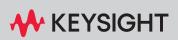
# D90103BQC 25GBASE-T Ethernet Test Application



METHODS OF IMPLEMENTATION

# Notices

#### © Keysight Technologies 2023

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

# Trademarks

UNIX is a registered trademark of UNIX System Laboratories in the U.S.A. and other countries. Target is copyrighted by Thru-Put Systems, Inc.

#### Version

Version 1.1.0.0

Edition

#### February 2023

Available in electronic format only

Keysight Technologies, Inc. 1900 Garden of the Gods Road Colorado Springs, CO 80907 USA

# Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW. KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE

# TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

#### **Technology Licenses**

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

# U.S. Government Rights

The Software is "commercial computer software," as defined by Federal Acquisition Regulation ("FAR") 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement ("DFARS") 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at

http://www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinguish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater

than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

# Safety Notices

# CAUTION

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

# WARNING

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

# Contents

# 1 Overview

# 25GBASE-T Ethernet Automated Testing–At a Glance 8

Required Equipment and Software 9

Hardware 9 Software 9 Licensing information 9

## In This Book 11

See Also 11

# 2 Installing the Test Application and Licenses

Installing the Test Applicatio	<b>n</b> 14
--------------------------------	-------------

# Installing the License Key 15

Using Keysight License Manager 5 15 Using Keysight License Manager 6 16

# 3 Preparing to Take Measurements

Calibrating the Oscilloscope 20

Starting the 25GBASE-T Ethernet Test Application 21

Connections for Conformance Tests 23

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

# RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture Description 28

Test Modes 29

# 5 U7237A 10GBase-T Transmitter Test Fixtures

#### U7237A 10GBase-T Transmitter Test Fixture Description 32

Fixture and Accessories 34 Dimension 34

Test Modes 35

# Characteristics, Regulatory and Safety Information 36

Electrical Characteristics 36 Operating and Non-operating Environmental Characteristics 36 Safety Information 37

# 6 Transmitter Timing Jitter (MASTER) Test

#### Procedure for Transmitter Timing Jitter (MASTER) Test 40

Running the Transmitter Timing Jitter (MASTER) Test using the 25GBase-T Test Application 40

#### Transmitter Timing Jitter (MASTER) Test–Implementation Methodology 42

Test Definition Notes from the Specification42Pass Condition43Measurement Algorithm43Test References43

# 7 Transmit Clock Frequency Test

#### **Procedure for Transmit Clock Frequency Test** 46

Running the Transmit Clock Frequency Test using the 25GBase-T Test Application 46

48

#### Transmit Clock Frequency Test–Implementation Methodology 48

Test Definition Notes from the SpecificationPass Condition48Measurement Algorithm48Test References49

# 8 Maximum Output Droop Test

### Procedure for Maximum Output Droop Test 52

Running the Maximum Output Droop Test using the 25GBase-T Test Application 52

54

# Maximum Output Droop Test–Implementation Methodology 54

Test Definition Notes from the SpecificationPass Condition55Measurement Algorithm55Test References55

# 9 Transmitter Power Spectral Density Test

# Procedure for Transmitter Power Spectral Density Test Using an External Spectrum Analyzer 58

Running the Transmitter Power Spectral Density Test using the 25GBASE-T Ethernet Test Application 58

# Procedure for Transmitter Power Spectral Density Test Using the Oscilloscope 61

Running the Transmitter Power Spectral Density Test using the 25GBASE-T Ethernet Test Application 61

#### Transmitter Power Spectral Density Test–Implementation Methodology 63

Test Definition Notes from the Specification65Pass Condition67Measurement Algorithm When Using an External Spectrum Analyzer68Measurement Algorithm When Using the Oscilloscope68Test References69

# 10 Power Level Test

#### Procedure for Power Level Test Using an External Spectrum Analyzer 72

Running the Power Level Test using the 25GBASE-T Ethernet Test Application 72

## Procedure for Power Level Test Using the Oscilloscope 75

Running the Power Level Test using the 25GBASE-T Ethernet Test Application 75

### Power Level Test–Implementation Methodology 77

Test Definition Notes from the Specification77Pass Condition77Measurement Algorithm Using an External Spectrum Analyzer78Measurement Algorithm Using the Oscilloscope78Test References79

# 11 Transmitter Linearity Tests

#### Procedure for Transmitter Linearity Tests Using an External Spectrum Analyzer 82

Running the Transmitter Linearity Tests using the 25GBASE-T Ethernet Test Application 82

# Procedure for Transmitter Linearity Tests Using the Oscilloscope 85

Running the Transmitter Linearity Tests using the 25GBase-T Test Application 85

#### Transmitter Linearity Tests–Implementation Methodology 88

Test Definition Notes from the Specification88Pass Condition89Measurement Algorithm When Using the External Spectrum Analyzer90Measurement Algorithm When Using the Oscilloscope91Test References92

# 12 Transmitter Nonlinear Distortion Tests

# Procedure for Transmitter Nonlinear Distortion Tests Using an External Spectrum Analyzer 94

Running the Transmitter Nonlinear Distortion tests using the 25GBASE-T Ethernet Test Application 94

#### Procedure for Transmitter Nonlinear Distortion Tests Using the Oscilloscope 98

Running the Transmitter Nonlinear Distortion tests using the 25GBASE-T Ethernet Test Application 98

# Connection Diagrams for Transmitter Nonlinear Distortion tests 102

Connection Diagram using Spectrum Analyzer 102 Connection Diagram using Oscilloscope 103

# Transmitter Nonlinear Distortion Tests–Implementation Methodology 104

Test Definition Notes from the Specification104Pass Condition104Measurement Algorithm When Using the External Spectrum Analyzer105Measurement Algorithm When Using the Oscilloscope105Test References106

# 13 MDI Return Loss Test

# Procedure for MDI Return Loss Test 108

Running the MDI Return Loss Test using the 25GBASE-T Ethernet Test Application 108

## MDI Return Loss Test–Implementation Methodology 113

Test Definition Notes from the Specification113Pass Condition115Measurement Algorithm115Test References115

## 14 MDI Impedance Balance Test

#### Procedure for MDI Impedance Balance Test 118

Running the MDI Impedance Balance Test using the 25GBASE-T Ethernet Test Application 118

# MDI Impedance Balance Test–Implementation Methodology 124

Test Definition Notes from the Specification124Pass Condition126Measurement Algorithm126Test References126

#### 15 Transmitter Timing Jitter (SLAVE) Test

#### Procedure for Transmitter Timing Jitter (SLAVE) Test 128

Running the Transmitter Timing Jitter (SLAVE) Test using the 25GBASE-T Ethernet Test Application 128

#### Transmitter Timing Jitter (SLAVE) Test–Implementation Methodology 131

Test Definition Notes from the Specification131Pass Condition132Measurement Algorithm132Test References132

Index

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 1 Overview

25GBASE-T Ethernet Automated Testing—At a Glance 8 Required Equipment and Software 9 In This Book 11



NOTE

# 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.

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

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 2 Installing the Test Application and Licenses

Installing the Test Application 14 Installing the License Key 15

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



# 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.

	Keysig	nt License Manager	
•		Licenses on	(localhost) 🔿
Connections		Full computer name:	.msr.is.keysight.com
ectio		Host ID:	PCSERNO, JBXXXXXXX
SU			

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.

Why do I need these tools?	
Install License File	Ctrl+I
Install License from Text	Ctrl+T
View License Alerts	Ctrl+L
Explore Transport URLs	
About Keysight License Manager	

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.

Keysight License	Manager 6	
Home		
Home	Licensing Version Copyright	= Keysight License Manager Ver: 6.0.3 Date: Nov 9 2018 = © Keysight Technologies 2000-2018
Environment	obpyright	- e keysigne leinneidgies 2000 2010
Environment	AGILEESOFD_SERVER_CONFIG	
View licenses	AGILEESOFD_SERVER_LOGFILE	<u>C:\ProgramData\Keysight\Licensing\Log\server_log.txt</u>
	SERVER_LICENSE_FILE	= <u>C:\ProgramData\Keysight\Licensing\Licenses\Server</u>
License usage	AGILEESOFD_LICENSE_FILE	= C:\ProgramData\Keysight\Licensing\Licenses\Other;C:\ProgramData\Keysight
	FLO_LICENSE_FILE	= C:\ProgramData\Keysight\Licensing\Licenses\Other;C:\ProgramData\Keysight
Borrow license	KAL_LICENSE_FILE	= C:\ProgramData\Keysight\Licensing\Licenses\Other;C:\ProgramData\Keysight
	AGILEESOFD_DEBUG_MODE	
	FLEXLM_TIMEOUT	
	Default Hostid	= XXXXadXXXXbe XXbaXeaceXee
	Ethernet Address	= XXXXadXXXXbe XXbaXeaceXee
	UUID	
	Physical MAC Address IP Address	<pre>= XXXXadXXXXbe PHY_ETHER=XXbaXeaceXee = 127.0.0.1</pre>
	Computer/Hostname	= 127.0.0.1
	Username	
	PATH	= C:\Program Files (x86)\Common Files\Intel\Shared Libraries\redist\intel6
	•	•
	Compact View	
		Refresh Glose Help

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.

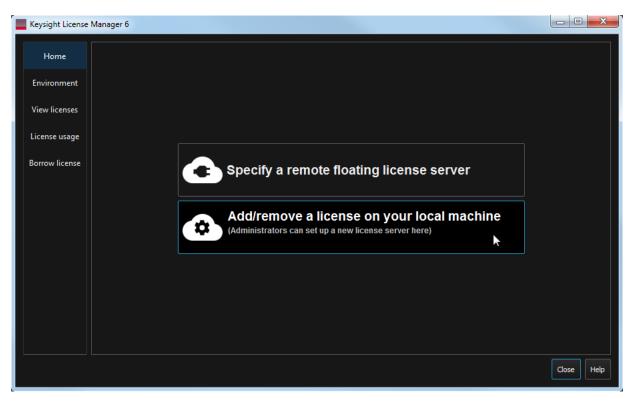


Figure 4 Home menu options to install licenses on Keysight License Manager 6

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

#### 2 Installing the Test Application and Licenses

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

3

# Preparing to Take Measurements

Calibrating the Oscilloscope 20 Starting the 25GBASE-T Ethernet Test Application 21

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.



# Calibrating the Oscilloscope

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



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.



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**.

25GBASE-T Test Application 25GBASE-T Device 1	
File View Tools Help	
Set Up Select Tests Configure Connect Run Automate Results HTML Report	
/Technology	n ê
Specification: IEEE 🔽 Data 10G 🔽 bps	
Connection	n I
Please determine the pair to be tested in the Configure Tab.	
Spectral Analysis	
🔘 Use Oscilloscope 🕒 Use Spectrum Analyzer	
Use Offline Waveform	
Enable Setup	
Fixture In Use	
○ ETH-TPA-RJ45CAT8-P ● U7237A	
External Texternant	
Vector Network Analyzer Spectrum Analyzer	∣ ∣⊧
O Connect to External Instrument	
Section External Instrument	
Bypass Cal Browse	
Not Connected Connect Edit	
Connect Edit Not Connected Connect	
Use Injecting Signal Olice Keysight 336124	
Use Keysight 81150/60/80A Not Connected Connect	
Source: Use Other	
	<u>ا</u>
Reports	n I
Comments	
	L
<	>
Messages	
Summaries (click for details) Filter Clear Details	
Application initialized and ready for use.	
2023-01-04 10:19:06:045 AM Connected to The primar ≥ 2023-01-04 10:19:11:453 AM Ready	
×	

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.

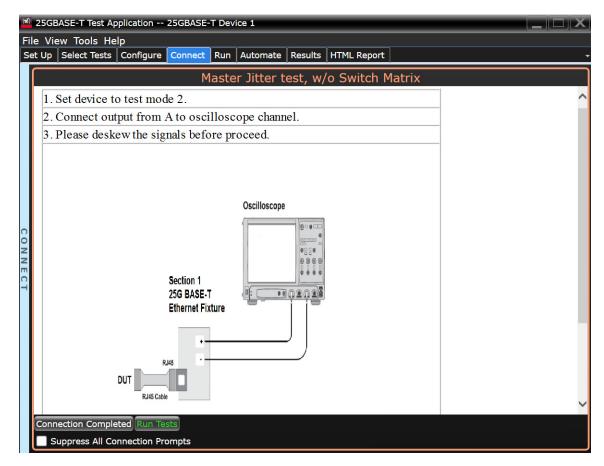


Figure 6 Physical connection diagram and instructions for conformance tests

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.

# NOTE

The Parallel Analysis of test pairs (Pair A, Pair B, Pair C, and Pair D) is not supported by Network Analyzer and Spectrum Analyzer.

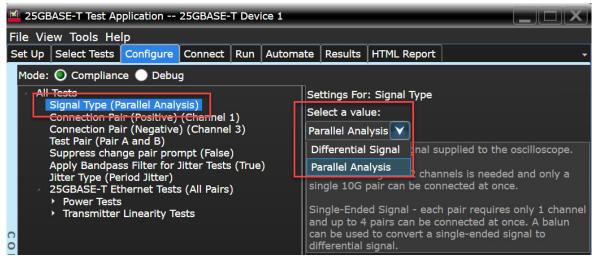
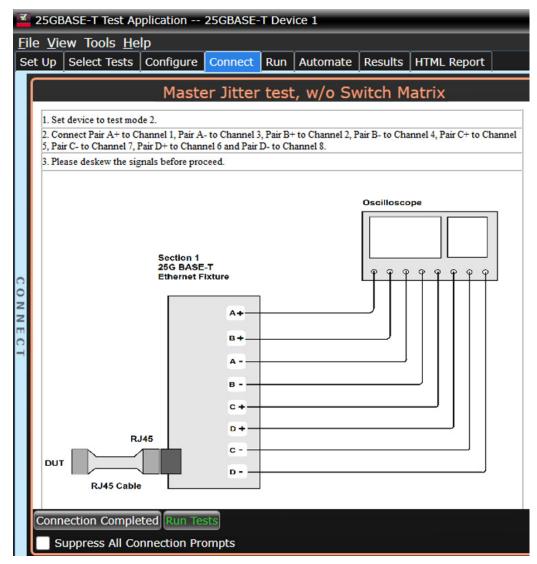


Figure 7 Parallel Analysis signal type selected in the Configure tab





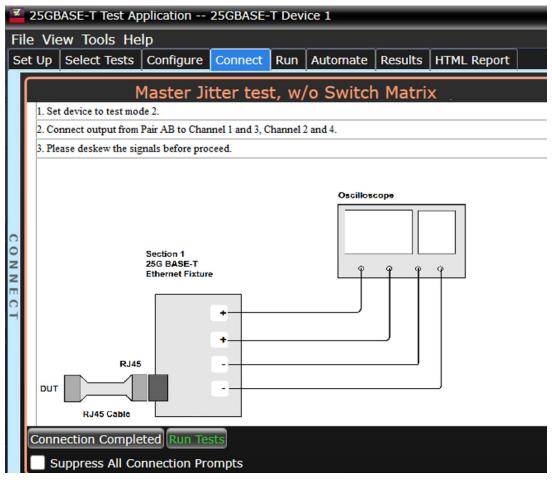


Figure 9 Physical connection diagram and instructions for conformance tests in MXR/UXR (4 channels) oscilloscope

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation



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

RJ-45 (8P8C) TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture Description 28 Test Modes 29

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.



# 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.

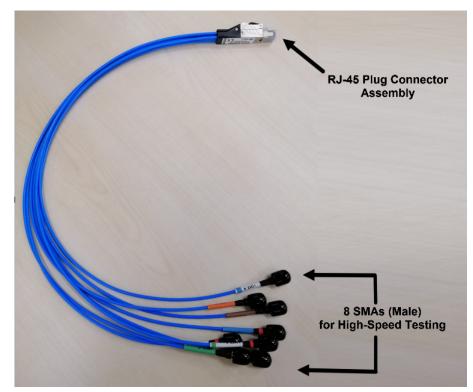


Figure 10 RJ-45 TPA Plug Test Adapter 25GBase-T Transmitter Test Fixture

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.

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

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 5

# U7237A 10GBase–T Transmitter Test Fixtures

U7237A 10GBase-T Transmitter Test Fixture Description 32 Test Modes 35 Characteristics, Regulatory and Safety Information 36

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.



# 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:

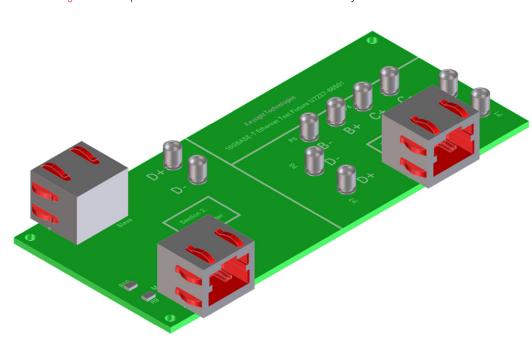
Transmitter Timing Jitter (SLAVE) Test

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

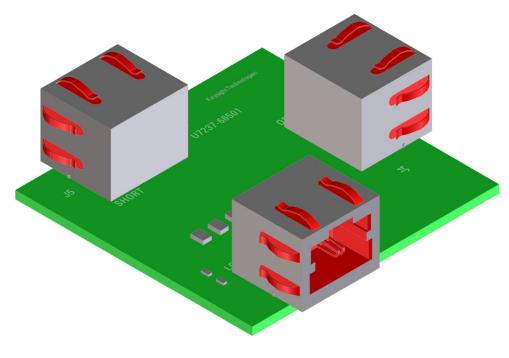


Figure 13 Section 3 of the U7237A 10GBase-T Transmitter Test Fixture

#### 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°C to 40°C Non-operating = - 51°C) to 71°C
Humidity	Operating = 95% RH at 40°C 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

#### 5 U7237A 10GBASE-T Transmitter Test Fixtures

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

6

## Transmitter Timing Jitter (MASTER) Test

Procedure for Transmitter Timing Jitter (MASTER) Test 40 Transmitter Timing Jitter (MASTER) Test–Implementation Methodology 42

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.



## 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.

🖬 25GE	BASE-T Test Ap	plication	25GBASE-	T Dev	ice 1					
File Vie	File View Tools Help									
Set Up	Select Tests	Configure	Connect	Run	Automate	Results	HTML Report			
SELECT T	<ul> <li>Trans</li> <li>Trans</li> <li>Maxi</li> <li>Powe</li> <li>Trans</li> <li>MDI</li> <li>25GBAS</li> </ul>	SE-T Etherni smitter Timi smit Clock F mum Outpu er Tests smitter Line Return Loss Impedance SE-T Etherni smitter Timi	ng Jitter (I irequency t Droop Te arity Tests Test Balance Te et Test (Pa	Master ests est ir D or	Ď					
Descri	Transmitter Tir .imits: RMS Pe iption: The tra rmance limits s	riodic Jitter nsmitter tim	(Master)(2 ning jitter o	of the	, device unde	r test (DL	JT) must be les	s than the		
	ence: IEEE Std Margin Formul n = ( ( Max - A	a: ===			.5.3.3			÷		

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 <u>+</u> 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*<sub>avg</sub>) accumulated over a sample size of 200000  $\pm$  20000.

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

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

#### 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*<sub>avg</sub>) 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.

#### 6 Transmitter Timing Jitter (MASTER) Test

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

## 7 Transmit Clock Frequency Test

Procedure for Transmit Clock Frequency Test 46 Transmit Clock Frequency Test–Implementation Methodology 48

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.



## 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.

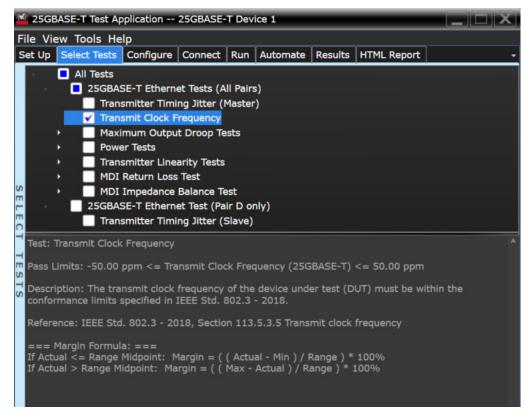


Figure 15 Selecting Transmitter Clock Frequency test

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 ± 50 ppm 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  $\pm$  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  $\pm$  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  $\pm$  50 ppm and 200 MHz  $\pm$  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  $\pm$  50 ppm for the 25GBase-T DUT, 800 MHz  $\pm$  50 ppm for the 10GBase-T DUT, 400 MHz  $\pm$  50 ppm for the MGBase-T (5.0G) DUT, 200 MHz  $\pm$  50 ppm for the MGBase-T (2.5G) DUT, 400MHz  $\pm$  50 ppm for the NBase-T (5.0G) DUT, and 200 MHz  $\pm$  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.

#### 7 Transmit Clock Frequency Test

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 8 Maximum Output Droop Test

Procedure for Maximum Output Droop Test 52 Maximum Output Droop Test–Implementation Methodology 54

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.



## 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:
- $\cdot~$  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.

#### 8 Maximum Output Droop Test

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

9

## Transmitter Power Spectral Density Test

Procedure for Transmitter Power Spectral Density Test Using an External Spectrum Analyzer 58 Procedure for Transmitter Power Spectral Density Test Using the Oscilloscope 61 Transmitter Power Spectral Density Test–Implementation Methodology 63

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.



## 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.

Keysight Connection Expert 2020	0	? _				
Instruments PXI/AXIe Chassis						
My Instruments + Add 2 🗄 <b>T</b>	Details for Keysight N9010B					
V 🔀 GPIB-USB (GPIB0)	ớ 🕼 \star 📑 📴 😉 💿 🌐					
No Instruments Found	Check Edit Remove Interactive IO Monitor Command BenchVue Web UI Soft Front Status IO Expert Panel					
V LAN (TCPIPO)	Manufacturer: Keysight					
N9010B, Keysight 10.66.101.135	ManUracutrer: Keysgint Model: N9010B Serial Number: MY57470895 Firmware Version: A.21.04					
No Instruments Found	Web Information: Product Page					
✓ USB (USB0)	Connection Strings					
No Instruments Found	VISA Address Aliases SICL Address          VISA Address       SICL Address         Image: TCPIP0::10.66.101.135::inst0::INSTR       Image: TCPIP0::10.66.101.135]:inst0         Installed IVI Drivers       Update					



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.

Vector Netwo	rk Analyzer	Spectrum Analy	/zer
O Connect to Extern	al Instrument	Balun Correction	
🔵 Use Data File			
Bypass Cal			Browse
Not Connected	Connect Edit		Connect

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.

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.

#### Table 4 Test Configuration Options Using 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.

🗹 25G	BAS	E-T Test A	Application	25GBASE-	T Dev	ice 1	_	_	_		X
File V	iew	Tools H	elp								
Set Up	Se	elect Tests	Configure	Connect	Run	Automate	Results	HTML	Report		+
SELECT TE		Tra Tra Ma: Pov V Tra Tra MD 25GB/	ASE-T Ethern nsmitter Timi nsmit Clock F kimum Outpu ver Tests Transmitter P Power Level nsmitter Line I Return Loss I Impedance ASE-T Ethern nsmitter Timi	ing Jitter (1 Frequency ut Droop Te ower Spect arity Tests s Test Balance Te et Test (Pa	Master sts ral De est ir D or	nsity					
N Test:	Trar	nsmitter P	ower Spectra	al Density							
	Limi	ts: Overa	ll = Pass								
Desc	riptio	on: To ver	ify that the t	ransmitter	power	spectral de	ensity mee	ets the	conform	nance limits specified in IEEE Std. 802.3 - 2018.	
	Reference: IEEE Std. 802.3 - 2018, Section 113.5.3.4 Transmitter power spectral density (PSD) and power level										
		gin Formı ( ( Actua	ula: === I - Min ) /   №	1in   ) * 10	0%						¥

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.

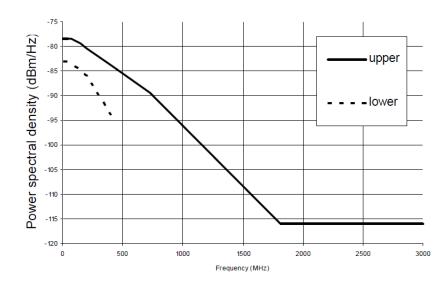
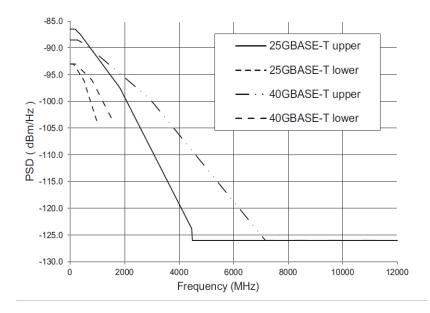


Figure 20 PSD vs. Frequency for a 10GBase-T DUT



Transmitter Power Spectral Density (PSD) with no power backoff

Figure 21 PSD vs. Frequency for a 25GBase-T DUT

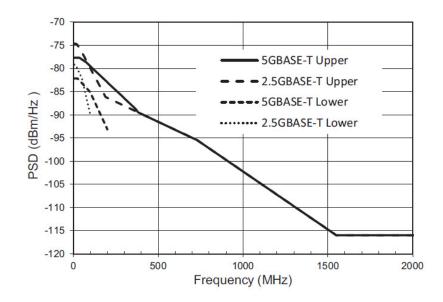


Figure 22 PSD vs. Frequency for MGBase-T / NBase-T DUT (2.5G & 5G)

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  $\Omega$  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.

$$-78.5 \text{ dBm/Hz} \qquad 0 < f \le 70$$
$$-78.5 - \left(\frac{f - 70}{80}\right) \text{dBm/Hz} \qquad 70 < f \le 150$$

Upper PSD 
$$(f) \le \begin{cases} -79.5 - \left(\frac{f - 150}{58}\right) dBm/Hz & 150 < f \le 730 \end{cases}$$
 (55–9)

$$-79.5 - \left(\frac{f - 330}{40}\right) dBm/Hz$$
 730 < f ≤ 1790

$$-116 \text{ dBm/Hz}$$
  $1790 < f \le 3000$ 

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

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  $\Omega$  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.

$$\begin{aligned} & \left\{ \begin{array}{ll} -88.5 - 10\log_{10}S \ dBm/Hz & 0 < \frac{f}{S} \le 280 \\ & -88.5 - 10\log_{10}S - \left(\frac{f}{S} - 280\right) \\ 320 \end{array} \right) dBm/Hz & 280 < \frac{f}{S} \le 600 \end{aligned} \\ & \text{Upper PSD } (f) \le \\ & -89.5 - 10\log_{10}S - \left(\frac{f}{S} - 600\right) \\ & -89.5 - 10\log_{10}S - \left(\frac{f}{S} - 1320\right) \\ & -89.5 - 10\log_{10}S - \left(\frac{f}{S} - 1320\right) \\ & -126 \ dBm/Hz & 7160 < \frac{f}{S} \le 12000 \\ & S \le 1000 \\$$

$$\text{Lower PSD } (f) \ge \begin{cases} -93 \text{ dBm/Hz} & 20 \le f \le 200 \\ -93 - \left(\frac{f}{S} - 200\right) \\ 200 \end{bmatrix} \text{dBm/Hz} & 200 < \frac{f}{S} \le 800 \\ -96 - \left(\frac{f}{S} - 800\right) \\ -96 - \left(\frac{f}{S} - 800\right) \\ 100 \end{bmatrix} \text{dBm/Hz} & 800 < \frac{f}{S} \le \frac{1600}{S} \end{cases}$$
(113–12)

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.

Lower PSD 
$$(f) \ge \begin{cases} -93 \text{ dBm/Hz} & 20 \le f \le 200 \\ -93 - \left(\frac{f}{S} - 200\right) \\ 200 \end{bmatrix} \text{dBm/Hz} & 200 < f \le 800 \\ -96 - \left(\frac{f}{S} - 800\right) \\ 100 \end{bmatrix} \text{dBm/Hz} & 800 < f \le 1600 \end{cases}$$

#### 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  $\Omega$  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.

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

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

(126 - 9)

and

$$\text{Lower PSD } (f) \ge \begin{cases} -82.2 - 10 \times \log_{10}(S) & \text{dBm/Hz} \quad 5 < 2\frac{f}{S} \le 50 \\ -82.2 - 10 \times \log_{10}S - \frac{\left(2\frac{f}{S} - 50\right)}{50} & \text{dBm/Hz} \quad 50 < 2\frac{f}{S} \le 200 \\ -85.2 - 10 \times \log_{10}S - \frac{\left(2\frac{f}{S} - 200\right)}{25} & \text{dBm/Hz} \quad 200 < 2\frac{f}{S} \le 400 \end{cases}$$
(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:

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

Where N = number of segments or cycles to compute.

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

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

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

power spectral density ( $V^2$  /Hz) = 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.

#### 9 Transmitter Power Spectral Density Test

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

## 10 Power Level Test

Procedure for Power Level Test Using an External Spectrum Analyzer 72 Procedure for Power Level Test Using the Oscilloscope 75 Power Level Test–Implementation Methodology 77

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.



## 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.

Keysight Connection Expert 2020	
Instruments PXI/AXIe Chassis	
My Instruments + Add 🕄 🗮 🕇	Details for Keysight N9010B
V 🔇 GPIB-USB (GPIB0)	😂 🕼 🙁 📑 🤷 🔄
No Instruments Found	Check Edit Remove Interactive IO Monitor Command BenchVue Web UI Soft Front Status IO Expert Panel
V LAN (TCPIPO)	Manufacturer: Keysight
VOI USB (USB0)	Model:N9010BSerial Number:MY57470895Firmware Version:A.21.04Web Information:Product PageConnection Strings
No Instruments Found	VISA Address Aliases SICL Address          VISA Address       Aliases SICL Address         Image: TCPIP0::10.66.101.135::inst0::INSTR       Image: TCPIP0::10.66.101.135];inst0         Installed IVI Drivers       Update <no drivers="" installed=""></no>

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.

External Instrument Vector Network Analyzer	Spectrum Analyzer	
O Connect to External Instrument	Balun Correction	
🔵 Use Data File		
Bypass Cal	Browse	
Not Connected Connect Edit	Connected to N9010B	

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.

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.

#### Table 6 Test Configuration Options Using 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 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.

M 25	5GB/	ASE-T	r Te	st Ap	plica	tion -	- 21	5GBASE-	T Dev	ce 1	_	_	_			
File	Vie	w To	ools	He	lp											
Set l	Jp	Sele	ct Te	sts	Con	figure	•   C	Connect	Run	Automate	Results	HTML	Report			
SELECT TES	, , , , ,			GBAS Trans Maxir Powe Trans MDI 1 GBAS	smitte smit e mum er Tes ansm wer l smitte Retur Impe SE-T	er Tin Clock Outp sts hitter Level er Lin rn Los edance Ether	ning Fre but I Pow eari ss T e Ba net	: Tests (A g Jitter (I equency Droop Te ver Spect ity Tests Test alance Te : Test (Pa g Jitter (!	Master Ists tral De Ist ir D or	nsity						
Tes	it: P	ower	Lev	el												
Pas	s Li	mits:	-1.	0000	dBn		Pov	ver Leve	(25G	BASE-T) <=	= 1.0000 d	dBm				
De	scrip	otion:		verify	y tha	t the	trai	nsmitter	power	level is wit	hin the co	onforma	nce limi	its	specified in IEEE Std. 802.3 - 2018.	
Ref	ferer	nce: I	IEEE	Std.	. 802	2.3 - 2	2018	8, Sectio	n 113.	5.3.4 Trans	mitter po	wer spe	ctral de	ensi	sity (PSD) and power level	
If A	Actua		= Ra	nge I	Midpo	oint:				al - Min ) /   Actual ) / R						Ŷ



## 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:

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:

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

- e Convert the amplitude to dBm.
- f Calculate the band power:

BP = (Bs /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.

10 Power Level Test

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 11 Transmitter Linearity Tests

Procedure for Transmitter Linearity Tests Using an External Spectrum Analyzer 82 Procedure for Transmitter Linearity Tests Using the Oscilloscope 85 Transmitter Linearity Tests–Implementation Methodology 88

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.



# 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.

Keysight Connection Expert 2020		• ? _
Instruments PXI/AXIe Chassis		
My Instruments + Add 😂 📰 🗡	Details for Keysight N9010B	
V 🔇 GPIB-USB (GPIB0)	🕄 🕼 🗙 📑 📴 🔮 🙆 🌐	
No Instruments Found	Check Edit Remove Interactive IO Monitor Command BenchVue Web UI Soft Front IO Expert Panel	
LAN (TCPIPO)     No10B, Keysight     10.66.101.135     Om (ASRL3)     No Instruments Found     USB (USBO)     No Instruments Found	Manufacturer:       Keysight         Model:       N9010B         Serial Number:       MY57470895         Ermware Version:       A.21.04         Web Information:       Product Page         Connection Strings         VISA Address       SICL Address         TCPIP0::10.66.101.135::inst0::INSTP:       Ian[10.66.101.135]:inst0         Installed IVI Drivers       Update	

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.

- External Instrument- Vector Networ	k Analyzer	Spectrum Analy	zer
O Connect to Externa	al Instrument	Balun Correction	
🔵 Use Data File			
Bypass Cal			Browse
Not Connected	Connect Edit	Connected to N9010B	Connect

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.

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.

#### Table 8 Test Configuration Options Using 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.



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.

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.		

#### Table 9 Test Configuration Options 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.

🔟 25GBASE-T Test Application 25GBASE-T Device 1						
File View Tools Help						
Set Up Select Tests Configure Connect Run Automate Results HTML Report						
<ul> <li>All Tests</li> <li>25GBASE-T Ethernet Tests (All Pairs)</li> <li>Transmitter Timing Jitter (Master)</li> <li>Transmit Clock Frequency</li> <li>Maximum Output Droop Tests</li> <li>Power Tests</li> <li>Y Transmitter Linearity Tests</li> <li>Y Two Tone Frequency Pair 1</li> <li>Y Two Tone Frequency Pair 2</li> <li>Y Two Tone Frequency Pair 3</li> <li>Y Two Tone Frequency Pair 4</li> <li>Y Two Tone Frequency Pair 5</li> <li>MDI Return Loss Test</li> <li>MDI Impedance Balance Test</li> <li>25GBASE-T Ethernet Test (Pair D only)</li> <li>Transmitter Timing Jitter (Slave)</li> </ul>						
Test: Two Tone Frequency Pair 1						
Pass Limits: Linearity Test: Two Tone Frequency Pair 1 (25GBASE-T) >= 54.500 dBc						
Description: To verify that the spurious free dynamic range of the transmitter meets the conformance limits specified in 113.5.3.2 of IEEE Std. 802.3 - 2018.						
Reference: IEEE Std. 802.3 - 2018, Section 113.5.3.2 Transmitter nonlinear distortion						
=== Margin Formula: === Margin = ( ( Actual - Min ) /   Min   ) * 100%						

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

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 X log<sub>10</sub>( $f/(100 \times 0.625)$ )} (113-9)

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 > 2.5 + min{52,58 - 20 X log<sub>10</sub>(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 ≥ 2.5 + min {52, 58 20log<sub>10</sub>(*f*/25)}
  - 25GBase-T: SFDR ≥ 2.5 + min{52,58 20 X log<sub>10</sub>(f/(100 x 0.625))}
  - MGBase-T and NBase-T: SFDR ≥ 2.5 + min{52,58 20 X log<sub>10</sub>(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	<u>&gt;</u> 54.5
2	78.906 & 80.469	<u>&gt;</u> 50.346
3	139.844 & 141.406	<u>&gt;</u> 45.449
4	216.406 & 219.531	<u>&gt;</u> 41.629
5	310.156 & 313.281	<u>&gt;</u> 38.540

#### Table 11 Test Limit of SFDR for 25GBase-T

Transmit Frequency	Frequency Pair (MHz)	Test Limit (dBc)
1	91.796 & 103.515	<u>&gt;</u> 54.5
2	197.265 & 201.171	<u>&gt;</u> 50.346
3	349.609 & 353.515	<u>&gt;</u> 45.449
4	541.015 & 548.828	<u>&gt;</u> 41.629
5	775.390 & 783.203	<u>&gt;</u> 38.540

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	<u>&gt;</u> 54.5	18.359 & 20.703	<u>&gt;</u> 54.5
Dual Tone 2	19.7265 & 20.11725	<u>&gt;</u> 54.5	39.453 & 40.2343	<u>&gt;</u> 54.5
Dual Tone 3	34.961 & 35.3515	<u>&gt;</u> 54.5	69.922 & 70.703	<u>&gt;</u> 51.47
Dual Tone 4	54.1015 & 54.88281	<u>&gt;</u> 53.67	108.203 & 109.7656	<u>&gt;</u> 47.649
Dual Tone 5	77.539 & 78.32031	<u>&gt;</u> 50.581	155.078 & 156.6406	<u>&gt;</u> 44.561

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

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



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:

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:

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.

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 12 Transmitter Nonlinear Distortion Tests

Procedure for Transmitter Nonlinear Distortion Tests Using an External Spectrum Analyzer 94 Procedure for Transmitter Nonlinear Distortion Tests Using the Oscilloscope 98 Connection Diagrams for Transmitter Nonlinear Distortion tests 102 Transmitter Nonlinear Distortion Tests–Implementation Methodology 104

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.



# 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.

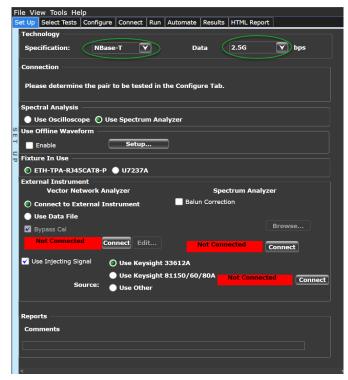


Figure 32 Set Up tab settings for Transmitter Nonlinear Distortion tests using Spectrum Analyzer

- 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.

Keysight Connection Expert 2020	· · · · · · · · · · · · · · · · · · ·	»?_
Instruments PXI/AXIe Chassis		
My Instruments + Add C 📰 T	Details for Keysight N9010B	
V 😫 GPIB-USB (GPIB0)	🕫 🗷 🗙 📑 📴 🖆 🔘 🌐 🖷	
No Instruments Found	Check Edit Remove Interactive IO Monitor Command BenchVue Web UI Soft Front Status IO Expert Panel	
LAN (TCPIPO)  N9010B, Keysight 10.66.101.135  COM (ASRL3)  No Instruments Found  USB (USB0)  No Instruments Found	Manufacturer:       Keysight         Model:       N90108         Senal Number:       MYS7470895         Ermware Version:       A.21.04         Web Information:       Product Page         Connection Strings       SICL Address         VISA Address       SICL Address         VISA Address       SICL Address         Installed IVI Drivers       Qudate         viso installed drivers>	9



- 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.

My Instruments	+Add 😂 🖽	T Details fo	or Keysig	ght N9030B							
Filter Instruments	.5.93	T 2	ľ	×		<del>.</del> @:	(=			.9≡	
E5080A, k 10.15.103.	Xeysight Technologies 174	Check Status	Edit	Remove Ir Manufacture	IO	IO Monitor Keysight	Command Expert	BenchVue	Web UI	Soft Front Panel	
MSOX932 141.183.18	<b>04A Infiniium, Keysight</b> 19.45			Model: Serial Numb Firmware Ve	ber: N	19030B 1Y563205 4.26.04	50				
MXR608A 10.66.96.2	Infiniium, Keysight 11		Co	Web Inform		Product Pa	ge				
N1000A, H 141.121.85	Keysight Technologies 5.108			VIS	SA Addres	S		Aliases	ŝ	GICL Address	
N5182B, A 141.183.21	Agilent Technologies 4.51				PIP0::10.66	5.97.228::ir	st0::INSTR	$\triangleright$	1	an[10.66.97.228	]:inst0
N5225B, F 141.183.11			Ins	talled IVI Drivers		ate					
N9030B, I 10.66.97.2											



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.

S	External Instrument Vector Network #	Analyzer	Spectrum Analy	yzer
ET	O Connect to External 1	Instrument	Balun Correction	
UP	🔵 Use Data File			
Ŭ	Bypass Cal			Browse
	Not Connected	Connect Edit		Connect
	🖌 Use Injecting Signal	🔵 Use Keysight 3	33612A	
		🔵 Use Keysight (	81150/60/80A Connected to	Connect
	Source:	Use Other		Conneck



Connected status for Spectrum Analyzer & for Keysight 33612A 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.

F	ile View Tools Help
5	et Up Select Tests Configure Connect Run Automate Results HTML Report
L	Technology
L	Specification: NBase-T V Data 2.5G V bps
	Connection
	Please determine the pair to be tested in the Configure Tab.
L	Spectral Analysis
L	🔘 Use Oscilloscope 🌑 Use Spectrum Analyzer
L	Use Offline Waveform
L	Enable Setup
L	Fixture In Use
L	🔘 ЕТН-ТРА-RJ45CAT8-Р 🌑 U7237A
SE	External Instrument Vector Network Analyzer Spectrum Analyzer
٦	Connect to External Instrument     Balun Correction
UΡ	
L	Browse
L	Not Connected Connect Edit Not Connected Connect
L	
L	✓ Use Injecting Signal O Use Keysight 33612A
L	Use Keysight 81150/60/80A Not Connected Connect
L	Source: 🕒 Use Other
L	J
	Reports
	Comments

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.



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.

∕External Instrument Vector Network An	alyzer	Spectrum Analy	zer
O Connect to External In	strument	Balun Correction	
🔵 Use Data File			Browse
Bypass Cal			
Not Connected	onnect Edit	Not Connected	Connect
🖌 Use Injecting Signal	O Use Keysight 3361	2A	
Source:	🔵 Use Keysight 8115	D/60/80A Connected to	33613A Connect
	🔵 Use Other		

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.



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.

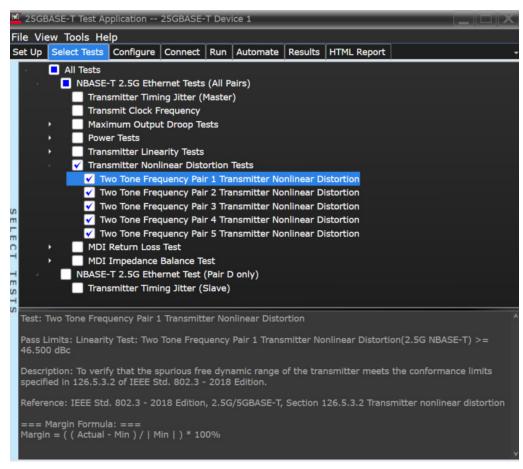


Figure 40 Selecting Transmitter Nonlinear Distortion tests

# Connection Diagrams for Transmitter Nonlinear Distortion tests

Connection Diagram using Spectrum Analyzer

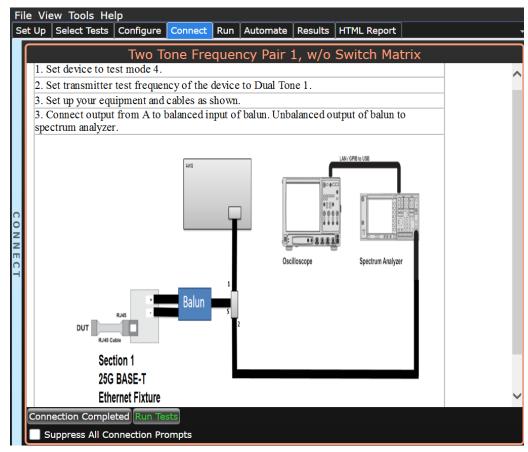


Figure 41 Connection diagram for Transmitter Nonlinear Distortion tests with a Spectrum Analyzer

Connection Diagram using Oscilloscope

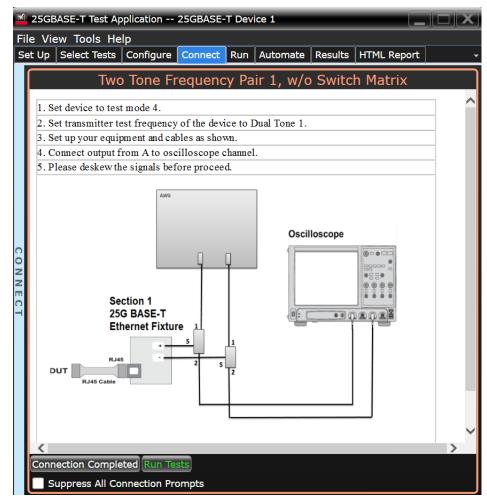


Figure 42 Connection diagram for Transmitter Nonlinear Distortion tests with an Oscilloscope

### 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:

SFDR  $\geq$  -5.5 + min{52,58 - 20log<sub>10</sub>(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: 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	<u>&gt;</u> 46.500
Dual Tone 2	19.7265 & 20.11725	<u>&gt;</u> 46.500
Dual Tone 3	34.961 & 35.3515	<u>&gt;</u> 46.500
Dual Tone 4	54.1015 & 54.88275	<u>&gt;</u> 45.670
Dual Tone 5	77.539 & 78.32031	<u>&gt;</u> 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,...,120Odd 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:

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:

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

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.

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 13 MDI Return Loss Test

Procedure for MDI Return Loss Test 108 MDI Return Loss Test–Implementation Methodology 113

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.

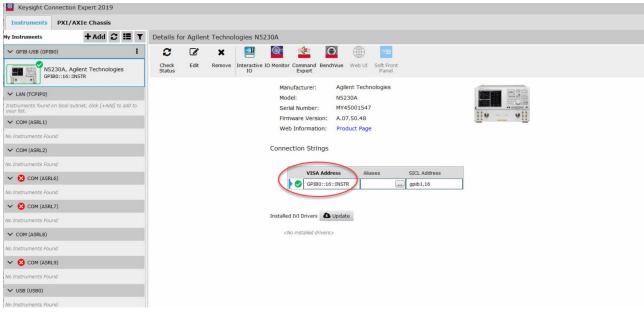


# Procedure for MDI Return Loss Test

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.





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.

Exter	nal Instrument	Coastrum Anal	
	Vector Network Analyzer	Spectrum Anal	уzег
တ္ 💽	connect to External Instrument	Balun Correction	
📕 🕒 u	lse Data File		
😑 🗖 В	ypass Cal		Browse
Cor	meeted to NS7300A Connect Edit	Not Connected	Connect

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.

Vector Network Analyzer					
Connect to External Instrument					
🔘 Use Data File					
Bypass Cal					
No File Specifie Connect	Edit				

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.

🗾 Data Files	-	
Return Loss Data File Pair A :		Browse
Return Loss Data File Pair B :		Browse
Return Loss Data File Pair C :		Browse
Return Loss Data File Pair D :		Browse
Impedance Balance Data File Pair A :		Browse
Impedance Balance Data File Pair B :		Browse
Impedance Balance Data File Pair C :		Browse
Impedance Balance Data File Pair D :		Browse
	Clear	ок



- 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.

-External Instru	nent ———					
Vector N	Vector Network Analyzer					
Connect to E	Connect to External Instrument					
🔘 Use Data Fil	🔘 Use Data File					
Bypass Cal						
PairA	Connect	Edit				

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.

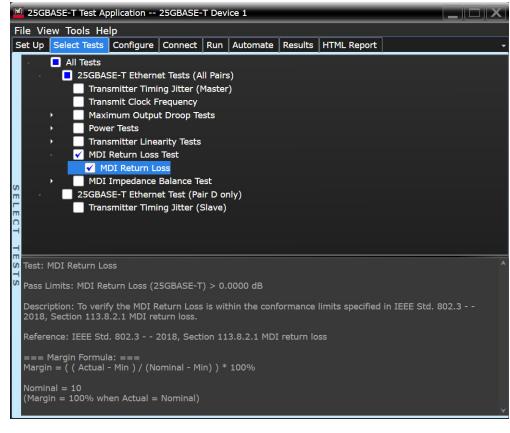


Figure 48 Selecting MDI Return Loss test

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.



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  $100 \Omega$  is attenuated, relative to the incident signal as per the relationship shown below for 10GBase-T:

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

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  $100 \Omega$  is attenuated, relative to the incident signal as per the relationship shown below for 25GBase-T:

Return loss ≥ {	16 16 - 10log <sub>10</sub> (f/40)	$1 \le f \le 40$ $40 < f \le 400$	(dB) (dB)	(113–39)
l	6	$400 < f \le 2000 \times S$	(dB)	

where f is in MHz.

6

#### 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  $100 \Omega$  is attenuated, relative to the incident signal as per the relationship shown below for MGBase-T and NBase-T:

Return loss 
$$\ge \begin{cases} 16 & 1 \le f \le 40 & (dB) \\ 16 - 10 \log_{10}(f/40) & 40 < f \le f_{max} & (dB) \end{cases}$$
 (126-38)

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<sub>10</sub>(*f*/40) from 40 MHz to 400 MHz, and at least 6-30log<sub>10</sub>(*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<sub>10</sub>(*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<sub>10</sub>(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 100  $\!\Omega$  .
- 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.

#### 13 MDI Return Loss Test

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 14 MDI Impedance Balance Test

Procedure for MDI Impedance Balance Test 118 MDI Impedance Balance Test–Implementation Methodology 124

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.

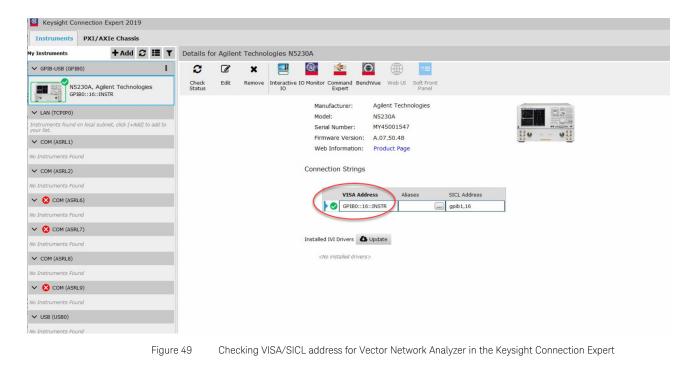


### Procedure for MDI Impedance Balance Test

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.



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.

ъ	kternal Instrument Vector Network Analyzer	Spectrum Ana	lyzer
s (	Oconnect to External Instrument	Balun Correction	
7	) Use Data File		
< [	Bypass Cal		Browse
þ	Connected to ND230A Connect Edit	Not Connected	Connect

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.

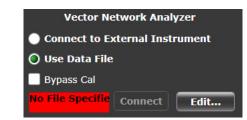


Figure 51 Use Data File Option for Vector Network Analyzer

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.

🖾 Data Files		-	
Return Loss Data File Pair A :	<b>I</b>		Browse
Return Loss Data File Pair B :			Browse
Return Loss Data File Pair C :			Browse
Return Loss Data File Pair D :	[		Browse
Impedance Balance Data File Pair A :			Browse
Impedance Balance Data File Pair B :			Browse
Impedance Balance Data File Pair C :			Browse
Impedance Balance Data File Pair D :			Browse
		Clear	ОК



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.

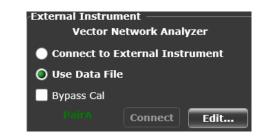
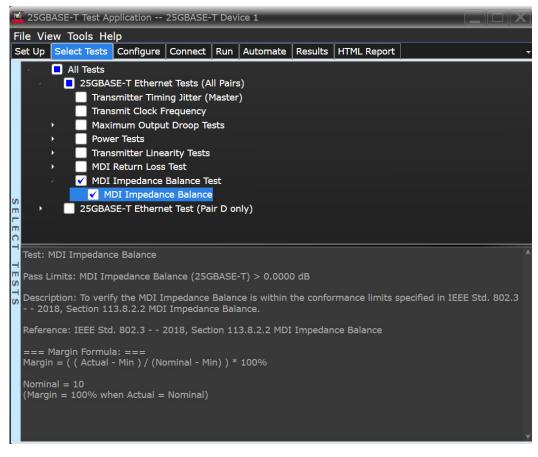


Figure 53 VNA pair information after the test application detects the data file

- 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.





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:

$$Bal(f) \ge \begin{cases} 48 & 1 \le f < 30 \quad (dB) \\ 44 - 19.2 \log_{10} \left(\frac{f}{50}\right) & 30 \le f \le 500 \quad (dB) \end{cases}$$
(55-55)

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:

$Bal(f) \geq \frac{1}{2}$	48	$1 \le f \le 40$	(dB)	(113-40)
2410)=	48 44 - 19.2log <sub>10</sub> (f/40)	$40 < f \le 2000 \times S$	(dB)	()

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:

(126 - 39)

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

For 5GBASE-T:

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

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 44-19.2log<sub>10</sub>(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 44-19.2log<sub>10</sub>(*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 48-20log<sub>10</sub>(f/10) from 10 MHz to 20 MHz, and at least 42-15log<sub>10</sub>(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 44-19.2log<sub>10</sub>(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 100  $\!\Omega$  .
- 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.

Keysight D90103BQC 25GBASE-T Ethernet Test Application Methods of Implementation

# 15 Transmitter Timing Jitter (SLAVE) Test

Procedure for Transmitter Timing Jitter (SLAVE) Test 128 Transmitter Timing Jitter (SLAVE) Test–Implementation Methodology 131

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.



### 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.

📕 25GI	BASE-T	Test Ap	oplication	25GBASE-	T Dev	ice 1					X
File Vi	- Y		· · · · · · · · · · · · · · · · · · ·				·	·			
Set Up	Selec	t Tests	Configure	Connect	Run	Automate	Results	HTML Report	ļ		-
SELEC	> > > > >	25GBAS Trans Trans Maxi Powe Trans MDI MDI 25GBAS	SE-T Ethern smitter Timi smit Clock F mum Outpu er Tests smitter Line Return Loss Impedance SE-T Ethern smitter Timi	ng Jitter (1 requency t Droop Te arity Tests Test Balance Te et Test (Pa	Master sts est ir D or	)					
m			ning Jitter ( riodic Jitter		-T) <	2.10 ps					^
ທ Descr limits	ription: specifi	The tra ed in IE	nsmitter tim EE Std. 802	ing jitter o .3 - 2018.	of the	device unde	r test (DL	JT) must be les	s than the o	conformance	
Refer	ence: I	EEE Std	. 802.3 - 20	18, Sectio	n 113	.5.3.3 Trans	mitter tim	ning jitter			
			a: === Actual ) /   M	lax   ) * 1	00%						•

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.



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  $1\text{ms} \pm 10\%$  is defined as the root mean square period difference from the average period (*T* - *T*<sub>avg</sub>) accumulated over a sample size of 200000  $\pm$  20000.

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

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

RMS period jitter over an integration time interval of  $1\text{ms} \pm 10\%$  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 < 
$$\sqrt{\frac{\sum [(T - Tavg)^2]}{Sample Size}}$$

#### 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*<sub>avg</sub>) accumulated over a sample size of 200000  $\pm$  20000.

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

#### 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.

## Index

## A

application software, installing, 14 application software, starting, 21 Automation tab, 22

## С

calibrating the oscilloscope, 20

## I

installation, 7,13

## L

license key, installing, 15

## Μ

Maximum Output Droop tests, 51 MDI Return Loss tests, 107, 117 measurements, preparing, 19 mouse, 9

## 0

Online Help, 11 oscilloscope calibration, 20

## Ρ

Power Level tests, 71

## R

Results tab, 22 Run Tests tab, 22

## Т

Transmit Clock Frequency tests, 45 Transmitter Linearity tests, 81, 93 Transmitter Power Spectral Density tests, 57 Transmitter Timing Jitter tests, 39, 127 Index



This information is subject to change without notice. © Keysight Technologies 2023 February 2023

www.keysight.com