N1091..CA Series IEEE 802.3 NRZ Compliance and Debug Application - Methods of Implementation

KEYSIGHT

METHODS OF IMPLEMENTATION

Notices

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In This Book

This manual describes the tests that are performed by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application in more detail.

- Chapter 1, "Overview" provides an overview of the compliance test application and the test groups in the IEEE 802.3 NRZ compliance test application.
- Chapter 2, "Getting Started" provides the necessary information for getting started with the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, including installing the application and licenses, making the required hardware connections, starting the application, and making a measurement.
- Chapter 3, "10GBASE-KR and 40GBASE-KR4 Tests" provides the Methods of Implementation (MOIs) for the 10GBASE-KR and 40GBASE-KR4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 4, "40GBASE-CR4 and 100GBASE-CR10 Tests" provides the Methods of Implementation (MOIs) for the 40GBASE-CR4 and 100GBASE-CR10 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 5, "100GBASE-KR4 Tests" provides the Methods of Implementation (MOIs) for the 100GBASE-KR4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 6, "100GBASE-CR4 Tests" provides the Methods of Implementation (MOIs) for the 100GBASE-CR4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 7, "25GBASE-KR Tests" provides the Methods of Implementation (MOIs) for the 25GBASE-KR tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 8, "XLAUI Tests" provides the Methods of Implementation (MOIs) for the XLAUI tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 9, "CAUI-10 Tests" provides the Methods of Implementation (MOIs) for the CAUI-10 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 10, "XLPPI Tests" provides the Methods of Implementation (MOIs) for the XLPPI tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 11, "CPPI Tests" provides the Methods of Implementation (MOIs) for the CPPI tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.
- Chapter 12, "CAUI-4 Tests" provides the Methods of Implementation (MOIs) for the CAUI-4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

See Also

- The N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's Online Help, which describes:
  - Starting the IEEE 802.3 Compliance Test Application.
  - Creating or opening a test project.
  - Setting up the IEEE 802.3 test environment.
  - Selecting tests.
  - Configuring selected tests.
  - Defining compliance limits.
  - Connecting the oscilloscope to the DUT.

- Running tests.
- Automating the application.
- Viewing test results.
- Viewing/exporting/printing the HTML test report.
- Understanding the Report.
- Exporting measurement results to web repository.
- Saving test projects.

Contents

1 Overview

The Keysight N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application enables compliance testing in adherence to the IEEE 802.3-2012, 2015 specifications. This chapter provides an overview of the compliance test application and the test groups in the IEEE 802.3 NRZ Compliance Test Application.

IEEE 802.3 NRZ Compliance Test Application — At A Glance

IEEE 802.3 NRZ Compliance Test Application is an automated software application that enables you to measure a significant subset of electrical transmitter parameters outlined in IEEE 802.3-2012, 2015 specifications through a host of logically grouped tests. Use the IEEE 802.3 NRZ Compliance Test Application with the DCA oscilloscope.

The N1091..CA Series IEEE 802.3 NRZ Compliance & Debug 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 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.

IEEE 802.3 NRZ Compliance Test Application Test Groups

The group of tests specified in this Methods of Implementation document pertains to the IEEE 802.3-2012, 2015 specifications. The relevant sections of the specifications define the electrical requirements of the signals for the following transmission standards.

Standard	Clause
10GBASE-KR	IEEE 802.3-2018 - Clause 72
40GBASE-KR4	IEEE 802.3-2018 - Clause 72
40GBASE-CR4	IEEE 802.3-2018 - Clause 85
100GBASE-CR10	IEEE 802.3-2018 - Clause 85
100GBASE-KR4	IEEE 802.3bj D3.2-2014 - Clause 93
100GBASE-CR4	IEEE 802.3bj D3.2-2014 - Clause 92
25GBASE-KR	IEEE 802.3bj D3.2-2014 - Clause 93
XLAUI	IEEE 802.3-2018 - Clause 83A
CAUI-10	IEEE 802.3-2018 - Clause 83A
XLPPI	IEEE 802.3-2018 - Clause 86A
CPPI	IEEE 802.3-2018 - Clause 86A
CAUI-4	IEEE 802.3bm D3.1-2015 - Clause 83D

2 Getting Started

This chapter provides the necessary information for getting started with the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, including installing the application and licenses, making the required hardware connections, starting the application, and making a measurement.

Getting Started

Perform the following steps to get started with the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

1 Review the system requirements. Refer to the Release Notes and *Getting Started Guide* for this application.
2 Install the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application. Refer to "Installing the Software" on page 19.
3 Install the required licenses. Refer to "Installing the License Key" on page 20.
4 Connect the hardware. Refer to the *Getting Started Guide* for this application.
5 Start the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application. Refer to "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
6 Make a measurement using N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application. Refer to "Making a Measurement" on page 25.

Installing the Software

1. Make sure you have the minimum version of FlexDCA software (see the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application Release Notes) by choosing **Help>About FlexDCA**... from the main menu.
2. Download the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application from the Keysight web site.
3. Install the application software.

Installing the License Key

For the most current license requirements, it is recommended to refer to the Data Sheet for this application.

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

Using Keysight License Manager 5

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

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

2 Copy the Host ID that appears on the top pane of the application. Note that x indicates numeric values.

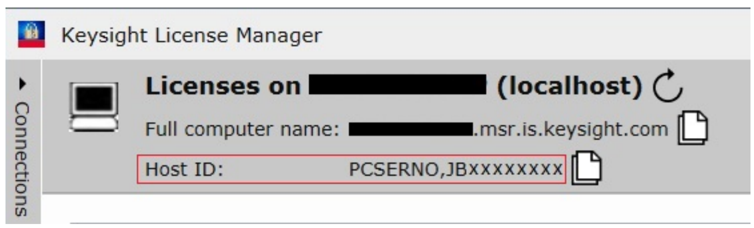


Figure 1 Viewing the Host ID information in Keysight License Manager 5

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

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

2 Launch Keysight License Manager.

3 From the configuration menu, use one of the options to install each license file.

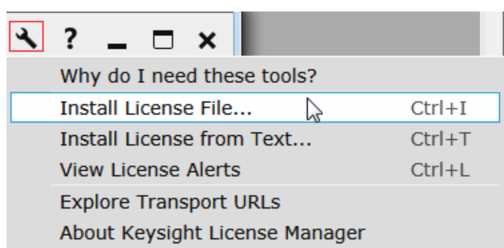


Figure 2 Configuration menu options to install licenses on Keysight License Manager 5

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

Using Keysight License Manager 6

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

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

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

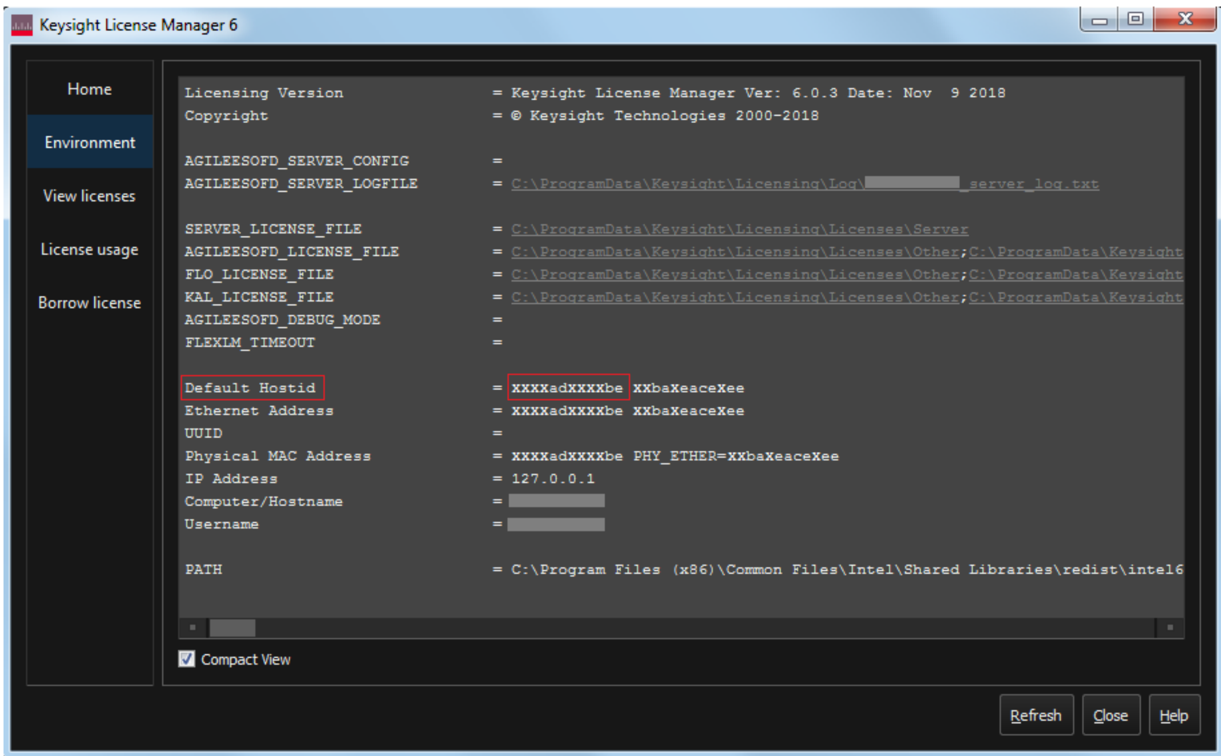


Figure 3 Viewing the Host ID information in Keysight License Manager 6

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

1 Save the license files on the machine, where you wish to run the Test Application and its features.
2 Launch Keysight License Manager 6.
3 From the Home tab, use one of the options to install each license file.

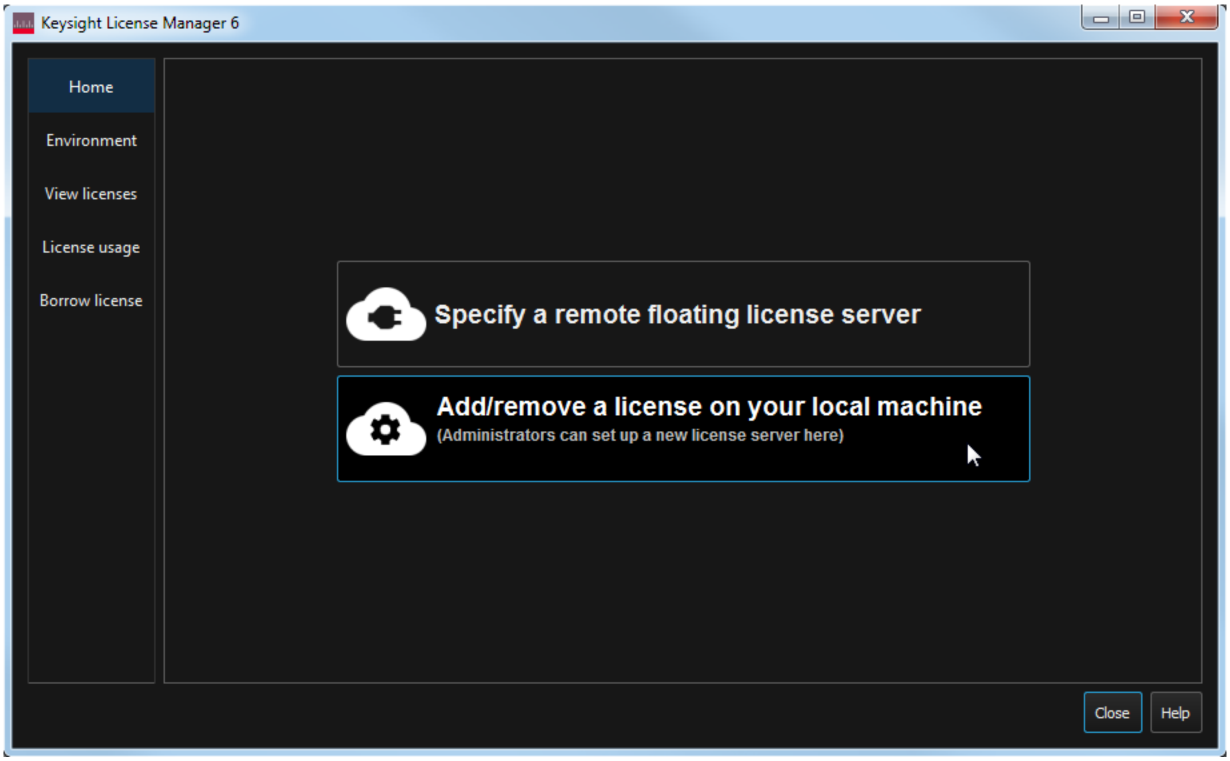


Figure 4 Home menu options to install licenses on Keysight License Manager 6

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

Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application

NOTE Before running the automated tests, you must calibrate the oscilloscope. After the oscilloscope has been calibrated, you are ready to start the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application and perform the measurements.

1 From the FlexDCA's main menu, choose **Apps>Automated Test Apps>N1091..CA IEEE802.3 Test App.**

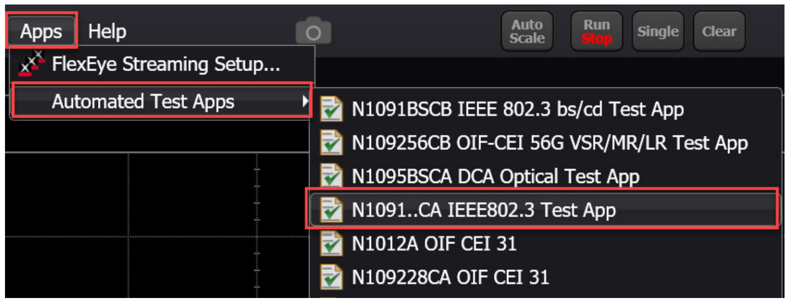


Figure 5 Starting the IEEE 802.3 NRZ Compliance Test Application

Alternatively, launch the N1091..CA IEEE802.3 Test App from the Start menu of the Windows operating system. Choose **Start > Keysight FlexDCA Applications > Launch 802.3 Test App**. The N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application is displayed.

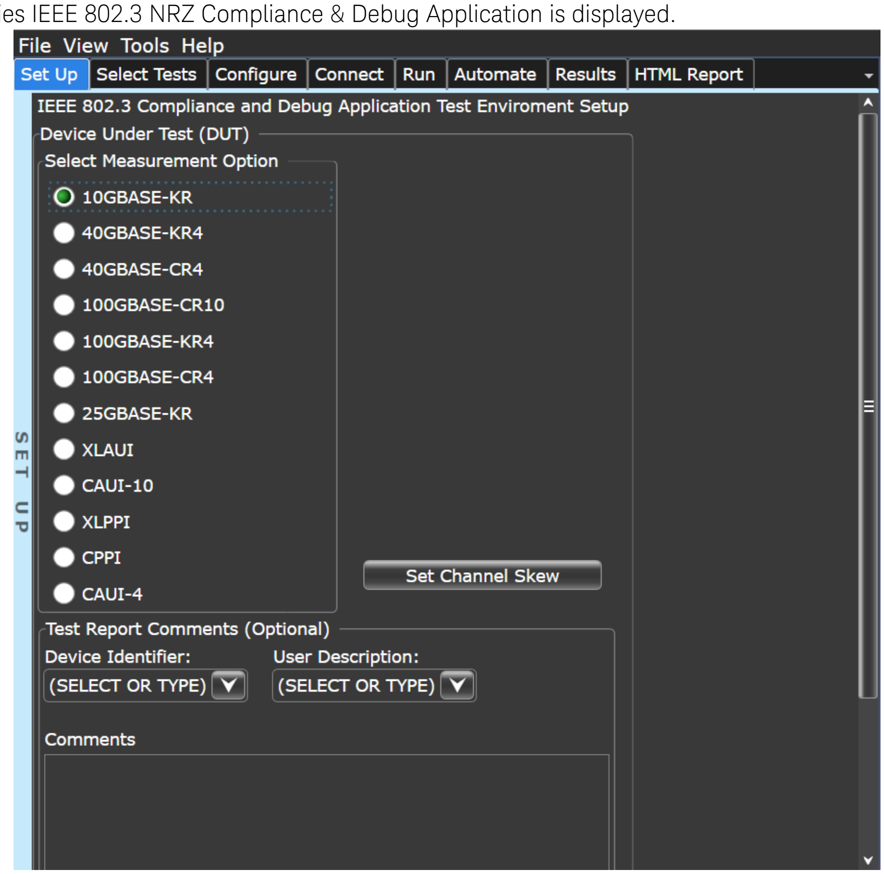


Figure 6 The IEEE 802.3 Compliance Test Application's default window

Figure 5 shows the procedure to launch the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application and Figure 6 shows the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application default window. 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.
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. This information appears in the HTML report.
Connect	Shows you how to connect the oscilloscope to the device under test for the tests to be run.
Run Tests	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.
Automation	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 compliance test report that can be printed.

NOTE

The configuration options shown under the **Set Up** tab of the IEEE 802.3 NRZ Compliance Test Application main window dictate the availability of various tests under the Select Tests tab.

Making a Measurement

Perform the following steps to make a measurement using the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

1 In the **Set Up** tab (shown in Figure 6), select the **Measurement Option**, configure the **Multi-Lane Test Option** and the associated settings, and whether you want to use a PNA/ENA/N1055A for performing return loss measurements.

2 In the **Select Tests** tab, select one or more tests, which appear according to the configuration done under the **Set Up** tab.

3 In the **Configure** tab, you may change the values assigned to one or more options to cater to the compliance requirements for the selected tests. By default, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application sets optimum values for each configuration parameter.

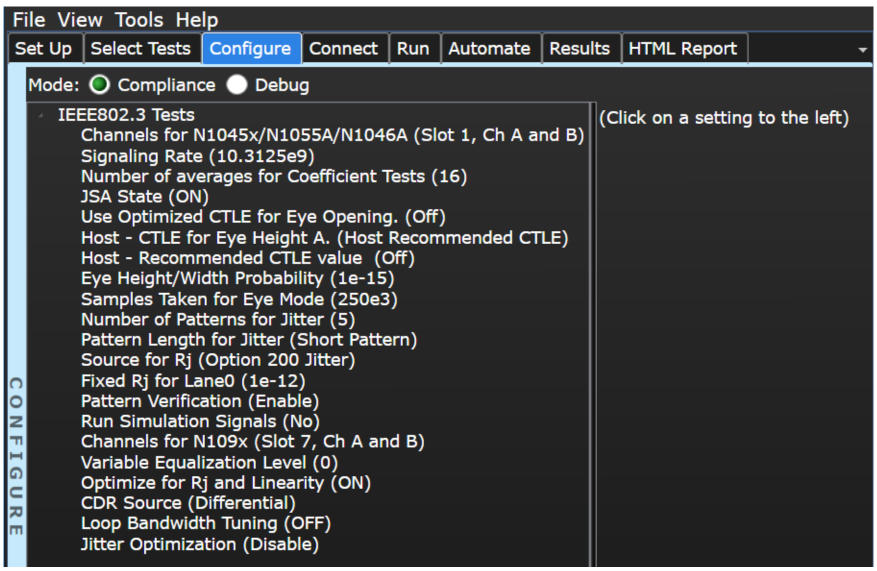


Figure 7 Configure tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application

4 In the **Connect** tab, view the instructions along with the connection digram to ensure that all requirements for the physical setup of the testing instruments and the DUT are met. Click **Connection Completed** to indicate to the Compliance Test Application that the required hardware setup is complete.

5 Click **Run Tests** under this tab if you wish to start running tests. However, if you wish to modify the run settings before performing test runs, switch to the **Run** tab.

6 In the **Run** tab, you may optionally modify one or more settings as described below, else click **Run** to start the test runs:

- determine the number of times each test must be run,
- automate specific actions in case of events,
- store results for certain type of test trials only,
- send email notifications if the test runs pause or stop during runs.

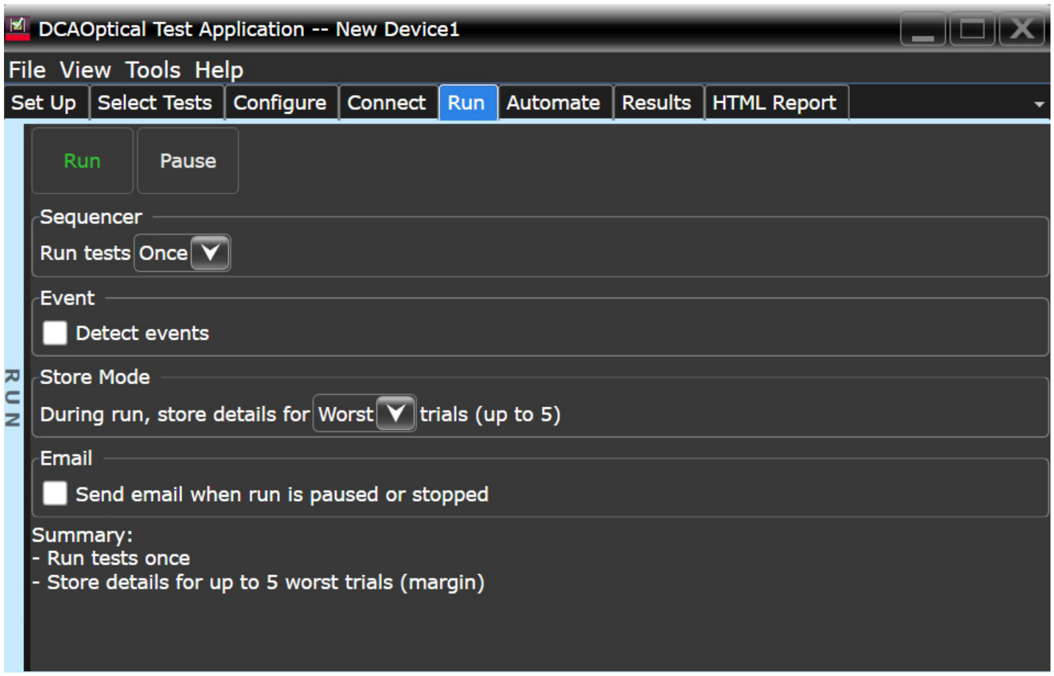


Figure 8 Run tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application

7 In the **Automate** tab, you may optionally configure automation scripts to perform specific actions/sequences within the Compliance Test Application.

8 In the **Results** tab, which appears automatically after test runs are complete, view the test results displayed for each selected test.

9 In the **HTML Report** tab, view a comprehensive report for each test within the Application. The Compliance Test Application enables exporting these results in CSV, PDF, or HTML format for the purpose of analysis.

To perform a high-level analysis on each measurement data, you may upload the results to the KS6800A Data analytics software. Refer to the *Online Help* for this application to understand this feature.

3 10GBASE-KR and 40GBASE-KR4 Tests

This section provides the Methods of Implementation (MOIs) for the 10GBASE-KR and 40GBASE-KR4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for 10GBASE-KR and 40GBASE-KR4 Tests

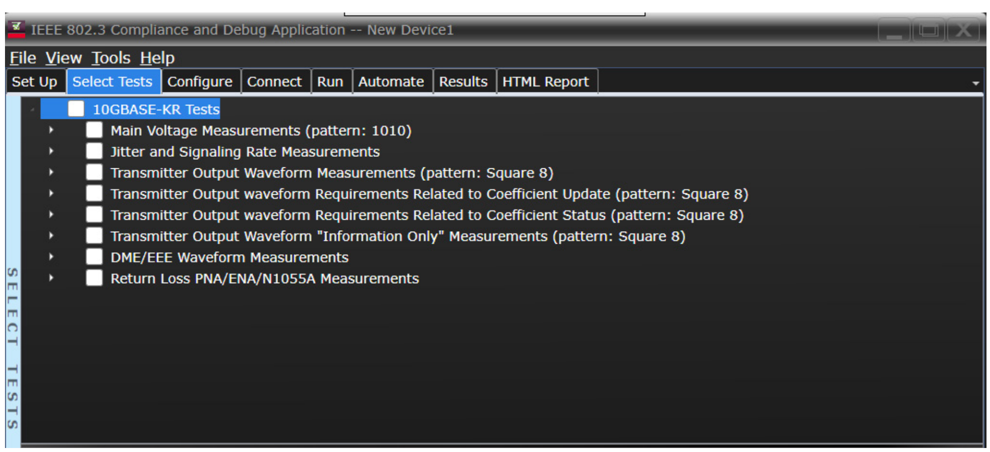
When performing the 10GBASE-KR and 40GBASE-KR4 tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.
3 Select the 10GBASE-KR or 40GBASE-KR4 Tests transmission standard in the **Select Measurement Option** section**.**
4 For the 40GBASE-KR4 tests, under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.
5 Configure other options on the Setup tab, as required.
6 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.
7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the 10GBASE-KR tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application. The 40GBASE-KR4 tests consists of the same test groups in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Main Voltage Measurements (pattern: 1010)

This section provides the Methods of Implementation (MOIs) for the Main Voltage Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

The 10GBASE-KR and 40GBASE-KR4 specifications can be found in IEEE 802.3ap section 72.7.1.

- Differential Peak-to-Peak Output Voltage with TX disabled (max 30 mV) (section 72.6.5).
- Common Mode Voltage (0-1.9 V) (section 72.7.1.4).
- Differential Peak-to-Peak Output Voltage (max 1200 mV) (section 72.7.1.4).

Differential Peak-to-Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is truly disabled (no valid data transitions).
3 Measure peak-to-peak voltage of the signal.
4 Compare the max peak-to-peak voltage to 30 mV.

Common Mode Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair is between 0-1.9 V.

NOTE **This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.**

PASS Condition The signal is between 0-1.9 V.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage of DUT+ and DUT-.
4 Compare the voltage measurement to 0-1.9 V.

Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is less than 1200 mV.

PASS Condition The differential signal max peak-to-peak voltage on a 1010 pattern is less than 1200 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and has a 1010 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the max peak-to-peak voltage to 1200 mV.

Jitter and Signaling Rate Measurements

This section provides the Methods of Implementation (MOIs) for the Jitter and Signaling Rate Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Transmitter Output Waveform Specifications

The 10GBASE-KR and 40GBASE-KR4 specifications can be found in IEEE 802.3ap section 72.7.1.

- Signaling Rate (10.3125 ±100 ppm GBd) (section 72.7.1.3).
- Max output jitter (max peak-to-peak)
  - Random Jitter (max 150 mUI) (section 72.7.1.9).
  - Deterministic Jitter (max 150 mUI) (section 72.7.1.9).
  - Duty Cycle Distortion (max 35 mUI) (section 72.7.1.9).
  - Total Jitter (max 280 mUI) (section 72.7.1.9).

Signaling Rate

The purpose of this test is to verify that the data rate mean is between 10.3125 ±100 ppm.

PASS Condition

The mean data rate is between 10.3125 ±100 ppm.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and data pattern exists (pattern 2 or 3 must be used for this test).
3. Set data rate measurement to 10.3125 Gb/s.
4. Set the DCA to Eye mode.
5. Measure the data rate.
6. Compare the measured data rate to 10.3125 ±100 ppm GBd.

Jitter (Random Jitter, Deterministic Jitter, Duty Cycle Distortion, and Total Jitter)

The purpose of this test is to verify that differential signal's Random Jitter is less than 150 mUI, Deterministic Jitter is less than 150 mUI, Duty Cycle Distortion is less than 35 mUI, and Total Jitter is less than 280 mUI. If all tests are selected, all tests are run on a single measurement. Each test can be run individually by selecting any or some of the tests.

PASS Conditions

- Random Jitter rms is less than 150 mUI.
- Deterministic p-p jitter is less than 150 mUI.
- Duty Cycle Distortion is less than 35 mUI.
- Total Jitter at BER of 10E-12 is less than 280 mUI.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and data pattern exists (pattern 2 or 3 must be used for all the tests other than Duty Cycle Distortion. For Duty Cycle Distortion, pattern 1010 must be used).
3. Set clock recovery to OJTF First Order PLL with Nominal Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4. Using Jitter mode, measure Random Jitter, Deterministic Jitter, Duty Cycle Distortion, and Total Jitter at BER of 10E-12.
5. Compare and report the values to their respective maximum specification.

Transmitter Output Waveform Measurements (pattern: Square 8)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Measurements for Transition Time using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Data Rate and Jitter Specifications

The 10GBASE-KR and 40GBASE-KR4 specifications can be found in IEEE 802.3ap section 72.7.1.

- Transition Time (20%-80%) – Rising Edge (24-47 ps) (section 72.7.1.7).
- Transition Time (20%-80%) – Falling Edge (24-47 ps) (section 72.7.1.7).

Transition Time - Rising Edge

The purpose of this test is to verify that the rising edge of the differential signal is between 24 to 47 ps.

PASS Condition

The min and max rise time of the signal are between 24 to 47 ps.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure min and max rise time of the entire signal.
4 Compare and report the min and max values to the valid range of 24-47 ps.

Transition Time - Falling Edge

The purpose of this test is to verify that the falling edge of the differential signal is between 24 to 47 ps.

PASS Condition

The min and max fall time of the signal are between 24 to 47 ps.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure min and max fall time of the entire signal.
4 Compare and report the min and max values to the valid range of 24-47 ps.

Transmitter Output Waveform - Coefficient Update Measurements (pattern: Square 8)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Coefficient Update Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Coefficient Update Specifications

The 10GBASE-KR and 40GBASE-KR4 specifications can be found in IEEE 802.3ap section 72.7.1.11 – Table 72-7.

Coefficient Update			Requirements		
c(1)	c(0)	c(−1)	v1(k) – v1(k – 1) (mV)	v2(k) – v2(k – 1) (mV)	v3(k) – v3(k – 1) (mV)
increment	hold	hold	−20 to −5	5 to 20	5 to 20
decrement	hold	hold	5 to 20	−20 to −5	−20 to −5
hold	increment	hold	5 to 20	5 to 20	5 to 20
hold	decrement	hold	−20 to −5	−20 to −5	−20 to −5
hold	hold	increment	5 to 20	5 to 20	−20 to −5
hold	hold	decrement	−20 to −5	−20 to −5	5 to 20

Coefficient Update c_1 inc c_0 hold c_1 hold

The purpose of this test is to verify that the difference in v1, v2, and v3 between coefficient updates, falls between the specified values in table 72-7 of IEEE 802.3ap.

PASS Condition

The difference in the coefficient update when c(1) is incremented to the previous state for v1, v2, and v3 are within the specified values.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Save v1, v2, v3 as v1(k-1), v2(k-1), and v3(k-1) values.
7 Pop up to ask user to Increment c(1). OK pressed.
8 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
9 Measure v2 – set the measurement to measure Pulse Top with Pulse width of 50%.
10 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
11 Subtract v1(k) – v1(k-1), v2(k)-v2(k-1), and v3(k)-v3(k-1).
12 Compare and report the values from step 12 to their respective value ranges in table 72-7 of IEEE 802.3ap.

Coefficient Update c_1 dec c_0 hold c_1 hold

The purpose of this test is to verify that the difference in v1, v2, and v3 between coefficient updates, falls between the specified values in table 72-7 of IEEE 802.3ap.

PASS Condition The difference in the coefficient update when c(1) is decremented to the previous state for v1, v2, and v3 are within the specified values.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Save v1, v2, v3 as v1(k-1), v2(k-1), and v3(k-1) values.
7 Pop up to ask user to decrement c(1). OK pressed.
8 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
9 Measure v2 – set the measurement to measure Pulse Top with Pulse width of 50%.
10 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
11 Subtract v1(k) – v1(k-1), v2(k)-v2(k-1), and v3(k)-v3(k-1).
12 Compare and report the values from step 12 to their respective value ranges in table 72-7 of IEEE 802.3ap.

Coefficient Update c_1 hold c_0 inc c_1 hold

The purpose of this test is to verify that the difference in v1, v2, and v3 between coefficient updates, falls between the specified values in table 72-7 of IEEE 802.3ap.

PASS Condition The difference in the coefficient update when c(0) is incremented to the previous state for v1, v2, and v3 are within the specified values.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Save v1, v2, v3 as v1(k-1), v2(k-1), and v3(k-1) values.
7 Pop up to ask user to Increment c(0). OK pressed.
8 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
9 Measure v2 – set the measurement to measure Pulse Top with Pulse width of 50%.
10 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
11 Subtract v1(k) – v1(k-1), v2(k)-v2(k-1), and v3(k)-v3(k-1).
12 Compare and report the values from step 12 to their respective value ranges in table 72-7 of IEEE 802.3ap.

Coefficient Update c_1 hold c_0 dec c_1 hold

The purpose of this test is to verify that the difference in v1, v2, and v3 between coefficient updates, falls between the specified values in table 72-7 of IEEE 802.3ap.

PASS Condition The difference in the coefficient update when c(0) is decremented to the previous state for v1, v2, and v3 are within the specified values.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Save v1, v2, v3 as v1(k-1), v2(k-1), and v3(k-1) values.
7 Pop up to ask user to decrement c(0). OK pressed.
8 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
9 Measure v2 – set the measurement to measure Pulse Top with Pulse width of 50%.
10 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
11 Subtract v1(k) – v1(k-1), v2(k)-v2(k-1), and v3(k)-v3(k-1).
12 Compare and report the values from step 12 to their respective value ranges in table 72-7 of IEEE 802.3ap.

Coefficient Update c_1 hold c_0 hold c_1 inc

The purpose of this test is to verify that the difference in v1, v2, and v3 between coefficient updates, falls between the specified values in table 72-7 of IEEE 802.3ap.

PASS Condition The difference in the coefficient update when c(-1) is incremented to the previous state for v1, v2, and v3 are within the specified values.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Save v1, v2, v3 as v1(k-1), v2(k-1), and v3(k-1) values.
7 Pop up to ask user to increment c(-1). OK pressed.
8 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
9 Measure v2 – set the measurement to measure Pulse Top with Pulse width of 50%.
10 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
11 Subtract v1(k) – v1(k-1), v2(k)-v2(k-1), and v3(k)-v3(k-1).
12 Compare and report the values from step 12 to their respective value ranges in table 72-7 of IEEE 802.3ap.

Coefficient Update c_1 hold c_0 hold c_1 dec

The purpose of this test is to verify that the difference in v1, v2, and v3 between coefficient updates, falls between the specified values in table 72-7 of IEEE 802.3ap.

PASS Condition The difference in the coefficient update when c(-1) is decremented to the previous state for v1, v2, and v3 are within the specified values.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Save v1, v2, v3 as v1(k-1), v2(k-1), and v3(k-1) values.

7 Pop up to ask user to decrement c(-1). OK pressed.
8 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
9 Measure v2 – set the measurement to measure Pulse Top with Pulse width of 50%.
10 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
11 Subtract v1(k) – v1(k-1), v2(k)-v2(k-1), and v3(k)-v3(k-1).
12 Compare and report the values from step 12 to their respective value ranges in table 72-7 of IEEE 802.3ap.

Transmitter Output Waveform - Coefficient Status Measurements (pattern: Square 8)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Coefficient Status Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Coefficient Status Specifications

The 10GBASE-KR and 40GBASE-KR4 specifications can be found in IEEE 802.3ap section 72.7.1.11 Table 72-8.

- Dv2 and Dv5 (max 40 mV peak-to-peak).
- (v1+v4)/v1, (v2+v5)/v2, and (v3+v6)/v3 shall not exceed 0.05.
- v2 as not defined in table 72-8 <= 40 mV.

Coefficient Status			Requirements		
c(1)	c(0)	c(−1)	R_{pre}	R_{pst}	v_2 (mV)
disabled	minimum	disabled	0.90 to 1.10	0.90 to 1.10	220 to 330
disabled	maximum	disabled	0.95 to 1.05	0.95 to 1.05	400 to 600
minimum	minimum	disabled	–	4.00 (min)	–
disabled	minimum	minimum	1.54 (min)	–	–

Coefficient Status c_1 dis c_0 min c_1 dis

The purpose of this test is to verify Rpre, Rpst, and v2 are within specification as defined in table 72-8 of IEEE 802.3ap. Additionally, to verify that Dv2 and Dv5 are less than 40 mV. Additionally, (v1+v4)/v1, (v2+v5)/v2, and (v3+v6)/v3 cannot exceed 0.05.

PASS Condition

Rpre, Rpst, v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3, Dv2 and Dv5 are within the respective defined specifications when c(1) is disabled, c(0) is at its minimum value, and c(-1) is disabled.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Pop up to ask user to change c(0) to minimum. OK pressed.
4 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
5 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
6 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
7 Measure v4 – set measurement to measure Voltage Overshoot on the falling edge.
8 Measure v5 – set measurement to measure Voltage Base with pulse width of 50%.
9 Measure v6 – set measurement to measure Voltage Preshoot on the rising edge.
10 Calculate Rpre = v3/v2, Rpst = v1/v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3.
11 Measure Dv2 – trigger on rising edge. Scale and center high pulse of the square pattern. Place histogram left limit at t1+2T and right limit t2-2T (t1, t2, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
12 Calculate Dv2 = v2(max) – v2(min) as measured in step 12 histogram.
13 Measure Dv5 – trigger on falling edge. Scale and center low pulse of the square pattern. Place histogram left limit at t2+2T and right limit t3-2T (t2, t3, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
14 Calculate Dv5 = v5(max)-v5(min as measured in step 14 histogram.

15 Compare and report the values from steps 11, 13, and 15 to their respective specification values.

Coefficient Status c_1 dis c_0 max c_1 dis

The purpose of this test is to verify Rpre, Rpst, and v2 are within specification as defined in table 72-8 of IEEE 802.3ap. Additionally, to verify that Dv2 and Dv5 are less than 40 mV. Additionally, (v1+v4)/v1, (v2+v5)/v2, and (v3+v6)/v3 cannot exceed 0.05.

PASS Condition Rpre, Rpst, v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3, Dv2 and Dv5 are within the respective defined specifications when c(1) is disabled, c(0) is at its maximum value, and c(-1) is disabled.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Pop up to ask user to change c(0) to maximum. OK pressed.
4 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
5 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
6 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
7 Measure v4 – set measurement to measure Voltage Overshoot on the falling edge.
8 Measure v5 – set measurement to measure Voltage Base with pulse width of 50%.
9 Measure v6 – set measurement to measure Voltage Preshoot on the rising edge.
10 Calculate Rpre = v3/v2, Rpst = v1/v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3.
11 Measure Dv2 – trigger on rising edge. Scale and center high pulse of the square pattern. Place histogram left limit at t1+2T and right limit t2-2T (t1, t2, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
12 Calculate Dv2 = v2(max) – v2(min) as measured in step 12 histogram.
13 Measure Dv5 – trigger on falling edge. Scale and center low pulse of the square pattern. Place histogram left limit at t2+2T and right limit t3-2T (t2, t3, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
14 Calculate Dv5 = v5(max)-v5(min as measured in step 14 histogram.
15 Compare and report the values from steps 11, 13, and 15 to their respective specification values.

Coefficient Status c_1 min c_0 min c_1 dis

The purpose of this test is to verify Rpst and v2 are within specification as defined in table 72-8 of IEEE 802.3ap. Additionally, to verify that Dv2 and Dv5 are less than 40 mV. Additionally, (v1+v4)/v1, (v2+v5)/v2, and (v3+v6)/v3 cannot exceed 0.05.

PASS Condition Rpst, v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3, Dv2 and Dv5 are within the respective defined specifications when c(1) is at its minimum, c(0) is at its minimum value, and c(-1) is disabled.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Pop up to ask user to change c(1) and c(0) to minimum. OK pressed.
4 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
5 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
6 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
7 Measure v4 – set measurement to measure Voltage Overshoot on the falling edge.
8 Measure v5 – set measurement to measure Voltage Base with pulse width of 50%.
9 Measure v6 – set measurement to measure Voltage Preshoot on the rising edge.
10 Calculate Rpst = v1/v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3.

11 Measure Dv2 – trigger on rising edge. Scale and center high pulse of the square pattern. Place histogram left limit at t1+2T and right limit t2-2T (t1, t2, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
12 Calculate Dv2 = v2(max) – v2(min) as measured in step 12 histogram.
13 Measure Dv5 – trigger on falling edge. Scale and center low pulse of the square pattern. Place histogram left limit at t2+2T and right limit t3-2T (t2, t3, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
14 Calculate Dv5 = v5(max)-v5(min as measured in step 14 histogram.
15 Compare and report the values from steps 11, 13, and 15 to their respective specification values.

Coefficient Status c_1 dis c_0 min c_1 min

The purpose of this test is to verify Rpre and v2 are within specification as defined in table 72-8 of IEEE 802.3ap. Additionally, to verify that Dv2 and Dv5 are less than 40 mV. Additionally, (v1+v4)/v1, (v2+v5)/v2, and (v3+v6)/v3 cannot exceed 0.05.

PASS Condition Rpre, v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3, Dv2 and Dv5 are within the respective defined specifications when c(0) is at its minimum, c(-1) is at its minimum value, and c(-1) is disabled.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Pop up to ask user to change c(0) and c(-1) to minimum. OK pressed.
4 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
5 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
6 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
7 Measure v4 – set measurement to measure Voltage Overshoot on the falling edge.
8 Measure v5 – set measurement to measure Voltage Base with pulse width of 50%.
9 Measure v6 – set measurement to measure Voltage Preshoot on the rising edge.
10 Calculate Rpre = v3/v2, (v1+v4)/v1, (v2+v5)/v2, (v3+v6)/v3.
11 Measure Dv2 – trigger on rising edge. Scale and center high pulse of the square pattern. Place histogram left limit at t1+2T and right limit t2-2T (t1, t2, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
12 Calculate Dv2 = v2(max) – v2(min) as measured in step 12 histogram.
13 Measure Dv5 – trigger on falling edge. Scale and center low pulse of the square pattern. Place histogram left limit at t2+2T and right limit t3-2T (t2, t3, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
14 Calculate Dv5 = v5(max)-v5(min as measured in step 14 histogram.
15 Compare and report the values from steps 11, 13, and 15 to their respective specification values.

Transmitter Output Waveform “Information Only” Measurements (pattern: Square 8)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform “Information Only” Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Manual Measurement Specifications

These tests are information only tests to show the values of v1..v6, Dv2, Dv5, Rpre, and Rpst at any status, update, etc., that you would like to measure.

Transmitter Output Waveform “Information Only” Measurements

The purpose of these tests is information only, to show the values of v1..v6, Dv2, Dv5, Rpre, and Rpst at any status, update, etc., that you would like to measure.

PASS Condition

Information only. No pass/fail criteria.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (square 8 pattern).
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Measure v4 – set measurement to measure Voltage Overshoot on the falling edge.
7 Measure v5 – set measurement to measure Voltage Base with pulse width of 50%.
8 Measure v6 – set measurement to measure Voltage Preshoot on the rising edge.
9 Calculate Rpre = v3/v2, Rpst = v1/v2.
10 Measure Dv2 – trigger on rising edge. Scale and center high pulse of the square pattern. Place histogram left limit at t1+2T and right limit t2-2T (t1, t2, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
11 Calculate Dv2 = v2(max) – v2(min) as measured in step 12 histogram.
12 Measure Dv5 – trigger on falling edge. Scale and center low pulse of the square pattern. Place histogram left limit at t2+2T and right limit t3-2T (t2, t3, and T defined in IEEE 802.3ap section 72.7.1.11 Figure 72-12).
13 Calculate Dv5 = v5(max)-v5(min as measured in step 14 histogram.
14 Report the values from steps 11, 13, and 15.

DME/EEE Waveform Measurements

This section provides the Methods of Implementation (MOIs) for the DME and EEE Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

DME/EEE Waveform Specifications

The 10GBASE-KR and 40GBASE-KR4 DME specifications can be found in IEEE 802.3ap section 73.5.1 Table 73-1 and section 73.5.3 Table 73-2. The 10GBASE-KR and 40GBASE-KR4 EEE specifications can be found in section 72.7.1 Table 72-6.

- DME Differential Peak-to-Peak Output Voltage (0.6-1.2 V).
- DME T1 (3.2 ns-0.01% to 3.2 ns+0.1%).
- DME T2 (6.2 ns-6.6 ns).
- DME T3 (3.0 ns-3.4 ns).
- EEE Differential Peak-to-Peak Output Voltage with TX disabled (max 30 mV).
- EEE Differential Peak-to-Peak Output Voltage with TX enabled (min 720 mV).
- EEE Common Mode Voltage Deviation (±150 mV).
- Initialize State Rpre (1.161 - 1.419).
- Initialize State Rpst (2.313 - 2.827).

DME Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is less than 1200 mV.

PASS Condition

The differential signal max peak-to-peak voltage on a 1010 pattern is less than 1200 mV.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and has a 1010 pattern.
3. Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4. Compare the min and max peak-to-peak voltage to be within 0.6 to 1.2 V.

DME T1-Transition Position Spacing (Period) Test

The purpose of this test is to verify that transition spacing of the DME signal is 3.2 ns ±0.01%.

PASS Condition

The mean period is between 3.2 ns ±0.01%.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected.
3. Request DUT in DME mode.
4. Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5. Compare the mean measurement to 3.2 ns ±0.01%.

DME T2-Clock Transition to Clock Transition Test

The purpose of this test is to verify clock to clock transition is 6.2 ns to 6.6 ns.

PASS Condition

The mean period is between 6.2 ns to 6.6 ns.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected.
3. Request DUT in DME mode.

4 Measure the rising to rising edge.
5 Compare the min and max values to measurement to 6.2 ns to 6.6 ns.

DME T3-Clock Transition to Data Transition Test

The purpose of this test is to verify clock to data transition is 3.0 ns to 3.4 ns.

PASS Condition The min and max UI time is between 3.0 ns to 3.4 ns.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected.
3 Request DUT in DME mode.
4 Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5 Compare the min and max values to measurement to 3.0 ns to 3.4 ns.

EEE Differential Peak-to-Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT to be EEE mode.
3 Check that the signal is truly with TX disabled (no valid data transitions).
4 Measure peak-to-peak voltage of the signal.
5 Compare the max peak-to-peak voltage to 30 mV.

EEE Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is greater or equal to 720 mV.

PASS Condition The differential signal max peak-to-peak voltage on a 1010 pattern is greater than or equal to 720 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT in EEE mode.
3 Verify that a signal is connected and has a 1010 pattern.
4 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
5 Compare the min voltage to be greater than or equal to 720 mV.

EEE Common Mode Deviation Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair of the pre-LPI signal and the LPI signal is within ±150 mV.

PASS Condition The signal voltage change between pre and post LPI is within 150 mV change.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Request DUT to be pre-LPI.
4 Measure the peak-to-peak voltage of the DUT+ and DUT-.

5 Request DUT to be in LPI.
6 Measure the peak-to-peak voltage of the DUT+ and DUT-.
7 Calculate Vpp(post)-Vpp(pre).
8 Compare the result from step 8 to ±150 mV.

Initialize State Rpre

The purpose of this test is to make Rpre measurement when in Initialize state.

PASS Condition 1.161 <= Initialize Rpre Result <= 1.419

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists. (square 8 pattern)
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Calculate Rpre = v3/v2.

Initialize State Rpst

The purpose of this test is to make Rpst measurement when in Initialize state.

PASS Condition 2.313 <= Initialize Rpst Result <= 2.827

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists. (square 8 pattern)
3 Measure v1 – set measurement to measure Voltage Overshoot on the rising edge.
4 Measure v2 – set measurement to measure Pulse Top with Pulse width of 50%.
5 Measure v3 – set measurement to measure Voltage Preshoot on the falling edge.
6 Calculate Rpst = v1/v2.

Return Loss PNA/ENA/N1055A Measurements

This section provides the Methods of Implementation (MOIs) for the Return Loss Measurements using a Keysight Sampling oscilloscope, PNA or ENA, and the IEEE 802.3 NRZ Test Application. The test application controls the PNA/ENA to set the test limits and run the test. You must ensure that the calibration must be done on the PNA/ENA.

Limits for Return Loss PNA/ENA measurements

The limits for tests under return loss PNA/ENA measurements can be found in section 72.7.1 of IEEE 802.3 specification. Refer to Table 72-6 for corresponding values.

- Differential Output Return Loss
- Common-mode Output Return Loss

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, click **Connect PNA/ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5. Compare the reported values with the specification to check for compliance.

4 40GBASE-CR4 and 100GBASE-CR10 Tests

This section provides the Methods of Implementation (MOIs) for the 40GBASE-CR4 and 100GBASE-CR10 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for 40GBASE-CR4 and 100GBASE-CR10 Tests

When performing the 40GBASE-CR4 and 100GBASE-CR10 tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.

2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.

3 Select the 40GBASE-CR4 or 100GBASE-CR10 transmission standard in the **Select Measurement Option** section.

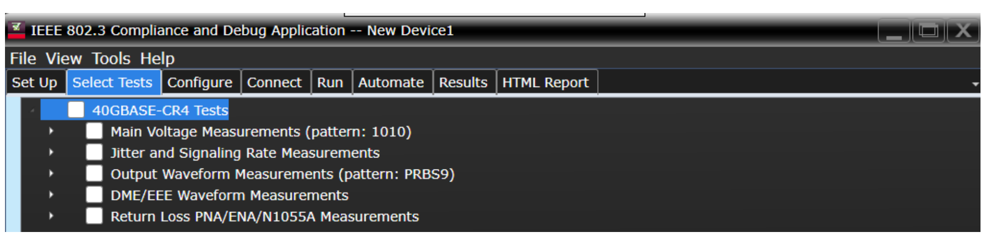
4 Under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.

5 Configure other options on the Setup tab, as required.

6 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.

7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the 40GBASE-CR4 tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application. The 100GBASE-CR10 tests consists of the same test groups in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Main Voltage Measurements (pattern: 1010)

This section provides the Methods of Implementation (MOIs) for the Main Voltage Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

The 40GBASE-CR4 and 100GBASE-CR10 specifications can be found in IEEE 802.3 section 85.8.3.

- Differential Peak-to-Peak Output Voltage with TX disabled (max 30 mV).
- Common Mode Voltage Limits Test (0-1.9 V).
- Common Mode AC Output Voltage (max 30 mV).
- Amplitude Peak-to-Peak Test (max 1200 mV).

Differential Peak-to-Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is truly disabled (no valid data transitions).
3 Measure peak-to-peak voltage of the signal.
4 Compare the max peak-to-peak voltage to 30 mV.

Common Mode Voltage Limits Test

The purpose of this test is to verify that the common mode signal of the differential pair is between 0-1.9 V.

NOTE **This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.**

PASS Condition The signal is between 0-1.9 V.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage of the DUT+ and DUT-.
4 Compare the voltage measurement to 0-1.9 V.

Common Mode AC Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair rms voltage does not exceed 30 mV.

NOTE **This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.**

PASS Condition The signal is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage of the DUT+ and DUT-.
4 Compare the voltage measurement to 30 mV.

Amplitude Peak-to-Peak Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is less than 1200 mV.

PASS Condition The differential signal max peak-to-peak voltage on a 1010 pattern is less than 1200 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal is connected and has a 1010 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the max peak-to-peak voltage to 1200 mV.

Jitter and Signaling Rate Measurements

This section provides the Methods of Implementation (MOIs) for the Jitter and Data Rate Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Transmitter Output Waveform Specifications

The 40GBASE-CR4 and 100GBASE-CR10 specifications can be found in IEEE 802.3 section 85.8.3.

- Signaling Rate (10.3125 ±100 ppm GBd).
- Jitter
  - Random Jitter (max 150 mUI).
  - Duty Cycle Distortion (max 35 mUI).
  - Total Jitter (max 250 mUI).

Signaling Rate

The purpose of this test is to verify that the data rate mean is between 10.3125 ±100 ppm.

PASS Condition

The mean data rate is between 10.3125 ±100 ppm.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Jitter (Random Jitter, Duty Cycle Distortion, and Total Jitter)

The purpose of this test is to verify that differential signal's Random Jitter is less than 150 mUI, Duty Cycle Distortion is less than 35 mUI, and Total Jitter is less than 250 mUI. If all tests are selected, all tests are run on a single measurement. Each test can be run individually by selecting any or some of the tests.

PASS Conditions

- Random Jitter rms is less than 150 mUI.
- Duty Cycle Distortion is less than 35 mUI.
- Total Jitter at BER of 10E-12 is less than 250 mUI.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 must be used for Random Jitter and Total Jitter tests. For Duty Cycle Distortion test, pattern 1010 must be used).
3 Set clock recovery to OJTF First Order PLL with Nominal Data Rate 10.3125 Gb/s and Loop Bandwidth to 4 MHz.
4 Using Jitter Mode, measure Random Jitter, Deterministic Jitter, Duty Cycle Distortion, and Total Jitter at BER of 10E-12.
5 Compare and report the values to their respective maximum specification.

Transmitter Output Waveform Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Measurements for Transition Time using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Transmitter Output Specifications

The 40GBASE-CR4 and 100GBASE-CR10 specifications can be found in IEEE 802.3 section 85.8.3.

- Transmitter DC Amplitude (340-600 mV)
- Linear Fit Pulse (0.63 * DC Amplitude)

Transmitter DC Amplitude

The purpose of this test is to verify that the Transmitter DC Amplitude as described in section 85.8.3.3 is between 0.34 and 0.6 V.

PASS Condition

The Transmitter DC Amplitude is between 0.34 and 0.6 V.

Measurement Algorithm

1 Check that signal is connected and the proper data pattern exists (PRBS9 is required for this test).
2 Capture the 511 bits of the PRBS9 pattern for M = Np+1 points per bit.
3 Calculate Transmitter DC amplitude using the equations in section 85.8.3.3.5. The result value is the sum of the columns of P1 (Equ 85-9).
4 Compare and report the result to 0.34-0.6 V.

Linear Fit Pulse

The purpose of this test is to verify that the Linear Fit Pulse as described in section 85.8.3.3 is greater than the Transmitter DC Amplitude * 0.63.

PASS Condition

The Linear Fit Pulse is greater than Transmitter DC Amplitude * 0.63.

Measurement Algorithm

1 Check that signal is connected and the proper data pattern exists (PRBS9 is required for this test).
2 Capture the 511 bits of the PRBS9 pattern for M = Np+1 points per bit.
3 Calculate Linear Fit Pulse using the equations in section 85.8.3.3.5. The result value read column wise from P1 (Equ 85-9).
4 Compare and report the result to 0.63* Transmitter DC Amplitude.

Max RMS normalized error

The purpose of this test is to verify that the maximum RMS normalized error as described in section 85.8.3 is less than or equal to 37m.

PASS Condition

The maximum RMS normalized error is less than or equal to 37m.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate Linear Fit Pulse using the equations in section 85.8.3.3.5.
5 Compute the difference between linear fit and the measured waveform defined in Eq (85-8).
6 Compare the result with the limit.

Abs Coefficient Step Size c(1) inc c(0) hold c(-1) hold

The purpose of this test is to verify that the difference amplitude between coefficient updates falls between the specified values 0.0083 and 0.05.

PASS Condition The difference in the coefficient update when c(1) is incremented to the previous is within 0.0083 to 0.05.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 Request that DUT be initialized.
4 Measure top/base amplitude (Amplitude1).
5 Save result from step 5.
6 Pop up to ask user to Increment c(1). OK pressed.
7 Measure top/base amplitude (Amplitude2).
8 Subtract Amplitude2 – Amplitude1.
9 Compare and report the values from step 9 to be in a range of 0.0083 to 0.05.

Abs Coefficient Step Size c(1) dec c(0) hold c(-1) hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates, falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(1) is decremented to the previous is within -0.0083 to -0.05.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 If previous abs test has not been run, request that DUT be initialized, else do nothing.
4 If previous abs test has not been run, measure top/base amplitude (Amplitude1), else Amplitude1 is equal to value of previous test Amplitude2.
5 Save result from step 5.
6 Pop up to ask user to Decrement c(1). OK pressed.
7 Measure top/base amplitude (Amplitude2).
8 Subtract Amplitude2 – Amplitude1.
9 Compare and report the values from step 9 to be in a range of -0.0083 to -0.05.

Abs Coefficient Step Size c(1) hold c(0) inc c(-1) hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(0) is incremented to the previous state is within 0.0083 to 0.05.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 If previous abs test has not been run, request that DUT be initialized, else do nothing.
4 If previous abs test has not been run, measure top/base amplitude (Amplitude1), else Amplitude1 is equal to value of previous test Amplitude2.
5 Save result from step 5.
6 Pop up to ask user to Increment c(0). OK pressed.

7 Measure top/base amplitude (Amplitude2).
8 Subtract Amplitude2 – Amplitude1.
9 Compare and report the values from step 9 to be in a range of 0.0083 to 0.05.

Abs Coefficient Step Size c(1) hold c(0) dec c(-1) hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.05 to -0.0083.

PASS Condition The difference in the coefficient update when c(0) is decremented to the previous state is within -0.05 and -0.0083.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 If previous abs test has not been run, request that DUT be initialized, else do nothing.
4 If previous abs test has not been run, measure top/base amplitude (Amplitude1), else Amplitude1 is equal to value of previous test Amplitude2.
5 Save result from step 5.
6 Pop up to ask user to Decrement c(0). OK pressed.
7 Measure top/base amplitude (Amplitude2).
8 Subtract Amplitude2 – Amplitude1.
9 Compare and report the values from step 9 to be in a range of -0.0083 to -0.05.

Abs Coefficient Step Size c(1) hold c(0) hold c(-1) inc

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(-1) is incremented to the previous state is within 0.0083 and 0.05.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 If previous abs test has not been run, request that DUT be initialized, else do nothing.
4 If previous abs test has not been run, measure top/base amplitude (Amplitude1), else Amplitude1 is equal to value of previous test Amplitude2.
5 Save result from step 5.
6 Pop up to ask user to Increment c(-1). OK pressed.
7 Measure top/base amplitude (Amplitude2).
8 Subtract Amplitude2 – Amplitude1.
9 Compare and report the values from step 9 to be in a range of 0.0083 to 0.05.

Abs Coefficient Step Size c(1) hold c(0) hold c(-1) dec

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.05 to -0.0083.

PASS Condition The difference in the coefficient update when c(-1) is decremented to the previous state is within -0.05 and -0.0083.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).

3 If previous abs test has not been run, request that DUT be initialized, else do nothing.
4 If previous abs test has not been run, measure top/base amplitude (Amplitude1), else Amplitude1 is equal to value of previous test Amplitude2.
5 Save result from step 5.
6 Pop up to ask user to Decrement c(-1). OK pressed.
7 Measure top/base amplitude (Amplitude2).
8 Subtract Amplitude2 – Amplitude1.
9 Compare and report the values from step 9 to be in a range of 0.0083 to 0.05.

Minimum Pre-cursor Full-scale Test

The purpose of this test is to verify that the minimum Pre-cursor is greater than or equal 1.54.

PASS Condition When the coefficients are set to c(1) zero c(0) minimum and c(-1) minimum, the pre-cursor full-scale ratio is greater than or equal 1.54.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 Pop up to ask user to supply sufficient increment or decrement requests to set c(1) zero c(0) minimum and c(-1) minimum. OK pressed.
4 Measure Vpreshoot and Vtop of the signal.
5 Calculate the pre-cursor Vpreshoot/Vtop.
6 Report and compare the value calculated in step 6 with 1.54.

Minimum Post-cursor Full-scale Test

The purpose of this test is to verify that the minimum Post-cursor is greater than or equal to 4.

PASS Condition When the coefficients are set to c(1)minimum c(0) minimum and c(-1) zero, the post-cursor full-scale ratio is greater than or equal to 4.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists (PRBS9 pattern).
3 Pop up to ask user to supply sufficient increment or decrement requests to set c(1) zero c(0) minimum and c(-1) minimum. OK pressed.
4 Measure VOvershoot and Vtop of the signal.
5 Calculate the pre-cursor VOvershoot/Vtop.
6 Report and compare the value calculated in step 6 with 4.

Far-end transmit output noise: Low insertion loss channel

The purpose of this test is to verify that the far-end transmit output noise for the low insertion loss channel is less than or equal to ICNlSpecLimit V.

PASS Condition The far-end transmit output noise for the low insertion loss channel is less than or equal to ICNlSpecLimit V.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and has a square 8 pattern.
3 Enable the Histogram and get the standard deviation.
4 Compare the standard deviation with the limit.

Far-end transmit output noise: High insertion loss channel

The purpose of this test is to verify that the far-end transmit output noise for the high insertion loss channel is less than or equal to ICNhSpecLimit V.

PASS Condition The far-end transmit output noise for the high insertion loss channel is less than or equal to ICNhSpecLimit V.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and has a square 8 pattern.
3 Enable the Histogram and get the standard deviation.
4 Compare the standard deviation with the limit.

DME/EEE Waveform Measurements

This section provides the Methods of Implementation (MOIs) for the DME and EEE Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

DME/EEE Waveform Specifications

The 40GBASE-CR4 and 100GBASE-CR10 DME specifications can be found in IEEE 802.3ap section 73.5.1 Table 73-1 and section 73.5.3 Table 73-2. The 40GBASE-CR4 and 100GBASE-CR10 specifications can be found in section 72.7.1 Table 72-6.

- DME Differential Peak-to-Peak Output Voltage (0.6-1.2 V).
- DME T1 (3.2 ns-0.01% to 3.2 ns+0.1%).
- DME T2 (6.2 ns-6.6 ns).
- DME T3 (3.0 ns-3.4 ns).
- EEE Differential Peak-to-Peak Output Voltage with TX disabled (max 30 mV).
- EEE Differential Peak-to-Peak Output Voltage (min 720 mV).
- EEE Common Mode Voltage Deviation (±150 mV).

DME Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is less than 1200 mV.

PASS Condition

The differential signal max peak-to-peak voltage on a 1010 pattern is less than 1200 mV.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and has a 1010 pattern.
3. Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4. Compare the min and max peak-to-peak voltage to be within 0.6 to 1.2 V.

DME T1-Transition Position Spacing (Period) Test

The purpose of this test is to verify that transition spacing of the DME signal is 3.2 ns ±0.01%.

PASS Condition

The mean period is between 3.2 ns ±0.01%.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal is connected.
3. Request DUT in DME mode.
4. Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5. Compare the mean measurement to 3.2 ns ±0.01%.

DME T2-Clock Transition to Clock Transition Test

The purpose of this test is to verify clock to clock transition is 6.2 ns to 6.6 ns.

PASS Condition

The mean period is between 6.2 ns to 6.6 ns.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal is connected.
3. Request DUT in DME mode.
4. Measure the rising to rising edge.
5. Compare the min and max values to measurement to 6.2 ns to 6.6 ns.

DME T3-Clock Transition to Data Transition Test

The purpose of this test is to verify clock to data transition is 3.0 ns to 3.4 ns.

PASS Condition The min and max UI time is between 3.0 ns to 3.4 ns.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal is connected.
3 Request DUT in DME mode.
4 Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5 Compare the min and max values to measurement to 3.0 ns to 3.4 ns.

EEE Differential Peak-to-Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT to be EEE mode.
3 Check that the signal is truly with TX disabled (no valid data transitions).
4 Measure peak-to-peak voltage of the signal.
5 Compare the max peak-to-peak voltage to 30 mV.

EEE Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is greater or equal to 720 mV.

PASS Condition The differential signal max peak-to-peak voltage on a 1010 pattern is greater than or equal to 720 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT in EEE mode.
3 Verify that a signal is connected and has a 1010 pattern.
4 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
5 Compare the min voltage to be greater than or equal to 720 mV.

EEE Common Mode Deviation Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair of the pre-LPI signal and the LPI signal is within ±150 mV.

PASS Condition The signal voltage change between pre and post LPI is within 150 mV change.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Request DUT to be pre-LPI.
4 Measure the peak-to-peak voltage of the DUT+ and DUT-.
5 Request DUT to be in LPI.
6 Measure the peak-to-peak voltage of the DUT+ and DUT-.
7 Calculate Vpp(post)-Vpp(pre).

8 Compare the result from step 8 to ±150 mV.

Return Loss PNA/ENA/N1055A Measurements

This section provides the Methods of Implementation (MOIs) for the Return Loss Measurements using a Keysight Sampling oscilloscope, PNA or ENA, and the IEEE 802.3 NRZ Test Application. The test application controls the PNA/ENA to set the test limits and run the test. You must ensure that the calibration must be done on the PNA/ENA.

Limits for Return Loss PNA/ENA measurements

The limits for tests under return loss PNA/ENA measurements can be found in section 85.8.3 of IEEE 802.3 specification. Refer to Table 85-5 for corresponding values.

- Differential Output Return Loss
- Common-mode Output Return Loss

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5 Compare the reported values with the specification to check for compliance.

5 100GBASE-KR4 Tests

This section provides the Methods of Implementation (MOIs) for the 100GBASE-KR4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for 100GBASE-KR4 Tests

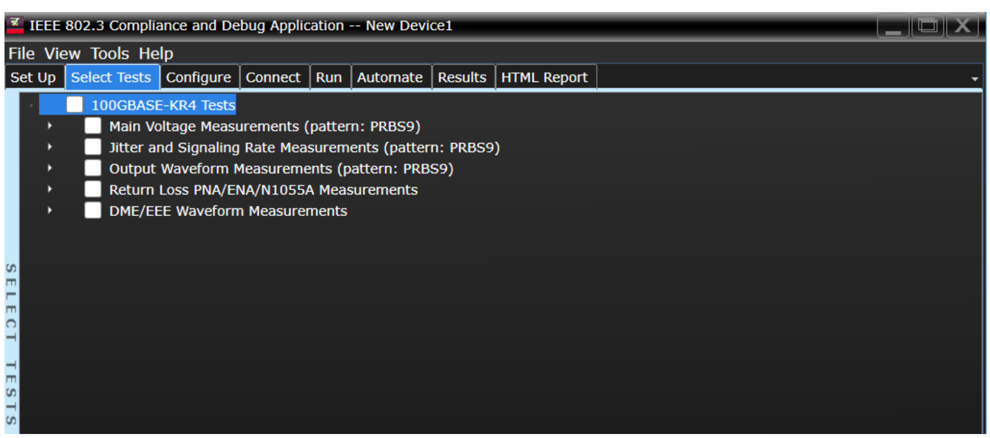
When performing the 100GBASE-KR4 tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.
3 Select the 100GBASE-KR4 Tests transmission standard in the **Select Measurement Option** section**.**
4 For the 100GBASE-KR4 tests, under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.
5 Configure other options on the Setup tab, as required.
6 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.
7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the 100GBASE-KR4 tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Main Voltage Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Main Voltage Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 93.8.1.3 of IEEE 802.3 specifications. Refer to Table 93-4 for corresponding values.

- Differential Peak to Peak Output Voltage with TX disabled (max 30 mV)
- DC Common Mode Output Voltage (0-1.9 V)
- AC Common Mode Output Voltage (max 12 mV)
- Differential Peak to Peak Output Voltage (max 1200 mV)

Differential Peak to Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is truly with TX disabled (no valid data transitions).
3 Measure peak-to-peak voltage of the signal.
4 Compare the max peak-to-peak voltage to 30 mV.

DC Common Mode Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair is between 0-1.9 V.

NOTE **This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.**

PASS Condition The signal is between 0-1.9 V.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to 0-1.9 V.

AC Common Mode Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair rms voltage does not exceed 12 mV.

NOTE **This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.**

PASS Condition The signal is less than 12 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to 12 mV.

Differential Peak to Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS9 pattern is less than 1200 mV.

PASS Condition The differential signal max peak to peak voltage on a PRBS9 pattern is less than 1200 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the max peak-to-peak voltage to 1200 mV.

Jitter and Signaling Rate Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Jitter and Signaling Rate Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Jitter and Signaling Rate Measurements

The limits for tests under jitter and signaling rate measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Signaling Rate (25.78125 ±100 ppm GBd) (section 93.8.1.2)
- Even-Odd Jitter (max 35mUI) (section 93.8.1.7)
- Bounded Uncorrelated Jitter (max 100mUI) (section 93.8.1.7)
- Total Uncorrelated Jitter (max 180mUI) (section 93.8.1.7)

Signaling Rate

The purpose of this test is to verify that the signaling rate mean is between 25.78125 ±100 ppm GBd.

PASS Condition

The mean signaling rate is between 25.78125 ±100 ppm GBd.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3. Set data rate measurement to 25.78125 Gb/s.
4. Set the DCA to Eye mode.
5. Measure the data rate.
6. Compare the measured data rate to 25.78125 ±100 ppm GBd.

Jitter (Even-Odd Jitter, Bounded Uncorrelated Jitter, Total Uncorrelated Jitter)

The purpose of this test is to verify that differential signal's Even-Odd Jitter is less that 35 mUI, Bounded Uncorrelated Jitter is less than 100 mUI, and Total Uncorrelated Jitter is less than 180 mUI. If all tests are selected, all tests are run on a single measurement. Each test can be run individually by selecting any or some of the tests.

PASS Conditions

- Even-Odd Jitter is less than 35 mUI.
- BUJ is less than 100 mUI.
- Total Uncorrelated Jitter rms is less than 180 mUI.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3. Set clock recovery to OJTF First Order PLL with Nominal Data Rate 25.78125 Gb/s and Loop Bandwidth to 10 MHz.
4. Using Jitter Mode, measure Even-Odd Jitter, BUJ, and TUJ at BER of 10E-12.
5. Compare and report the values to their respective maximum specification.

Output Waveform Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Output Waveform Measurements

The limits for tests under output waveform measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Steady State Voltage Vf (400-600 mV) (section 93.8.1.5.2)
- Linear Fit Pulse Peak (0.71 * Vf) (section 93.8.1.5.2)
- Signal-to-noise-and-distortion ratio (27 dB) (section 93.8.1.6)

Steady State Voltage Vf

The purpose of this test is to verify that the Steady State Voltage as described in section 85.8.3.3 is between 0.4 and 0.6 V.

PASS Condition

The Steady State Voltage is between 0.4 and 0.6 V.

Measurement Algorithm

1. Capture one full PRBS9 pattern and scale.
2. Calculate Vf using the equations in section 92.8.3.7. The result value is the sum of the columns in P1 (Equ 92-9).
3. Compare and report the result to 0.4-0.6 V.

Linear Fit Pulse Peak

The purpose of this test is to verify that the Linear Fit Pulse as described in section 85.8.3.3 is greater than the Vf * 0.71.

PASS Condition

The Linear Fit Pulse is greater than Vf * 0.71.

Measurement Algorithm

1. Capture one full PRBS9 pattern and scale.
2. Calculate p(k) linear fit using the equations in section 85.8.3.3.5. The result value is the max of p(k).
3. Compare and report the result to 0.71*Vf.

Signal-to-noise-and-distortion ratio

The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) is greater than 27dB.

PASS Condition

The SNDR must be greater than 27dB.

Measurement Algorithm

1. Calculate SNDR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.
2. Compare and report the value of SNDR with 27dB.

Normalized Coefficient Step Size Measurements

Limits for Normalized Coefficient Step Size Measurements

The limits for tests under normalized coefficient step size measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- abs coefficient step size (min. 0.0083) (section 93.8.1.5.4)
- abs coefficient step size (max. 0.05) (section 93.8.1.5.4)

abs Coefficient Step Size c(1) inc c(0)hold c(-1)hold

The purpose of this test is to verify that the difference amplitude between coefficient updates falls between the specified values 0.0083 and 0.05.

PASS Condition The difference in the coefficient update when c(1) is incremented to the previous is within 0.0083 to 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

abs Coefficient Step Size c(1)dec c(0)hold c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates, falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(1) is decremented to the previous is within -0.0083 to -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083 for dec.

abs Coefficient Step Size c(1)hold c(0)inc c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(0) is incremented to the previous state is within 0.0083 to 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.

5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

abs Coefficient Step Size c(1)hold c(0)dec c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(0) is decremented to the previous state is within -0.0083 and -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083 for dec.

abs Coefficient Step Size c(1)hold c(0)hold c(-1)inc

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(-1) is incremented to the previous state is within 0.0083 and 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

abs Coefficient Step Size c(1)hold c(0)hold c(-1)dec

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(-1) is decremented to the previous state is within -0.0083 and -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083 for dec.

Full Scale Range Tests

Limits for Full Scale Range Tests The limits for tests under full scale range tests can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- minimum Pre-cursor Full-scale Range (1.54) (section 93.8.1.5.5)
- minimum Post-cursor Full-scale Range (4) (section 93.8.1.5.5)

Minimum Pre-cursor Full-scale Test

The purpose of this test is to verify that the minimum Pre-cursor is greater than or equal to 1.54.

PASS Condition When the coefficients are set to c(1) zero c(0) minimum and c(-1) minimum, the pre-cursor full-scale ratio is greater than or equal 1.54.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition (only if not previously have 'PRESET' measurement on same trial from step size).
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition (if not previously done in same trial on step size).
4 Define matrix Rm using Equation (92-4) from IEEE 802.3 (if not previously done in same trial on step size).
5 Request to change the Tx setting to c(-1) zero and c(0) and c(1) to their minimum values.
6 Calculate linear fit pulse response.
7 Calculate coefficients with equation (92-5).
8 Calculate precursor ratio (c(0) – c(-1))/(c(0) + c(-1)).
9 Report and compare the value calculated in step 8 with 1.54.

Minimum Post-cursor Full-scale Test

The purpose of this test is to verify that the minimum Post-cursor is greater than or equal to 4.

PASS Condition When the coefficients are set to c(1) minimum c(0) minimum and c(-1) zero, the post-cursor full-scale ratio is greater than or equal to 4.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition (only if not previously have 'PRESET' measurement on same trial from step size).
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition (if not previously done in same trial on step size).
4 Define matrix Rm using Equation (92-4) from IEEE 802.3 (if not previously done in same trial on step size).
5 Request to change the Tx setting to c(1) zero and c(0) and c(-1) to their minimum values.
6 Calculate linear fit pulse response.
7 Calculate coefficients with equation (92-5).
8 Calculate postcursor ratio (c(0) – c(1))/(c(0) + c(1)).
9 Report and compare the value calculated in the previous step with 4.

Coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1))

The purpose of this test is to verify that the specified ratio of the coefficients is greater than or equal to 1.161000 and less than or equal to 1.419000.

PASS Condition The specified ratio of the coefficients is greater than or equal to 1.161000 and less than or equal to 1.419000.

Measurement Algorithm

1 Request the transmitter to be set to initialize condition.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate the coefficients defined in (92-5).
5 Calculate the coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1)) based on the results.
6 Compare the result with the limit.

Coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1))

The purpose of this test is to verify that the specified ratio of the coefficients is greater than or equal to 2.313000 and less than or equal to 2.827000.

PASS Condition The specified ratio of the coefficients is greater than or equal to 2.313000 and less than or equal to 2.827000.

Measurement Algorithm

1 Request the transmitter to be set to initialize condition.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate the coefficients defined in (92-5).
5 Calculate the coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1)) based on the results.
6 Compare the result with the limit.

Return Loss PNA/ENA/N1055A Measurements

This section provides the Methods of Implementation (MOIs) for the Return Loss PNA/ENA/N1055A Measurements using a Keysight Sampling oscilloscope, a PNA or an ENA and the IEEE 802.3 NRZ Test Application. The test application controls the PNA/ENA to set the test limits and run the test. You must ensure that calibration is done on the PNA/ENA.

Limits for Return Loss PNA/ENA Measurements

The limits for tests under return loss PNA/ENA/N1055A measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Differential Output Return Loss (refer to section 93.8.1.4 and see Eq. 93-3)
- Common-mode Output Return Loss (refer to section 93.8.1.4 and see Eq. 93-4)

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5. Compare the reported values with the specification to check for compliance.

DME/EEE Waveform Measurements

This section provides the Methods of Implementation (MOIs) for the DME and EEE Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for DME/EEE Waveform Measurements

The limits for tests under DME/EEE Waveform measurements can be found in various sections of IEEE 802.3 specification. The 100GBASE-KR4 DME specifications can be found in IEEE 802.3ap-2012 section 73.5.1 Table 73-1 and section 73.5.3 Table 73-2. The 100GBASE-KR4 EEE specifications can be found in section 72.7.1 Table 72-6.

- DME Differential Peak-to-Peak Output Voltage (0.6-1.2 V).
- DME T1 (3.2 ns-0.01% to 3.2 ns+0.1%).
- DME T2 (6.2 ns-6.6 ns).
- DME T3 (3.0 ns-3.4 ns).
- EEE Differential Peak-to-Peak Output Voltage with TX disabled (max 30 mV).
- EEE Differential Peak-to-Peak Output Voltage with TX enabled (min 720 mV).
- EEE Common Mode Voltage Deviation (±150 mV).

DME Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is less than 1200 mV.

PASS Condition

The differential signal max peak-to-peak voltage on a 1010 pattern is less than 1200 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and has a 1010 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the min and max peak-to-peak voltage to be within 0.6 to 1.2 V.

DME T1-Transition Position Spacing (Period) Test

The purpose of this test is to verify that transition spacing of the DME signal is 3.2 ns ±0.01%.

PASS Condition

The mean period is between 3.2 ns ±0.01%.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected.
3 Request DUT in DME mode.
4 Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5 Compare the mean measurement to 3.2 ns ±0.01%.

DME T2-Clock Transition to Clock Transition Test

The purpose of this test is to verify clock to clock transition is 6.2 ns to 6.6 ns.

PASS Condition

The mean period is between 6.2 ns to 6.6 ns.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected.
3 Request DUT in DME mode.
4 Measure the rising to rising edge.
5 Compare the min and max values to measurement to 6.2 ns to 6.6 ns.

DME T3-Clock Transition to Data Transition Test

The purpose of this test is to verify clock to data transition is 3.0 ns to 3.4 ns.

PASS Condition The min and max UI time is between 3.0 ns to 3.4 ns.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected.
3 Request DUT in DME mode.
4 Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5 Compare the min and max values to measurement to 3.0 ns to 3.4 ns.

EEE Differential Peak-to-Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT to be EEE mode.
3 Check that the signal is truly with TX disabled (no valid data transitions).
4 Measure peak-to-peak voltage of the signal.
5 Compare the max peak-to-peak voltage to 30 mV.

EEE Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is greater or equal to 720 mV.

PASS Condition The differential signal max peak-to-peak voltage on a 1010 pattern is greater than or equal to 720 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT in EEE mode.
3 Verify that a signal is connected and has a 1010 pattern.
4 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
5 Compare the min voltage to be greater than or equal to 720 mV.

EEE Common Mode Deviation Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair of the pre-LPI signal and the LPI signal is within ±150 mV.

PASS Condition The signal voltage change between pre and post LPI is within 150 mV change.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Request DUT to be pre-LPI.
4 Measure the peak-to-peak voltage.
5 Request DUT to be in LPI.
6 Measure the peak-to-peak voltage again.
7 Calculate Vpp(post)-Vpp(pre).
8 Compare the result from step 8 to ±150 mV.

6 100GBASE-CR4 Tests

This section provides the Methods of Implementation (MOIs) for the 100GBASE-CR4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for 100GBASE-CR4 Tests

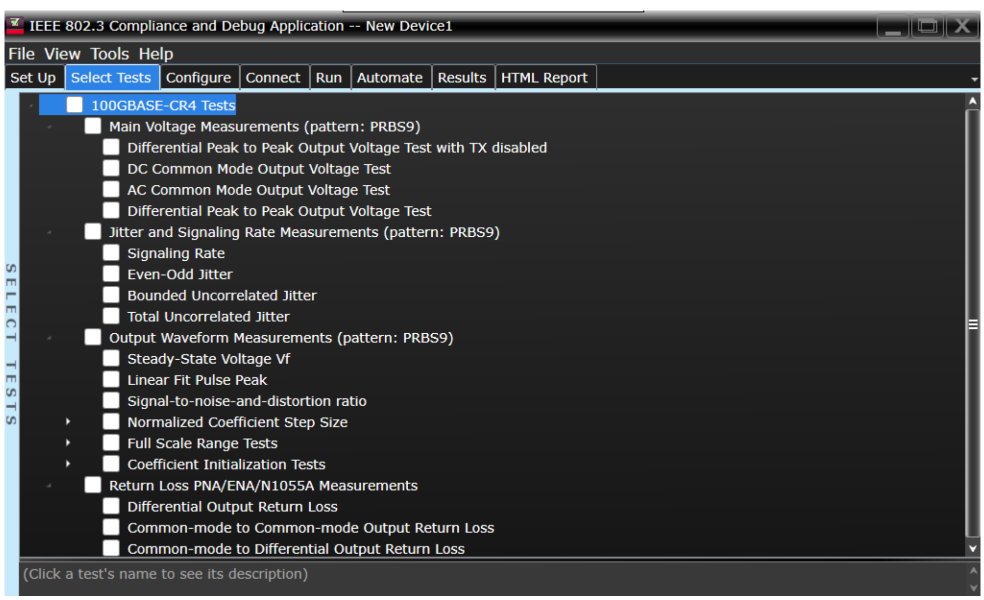
When performing the 100GBASE-CR4 tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.
3 Select the 100GBASE-CR4 Tests transmission standard in the **Select Measurement Option** section**.**
4 For the 100GBASE-CR4 tests, under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.
5 Configure other options on the Setup tab, as required.
6 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.
7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the 100GBASE-CR4 tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Main Voltage Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Main Voltage Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 92.8.3.1 of IEEE 802.3 specifications. Refer to Table 92-6 for corresponding values.

- Differential Peak to Peak Output Voltage with TX disabled (max 35 mV)
- DC Common Mode Output Voltage (max 1.9 V)
- AC Common Mode Output Voltage (max 30 mV)
- Differential Peak to Peak Output Voltage (max 1200 mV)

Differential Peak to Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 35 mV.

PASS Condition

The max peak-to-peak voltage is less than 35 mV.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is truly with TX disabled (no valid data transitions).
3. Measure peak-to-peak voltage of the signal.
4. Compare the max peak-to-peak voltage to 35 mV.

DC Common Mode Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair is between 0-1.9 V.

NOTE

This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.

PASS Condition

The signal is between 0-1.9 V.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal and that the connection is dual-single ended.
3. Measure the peak-to-peak voltage.
4. Compare the voltage measurement to 0-1.9 V.

AC Common Mode Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair rms voltage does not exceed 30 mV.

NOTE

This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.

PASS Condition

The signal is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to 30 mV.

Differential Peak to Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS9 pattern is less than 1200 mV.

PASS Condition The differential signal max peak to peak voltage on a PRBS9 pattern is less than 1200 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that signal is connected and has a PRBS9 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the max peak-to-peak voltage to 1200 mV.

Jitter and Signaling Rate Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Jitter and Signaling Rate Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Jitter and Signaling Rate Measurements

The limits for tests under jitter and signaling rate measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 92-6 for corresponding values.

- Signaling Rate (25.78125 ±100 ppmGBd) (section 92.8.3.9)
- Even-Odd Jitter (-35mUI - 35mUI) (section 92.8.3.8.1)
- Bounded Uncorrelated Jitter (max 100 mUI) (section 92.8.3.8.2)
- Total Uncorrelated Jitter (max 180mUI) (section 92.8.3.8.2)

Signaling Rate

The purpose of this test is to verify that the signaling rate mean is between 25.78125 ±100 ppmGBd.

PASS Condition

The mean signaling rate is between 25.78125 ±100 ppm GBd.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set data rate measurement to 25.78125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 25.78125 ±100 ppm GBd.

Jitter (Even-Odd Jitter, Bounded Uncorrelated Jitter, Total Uncorrelated Jitter)

The purpose of this test is to verify that differential signal's Even-Odd Jitter is less that 35 mUI, Bounded Uncorrelated Jitter is less than 100 mUI, and Total Uncorrelated Jitter is less than 180 mUI. If all tests are selected, all tests are run on a single measurement. Each test can be run individually by selecting any or some of the tests.

PASS Conditions

- Even-Odd Jitter is less than 35 mUI.
- Bounded Uncorrelated Jitter is less than 100 mUI.
- Total Uncorrelated Jitter rms is less than 180 mUI.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set clock recovery to OJTF First Order PLL with Nominal Data Rate 25.78125Gb/s and Loop Bandwidth to 10 MHz.
4 Using Jitter Mode, measure Even-Odd Jitter, BUJ, and TUJ at BER of 10E-12.
5 Compare the values to their respective maximum specification.

Output Waveform Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Output Waveform Measurements

The limits for tests under output waveform measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 92-6 for corresponding values.

- Steady State Voltage Vf (340-600 mV) (section 92.8.3.7.2)
- Linear Fit Pulse Peak (0.45 * Vf) (section 92.8.3.7.2)
- Signal-to-noise-and-distortion ratio (26 dB) (section 92.8.3.7.2)

Steady State Voltage Vf

The purpose of this test is to verify that the Steady State Voltage as described in section 85.8.3.3 is between 0.34 and 0.6 V.

PASS Condition

The Steady State Voltage is between 0.34 and 0.6 V.

Measurement Algorithm

1. Capture one full PRBS9 pattern and scale.
2. Calculate Vf using the equations in section 85.8.3.3.5. The result value is the sum of the columns in P1 (Eq. 85-9).
3. Compare and report the result to 0.34-0.6 V.

Linear Fit Pulse Peak

The purpose of this test is to verify that the Linear Fit Pulse as described in section 85.8.3.3 is greater than the Vf * 0.45.

PASS Condition

The Linear Fit Pulse is greater than Vf * 0.45.

Measurement Algorithm

1. Capture one full PRBS9 pattern and scale.
2. Calculate p(k) linear fit using the equations in section 85.8.3.3.5. The result value is the max of p(k).
3. Compare and report the result to 0.45*Vf.

Signal-to-noise-and-distortion ratio

The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) is greater than 26dB.

PASS Condition

The SNDR must be greater than or equal to 26dB.

Measurement Algorithm

1. Calculate SNDR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.
2. Compare and report the value of SNDR with 26 dB.

Normalized Coefficient Step Size Measurements

Limits for Normalized Coefficient Step Size Measurements

The limits for tests under normalized coefficient step size measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 92-6 for corresponding values.

abs Coefficient Step Size c(1)inc c(0)hold c(-1)hold

The purpose of this test is to verify that the difference amplitude between coefficient updates falls between the specified values 0.0083 and 0.05.

PASS Condition The difference in the coefficient update when c(1) is incremented to the previous is within 0.0083 to 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3.
5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the equalized coefficients using equation (85-13).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate the equalized coefficients using equation (85-13).
10 Compare result to previous setting.
11 Loop steps 7-10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

abs Coefficient Step Size c(1)dec c(0)hold c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates, falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(1) is decremented to the previous is within -0.0083 to -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the equalized coefficients using equation (85-13).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate the equalized coefficients using equation (85-13).
10 Compare result to previous setting.
11 Loop steps 7-10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083.

abs Coefficient Step Size c(1)hold c(0)inc c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(0) is incremented to the previous state is within 0.0083 to 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3.

5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the equalized coefficients using equation (85-13).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate the equalized coefficients using equation (85-13).
10 Compare result to previous setting.
11 Loop steps 7-10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

abs Coefficient Step Size c(1)hold c(0)dec c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(0) is decremented to the previous state is within -0.0083 and -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the equalized coefficients using equation (85-13).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate the equalized coefficients using equation (85-13).
10 Compare result to previous setting.
11 Loop steps 7-10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083.

abs Coefficient Step Size c(1)hold c(0)hold c(-1)inc

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(-1) is incremented to the previous state is within 0.0083 and 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3.
5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the equalized coefficients using equation (85-13).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate the equalized coefficients using equation (85-13).
10 Compare result to previous setting.
11 Loop steps 7-10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

abs Coefficient Step Size c(1)hold c(0)hold c(-1)dec

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(-1) is decremented to the previous state is within -0.0083 and -0.05.

Measurement Algorithm

1. Request transmitter to be set to 'PRESET' condition.
2. Capture one full PRBS9 pattern and scale.
3. Calculate linear fit pulse response at 'PRESET' condition.
4. Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3.
5. Request to change the Tx setting to a Baseline condition that allows for decrement.
6. Calculate the equalized coefficients using equation (85-13).
7. Request to change the Tx setting to decrement.
8. Calculate linear fit pulse response.
9. Calculate the equalized coefficients using equation (85-13).
10. Compare result to previous setting.
11. Loop steps 7-10 for as many decrements to be tested.
12. Compare and report the values and verify they are in the range of -0.05 to -0.0083.

Full Scale Range Tests

Limits for Full Scale Range Tests The limits for tests under full scale range tests can be found in various sections of IEEE 802.3 specification. Refer to Table 92-6 for corresponding values.

- Minimum precursor full-scale ratio (1.54) (section 92.8.3.7.5)
- Minimum precursor full-scale ratio (4) (section 92.8.3.7.5)

Minimum Pre-cursor Full-scale Ratio

The purpose of this test is to verify that the minimum Pre-cursor is greater than or equal 1.54.

PASS Condition When the coefficients are set to c(1) zero c(0) minimum and c(-1) minimum, the pre-cursor full-scale ratio is greater than or equal 1.54.

Measurement Algorithm

1. Request transmitter to be set to 'PRESET' condition (only if not previously have 'PRESET' measurement on same trial from step size).
2. Capture one full PRBS9 pattern and scale.
3. Calculate linear fit pulse response at 'PRESET' condition (if not previously done in same trial on step size).
4. Define matrix Rm using Equation (92-4) and w using equation (85-2) from IEEE 802.3 (if not previously done in same trial on step size).
5. Request to change the Tx setting to c(-1) zero and c(0) and c(1) to their minimum values.
6. Calculate linear fit pulse response.
7. Calculate equalized coefficients using equation (85-13).
8. Calculate precursor ratio (c(0) – c(1))/(c(0) + c(1)).
9. Report and compare the value calculated in step 8 with 1.54.

Minimum Post-cursor Full-scale Ratio

The purpose of this test is to verify that the minimum Post-cursor is greater than or equal to 4.

PASS Condition When the coefficients are set to c(1) minimum c(0) minimum and c(-1) zero, the post-cursor full-scale ration is greater than or equal to 4.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition (only if not previously have 'PRESET' measurement on same trial from step size).
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition (if not previously done in same trial on step size).
4 Define matrix Rm using Equation (92-4) and w using equation (85-2)from IEEE 802.3 (if not previously done in same trial on step size).
5 Request to change the Tx setting to c(1) zero and c(0) and c(-1) to their minimum values.
6 Calculate linear fit pulse response.
7 Calculate equalized coefficients using equation (85-13).
8 Calculate precursor ratio (c(0) – c(1))/(c(0) + c(1)).
9 Report and compare the value calculated in the previous step with 4.

Coefficient Initialization Tests

Limits for Coefficient Initialization Tests The limits for tests under coefficient initialization tests can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1)) (1.161000 - 1.419000) (section 92.8.3.5.3)
- Coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1)) (2.313000 - 2.827000) (section 92.8.3.5.3)

Coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1))

The purpose of this test is to verify that the specified ratio of the coefficients is greater than or equal to 1.161000 and less than or equal to 1.419000.

PASS Condition The specified ratio of the coefficients is greater than or equal to 1.161000 and less than or equal to 1.419000.

Measurement Algorithm

1 Request the transmitter to be set to initialize condition.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate the coefficients defined in (92-5).
5 Calculate the coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1)) based on the results.
6 Compare the result with the limit.

Coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1))

The purpose of this test is to verify that the specified ratio of the coefficients is greater than or equal to 2.313000 and less than or equal to 2.827000.

PASS Condition The specified ratio of the coefficients is greater than or equal to 2.313000 and less than or equal to 2.827000.

Measurement Algorithm

1 Request the transmitter to be set to initialize condition.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate the coefficients defined in (92-5).
5 Calculate the coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1)) based on the results.

6 Compare the result with the limit.

Return Loss PNA/ENA/N1055A Measurements

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Full-Scale Range Measurements using a Keysight Sampling oscilloscope, a PNA or an ENA and the IEEE 802.3 NRZ Test Application. The test application controls the PNA/ENA to set the test limits and run the test. You must ensure that calibration is done on the PNA/ENA.

Limits for Return Loss PNA/ENA measurements

The limits for tests under return loss PNA/ENA measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 92-6 for corresponding values.

- Differential Output Return Loss (see Eq. 92-1)
- Common-mode to Common-mode Output Return Loss (see Eq. 92-3)
- Common-mode to differential mode Output Return Loss (see Eq. 92-2)

Measurement Algorithm (common for all three tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5. Compare the reported values with the specification to check for compliance.

7 25GBASE-KR Tests

This section provides the Methods of Implementation (MOIs) for the 25GBASE-KR tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for 25GBASE-KR Tests

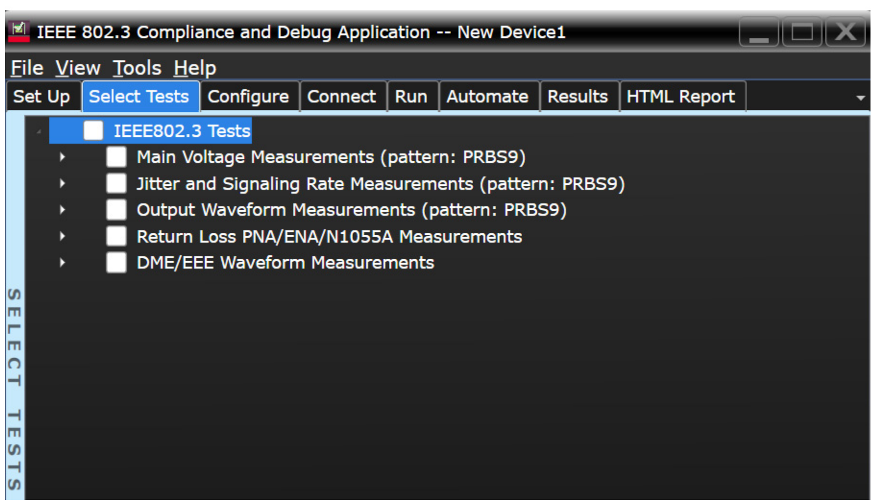
When performing the 25GBASE-KR tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.
3 Select the 25GBASE-KR Tests transmission standard in the **Select Measurement Option** section**.**
4 Configure other options on the Setup tab, as required.
5 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.
6 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the 25GBASE-KR tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Main Voltage Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Main Voltage Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 93.8.1.3 of IEEE 802.3 specifications. Refer to Table 93-4 for corresponding values.

- Differential Peak to Peak Output Voltage with TX disabled (max 30 mV)
- DC Common Mode Output Voltage (0-1.9 V)
- AC Common Mode Output Voltage (max 12 mV)
- Differential Peak to Peak Output Voltage (max 1200 mV)

Differential Peak to Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition

The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is truly with TX disabled (no valid data transitions).
3. Measure peak-to-peak voltage of the signal.
4. Compare the max peak-to-peak voltage to 30 mV.

DC Common Mode Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair is between 0-1.9 V.

NOTE

This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.

PASS Condition

The signal is between 0-1.9 V.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal and that the connection is dual-single ended.
3. Measure the peak-to-peak voltage.
4. Compare the voltage measurement to 0-1.9 V.

AC Common Mode Output Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair rms voltage does not exceed 12 mV.

NOTE

This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.

PASS Condition

The signal is less than 12 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to 12 mV.

Differential Peak to Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS9 pattern is less than 1200 mV.

PASS Condition The differential signal max peak to peak voltage on a PRBS9 pattern is less than 1200 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the max peak-to-peak voltage to 1200 mV.

Jitter and Signaling Rate Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Jitter and Signaling Rate Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Jitter and Signaling Rate Measurements

The limits for tests under jitter and signaling rate measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Signaling Rate (25.78125 ±100 ppm GBd) (section 93.8.1.2)
- Even-Odd Jitter (max 35mUI) (section 93.8.1.7)
- Bounded Uncorrelated Jitter (max 100mUI) (section 93.8.1.7)
- Total Uncorrelated Jitter (max 180mUI) (section 93.8.1.7)

Signaling Rate

The purpose of this test is to verify that the signaling rate mean is between 25.78125 ±100 ppm GBd.

PASS Condition

The mean signaling rate is between 25.78125 ±100 ppm GBd.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set data rate measurement to 25.78125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 25.78125 ±100 ppm GBd.

Jitter (Even-Odd Jitter, Bounded Uncorrelated Jitter, Total Uncorrelated Jitter)

The purpose of this test is to verify that differential signal's Even-Odd Jitter is less that 35 mUI, Bounded Uncorrelated Jitter is less than 100 mUI, and Total Uncorrelated Jitter is less than 180 mUI. If all tests are selected, all tests are run on a single measurement. Each test can be run individually by selecting any or some of the tests.

PASS Conditions

- Even-Odd Jitter is less than 35 mUI.
- BUJ is less than 100 mUI.
- Total Uncorrelated Jitter rms is less than 180 mUI.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set clock recovery to OJTF First Order PLL with Nominal Data Rate 25.78125 Gb/s and Loop Bandwidth to 10 MHz.
4 Using Jitter Mode, measure Even-Odd Jitter, BUJ, and TUJ at BER of 10E-12.
5 Compare and report the values to their respective maximum specification.

Output Waveform Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Transmitter Output Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for Output Waveform Measurements

The limits for tests under output waveform measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Steady State Voltage Vf (400-600 mV) (section 93.8.1.5.2)
- Linear Fit Pulse Peak (0.71 * Vf) (section 93.8.1.5.2)
- Signal-to-noise-and-distortion ratio (27 dB) (section 92.8.3.7)

Steady State Voltage Vf

The purpose of this test is to verify that the Steady State Voltage as described in section 85.8.3.3 is between 0.4 and 0.6 V.

PASS Condition

The Steady State Voltage is between 0.4 and 0.6 V.

Measurement Algorithm

1 Capture one full PRBS9 pattern and scale.
2 Calculate Vf using the equations in section 92.8.3.7. The result value is the sum of the columns in P1 (Equ 92-9).
3 Compare and report the result to 0.4-0.6 V.

Linear Fit Pulse Peak

The purpose of this test is to verify that the Linear Fit Pulse as described in section 85.8.3.3 is greater than the Vf * 0.75.

PASS Condition

The Linear Fit Pulse is greater than Vf * 0.75.

Measurement Algorithm

1 Capture one full PRBS9 pattern and scale.
2 Calculate p(k) linear fit using the equations in section 85.8.3.3.5. The result value is the max of p(k).
3 Compare and report the result to 0.75*Vf.

Signal-to-noise-and-distortion ratio

The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) is greater than 27dB.

PASS Condition

The SNDR must be greater than 27dB.

Measurement Algorithm

1 Calculate SNDR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.
2 Compare and report the value of SNDR with 27dB.

Normalized Coefficient Step Size Measurements

Limits for Normalized Coefficient Step Size Measurements

The limits for tests under normalized coefficient step size measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Normalized coefficient step size (min. 0.0083) (section 93.8.1.5.4)
- Normalized coefficient step size (max. 0.05) (section 93.8.1.5.4)

Normalized Coefficient Step Size c(1) inc c(0)hold c(-1)hold

The purpose of this test is to verify that the difference amplitude between coefficient updates falls between the specified values 0.0083 and 0.05.

PASS Condition The difference in the coefficient update when c(1) is incremented to the previous is within 0.0083 to 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

Normalized Coefficient Step Size c(1)dec c(0)hold c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates, falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(1) is decremented to the previous is within -0.0083 to -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083 for dec.

Normalized Coefficient Step Size c(1)hold c(0)inc c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(0) is incremented to the previous state is within 0.0083 to 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.

5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

Normalized Coefficient Step Size c(1)hold c(0)dec c(-1)hold

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(0) is decremented to the previous state is within -0.0083 and -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083 for dec.

Normalized Coefficient Step Size c(1)hold c(0)hold c(-1)inc

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of 0.0083 to 0.05.

PASS Condition The difference in the coefficient update when c(-1) is incremented to the previous state is within 0.0083 and 0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for increment.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to increment.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many increments to be tested.
12 Compare and report the values and verify they are in the range of 0.0083 to 0.05.

Normalized Coefficient Step Size c(1)hold c(0)hold c(-1)dec

The purpose of this test is to verify that the difference in amplitude between the coefficient updates falls between the specified values of -0.0083 to -0.05.

PASS Condition The difference in the coefficient update when c(-1) is decremented to the previous state is within -0.0083 and -0.05.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition.
4 Define matrix Rm using Equation (92-4) from IEEE802.3.
5 Request to change the Tx setting to a Baseline condition that allows for decrement.
6 Calculate the coefficients defined in (92-5).
7 Request to change the Tx setting to decrement.
8 Calculate linear fit pulse response.
9 Calculate coefficients of new waveform with equation (92-5).
10 Compare result to previous setting.
11 Loop steps 7 – 10 for as many decrements to be tested.
12 Compare and report the values and verify they are in the range of -0.05 to -0.0083 for dec.

Full Scale Range Tests

Limits for Full Scale Range Tests The limits for tests under full scale range tests can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- minimum Pre-cursor Full-scale Range (1.54) (section 93.8.1.5.5)
- minimum Post-cursor Full-scale Range (4) (section 93.8.1.5.5)

Minimum Pre-cursor Full-scale Test

The purpose of this test is to verify that the minimum Pre-cursor is greater than or equal to 1.54.

PASS Condition When the coefficients are set to c(1) zero c(0) minimum and c(-1) minimum, the pre-cursor full-scale ratio is greater than or equal 1.54.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition (only if not previously have 'PRESET' measurement on same trial from step size).
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition (if not previously done in same trial on step size).
4 Define matrix Rm using Equation (92-4) from IEEE 802.3 (if not previously done in same trial on step size).
5 Request to change the Tx setting to c(-1) zero and c(0) and c(1) to their minimum values.
6 Calculate linear fit pulse response.
7 Calculate coefficients with equation (92-5).
8 Calculate precursor ratio (c(0) – c(-1))/(c(0) + c(-1)).
9 Report and compare the value calculated in step 8 with 1.54.

Minimum Post-cursor Full-scale Test

The purpose of this test is to verify that the minimum Post-cursor is greater than or equal to 4.

PASS Condition When the coefficients are set to c(1) minimum c(0) minimum and c(-1) zero, the post-cursor full-scale ratio is greater than or equal to 4.

Measurement Algorithm

1 Request transmitter to be set to 'PRESET' condition (only if not previously have 'PRESET' measurement on same trial from step size).
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at 'PRESET' condition (if not previously done in same trial on step size).
4 Define matrix Rm using Equation (92-4) from IEEE 802.3 (if not previously done in same trial on step size).
5 Request to change the Tx setting to c(1) zero and c(0) and c(-1) to their minimum values.
6 Calculate linear fit pulse response.
7 Calculate coefficients with equation (92-5).
8 Calculate postcursor ratio (c(0) – c(1))/(c(0) + c(1)).
9 Report and compare the value calculated in the previous step with 4.

Coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1))

The purpose of this test is to verify that the specified ratio of the coefficients is greater than or equal to 1.161000 and less than or equal to 1.419000.

PASS Condition The specified ratio of the coefficients is greater than or equal to 1.161000 and less than or equal to 1.419000.

Measurement Algorithm

1 Request the transmitter to be set to initialize condition.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate the coefficients defined in (92-5).
5 Calculate the coefficient Initialization (c(0)+c(1)-c(-1))/(c(0)+c(1)+c(-1)) based on the results.
6 Compare the result with the limit.

Coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1))

The purpose of this test is to verify that the specified ratio of the coefficients is greater than or equal to 2.313000 and less than or equal to 2.827000.

PASS Condition The specified ratio of the coefficients is greater than or equal to 2.313000 and less than or equal to 2.827000.

Measurement Algorithm

1 Request the transmitter to be set to initialize condition.
2 Verify that a signal is connected and has a PRBS9 pattern.
3 Capture the 511 bits of the PRBS9 pattern.
4 Calculate the coefficients defined in (92-5).
5 Calculate the coefficient Initialization (c(0)-c(1)+c(-1))/(c(0)+c(1)+c(-1)) based on the results.
6 Compare the result with the limit.

Return Loss PNA/ENA/N1055A Measurements

This section provides the Methods of Implementation (MOIs) for the Return Loss PNA/ENA/N1055A Measurements using a Keysight Sampling oscilloscope, a PNA or an ENA and the IEEE 802.3 NRZ Test Application. The test application controls the PNA/ENA to set the test limits and run the test. You must ensure that calibration is done on the PNA/ENA.

Limits for Return Loss PNA/ENA Measurements

The limits for tests under return loss PNA/ENA/N1055A measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 93-4 for corresponding values.

- Differential Output Return Loss (refer to section 93.8.1.4 and see Eq. 93-3)
- Common-mode Output Return Loss (refer to section 93.8.1.4 and see Eq. 93-4)

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5. Compare the reported values with the specification to check for compliance.

DME/EEE Waveform Measurements

This section provides the Methods of Implementation (MOIs) for the DME and EEE Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Compliance Test Application.

Limits for DME/EEE Waveform Measurements

The limits for tests under DME/EEE Waveform measurements can be found in various sections of IEEE 802.3 specification. The 25GBASE-KR DME specifications can be found in IEEE 802.3ap-2012 section 73.5.1 Table 73-1 and section 73.5.3 Table 73-2. The 25GBASE-KR EEE specifications can be found in section 72.7.1 Table 72-6.

- DME Differential Peak-to-Peak Output Voltage (0.6-1.2 V).
- DME T1 (3.2 ns-0.01% to 3.2 ns+0.1%).
- DME T2 (6.2 ns-6.6 ns).
- DME T3 (3.0 ns-3.4 ns).
- EEE Differential Peak-to-Peak Output Voltage with TX disabled (max 30 mV).
- EEE Differential Peak-to-Peak Output Voltage with TX enabled (min 720 mV).
- EEE Common Mode Voltage Deviation (±150 mV).

DME Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is less than 1200 mV.

PASS Condition

The differential signal max peak-to-peak voltage on a 1010 pattern is less than 1200 mV.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and has a 1010 pattern.
3. Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4. Compare the min and max peak-to-peak voltage to be within 0.6 to 1.2 V.

DME T1-Transition Position Spacing (Period) Test

The purpose of this test is to verify that transition spacing of the DME signal is 3.2 ns ±0.01%.

PASS Condition

The mean period is between 3.2 ns ±0.01%.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected.
3. Request DUT in DME mode.
4. Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5. Compare the mean measurement to 3.2 ns ±0.01%.

DME T2-Clock Transition to Clock Transition Test

The purpose of this test is to verify clock to clock transition is 6.2 ns to 6.6 ns.

PASS Condition

The mean period is between 6.2 ns to 6.6 ns.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected.
3. Request DUT in DME mode.
4. Measure the rising to rising edge.
5. Compare the min and max values to measurement to 6.2 ns to 6.6 ns.

DME T3-Clock Transition to Data Transition Test

The purpose of this test is to verify clock to data transition is 3.0 ns to 3.4 ns.

PASS Condition The min and max UI time is between 3.0 ns to 3.4 ns.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected.
3 Request DUT in DME mode.
4 Measure the unit interval of the differential DME signal – set UI measurement to SEMI, 3.2e-9.
5 Compare the min and max values to measurement to 3.0 ns to 3.4 ns.

EEE Differential Peak-to-Peak Output Voltage Test with TX Disabled

The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition The max peak-to-peak voltage is less than 30 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT to be EEE mode.
3 Check that the signal is truly with TX disabled (no valid data transitions).
4 Measure peak-to-peak voltage of the signal.
5 Compare the max peak-to-peak voltage to 30 mV.

EEE Differential Peak-to-Peak Output Voltage Test

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a 1010 pattern is greater or equal to 720 mV.

PASS Condition The differential signal max peak-to-peak voltage on a 1010 pattern is greater than or equal to 720 mV.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Request DUT in EEE mode.
3 Verify that a signal is connected and has a 1010 pattern.
4 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
5 Compare the min voltage to be greater than or equal to 720 mV.

EEE Common Mode Deviation Voltage Test

The purpose of this test is to verify that the common mode signal of the differential pair of the pre-LPI signal and the LPI signal is within ±150 mV.

PASS Condition The signal voltage change between pre and post LPI is within 150 mV change.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Request DUT to be pre-LPI.
4 Measure the peak-to-peak voltage.
5 Request DUT to be in LPI.
6 Measure the peak-to-peak voltage again.
7 Calculate Vpp(post)-Vpp(pre).
8 Compare the result from step 8 to ±150 mV.

8 XLAUI Tests

This section provides the Methods of Implementation (MOIs) for the XLAUI tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for XLAUI Tests

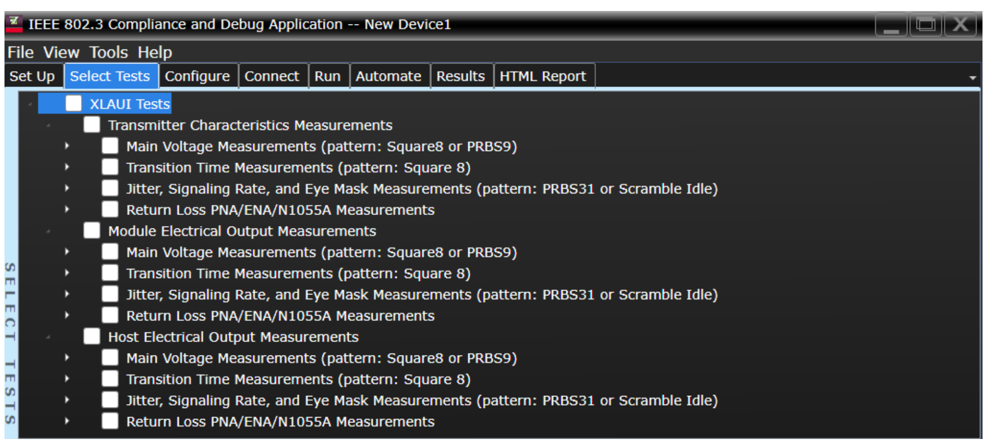
When performing the XLAUI tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.
3 Select the XLAUI transmission standard in the **Select Measurement Option** section**.**
4 Under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.
5 Configure other options on the Setup tab, as required.
6 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.
7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the XLAUI tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Transmitter Characteristics Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 83-A of IEEE 802.3 specifications. Refer to Table 83A-1 for corresponding values.

- Single-Ended Output Voltage Test (-400mV - 4V)
- Maximum Differential Output Voltage Peak-to-Peak (max. 760 mV)
- De-emphasis (4.4 dB - 7.0 dB)
- Minimum VMA (min. VMA_min V)
- Common Mode AC Output Voltage Test (max 15.0 mV)

Single-Ended Output Voltage Test

Test Overview

The purpose of this test is to verify that the minimum voltage on a single-ended signal is greater than -400mV and that the maximum voltage is less than 4V.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the minimum and maximum voltage on each single-ended signal.
4 Compare the voltage measurements with the range between -400mV and 4V.

Maximum Differential Output Voltage Peak-to-Peak

Test Overview

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal is less than 760mV.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is connected.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the maximum peak-to-peak voltage to 760mV.

De-emphasis

Test Overview

The purpose of this test is to measure and verify that the de-emphasis of the signal is greater than or equal to 4.40dB and less than or equal to 7.00dB.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Measure the differential peak-peak and Voltage Modulation Amplitude (VMA).
4. Calculate the de-emphasis with the differential peak-peak and VMA results using Equation (83A-3).
5. Compare the de-emphasis result with the limit.

Minimum VMA

Test Overview The purpose of this test is to measure and verify the minimum VMA.

> **NOTE** This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Calculate the rise time and fall time and compare to get the worst result.
4. Calculate the minimum VMA using Equation (83A-4).
5. Compare the result with the limit.

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the common-mode voltage of the signal does not exceed 15.0 mV.

> **NOTE** This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal and that the connection is dual single-ended.
3. Measure the peak-to-peak voltage.
4. Compare the voltage measurement with 15.0 mV.

Transition Time Measurements (pattern: Square8)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under transition time measurements can be found in section 83A of IEEE 802.3 specifications. Refer to Table 83A-1 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (24ps)
- Minimum Output Fall Time (20% - 80%) (24ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square 8.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 24ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square 8.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 24ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements The limits for tests under jitter, signaling rate, and eye mask measurements can be found in various sections of IEEE 802.3 specifications. Refer to Table 83A-1 for corresponding values.

- Signaling Rate (10.3125 ±100 ppm GBd)
- Eye Mask (max. 100%)
- Deterministic Jitter (max. 0.17 UI)
- Total Jitter (max. 0.32 UI)

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate mean is between 10.3125 ±100 ppm GBd.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that Transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

Deterministic Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 170mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and data pattern exists.
3. Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4. Using Jitter Mode, measure the Random Jitter with short pattern.
5. Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6. Insert PRBS31 pattern and measure Deterministic Jitter in Eye Mode.
7. Compare the value with the maximum limit in the specification.

Total Jitter

Test Overview The purpose of this test is to measure and verify that the total jitter of the signal is less than or equal to 320mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and data pattern exists.
3. Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4. Using Jitter Mode, measure the Random Jitter with short pattern.
5. Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6. Insert PRBS31 pattern and measure Total Jitter in Eye Mode.
7. Compare the value with the maximum limit in the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected instrument is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 83A-1 for corresponding information.

- Differential Output Return Loss (section 83A.3.3.3; see Eq. 83A-5)
- Common-mode Output Return Loss (section 83A.3.3.4; see Eq. 83A-6)

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3. Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6. Compare the reported values with the specification to check for compliance.

Module Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-3 for corresponding values.

- Maximum Differential Output Voltage Peak-to-Peak (max. 760mV)
- De-emphasis (3.5dB - 6.0dB)
- Minimum VMA (min. VMA_min V)
- Common Mode AC Output Voltage Test (max 15mV)

Maximum Differential Output Voltage Peak-to-Peak

Test Overview

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal is less than or equal to 760mV.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is connected, has TX enabled and has a Square8 or PRBS9 pattern.
3. Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4. Compare the maximum peak-to-peak voltage to 760mV.

De-emphasis

Test Overview

The purpose of this test is to measure and verify that the de-emphasis of the signal is greater than or equal to 3.50dB and less than or equal to 6.00dB.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Measure the differential peak-peak and Voltage Modulation Amplitude (VMA).
4. Calculate the de-emphasis with the differential peak-peak and VMA results using Equation (83A-3).
5. Compare the de-emphasis result with the limit.

Minimum VMA

Test Overview

The purpose of this test is to measure and verify the minimum VMA.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Calculate the rise time and fall time and compare to get the worst result.
4. Calculate the minimum VMA using Equation (83A-4).
5. Compare the result with the limit.

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the common-mode voltage of the signal does not exceed 15mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal and that the connection is dual single-ended.
3. Measure the peak-to-peak voltage.
4. Compare the voltage measurement with 15mV.

Transition Time Measurements (pattern: Square8)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under transition time measurements can be found in section 83-B of IEEE 802.3 specifications. Refer to Table 83B-3 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (24ps)
- Minimum Output Fall Time (20% - 80%) (24ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is Square8.
3. Measure rise time from 20% to 80% of the signal amplitude.
4. Compare the minimum rise time with 24ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 24ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements

The limits for tests under main voltage measurements can be found in section 83-B of IEEE 802.3 specifications. Refer to Table 83B-3 for corresponding values.

- Signaling Rate “Information Only”
- Eye Mask (max. 100 percent)
- Deterministic Jitter (max. 250 mUI)
- Total Jitter (max. 400 mUI)

Signaling Rate “Information Only”

Test Overview The purpose of this test is to verify the signaling rate.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that Transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

Deterministic Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 250mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Deterministic Jitter in Eye Mode.

7 Compare the value with the maximum limit in the specification.

Total Jitter

Test Overview The purpose of this test is to measure and verify that the total jitter of the signal is less than or equal to 400mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Total Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected instrument is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83B of IEEE 802.3 specification.

- Differential Input Return Loss - TP1 (see Eq. 83B-5)
- Differential Output Return Loss - TP4 (see Eq. 83B-5)
- Common-mode Output Return Loss (see Eq. 86A-2)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA /N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

Host Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedure described in this section is performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for test under main voltage measurements can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-5 for corresponding values.

- Common Mode AC Output Voltage Test (max 20mV)

Common Mode AC Output Voltage Test

Test Overview

The purpose of this test is to verify that the voltage for common mode signal does not exceed 20mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the AC common-mode voltage.
4 Compare the voltage measurement with 20mV.

Transition Time Measurements (pattern: Square8)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements

The limits for tests under this test group can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-5 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (24ps)
- Minimum Output Fall Time (20% - 80%) (24ps)

Minimum Output Rise Time (20%-80%)

Test Overview

The purpose of this test is to verify that the minimum rise time is 24ps.

Pass Condition

Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 24ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is Square8.
3. Measure fall time from 20% to 80% of the signal amplitude.
4. Compare the minimum fall time with 24ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements The limits for tests under main voltage measurements can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-5 for corresponding values.

- Signaling Rate “Information Only”
- Eye Mask (max 100 percent)
- Deterministic Jitter (max 420mUI)
- Total Jitter (max 620mUI)

Signaling Rate

Test Overview The purpose of this test is to verify the signaling rate mean.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3. Set data rate measurement to 10.3125 Gb/s.
4. Set the DCA to Eye mode.
5. Measure the data rate.
6. Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that Transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit valid pattern.
3. Navigate to Eye mode and load the defined mask file.
4. Verify the eye so that it does not violate the defined mask.

Deterministic Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 420mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and data pattern exists.

3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Deterministic Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Total Jitter

Test Overview The purpose of this test is to measure and verify that the total jitter of the signal is less than or equal to 620mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Total Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Return Loss ENA/PNA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83B of IEEE 802.3 specification.

- Differential Input Return Loss - TP1a (see Eq. 83B-7)
- Differential Output Return Loss - TP4a (see Eq. 83B-7)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA /N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

9 CAUI-10 Tests

This section provides the Methods of Implementation (MOIs) for the CAUI-10 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for CAUI-10 Tests

When performing the CAUI-10 tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.

2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.

3 Select the CAUI-10 transmission standard in the **Select Measurement Option** section**.**

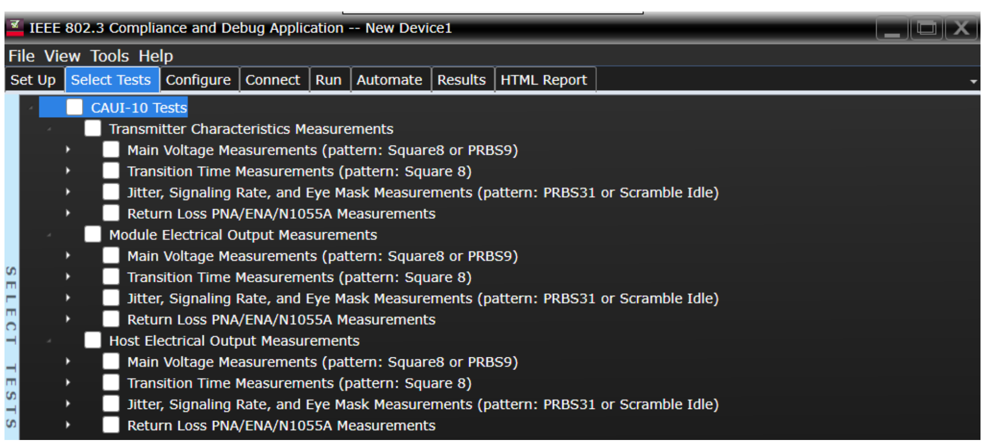
4 Under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.

5 Configure other options on the Setup tab, as required.

6 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.

7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the CAUI-10 tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Transmitter Characteristics Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 83-A of IEEE 802.3 specifications. Refer to Table 83A-1 for corresponding values.

- Single-Ended Output Voltage Test (-400mV - 4V)
- Maximum Differential Output Voltage Peak-to-Peak (max. 760 mV)
- De-emphasis (4.4 dB - 7.0 dB)
- Minimum VMA (min. VMA_min V)
- Common Mode AC Output Voltage Test (max 15.0 mV)

Single-Ended Output Voltage Test

Test Overview The purpose of this test is to verify that the minimum voltage on a single-ended signal is greater than -400mV and that the maximum voltage is less than 4V.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the minimum and maximum voltage on each single-ended signal.
4 Compare the voltage measurements with the range between -400mV and 4V.

Maximum Differential Output Voltage Peak-to-Peak

Test Overview The purpose of this test is to verify that the peak-to-peak voltage of the differential signal is less than 760mV.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is connected.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the maximum peak-to-peak voltage to 760mV.

De-emphasis

Test Overview The purpose of this test is to measure and verify that the de-emphasis of the signal is greater than or equal to 4.40dB and less than or equal to 7.00dB.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Measure the differential peak-peak and Voltage Modulation Amplitude (VMA).
4. Calculate the de-emphasis with the differential peak-peak and VMA results using Equation (83A-3).
5. Compare the de-emphasis result with the limit.

Minimum VMA

Test Overview The purpose of this test is to measure and verify the minimum VMA.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Calculate the rise time and fall time and compare to get the worst result.
4. Calculate the minimum VMA using Equation (83A-4).
5. Compare the result with the limit.

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the common-mode voltage of the signal does not exceed 15.0 mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal and that the connection is dual single-ended.
3. Measure the peak-to-peak voltage.
4. Compare the voltage measurement with 15.0 mV.

Transition Time Measurements (pattern: Square8)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under transition time measurements can be found in section 83A of IEEE 802.3 specifications. Refer to Table 83A-1 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (min. 24ps)
- Minimum Output Fall Time (20% - 80%) (min. 24ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is Square 8.
3. Measure rise time from 20% to 80% of the signal amplitude.
4. Compare the minimum rise time with 24ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is Square 8.
3. Measure fall time from 20% to 80% of the signal amplitude.
4. Compare the minimum fall time with 24ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements The limits for tests under jitter, signaling rate, and eye mask measurements can be found in various sections of IEEE 802.3 specifications. Refer to Table 83A-1 for corresponding values.

- Signaling Rate (10.3125 ±100 ppmGBd)
- Eye Mask (max. 100%)
- Deterministic Jitter (max. 0.17UI)
- Total Jitter (max. 0.32UI)

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate mean is between 10.3125 ±100 ppm GBd.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3. Set data rate measurement to 10.3125 Gb/s.
4. Set the DCA to Eye mode.
5. Measure the data rate.
6. Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that Transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit valid pattern.
3. Navigate to Eye mode and load the defined mask file.
4. Verify the eye so that it does not violate the defined mask.

Deterministic Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 0.17UI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Deterministic Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Total Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 0.32UI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Total Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected instrument is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 83A-1 for corresponding information.

- Differential Output Return Loss (section 83A.3.3.3; see Eq. 83A-5)
- Common-mode Output Return Loss (section 83A.3.3.4; see Eq. 83A-6)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

Module Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements The limits for tests under main voltage measurements can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-3 for corresponding values.

- Maximum Differential Output Voltage Peak-to-Peak (max. 760mV)
- De-emphasis (3.5dB - 6.0dB)
- Minimum VMA (min. VMA_min V)
- Common Mode AC Output Voltage Test (max 15mV)

Maximum Differential Output Voltage Peak-to-Peak

Test Overview The purpose of this test is to verify that the peak-to-peak voltage of the differential signal is less than or equal to 760mV.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is connected, has TX enabled and has a Square8 or PRBS9 pattern.
3. Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4. Compare the maximum peak-to-peak voltage to 760mV.

De-emphasis

Test Overview The purpose of this test is to measure and verify that the de-emphasis of the signal is greater than or equal to 3.5dB and less than or equal to 6.0dB.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3. Measure the differential peak-peak and Voltage Modulation Amplitude (VMA).
4. Calculate the de-emphasis with the differential peak-peak and VMA results using Equation (83A-3).
5. Compare the de-emphasis result with the limit.

Minimum VMA

Test Overview The purpose of this test is to measure and verify the minimum VMA.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit square 8 or PRBS9 pattern.
3 Calculate the rise time and fall time and compare to get the worst result.
4 Calculate the minimum VMA using Equation (83A-4).
5 Compare the result with the limit.

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the common-mode voltage of the signal does not exceed 15mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement with 15mV.

Transition Time Measurements (pattern: Square8)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under transition time measurements can be found in section 83-B of IEEE 802.3 specifications. Refer to Table 83B-3 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (24ps)
- Minimum Output Fall Time (20% - 80%) (24ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 24ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 24ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements

The limits for tests under main voltage measurements can be found in section 83-B of IEEE 802.3 specifications. Refer to Table 83B-3 for corresponding values.

- Signaling Rate “Information Only”
- Eye Mask (max. 100 percent)
- Deterministic Jitter (max. 250 mUI)
- Total Jitter (max. 400 mUI)

Signaling Rate “Information Only”

Test Overview The purpose of this test is to verify that the signaling rate mean is between ±100 ppm GBd.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that Transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

Deterministic Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 250mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Deterministic Jitter in Eye Mode.

7 Compare the value with the maximum limit in the specification.

Total Jitter

Test Overview The purpose of this test is to measure and verify that the total jitter of the signal is less than or equal to 400mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Total Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected instrument is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83B of IEEE 802.3 specification.

- Differential Input Return Loss - TP1 (see Eq. 83B-5)
- Differential Output Return Loss - TP4 (see Eq. 83B-5)
- Common-mode Output Return Loss (see Eq. 86A-2)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA /N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

Host Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedure described in this section is performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements The limits for test under main voltage measurements can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-5 for corresponding values.

- Common Mode AC Output Voltage Test (max 20mV)

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the voltage for common mode signal does not exceed 20mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the AC common-mode voltage.
4 Compare the voltage measurement with 20mV.

Transition Time Measurements (pattern: Square8)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under this test group can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-5 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (24ps)
- Minimum Output Fall Time (20% - 80%) (24ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 24ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 24ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 24ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements The limits for tests under main voltage measurements can be found in section 83B of IEEE 802.3 specifications. Refer to Table 83B-5 for corresponding values.

- Signaling Rate “Information Only”
- Eye Mask (max 100 percent)
- Deterministic Jitter (max 420mUI)
- Total Jitter (max 620mUI)

Signaling Rate

Test Overview The purpose of this test is to verify the signaling rate mean.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that Transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

Deterministic Jitter

Test Overview The purpose of this test is to measure and verify that the deterministic jitter of the signal is less than or equal to 420mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.

3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Deterministic Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Total Jitter

Test Overview The purpose of this test is to measure and verify that the total jitter of the signal is less than or equal to 620mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure Total Jitter in Eye Mode.
7 Compare the value with the maximum limit in the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83B of IEEE 802.3 specification.

- Differential Input Return Loss - TP1a (see Eq. 83B-7)
- Differential Output Return Loss - TP4a (see Eq. 83B-7)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA /N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

10 XLPPI Tests

This section provides the Methods of Implementation (MOIs) for the XLPPI tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for XLPPI Tests

When performing the XLPPI tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.

2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.

3 Select the XLPPI transmission standard in the **Select Measurement Option** section**.**

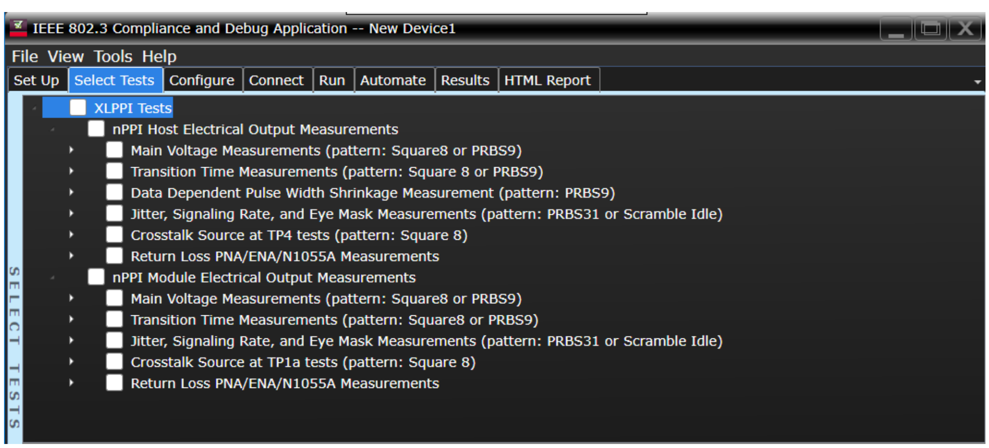
4 Under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.

5 Configure other options on the Setup tab, as required.

6 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.

7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the XLPPI tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



nPPI Host Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for test under main voltage measurements can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-1 for corresponding values.

- Single-Ended Output Voltage Test (-300mV - 4V)
- Qsq (min 45V/V)
- Common Mode AC Output Voltage Test (max 15mV)

Single-Ended Output Voltage Test

Test Overview

The purpose of this test is to verify that the single-ended output voltage lies between -300mV and 4V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 In oscilloscope mode, measure the Vmax and Vmin.
4 Compare the worst result to the measurement limit.

Qsq

Test Overview

The purpose of this test is to verify that the Qsq value is greater than or equal to 45V/V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 In Jitter Mode, turn on Amplitude Measure and get the signal amplitude, RN(rms) Ones and RN(rms) Zeros.
5 Calculate the Qsq using Equation (86A-13).

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal does not exceed 15mV.

> **NOTE** This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that there is a signal and that the connection is dual single-ended.
3. Measure the AC common-mode voltage.
4. Compare the voltage measurement with 15mV.

Transition Time Measurements (pattern: Square8 or PRBS9)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-1 for corresponding values.

- Output Rise Time (20% - 80%) (min. 28ps)
- Output Fall Time (20% - 80%) (min. 28ps)

Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is Square8 or PRBS9.
3. Measure rise time from 20% to 80% of the signal amplitude.
4. Compare the minimum rise time with 28ps.

Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that the signal is Square8 or PRBS9.
3. Measure fall time from 20% to 80% of the signal amplitude.
4. Compare the minimum fall time with 28ps.

Data Dependent Pulse Width Shrinkage Measurement (pattern: PRBS9)

Data Dependent Pulse Width Shrinkage (DDPWS)

Test Overview The purpose of this test is to verify that the DDPWS does not exceed 70mUI.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition DDPWS does not exceed 70mUI.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and apply PRBS9 pattern.
3. Set clock recovery to OJTF First Order PLL with Data Rate 10.3125 Gb/s and Loop Bandwidth to 4MHz.
4. In Jitter Mode, measure DDPWS.
5. Compare the result with the limit.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements

The limits for the tests under this test group can be found in section 86A of IEEE 802.3 specifications.

- Signaling Rate "Information Only"
- Eye Mask (max 100 percent)
- J2 Jitter (max 170mUI)
- J9 Jitter (max 290mUI)

Signaling Rate "Information Only"

Test Overview The purpose of this test is to verify the signaling rate.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3. Set data rate measurement to 10.3125 Gb/s.
4. Set the DCA to Eye mode.
5. Measure the data rate.
6. Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Verify that a signal is connected and transmit valid pattern.
3. Navigate to Eye mode and load the defined mask file.
4. Verify the eye so that it does not violate the defined mask.

J2 Jitter

Test Overview The purpose of this test is to verify that the J2 Jitter is less than or equal to 170mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J2 Jitter in Eye Mode.
7 Compare and report the value to the specification.

J9 Jitter

Test Overview The purpose of this test is to verify that the J9 Jitter is less than or equal to 290mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J9 Jitter in Eye Mode.
7 Compare and report the value to the specification.

Crosstalk Source at TP4 Tests (pattern: Square 8)

The Crosstalk Source at TP4 Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Crosstalk Source at TP4 Measurements The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-1 for corresponding values.

- Crosstalk Source VMA (min 700mV)
- Crosstalk Source Rise Time (min 34ps)
- Crosstalk Source Fall Time (min 34ps)

Crosstalk Source VMA

Test Overview The purpose of this test is to verify that the crosstalk source VMA is equal to or more than 700mV.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the amplitude voltage.
4 Compare the result to the specification.

Crosstalk Source Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source rise time (20%-80%) is equal to or more than 34ps.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the rise time.

4 Compare the result to the specification.

Crosstalk Source Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source fall time (20%-80%) is equal to or more than 34ps.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the fall time.
4 Compare the result to the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 86A of IEEE 802.3 specification. Refer to Table 86A-1 for corresponding values.

- Differential Output Return Loss (see Eq. 86A-1)
- Common-mode Output Return Loss (see Eq. 86A-1)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA is physically connected and calibrated.
2 IIn the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

nPPI Module Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for test under main voltage measurements can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Single-Ended Output Voltage Test (-300 mV - 4V)
- Common Mode AC Output Voltage Test (max. 7.5mV)

Single-Ended Output Voltage Test

Test Overview

The purpose of this test is to verify that the voltage of the single-ended signal lies between -300mV and 4V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 In oscilloscope mode, measure the Vmax and Vmin.
4 Compare the worst result to the measurement limit.

Common Mode AC Output Voltage Test

Test Overview

The purpose of this test is to verify that the common mode signal does not exceed 7.5mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the AC common-mode voltage.
4 Compare the voltage measurement with 7.5mV.

Transition Time Measurements (pattern: Square8 or PRBS9)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements

The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Output Rise Time (20% - 80%) (min. 28ps)
- Output Fall Time (20% - 80%) (min. 28ps)

Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8 or PRBS9.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 28ps.

Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8 or PRBS9.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 28ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements

The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Signaling Rate “Information Only”
- Eye Mask (max 100 percent)
- J2 Jitter (max 420mUI)
- J9 Jitter (max 650mUI)

Signaling Rate “Information Only”

Test Overview The purpose of this test is to verify the signaling rate.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

J2 Jitter

Test Overview The purpose of this test is to verify that the J2 Jitter is less than or equal to 420mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with data rate 10.3125Gb/s and loop bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J2 Jitter in Eye Mode.
7 Compare and report the value to the specification.

J9 Jitter

Test Overview The purpose of this test is to verify that the J9 Jitter is less than or equal to 650mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with data rate 10.3125Gb/s and loop bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J9 Jitter in Eye Mode.
7 Compare and report the value to the specification.

Crosstalk Source at TP1a Tests (pattern: Square 8)

The Crosstalk Source at TP1a measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Crosstalk Source at TP1a Measurements The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Crosstalk Source VMA (min 700mV)
- Crosstalk Source Rise Time (20%-80%) (min. 37ps)
- Crosstalk Source Fall Time (20%-80%) (min. 37ps)

Crosstalk Source VMA

Test Overview The purpose of this test is to verify that the crosstalk source VMA is equal to or greater than 700mV.

Pass Condition Refer to Limits for Crosstalk Source at TP1a Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the amplitude voltage.
4 Compare the result to the specification.

Crosstalk Source Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source rise time (20%-80%) is equal to or greater than 37ps.

Pass Conditions Refer to Limits for Crosstalk Source at TP1a Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the rise time.
4 Compare the result to the specification.

Crosstalk Source Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source fall time (20%-80%) is equal to or greater than 37ps.

Pass Conditions Refer to Limits for Crosstalk Source at TP1a Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the fall time.
4 Compare the result to the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 86A of IEEE 802.3 specification.

- Differential Output Return Loss (see Eq. 86A-3)
- Common-mode Output Return Loss (see Eq. 86A-3)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA/N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

11 CPPI Tests

This section provides the Methods of Implementation (MOIs) for the CPPI tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for CPPI Tests

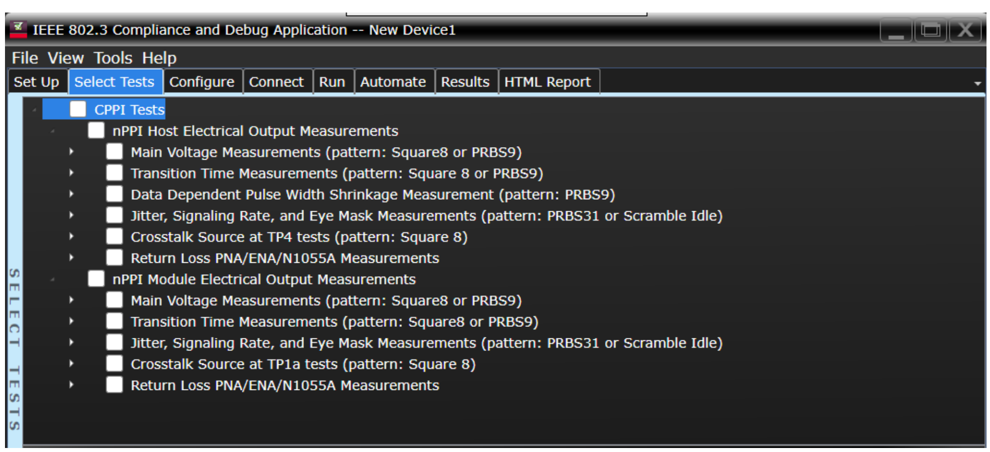
When performing the CPPI tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.
2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.
3 Select the CPPI transmission standard in the **Select Measurement Option** section**.**
4 Under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.
5 Configure other options on the Setup tab, as required.
6 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.
7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the CPPI tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



nPPI Host Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for test under main voltage measurements can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-1 for corresponding values.

- Single-Ended Output Voltage Test (-300mV - 4V)
- Qsq (min 43V/V)
- Common Mode AC Output Voltage Test (max 15mV)

Single-Ended Output Voltage Test

Test Overview

The purpose of this test is to verify that the single-ended output voltage lies between -300mV and 4V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 In oscilloscope mode, measure the Vmax and Vmin.
4 Compare the worst result to the measurement limit.

Qsq

Test Overview

The purpose of this test is to verify that the Qsq value is greater than or equal to 43V/V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data..
2 Check that the signal is connected and data pattern exists.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 In Jitter Mode, turn on Amplitude Measure and get the signal amplitude, RN(rms) Ones and RN(rms) Zeros.
5 Calculate the Qsq using Equation (86A-13).

Common Mode AC Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal does not exceed 15mV.

> **NOTE** This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the AC common-mode voltage.
4 Compare the voltage measurement with 15mV.

Transition Time Measurements (pattern: Square8 or PRBS9)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-1 for corresponding values.

- Output Rise Time (20% - 80%) (min. 28ps)
- Output Fall Time (20% - 80%) (min. 28ps)

Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8 or PRBS9.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 28ps.

Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8 or PRBS9.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 28ps.

Data Dependent Pulse Width Shrinkage Measurement (pattern: PRBS9)

Data Dependent Pulse Width Shrinkage (DDPWS)

Test Overview The purpose of this test is to verify that the DDPWS does not exceed 70mUI.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition DDPWS does not exceed 70mUI.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply PRBS9 pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125 Gb/s and Loop Bandwidth to 4MHz.
4 In Jitter Mode, measure DDPWS.
5 Compare the result with the limit.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements The limits for the tests under this test group can be found in section 86A of IEEE 802.3 specifications.

- Signaling Rate “Information Only”
- Eye Mask (max 100 percent)
- J2 Jitter (max 170mUI)
- J9 Jitter (max 290mUI)

Signaling Rate “Information Only”

Test Overview The purpose of this test is to verify the signaling rate.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

J2 Jitter

Test Overview The purpose of this test is to verify that the J2 Jitter is less than or equal to 170mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J2 Jitter in Eye Mode.
7 Compare the value with the defined limit.

J9 Jitter

Test Overview The purpose of this test is to verify that the J9 Jitter is less than or equal to 290mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J9 Jitter in Eye Mode.
7 Compare the value with the defined limit.

Crosstalk Source at TP4 Tests (pattern: Square 8)

The Crosstalk Source at TP4 Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Crosstalk Source at TP4 Measurements The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-1 for corresponding values.

- Crosstalk Source VMA (min 700mV)
- Crosstalk Source Rise Time (min 34ps)
- Crosstalk Source Fall Time (min 34ps)

Crosstalk Source VMA

Test Overview The purpose of this test is to verify that the crosstalk source VMA is equal to or more than 700mV.

Pass Condition Refer to Limits for Crosstalk Source at TP4 Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the amplitude voltage.
4 Compare the result to the specification.

Crosstalk Source Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source rise time (20%-80%) is equal to or more than 34ps.

Pass Conditions Refer to Limits for Crosstalk Source at TP4 Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the rise time.

4 Compare the result to the specification.

Crosstalk Source Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source fall time (20%-80%) is equal to or more than 34ps.

Pass Conditions Refer to Limits for Crosstalk Source at TP4 Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that the signal is connected and apply Square 8 pattern.
3. Measure the fall time.
4. Compare the result to the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83A of IEEE 802.3 specification.

- Differential Output Return Loss (see Eq. 86A-1)
- Common-mode Output Return Loss (see Eq. 86A-1)

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3. Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6. Compare the reported values with the specification to check for compliance.

nPPI Module Electrical Output Measurements

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for test under main voltage measurements can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Single-Ended Output Voltage Test (-300 mV - 4V)
- Common Mode AC Output Voltage Test (max 7.5mV)

Single-Ended Output Voltage Test

Test Overview

The purpose of this test is to verify that the voltage of the single-ended signal lies between -300mV and 4V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and data pattern exists.
3 In oscilloscope mode, measure the Vmax and Vmin.
4 Compare the worst result to the measurement limit.

Common Mode AC Output Voltage Test

Test Overview

The purpose of this test is to verify that the common mode signal does not exceed 7.5mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the AC common-mode voltage.
4 Compare the voltage measurement with 7.5mV.

Transition Time Measurements (pattern: Square8 or PRBS9)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements

The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Output Rise Time (20% - 80%) (min. 28ps)
- Output Fall Time (20% - 80%) (min. 28ps)

Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8 or PRBS9.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 28ps.

Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 28ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8 or PRBS9.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 28ps.

Jitter, Signaling Rate, and Eye Mask Measurements (pattern: PRBS31 or Scramble Idle)

The Jitter, Signaling Rate, and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements

The limits for tests under this test group can be found in section 86A of IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Signaling Rate “Information Only”
- Eye Mask (max 100 percent)
- J2 Jitter (max 420mUI)
- J9 Jitter (max 650mUI)

Signaling Rate “Information Only”

Test Overview The purpose of this test is to verify the signaling rate.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS31 or Scramble Idle must be used for this test).
3 Set data rate measurement to 10.3125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 10.3125 ±100 ppm GBd.

Eye Mask

Test Overview The purpose of this test is to verify that transmitter eye does not violate the defined mask.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that a signal is connected and transmit valid pattern.
3 Navigate to Eye mode and load the defined mask file.
4 Verify the eye so that it does not violate the defined mask.

J2 Jitter

Test Overview The purpose of this test is to verify that the J2 Jitter is less than or equal to 420mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J2 Jitter in Eye Mode.
7 Compare and report the value to the specification.

J9 Jitter

Test Overview The purpose of this test is to verify that the J9 Jitter is less than or equal to 650mUI.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply valid pattern.
3 Set clock recovery to OJTF First Order PLL with Data Rate 10.3125Gb/s and Loop Bandwidth to 4MHz.
4 Using Jitter Mode, measure the Random Jitter with short pattern.
5 Navigate to Eye mode and insert the Random Jitter result measured in Jitter mode.
6 Insert PRBS31 pattern and measure J9 Jitter in Eye Mode.
7 Compare and report the value to the specification.

Crosstalk Source at TP1a Tests (pattern: Square 8)

The Crosstalk Source at TP1a measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Crosstalk Source at TP1a Measurements The limits for tests under this test group can be found in section 86Aof IEEE 802.3 specifications. Refer to Table 86A-3 for corresponding values.

- Crosstalk Source VMA (min 700mV)
- Crosstalk Source Rise Time (20%-80%) (min. 37ps)
- Crosstalk Source Fall Time (20%-80%) (min. 37ps)

Crosstalk Source VMA

Test Overview The purpose of this test is to verify that the crosstalk source VMA is equal to or greater than 700mV.

Pass Condition Refer to Limits for Crosstalk Source at TP1a Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the amplitude voltage.
4 Compare the result to the specification.

Crosstalk Source Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source rise time (20%-80%) is equal to or greater than 37ps.

Pass Conditions Refer to Limits for Crosstalk Source at TP1a Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the rise time.
4 Compare the result to the specification.

Crosstalk Source Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the crosstalk source fall time (20%-80%) is equal to or greater than 37ps.

Pass Conditions Refer to Limits for Crosstalk Source at TP1a Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is connected and apply Square 8 pattern.
3 Measure the fall time.
4 Compare the result to the specification.

Return Loss PNA/ENA/N1055A Measurements

The Return Loss PNA/ENA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 86A of IEEE 802.3 specification.

- Differential Output Return Loss (see Eq. 86A-3)
- Common-mode Output Return Loss (see Eq. 86A-3)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA/N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Test Application, select an appropriate option (PNA, ENA, or N1055A) from the drop-down under the Comments box.
3 Click **Connect PNA/ENA** to establish connectivity to the connected equipment.
4 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
5 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
6 Compare the reported values with the specification to check for compliance.

12 CAUI-4 Tests

This section provides the Methods of Implementation (MOIs) for the CAUI-4 tests using a Keysight DCA oscilloscope and the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Connection for CAUI-4 Tests

When performing the CAUI-4 tests, the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application will prompt you to make the proper connections. The connections for these tests depend on the specific options selected under the Set Up tab. Refer to the **Connect** tab in the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application for the exact connections.

You can configure other settings used in these tests in the **Configure** tab of the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.

Test Procedure

1 Start the automated test application as described in "Starting the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application" on page 23.

2 In the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application, click the **Set Up** tab.

3 Select the CAUI-4 transmission standard in the **Select Measurement Option** section**.**

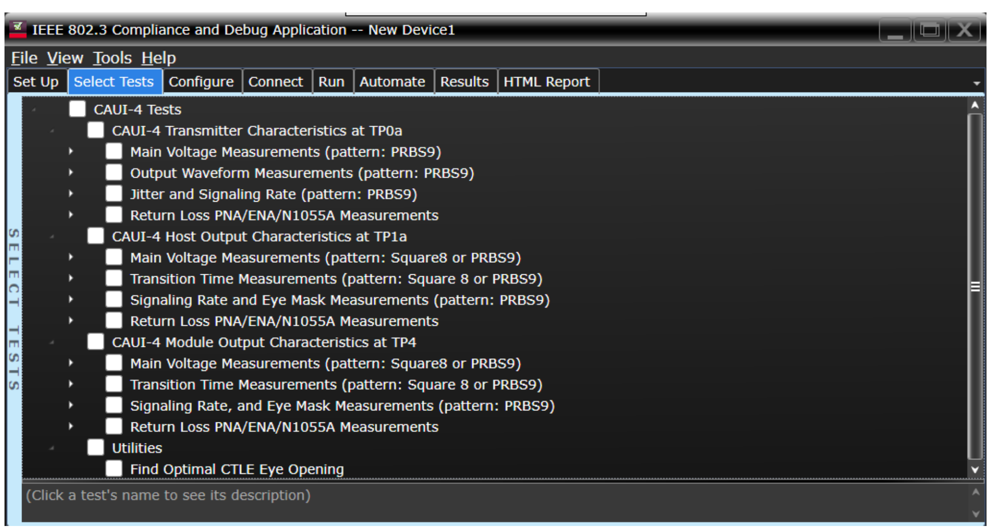
4 Under the **Multi-Lane Test Option** section, select a suitable option based on your setup. The available options include Switch Matrix, N1045x/55A/46A, and Single Lane. Based on your selection, you might need to configure additional settings related to the Switch Matrix or lane selection.

5 Configure other options on the Setup tab, as required.

6 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.

7 Follow the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application's task flow to set up the configuration options, run the tests, and view the tests results.

The following image shows the test groups contained in the CAUI-4 tests offered by the N1091..CA Series IEEE 802.3 NRZ Compliance & Debug Application.



Transmitter Characteristics at TP0a

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the CAUI-4 Main Voltage Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements The limits for tests under main voltage measurements can be found in section 93.8.1.3 of IEEE 802.3 specifications. Refer to Table 83D-1 for corresponding values.

- Differential Peak to Peak Output Voltage Test with TX disabled (max 30 mV)
- Differential Peak to Peak Output Voltage Test (max 1200 mV)
- AC Common Mode Output Voltage Test (max 12 mV)
- DC Common Mode Output Voltage Test (0 to 1.9 V)

NOTE A test system with a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth is to be used for all transmitter signal measurements, unless otherwise specified.

Differential Peak to Peak Output Voltage Test with TX Disabled

Test Overview The purpose of this test is to verify that when TX is disabled the peak-to-peak voltage is less than 30 mV.

PASS Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that the signal is truly with TX disabled (no valid data transitions).
3 Measure peak-to-peak voltage of the signal.
4 Compare the max peak-to-peak voltage to 30 mV.

Differential Peak to Peak Output Voltage Test

Test Overview The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS9 pattern is less than 1200 mV.

PASS Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal connected and has a PRBS9 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the max peak-to-peak voltage to 1200 mV.

AC Common Mode Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal of the differential pair rms voltage does not exceed 12 mV.

NOTE This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.

PASS Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to 12 mV.

DC Common Mode Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal of the differential pair is between 0-1.9 V.

NOTE This measurement can be done only with dual-single ended connection; it cannot be done with a differential probing connection.

PASS Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual-single ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to 0-1.9 V.

Output Waveform Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Output Waveform Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Output Waveform Measurements The limits for some tests under output waveform measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 83D-1 for corresponding values.

- Steady-State Voltage Vf (400 to 600 mV) (section 93.8.1.5.2)*
- Linear Fit Pulse Peak (0.71 x Vf) (section 93.8.1.5.2)*
- Signal-to-noise-and-distortion ratio (27 dB) (section 93.8.1.6)*

* The values of the parameters are measured as defined in the referenced subclause except that the values of Np and Nw are 5.

Steady State Voltage V_f

Test Overview The purpose of this test is to verify that the Steady State Voltage is between 0.4V and 0.6V.

Pass Condition Refer to Limits for Output Waveform Measurements.

Measurement Algorithm

1 Check that signal is connected and proper data pattern exists (PRBS9 must be used for this test).
2 Capture the 8191 bits of the PRBS9 pattern.
3 Calculate V_f using the equations in section 85.8.3.3. The resulting value is the sum of columns of p(k)/M. N_p = 200, D_p = 2.
4 Compare and report the resulting value in the range between 0.4V and 0.6V.

Linear Fit Pulse Peak

Test Overview The purpose of this test is to verify that the Linear Fit Pulse meets the specified standards.

NOTE **Run the Steady-State Voltage Vf test as a prerequisite to running the Linear Fit Pulse Peak test.**

Pass Conditions Refer to Limits for Output Waveform Measurements.

Measurement Algorithm

1 Check that signal is connected and proper data pattern exists (PRBS9 must be used for this test).
2 Capture the 8191 bits of the PRBS9 pattern.
3 Calculate Linear Fit Pulse using the equations in section 85.8.3.3.5. The resulting value is the peak value of p(k). N_p = 200, D_p = 2.
4 Compare the resulting value to the specified standards.

Signal-to-noise-and-distortion ratio

Test Overview The purpose of this test is to verify that the Signal-to-noise-and-distortion ratio (SNDR) meets the specified standards.

Pass Condition Refer to Limits for Output Waveform Measurements.

Measurement Algorithm

1 Calculate SNDR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.
2 Compare the resulting value of SNDR to the specified standards.

Pre and Post Equalization Tests

Test Overview The purpose of these tests is to verify the Pre-cursor and Post-cursor equalization ratios.

Pass Condition Refer to the respective sections described below.

Measurement Algorithm To know about the measurement algorithm for each Pre and Post Equalization Tests, see:

- "**Pre-cursor equalization Local_eq_cm1(0)**" on page 155
- "**Pre-cursor equalization Local_eq_cm1(1)**" on page 156
- "**Pre-cursor equalization Local_eq_cm1(2)**" on page 156
- "**Pre-cursor equalization Local_eq_cm1(3)**" on page 156
- "**Post-cursor equalization Local_eq_c1(0)**" on page 157
- "**Post-cursor equalization Local_eq_c1(1)**" on page 157
- "**Post-cursor equalization Local_eq_c1(2)**" on page 158
- "**Post-cursor equalization Local_eq_c1(3)**" on page 158
- "**Post-cursor equalization Local_eq_c1(4)**" on page 158
- "**Post-cursor equalization Local_eq_c1(5)**" on page 159

Pre-cursor equalization Local_eq_cm1(0)

Test Overview The purpose of this test is to verify that the Pre-cursor equalization ratio is 0 ± 0.04.

Pass Condition When the Pre-cursor equalization with weight Local_eq_cm1 = 0, the ratio defined by C(-1) / [|C(-1)| + |C(0)| + |C(1)|] must be within 0 ± 0.04. Refer to Table 83D-2 in section 83D.3.1.1 in the IEEE802.3 specification.

Measurement Algorithm

1 Request Transmitter to be set to "PRESET" condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at "PRESET" condition.

4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Pre-cursor equalization with weight local_eq_cm1 = 0.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate pre-cursor ratio using the equation C(-1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of pre-cursor ratio with 0 ± 0.04.

Pre-cursor equalization Local_eq_cm1(1)

Test Overview The purpose of this test is to verify that the Pre-cursor equalization ratio is -0.05 ± 0.04.

Pass Condition When the Pre-cursor equalization with weight Local_eq_cm1 = 1, the ratio defined by C(-1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.05 ± 0.04. Refer to Table 83D-2 in section 83D.3.1.1 in the IEEE802.3 specification.

Measurement Algorithm Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to “PRESET” condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at “PRESET” condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Pre-cursor equalization with weight local_eq_cm1 = 1.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate pre-cursor ratio using the equation C(-1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of pre-cursor ratio with -0.05 ± 0.04.

Pre-cursor equalization Local_eq_cm1(2)

Test Overview The purpose of this test is to verify that the Pre-cursor equalization ratio is -0.1 ± 0.04.

Pass Condition When the Pre-cursor equalization with weight Local_eq_cm1 = 2, the ratio defined by C(-1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.1 ± 0.04. Refer to Table 83D-2 in section 83D.3.1.1 in the IEEE802.3 specification.

Measurement Algorithm Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to “PRESET” condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at “PRESET” condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Pre-cursor equalization with weight local_eq_cm1 = 2.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate pre-cursor ratio using the equation C(-1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of pre-cursor ratio with -0.1 ± 0.04.

Pre-cursor equalization Local_eq_cm1(3)

Test Overview The purpose of this test is to verify that the Pre-cursor equalization ratio is -0.15 ± 0.04.

Pass Condition When the Pre-cursor equalization with weight Local_eq_cm1 = 3, the ratio defined by C(-1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.15 ± 0.04. Refer to Table 83D-2 in section 83D.3.1.1 in the IEEE802.3 specification.

Measurement Algorithm

Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to "PRESET" condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at "PRESET" condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Pre-cursor equalization with weight local_eq_cm1 = 1.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate pre-cursor ratio using the equation C(-1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of pre-cursor ratio with -0.15 ± 0.04.

Post-cursor equalization Local_eq_c1(0)

Test Overview

The purpose of this test is to verify that the Post-cursor equalization ratio is 0 ± 0.04.

Pass Condition

When the Post-cursor equalization with weight Local_eq_c1 = 0, the ratio defined by C(1) / [|C(-1)| + |C(0)| + |C(1)|] must be within 0 ± 0.04. Refer to Table 83D-3 in section 83D.3.2 in the IEEE802.3 specification.

Measurement Algorithm

Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to "PRESET" condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at "PRESET" condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Post-cursor equalization with weight local_eq_c1 = 0.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate post-cursor ratio using the equation C(1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of post-cursor ratio with 0 ± 0.04.

Post-cursor equalization Local_eq_c1(1)

Test Overview

The purpose of this test is to verify that the Post-cursor equalization ratio is -0.05 ± 0.04.

Pass Condition

When the Post-cursor equalization with weight Local_eq_c1 = 1, the ratio defined by C(1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.05 ± 0.04. Refer to Table 83D-3 in section 83D.3.2 in the IEEE802.3 specification.

Measurement Algorithm

Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to "PRESET" condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at "PRESET" condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Post-cursor equalization with weight local_eq_c1 = 1.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate post-cursor ratio using the equation C(1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of post-cursor ratio with -0.05 ± 0.04.

Post-cursor equalization Local_eq_c1(2)

Test Overview The purpose of this test is to verify that the Post-cursor equalization ratio is -0.1 ± 0.04.

Pass Condition When the Post-cursor equalization with weight Local_eq_c1 = 2, the ratio defined by C(1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.1 ± 0.04. Refer to Table 83D-3 in section 83D.3.2 in the IEEE802.3 specification.

Measurement Algorithm Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to “PRESET” condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at “PRESET” condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Post-cursor equalization with weight local_eq_c1 = 2.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate post-cursor ratio using the equation C(1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of post-cursor ratio with -0.1 ± 0.04.

Post-cursor equalization Local_eq_c1(3)

Test Overview The purpose of this test is to verify that the Post-cursor equalization ratio is -0.15 ± 0.04.

Pass Condition When the Post-cursor equalization with weight Local_eq_c1 = 3, the ratio defined by C(1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.15 ± 0.04. Refer to Table 83D-3 in section 83D.3.2 in the IEEE802.3 specification.

Measurement Algorithm Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to “PRESET” condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at “PRESET” condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Post-cursor equalization with weight local_eq_c1 = 3.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate post-cursor ratio using the equation C(1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of post-cursor ratio with -0.15 ± 0.04.

Post-cursor equalization Local_eq_c1(4)

Test Overview The purpose of this test is to verify that the Post-cursor equalization ratio is -0.2 ± 0.04.

Pass Condition When the Post-cursor equalization with weight Local_eq_c1 = 4, the ratio defined by C(1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.2 ± 0.04. Refer to Table 83D-3 in section 83D.3.2 in the IEEE802.3 specification.

Measurement Algorithm Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to “PRESET” condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at “PRESET” condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Post-cursor equalization with weight local_eq_c1 = 4.

6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate post-cursor ratio using the equation C(1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of post-cursor ratio with -0.2 ± 0.04.

Post-cursor equalization Local_eq_c1(5)

Test Overview The purpose of this test is to verify that the Post-cursor equalization ratio is -0.25 ± 0.04.

Pass Condition When the Post-cursor equalization with weight Local_eq_c1 = 5, the ratio defined by C(1) / [|C(-1)| + |C(0)| + |C(1)|] must be within -0.25 ± 0.04. Refer to Table 83D-3 in section 83D.3.2 in the IEEE802.3 specification.

Measurement Algorithm Skip to step 5 if the first four steps have already been measured/calculated in a previous equalization test of the same trial.

1 Request Transmitter to be set to “PRESET” condition.
2 Capture one full PRBS9 pattern and scale.
3 Calculate linear fit pulse response at “PRESET” condition.
4 Define matrix Rm using equation (92-4) from IEEE 802.3.
5 Request to change the eq setting to Post-cursor equalization with weight local_eq_c1 = 5.
6 Calculate linear fit pulse response.
7 Calculate coefficients using equation (92-5) from IEEE 802.3.
8 Calculate post-cursor ratio using the equation C(1) / [|C(-1)| + |C(0)| + |C(1)|].
9 Compare and report the value of post-cursor ratio with -0.25 ± 0.04.

Jitter and Signaling Rate Measurements (pattern: PRBS9)

This section provides the Methods of Implementation (MOIs) for the Jitter and Signaling Rate Measurements using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Jitter and Signaling Rate Measurements The limits for tests under jitter and signaling rate measurements can be found in various sections of IEEE 802.3 specification. Refer to Table 83D-1 for corresponding values.

- Signaling Rate (25.78125 ±100 ppm GBd) (section 93.8.1.2)
- Even-Odd Jitter (max 35 mUI) (section 92.8.3.8)
- Bounded Uncorrelated Jitter (max 100 mUI)[a] (section 92.8.3.8)
- Total Uncorrelated Jitter (max 260 mUI)[a,b] (section 92.8.3.8)

a Effective bounded uncorrelated jitter and effective total uncorrelated jitter are measured as defined in 92.8.3.9.2 except that the range for fitting CDFLi and CDFRi, as defined in (92.8.3.8.2 c), shall be from 10^{-6} to 10^{-4}.

b Effective total uncorrelated jitter, peak-to-peak is specified to a 10^{-15} probability.

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate mean is between 25.78125 ±100 ppm GBd.

PASS Condition Refer to Limits for Jitter and Signaling Rate Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set data rate measurement to 25.78125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 25.78125 ±100 ppm GBd.

Jitter (Even-Odd Jitter, Bounded Uncorrelated Jitter, Total Uncorrelated Jitter)

Test Overview

The purpose of this test is to verify that differential signal's Even-Odd Jitter is less that 35 mUI, Bounded Uncorrelated Jitter is less than 100 mUI, and Total Uncorrelated Jitter is less than 260 mUI. If all tests are selected, all tests are run on a single measurement. Each test can be run individually by selecting any or some of the tests.

PASS Conditions

- Refer to Limits for Jitter and Signaling Rate Measurements.

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3. Set clock recovery to OJTF First Order PLL with Nominal Data Rate 25.78125 Gb/s and Loop Bandwidth to 10 MHz.
4. Using Jitter Mode, measure Even-Odd Jitter, BUJ, and TUJ at BER of 10E-12.
5. Compare and report the values to their respective maximum specification.

Return Loss PNA/ENA/N1055A Measurements

This section provides the Methods of Implementation (MOIs) for the Return Loss Measurements using a Keysight Sampling oscilloscope, PNA or ENA, and the IEEE 802.3 NRZ Test Application. The test application controls the PNA/ENA to set the test limits and run the test. You must ensure that the calibration must be done on the PNA/ENA.

Limits for Return Loss PNA/ENA measurements

The limits for tests under return loss PNA/ENA measurements can be found in section 93.8.1.4 of IEEE 802.3 specification. Refer to Table 83D-1 for corresponding values.

- Differential Output Return Loss (see Eq. 93-3)
- Common-mode Output Return Loss (see Eq. 93-4)

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, click **Connect PNA/ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5. Compare the reported values with the specification to check for compliance.

Host Output Characteristics at TP1a

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements

The limits for tests under main voltage measurements can be found in section 83E.3.1.2 of IEEE 802.3 specifications. Refer to Table 83E-1 for corresponding values.

- Differential Peak to Peak Output Voltage Test with TX disabled (max 35 mV)
- Differential Peak to Peak Output Voltage Test (max 900 mV)
- AC Common Mode Output Voltage Test (max 17.5 mV)
- DC Common Mode Output Voltage Test (-0.3 to 2.8 V)
- Single-Ended Output Voltage Test (-0.4 to 3.3 V)

Differential Peak to Peak Output Voltage Test with TX Disabled

Test Overview

The purpose of this test is to verify that when TX is disabled, the peak-to-peak voltage must be less than 35mV.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain a sample or acquire the signal data.
2 Ensure that TX is disabled on the acquired signal (no valid data transitions).
3 Measure peak-to-peak voltage of the signal.
4 Compare the maximum peak-to-peak voltage to 35mV.

Differential Peak to Peak Output Voltage Test

Test Overview

The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a Square8 or PRBS9 pattern is less than 900mV.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is connected, has TX enabled and has either a Square8 or a PRBS9 pattern.
3 Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
4 Compare the maximum peak-to-peak voltage with 900mV.

AC Common Mode Output Voltage Test

Test Overview

The purpose of this test is to verify that the common mode signal does not exceed 17.5mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition

Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the AC common-mode voltage.
4 Compare the voltage measurement with 17.5mV.

DC Common Mode Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal is between -300mV and 2.8V.

NOTE This measurement can be done only with dual-single ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Measure the DC common-mode voltage.
3 Compare the voltage measurement to the range between -300mV and 2.8V.

Single-ended Output Voltage Test

Test Overview The purpose of this test is to verify that the minimum voltage on a single-ended signal is greater than -400mV and that the maximum voltage is less than 3.3V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the minimum and maximum voltage on each single-ended signal.
4 Compare the voltage measurements with the range between -400mV and 3.3V.

Transition Time Measurements (pattern: Square8 or PRBS9)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under main voltage measurements can be found in section 83E.3.1.5 of IEEE 802.3 specifications. Refer to Table 83E-1 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (10ps)
- Minimum Output Fall Time (20% - 80%) (10ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 10ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure rise time from 20% to 80% of the signal amplitude.

4 Compare the minimum rise time with 10ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 10ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is Square8.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 10ps.

Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS9)

The Signaling Rate and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate and Eye Mask Measurements The limits for tests under main voltage measurements can be found in various sections of IEEE 802.3 specifications. Refer to Table 83E-1 for corresponding values.

- Signaling Rate (25.78125 ±100 ppm GBd) (section 83E.3.1.1)
- Eye Height A (95 mV) (section 83E.3.1.6)
- Eye Width (0.46 UI) (section 83E.3.1.6)
- Eye Height B (80 mV) (section 83E.3.1.6)

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate mean is between 25.78125 ±100 ppm GBd.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set data rate measurement to 25.78125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 25.78125 ±100 ppm GBd.

Eye Height A

Test Overview The purpose of this test is to verify that for a defined range of CTLE settings, the Eye Height A is greater than 95mV. The CTLE values range from 1dB lower than the user-defined optimal CTLE to 1dB higher than the user-defined optimal CTLE.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:
   - This setting can be characterized and automatically set by using the "Find Optimal CTLE Eye Opening test under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE setting from the **Use Optimized CTLE for Eye Opening** drop-down options in the **Configure** tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
2 Select which CTLE setting to test in the **Configure** tab (Host Recommended CTLE, 1 dB lower than optimal CTLE, or 1 dB higher than optimal CTLE).
3 Obtain sample or acquire signal data.
4 Set selected CTLE setting as per table 83E-2.
5 Set Clock Recovery to First Order PLL with Loop Bandwidth = 10 MHz.

6 Measure the Eye Height A at an **Eye Height/Width Probability** setting of 1E-5.
7 Compare the Eye Height A with 95mV. Report the resulting value.

Eye Width

Test Overview The purpose of this test is to verify that for a defined range of CTLE settings, the Eye Width is greater than 460mUI. The CTLE values range from 1dB lower than the user-defined optimal CTLE to 1dB higher than the user-defined optimal CTLE.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:
   - This setting can be characterized and automatically set by using the "Find Optimal CTLE Eye Opening test under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE setting from the **Use Optimized CTLE for Eye Opening** drop-down options in the **Configure** tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
2 Select which CTLE setting to test in the **Configure** tab (Host Recommended CTLE, 1 dB lower than optimal CTLE, or 1 dB higher than optimal CTLE).
3 Obtain sample or acquire signal data.
4 Set selected CTLE setting as per table 83E-2.
5 Set Clock Recovery to First Order PLL with Loop Bandwidth = 10 MHz.
6 Measure the Eye Height A at an **Eye Height/Width Probability** setting of 1E-5.
7 Compare the measured Eye Width with 460mUI. Report the resulting value.

Eye Height B

Test Overview The purpose of this test is to verify that all of the following CTLE settings, Eye Height B is greater than 80 mV. CTLE settings are:

- Host Recommended CTLE
- 1 dB lower than optimal CTLE
- 1 dB higher than optimal CTLE

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:
   - This setting can be characterized and automatically set by using the "Find Optimal CTLE Eye Opening test under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE setting from the **Use Optimized CTLE for Eye Opening** drop-down options in the **Configure** tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
2 Select a configuration value for the **Host - Recommended CTLE value** setting in the **Configure** tab.
3 Obtain sample or acquire signal data.
4 Set CTLE setting to 1 dB lower than optimal.
5 Set clock recovery to First Order PLL with Loop Bandwidth = 10 MHz.
6 Measure Eye Height at 1E-5.
7 Repeat steps 3-7 with remaining CTLE settings – 1 dB higher than optimal CTLE and Host Recommended CTLE.
8 Compare the measured Eye Height B with 80 mV.

Return Loss ENA/PNA/N1055A Measurements

The Return Loss ENA/PNA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA or ENA and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements

The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83E.3.1.3 of IEEE 802.3 specification. Refer to Table 83E-1 for corresponding values.

- Differential Output Return Loss (see Eq. 83E-2)
- Common-mode to Differential Output Return Loss (see Eq. 83E-3)

Measurement Algorithm (common for both tests)

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Test Application, click **Connect PNA/ ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.
5. Compare the reported values with the specification to check for compliance.

Module Output Characteristics at TP4

NOTE Use a test system that consists of a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth for all output signal measurements, unless stated otherwise.

Main Voltage Measurements (pattern: Square8 or PRBS9)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Main Voltage Measurements The limits for tests under main voltage measurements can be found in section 83E.3.1.2 of IEEE 802.3 specifications. Refer to Table 83E-3 for corresponding values.

- Differential Output Voltage Test (max. 900 mV)
- AC Common Mode Output Voltage Test (max 17.5 mV)
- DC Common Mode Output Voltage Test* (-350 to 2850 mV)

* DC common mode voltage is generated by the host. Specification includes effects of ground offset voltage.

Differential Output Voltage Test

Test Overview The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS9 pattern is less than 900mV.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is connected, has TX enabled and has a PRBS9 pattern.
3 Measure the peak-to-peak voltage of the differential signal of DUT+ and DUT-.
4 Compare the maximum peak-to-peak voltage to 900mV.

AC Common Mode Output Voltage Test

Test Overview The purpose of this test is to verify that the common-mode voltage of the signal does not exceed 17.5mV.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement with 17.5mV.

DC Common Mode Voltage Test

Test Overview The purpose of this test is to verify that the common-mode voltage of the signal is between -350mV and 2.85V.

NOTE This measurement can be done only with dual single-ended connection but not with a differential probing connection.

Pass Condition Refer to Limits for Main Voltage Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that there is a signal and that the connection is dual single-ended.
3 Measure the peak-to-peak voltage.
4 Compare the voltage measurement to the range between -350mV and 2.85V.

Transition Time Measurements (pattern: Square8 or PRBS9)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Transition Time Measurements The limits for tests under main voltage measurements can be found in section 83E.3.1.5 of IEEE 802.3 specifications. Refer to Table 83E-3 for corresponding values.

- Minimum Output Rise Time (20% - 80%) (12ps)
- Minimum Output Fall Time (20% - 80%) (12ps)

Minimum Output Rise Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum rise time is 12ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is PRBS9.
3 Measure rise time from 20% to 80% of the signal amplitude.
4 Compare the minimum rise time with 12ps.

Minimum Output Fall Time (20%-80%)

Test Overview The purpose of this test is to verify that the minimum fall time is 12ps.

Pass Condition Refer to Limits for Transition Time Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is PRBS9.
3 Measure fall time from 20% to 80% of the signal amplitude.
4 Compare the minimum fall time with 12ps.

Signaling Rate, and Eye Mask Measurements (pattern: PRBS9)

The Signaling Rate and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Limits for Signaling Rate, and Eye Mask Measurements The limits for tests under main voltage measurements can be found in various sections of IEEE 802.3 specifications. Refer to Table 83E-3 for corresponding values.

- Signaling Rate (25.78125 ±100 ppm GBd) (section 83E.3.1.1)
- Eye Height (228 mV) (section 83E.3.2.1)
- Eye Width (0.57 UI) (section 83E.3.2.1)
- Vertical Eye Closure (5.5 dB) (section 83E.4.2.1)

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate mean is between 25.78125 ±100 ppm GBd.

Pass Condition Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Check that signal is connected and data pattern exists (PRBS9 must be used for this test).
3 Set data rate measurement to 25.78125 Gb/s.
4 Set the DCA to Eye mode.
5 Measure the data rate.
6 Compare the measured data rate to 25.78125 ±100 ppm GBd.

Eye Height

Test Overview The purpose of this test is to verify that for a defined range of CTLE settings, the Eye Height is greater than 228mV. The CTLE values range from 1dB lower than the user-defined optimal CTLE to 1dB higher than the user-defined optimal CTLE.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:
   - This setting can be characterized and automatically set by using the "Find Optimal CTLE Eye Opening test under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE setting from the **Use Optimized CTLE for Eye Opening** drop-down options in the **Configure** tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
2 Select which CTLE setting to test in the **Configure** tab (Host Recommended CTLE, 1 dB lower than optimal CTLE, or 1 dB higher than optimal CTLE).
3 Obtain sample or acquire signal data.
4 Set selected CTLE setting as per table 83E-2.
5 Set Clock Recovery to First Order PLL with Loop Bandwidth = 10 MHz.
6 Measure the Eye Height at an **Eye Height/Width Probability** setting of 1E-5.
7 Compare the Eye Height with 228mV. Report the resulting value.

Eye Width

Test Overview The purpose of this test is to verify that for a defined range of CTLE settings, the Eye Width is greater than 570mUI. The CTLE values range from 1dB lower than the user-defined optimal CTLE to 1dB higher than the user-defined optimal CTLE.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:
   - This setting can be characterized and automatically set by using the "Find Optimal CTLE Eye Opening test under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE setting from the **Use Optimized CTLE for Eye Opening** drop-down options in the **Configure** tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.
2 Select which CTLE setting to test in the **Configure** tab (Host Recommended CTLE, 1 dB lower than optimal CTLE, or 1 dB higher than optimal CTLE).
3 Obtain sample or acquire signal data.
4 Set selected CTLE setting as per table 83E-2.
5 Set Clock Recovery to First Order PLL with Loop Bandwidth = 10 MHz.
6 Measure the Eye Height at an **Eye Height/Width Probability** setting of 1E-5.
7 Compare the Eye Width with 570mUI. Report the resulting value.

Vertical Eye Closure

Test Overview The purpose of this test is to verify that the Vertical Eye Closure at EH5 (1E-5) is less than 5.5 dB.

Pass Conditions Refer to Limits for Signaling Rate and Eye Mask Measurements.

Measurement Algorithm

1 For the optimal CTLE, you may approach in one of the following ways:
   - This setting can be characterized and automatically set by using the "Find Optimal CTLE Eye Opening" test under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE setting from the **Use Optimized CTLE for Eye Opening** drop-down options in the **Configure** tab. The selected CTLE setting is called as 'User-defined optimal CTLE'.

2 Obtain sample or acquire signal data.

3 Measure the Vertical Eye Closure at an **Eye Height/Width Probability** setting of 1E-5 (EH5).

4 On the Oscilloscope,
   a set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (25.78125 Gbps) and Loop Bandwidth to 4 MHz.
   b Set 4^{th} Order Bessel Thompson filter to 33 GHz with 3 dB gain.

5 Measure and calculate AV as the mean value of logic 1 minus the mean value of logic 0 at the central 5% of the eye.

6 Calculate Vertical Eye Closure (VEC) using the equation:

$$VEC = 20\log(AV/EH5)$$

7 Compare the Vertical Eye Closure with 5.5 dB. Report the resulting value.

Return Loss ENA/PNA/N1055A Measurements

The Return Loss ENA/PNA/N1055A Measurement procedures that are described in this section are performed using a Keysight Sampling oscilloscope, PNA, ENA or N1055A and the IEEE 802.3 NRZ Test Application. The Test Application controls the PNA/ENA/N1055A to set the test limits and run the tests. You must ensure that the connected PNA/ENA/N1055A is calibrated.

Limits for Return Loss PNA/ENA/N1055A Measurements The limits for tests under return loss PNA/ENA/N1055A measurements can be found in section 83E.3.1.3 of IEEE 802.3 specification. Refer to Table 83E-3 for corresponding values.

- Differential Output Return Loss (see Eq. 83E-2)
- Common-mode to Differential Output Return Loss (see Eq. 83E-3)

Measurement Algorithm (common for both tests)

1 Ensure that the PNA/ENA is physically connected and calibrated.

2 In the **Set Up** tab of the Test Application, click **Connect PNA/ENA** to establish connectivity to the connected equipment.

3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.

4 Click **Run** under the **Run** tab. The Test Application automatically calculates the return loss.

5 Compare the reported values with the specification to check for compliance.

Utilities

This section provides the Methods of Implementation (MOIs) for the Utilities available for each combination of Standard Option and Signal Type to find the optimal CTLE Eye Opening.

Run the CTLE utility test documented in this section before running the corresponding Eye Width/Eye Height tests. The following is the general sequence of steps to be followed:

1 Run the Utility called “Find Optimal CTLE Eye Opening” to determine the correct CTLE value to use in subsequent tests, such as Eye Height and Eye Width.
Run the Utility standalone (do not run with other tests).
After running the utility, the “Use Optimized CTLE for Eye Opening” setting on the Configure tab will be set with the optimal value.

Deselect the Utility for subsequent tests and select the desired tests to be run.

It is recommended to group tests that use the same pattern. The tests are run in order, from top to bottom.

NOTE Ensure that the **Signaling Rate** setting in the **Configure** tab of the Compliance Test Application must match the frequency of the acquired input signal.

Find Optimal CTLE Eye Opening

The procedure described in this section to find Optimal CTLE Eye Opening are performed using a Keysight DCA oscilloscope and the IEEE 802.3 NRZ Test Application.

Test Overview The purpose of this test is to loop through CTLE settings to find the optimal CTLE setting for the largest area of the Eye.

Measurement Algorithm

1 Set the CTLE value to match the value set for the option **Start value for CTLE utility for Eye Opening** in the **Configure** tab.
2 Obtain or acquire signal data.
3 On the Oscilloscope, Clock Recovery is set to OJTF First Order PLL with Nominal Data Rate and Loop Bandwidth. Set 4^{th} Order Bessel Thompson filter to 33 GHz with 3 dB gain.
4 Measure Eye Height and Eye Width.
5 Calculate area of the center eye using the formula EH1*EW1.
6 Repeat the previous steps for each CTLE setting until the CTLE value attains the value set for the option **Stop value for CTLE utility for Eye Opening** in the **Configure** tab.
7 Report the CTLE setting with the largest eye area. The Application automatically changes the configured CTLE setting to the optimal value.