 Transmitter Timing Jitter (SLAVE) Test

This section provides the Methods of Implementation (MOIs) for Transmitter Timing Jitter (SLAVE) test using a Keysight Infiniium MXR Oscilloscope or a Keysight Infiniium UXR Oscilloscope; 25GBase-T Transmitter Test Fixture and the 25GBase-T Conformance Test Application.

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Procedure for Transmitter Timing Jitter (SLAVE) Test

Running the Transmitter Timing Jitter (SLAVE) Test using the 25GBASE-T Ethernet Test Application

1   Start the 25GBASE-T Ethernet Test Application as described in "Starting the 25GBASE-T Ethernet Test Application" on page 21.

2   To make connections for the Transmitter Timing Jitter (SLAVE) test, refer to "Connections for Conformance Tests" on page 23.

3   Connect one end of the RJ45 cable to the SLAVE DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

4   Similarly, connect one end of the RJ45 cable to the MASTER DUT and another end to the connector on the Section 1 of the 25GBase-T Transmitter Test Fixture.

5   Connect the D+ and D- SMP/SMA connectors to the any two of the oscilloscope channels by using RJ-45 TPA cable.

6   In the 25GBASE-T Ethernet Test Application, click the **Set Up** tab.

7   Select one of the following options under **Technology** to run tests on the DUT based on the respective technology standards. The **Select Tests** tab lists tests based on the technology you select.

    ·   **Specification: IEEE** and **Data Rate: 10G** or **25G**,

    ·   **Specification: MGBASE-T** and **Data Rate: 5.0G** or **2.5G**,

    ·   **Specification: NBASE-T** and **Data Rate: 5.0G** or **2.5G**

8   Based on the test requirements, select the appropriate options and perform connections in the **Spectral Analysis** and **External Instruments** areas.

9   Enter your comments in the **Comments** text box.

10 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.
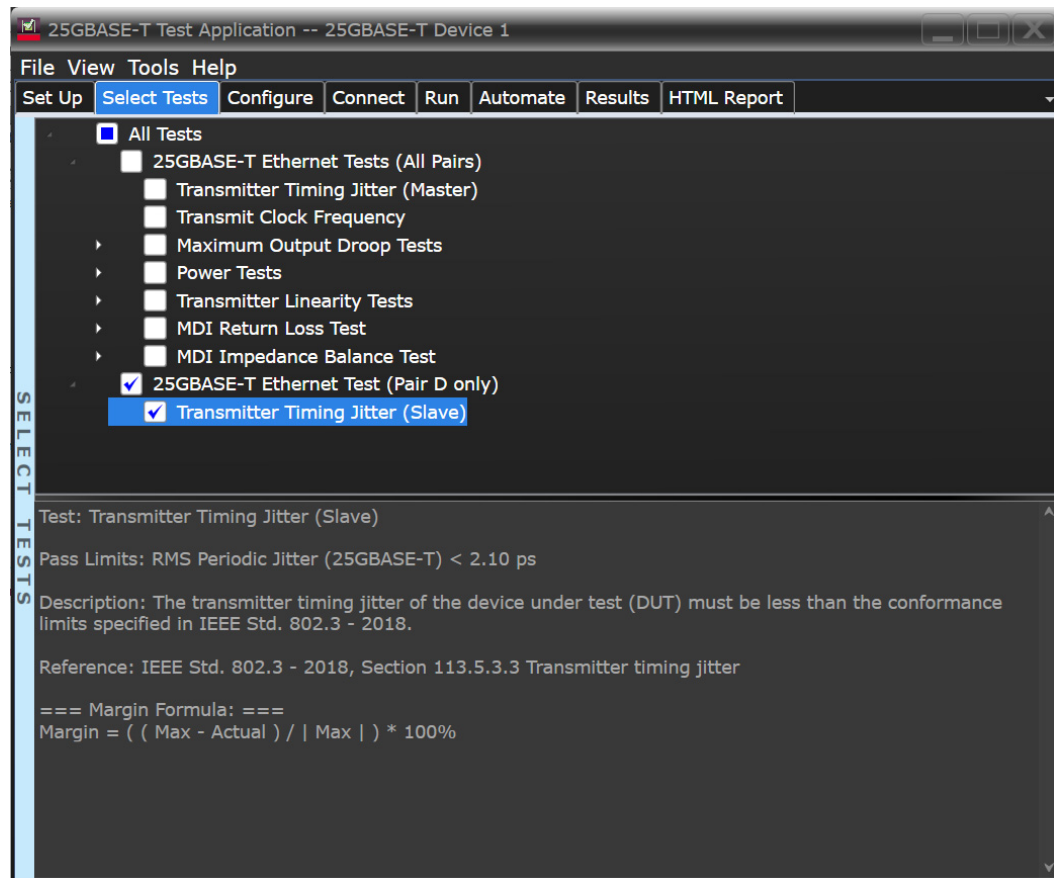
Figure 55   Selecting Transmitter Timing Jitter (SLAVE) test

11 Follow the 25GBASE-T Ethernet Test Application's task flow to set up the configuration options (see Table 16), run the test, and view the test results.

Table 16   Test Configuration Options

Configuration Option	Description
Connection Pair (Positive)	The channel number for connection pair positive.
Connection Pair (Negative)	The channel number for connection pair negative.
Signal Type	Type of signal generated on the Oscilloscope.
Sampling Rate [Debug mode]	Sampling Rate configured on the Oscilloscope.
Apply Band Pass Filter for Jitter Tests	Apply a a bandpass filter at the input for jitter tests.
Band Pass Filter Center Frequency [Debug Mode]	Center Frequency of the Band Pass Filter
Band Pass Filter Bandwidth [Debug Mode]	Bandwidth of the Band Pass Filter

Note: The **Configure** tab of the 25GBASE-T Ethernet Test Application displays the default values for the options listed in the table. Refer to the 25GBASE-T Ethernet Test Application's Online Help to see how to change the values, if required.

| NOTE | To run the Transmitter Timing Jitter (SLAVE) Test, you need to select only Pair D, therefore the Parallel Analysis signal type is not supported by this test. |

Transmitter Timing Jitter (SLAVE) Test—Implementation Methodology

The purpose of the Transmitter Timing Jitter (SLAVE) test is to verify that the SLAVE transmitter timing jitter of the device under test (DUT) is within the conformance limits specified in:

- Clause 55.5.3.3 of *IEEE 802.3-2018* for the 10GBase-T DUT.
- Clause 113.5.3.3 of *IEEE 802.3-2018* for the 25GBase-T DUT.
- Clause 126.5.3.3 of *IEEE 802.3-2018* for the MGBase-T and NBase-T DUT.

For the 10GBase-T, the obtained timing jitter must be less than 5.5 ps over a sample size of 200000 $\pm$ 20000. The jitter value is to be verified for Pair D only where the MASTER PHY is set to test mode 1 and SLAVE PHY is set in Test Mode 3.

For the 25GBase-T, the obtained timing jitter must be less than 2.1 ps over a sample size of 200000 $\pm$ 20000. The jitter value is to be verified for Pair D only where the MASTER PHY is set to test mode 1 and SLAVE PHY is set in Test Mode 3.

For the MGBase-T and NBase-T (5.0G), the obtained timing jitter must be less than 7.2 ps and must be less than 10 ps for the NBase-T and MGBase-T (2.5G) over a sample size of 200000 $\pm$ 20000. The jitter value is to be verified for Pair D only where the MASTER PHY is set to test mode 1 and SLAVE PHY is set in Test Mode 3.

Test Definition Notes from the Specification

10GBase-T, Spec IEEE 802.3—2018 Clause 55.5.3.3 Transmitter Timing Jitter

RMS period jitter over an integration time interval of 1ms $\pm$ 10% is defined as the root mean square period difference from the average period $(T - T_{avg})$ accumulated over a sample size of 200000 $\pm$ 20000.

$$RMS\ period\ jitter < \sqrt{\frac{\left(\sum [(T - Tavg)^2]\right)}{Sample\ Size}}$$

25GBase-T, Spec IEEE 802.3—2018 Clause 113.5.3.3 Transmitter Timing Jitter

RMS period jitter over an integration time interval of 1ms $\pm$ 10% is defined as the root mean square period difference from the average period $(T - T_{avg})$ accumulated over a sample size of 200000 $\pm$ 20000.

$$RMS\ period\ jitter < \sqrt{\frac{\left(\sum [(T - Tavg)^2]\right)}{Sample\ Size}}$$

MGBase-T and NBase-T, IEEE 802.3—2018 Clause 126.5.3.3 Transmitter Timing Jitter

RMS period jitter over an integration time interval of 4 ms $\pm$ 10% (2.5G mode) or 2 ms $\pm$ 10% (5.0G mode) is defined as the root mean square period difference from the average period $(T - T_{avg})$ accumulated over a sample size of 200000 $\pm$ 20000.

$$RMS\ period\ jitter < \sqrt{\frac{\left(\sum [(T - Tavg)^2]\right)}{Sample\ Size}}$$

Pass Condition

The RMS period jitter measured at the MDI must be:

- Less than 5.5 ps for all the test pairs of 10GBase-T test.
- Less than 2.1 ps for all the test pairs of 25GBase-T test.
- Less than 10 ps for all the test pairs of MGBase-T and NBase-T (2.5G) test.
- Less than 7.2 ps for all the test pairs of MGBase-T and NBase-T (5.0G) test.

Measurement Algorithm

1 Configure the SLAVE DUT to produce Test Mode 3 and the MASTER DUT to produce Test Mode 1 signal.
2 On the Infiniium oscilloscope,
   a Convert the single ended signal to differential signal:
   FUNC2 = D+ (default Channel1) subtract D- (default Channel3) to get the differential signal.
   b Trigger on the rising edge of D+. Set the trigger level to offset voltage of D+.
   c In the **Configure** tab of the Conformance Test Application, set the sampling rate:
   - On the UXR Oscilloscopes, set the value as 32 GSa/s.
   - On the MXR oscilloscopes, set the value as 16 GSa/s.
   d The number of acquisitions to be taken depends on the time range and the memory depth you select:
   Number of Acq = Time Range / (Memory Depth * 1/Sampling Rate)
   e Enable the histogram and measure the period to the acquired waveform.
   f Take the standard deviation from the histogram statistics.
   g Compare the test result with the conformance test limit.

Test References

- See Clause 55.5.3.3 Transmitter Timing Jitter in the *IEEE 802.3-2018 Standard* for the 10GBase-T.
- See Clause 113.5.3.3 Transmitter Timing Jitter in the *IEEE 802.3-2018 Standard* for the 25GBase-T.
- See Clause 126.5.3.3 Transmitter Timing Jitter in the *IEEE 802.3-2018 Standard* for the MGBase-T and NBase-T.

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