N1091CKCA IEEE 802.3ck FlexDCA Conformance Application

Notices

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Safety Notices

CAUTION

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

WARNING

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

IEEE 802.3ck FlexDCA Conformance Application—At a Glance

The Keysight N1091CKCA IEEE 802.3ck FlexDCA Conformance Application is an Ethernet test solution that covers the electrical timing parameters for PAM4 specification (IEEE 802.3ck).

The main features of the IEEE 802.3ck FlexDCA Conformance Application are:

- Complete coverage of specification-based chip-to-chip (C2C) and chip-to-module (C2M) tests, CR tests, and KR tests
- Data Analytics

The IEEE 802.3ck FlexDCA Conformance 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.
- Allows you to determine the number of trials for each test.
- Provides detailed information of each test that has been run. The result of maximum 25 worst trials can be displayed at any one time.
- Creates a printable HTML report of the tests that have been run. This report includes pass/fail limits, margin analysis, and screen shots.

Supported Hardware and Software

To run the automated tests on PAM4 signals using the IEEE 802.3ck FlexDCA Conformance Application, you need the following hardware and software:

Hardware:
- N1000A DCA-X Wide-Bandwidth Oscilloscope mainframe + N1060A Precision Waveform Analyzer Or
- N1000A DCA-X Wide-Bandwidth Oscilloscope mainframe + N1040A Dual Electrical Channel Module or N1045A/B or N1046A Remote Sampling Head + N107x 64 GBd Clock Recovery Or
- N1000A DCA-X Wide-Bandwidth Oscilloscope mainframe + N1040A Dual Electrical Channel Module or N1045A/B or N1046A Remote Sampling Head + N1060A Precision Waveform Analyzer as Clock Recovery Or
- N1000A DCA-X Wide-Bandwidth Oscilloscope mainframe + N1060A Precision Waveform Analyzer as Clock Recovery + external clock Or
- N1000A DCA-X Wide-Bandwidth Oscilloscope mainframe + N1040A Dual Electrical Channel Module or N1045A/B or N1046A Remote Sampling Head + external clock
- N1055A Remote Sampling Head
- PNA Network Analyzer

Software:
- N1000A DCA-X Mainframe Software (For the minimum version of oscilloscope software, see the N1091CKCA release notes)
- N1091CKCA IEEE 802.3ck FlexDCA Conformance Application software

Licenses:
- For the required licenses for the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application/, refer to the Data Sheet.

Contents

4 CR Tests

5 KR Tests

1 Installing the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application

If you purchased the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application separate from your DCA oscilloscope, you must install the software and license key.

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Installing the Software

1   Make sure you have the minimum version of DCA oscilloscope software (see the N1091CKCA release notes) by selecting **Help > About FlexDCA...** from the main menu.

2   To obtain the N1091CKCA Conformance Test Application, go to Keysight website: http://www.keysight.com/find/N1091CKCA.

3   In the web page's **Trials & Licenses** tab, click the **Details and Download** button to view instructions for downloading and installing the application software.

Installing the License Key

Refer to the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application Data Sheet to know about the various licenses pertaining to Keysight N1091CKCA IEEE 802.3ck FlexDCA Conformance Application and also about the other licenses that are required to unlock some additional features.

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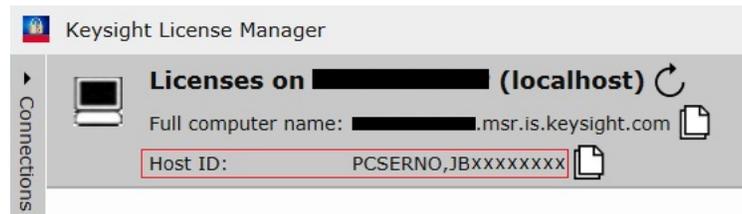
Figure 1   Viewing the Host ID information in Keysight License Manager 5

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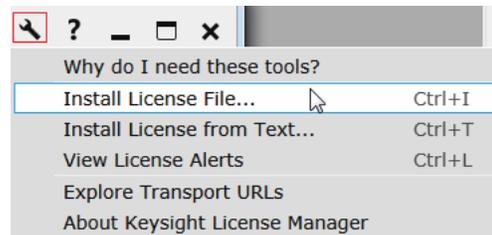
Figure 2   Configuration menu options to install licenses on Keysight License Manager 5

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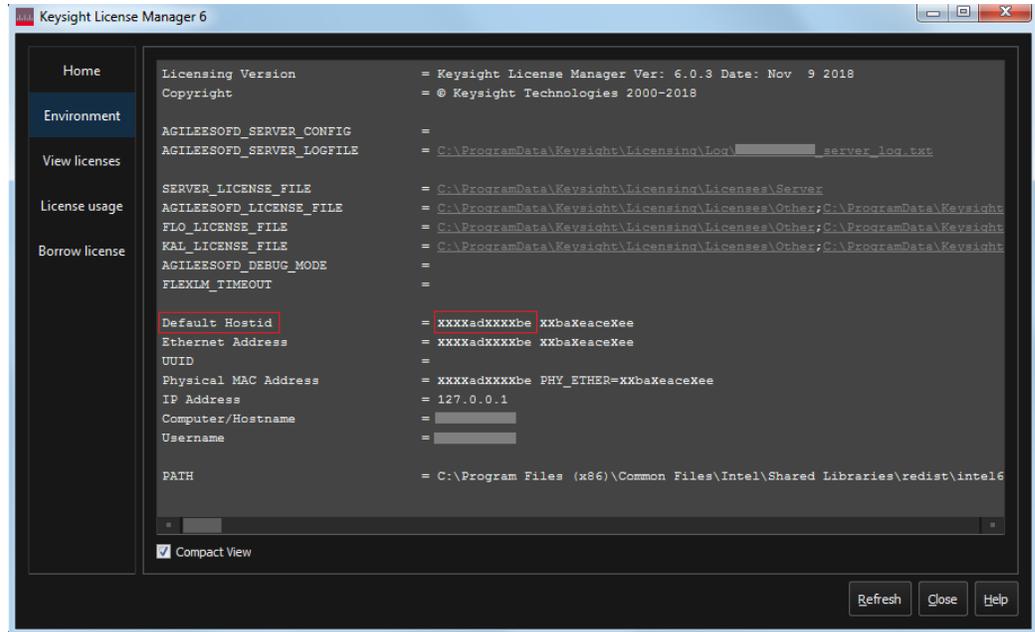
Figure 3   Viewing the Host ID information in Keysight License Manager 6

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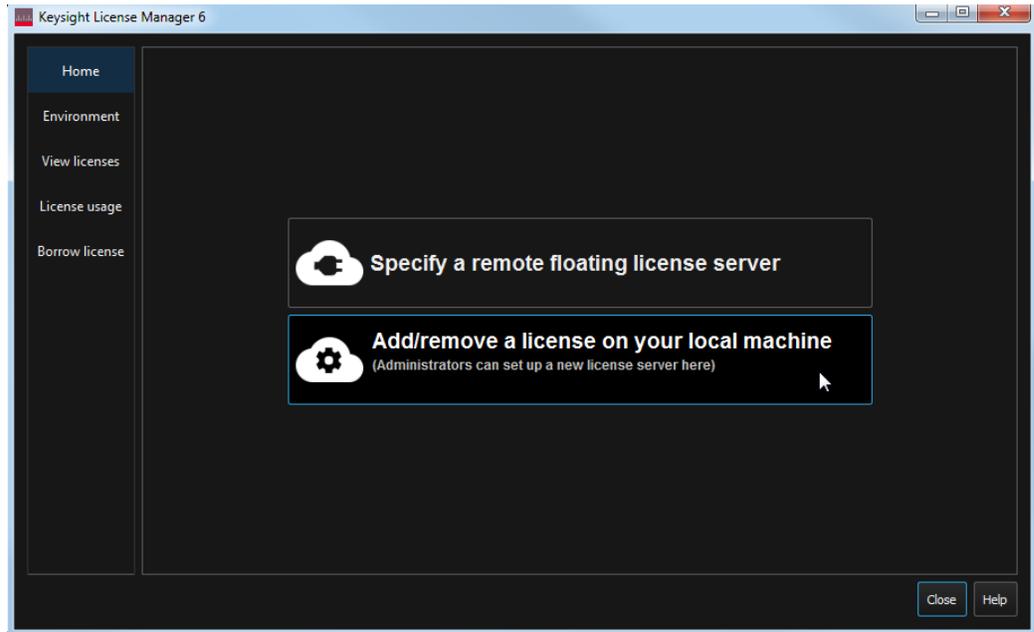
Figure 4   Home menu options to install licenses on Keysight License Manager 6

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

1　Installing the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application

2 Preparing to Take Measurements

Before running the automated tests, you should calibrate the oscilloscope. After the oscilloscope has been calibrated, you are ready to start the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application and perform the measurements.

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Calibrating the Oscilloscope

If you haven't already calibrated the oscilloscope, follow the calibration instructions described within the Help manuals available with the Oscilloscope you are using.

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

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

Starting the Conformance Test Application

1   Ensure that the Device Under Test (DUT) is operating and set to desired test modes.
2   To start the Conformance Test Application, from the FlexDCA software's main menu, select **Apps > Automated Test Apps > N1091CKCA IEEE 802.3ck Electrical Tx Test App**.
3   The Keysight N1091CKCA IEEE 802.3ck FlexDCA Conformance Application appears.
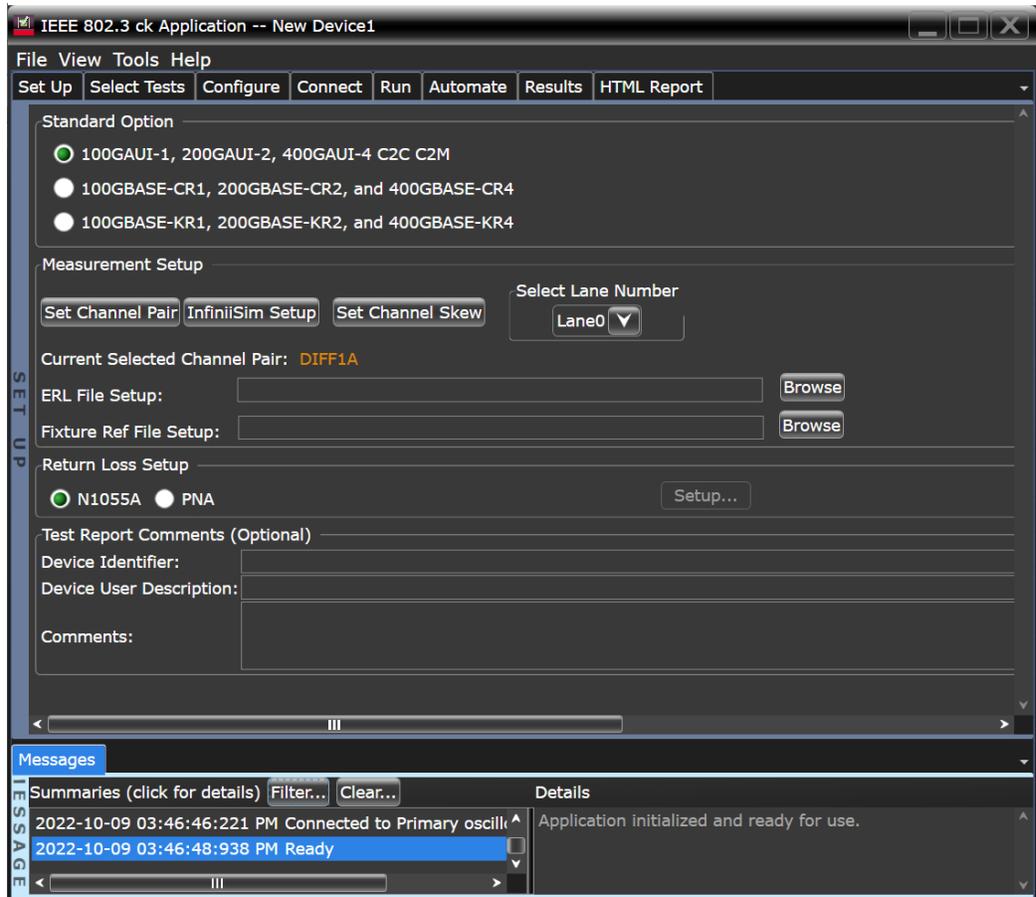
Figure 5   The N1091CKCA IEEE 802.3ck FlexDCA Conformance Application Main window

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

Table 1   Task flow under various tabs

Tab Name	Task flow
Set Up	Lets you identify and set up the test environment, including information about the device under test. The **Device Identifier**, **User Description**, and **Comments** are all printed in the final HTML report. Select the **Standard Option** against which the DUT should be tested. **Set Channel Pair** enables you to select the channel pair for performing measurement. Set up InfiniiSim with the **InfiniiSim Setup** button. InfiniiSim is used to de-embed any cables used in the test setup. For more information on how to perform de-embedding using InfiniiSim, see *Configuring InfiniiSim* in the Online Help for this application. With the **Set Channel Skew** button, the channels can be visually adjusted and skewed. This control enables you to either select channels for running the skew calibration or manually enter the skew values for the channel. The **Select Lane Number** enables you to choose a lane for testing. This also enables you to identify the tested lane in a test report more easily. In the **ERL File Setup** field, specify the s-parameter file created using a VNA module. This file is then used for measuring the effective return loss (ERL test). In the **Fixture Ref File Setup** field, the s-parameter file for the fixtures used can be specified. This file is used for the dERL, dVf, and dRpeak tests. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture. See "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33. Use the **N1055A** and **PNA** controls to connect to N1055A or a PNA device, respectively.
Select Tests	Lets you select the tests you want to run. The tests are organized hierarchically so you can select all tests in a group. After tests are run, status indicators show which tests have passed, failed, or not been run, and there are indicators for the test groups.
Configure	Lets you configure test parameters (for example, channels used in test, Number of UI to test, scope bandwidth, etc.).
Connect	Shows you how to connect the oscilloscope to the device under test for the tests that are to be run.
Run	Starts the automated tests. If the connections to the device under test need to be changed while multiple tests are running, the tests pause, show you how to change the connection, and wait for you to confirm that the connections have been changed before continuing.
Automate	Lets you construct scripts of commands that drive execution of the application.
Results	Contains more detailed information about the tests that have been run. You can change the thresholds at which marginal or critical warnings appear.
HTML Report	Shows a conformance test report that can be printed.

Configuring Test App for test runs

This section provides the primary steps that you must perform to run one or more conformance tests on the DUT, which is connected to Oscilloscope.

1   In the **Set Up** tab (shown in Figure 5), select the **Standard Option** to filter the test groups in accordance with the connected DUT.

2   You may configure the rest of the settings as described in Table 1 on page 18.

3   In the **Select Tests** tab, select one or more tests, which appear according to the configuration done under the **Set Up** tab. Each section of this manual displays the appearance of the **Select Tests** tab for each test type.

4   In the **Configure** tab, you may change the values assigned to one or more options to cater to the conformance requirements for the selected tests. By default, the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application sets optimum values for each configuration parameter.
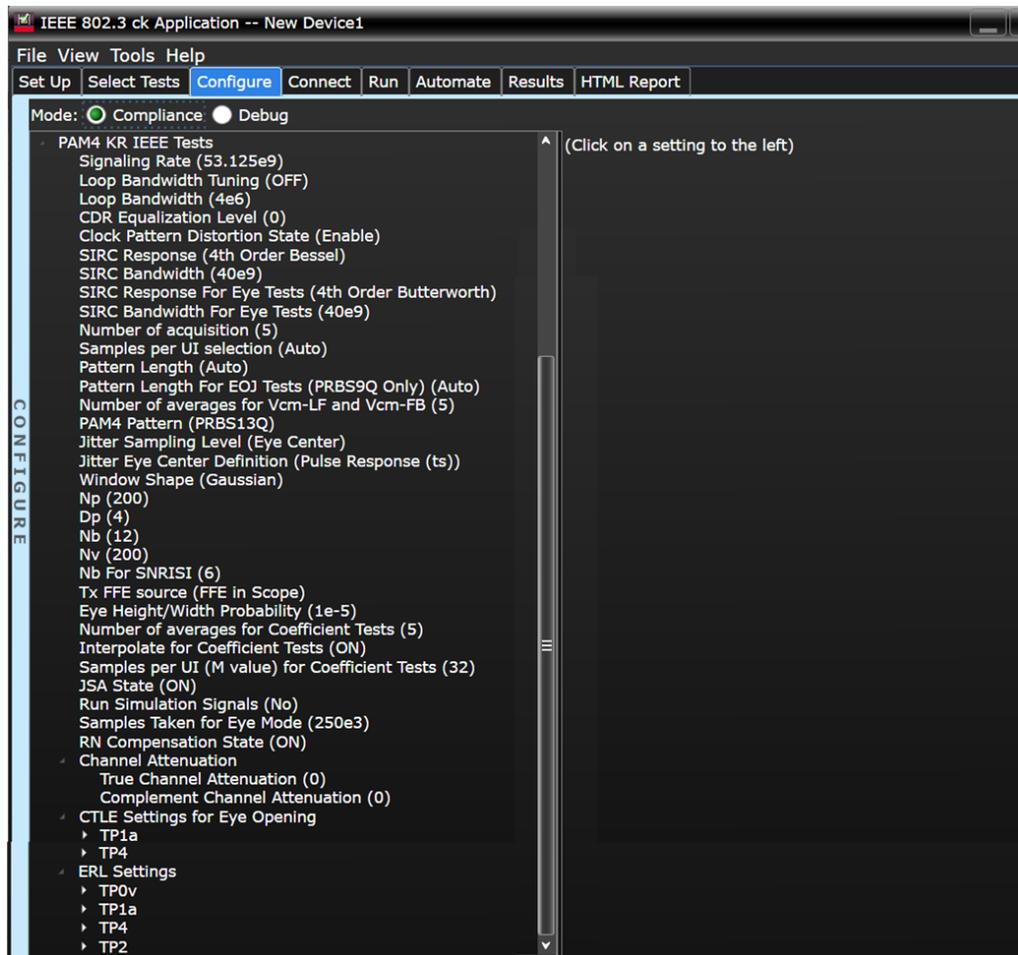
Figure 6   Configure tab in the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application

5   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 Conformance Test Application that the required hardware setup is complete. The connection diagram for most of the tests matches the one shown in Figure 7. However, it is a good practice to verify the connection diagram and instructions displayed under this tab. The Conformance Test Application automatically indicates any changes in connections, if needed, during test runs.

6   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.

Figure 7   Connect tab in the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application

7   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.
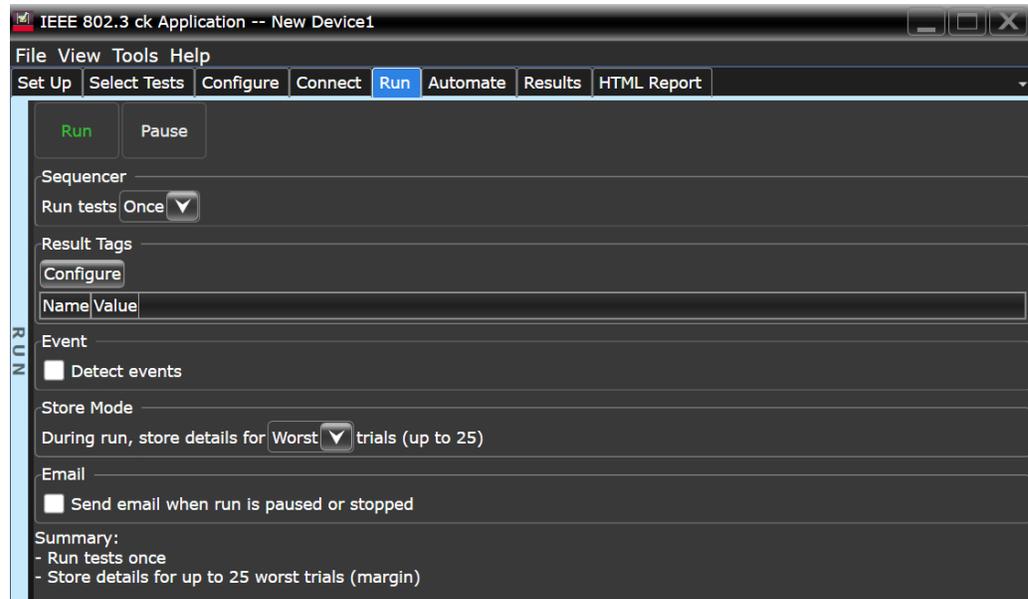
Figure 8   Run tab in the N1091CKCA IEEE 802.3ck FlexDCA Conformance Application

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

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

10 In the **HTML Report** tab, view a comprehensive report for each test within the Application. The Conformance Test Application enables exporting these results in CSV 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 Keysight KS6800A Series Analytics Software. Refer to "Exporting Measurement Results to Repository" on page 22 to understand an overview on the functionality of this feature.

Exporting Measurement Results to Repository

The Upload Results To Repository feature is an add-on to the Keysight Test Application, where it expands the boundaries of storing and analyzing the measurement results to a wider audience, who may be based in multiple sites across various geographical locations. Along with the feature of exporting test results from the Test Application into your local disk in a CSV or HTML file format, you have the option to upload the test results to a Dataset on a Web Repository. Based on your requirements, you may either upload only a single measurement trial or upload huge volumes of measurement results to any Dataset.

Not only can remote users with an active Internet connection access these Datasets and the corresponding test results on the Web Repository, but they have the option to add and delete Datasets on the Web Server. In the Upload Results To Repository feature, you can even modify the Dataset properties, which are helpful especially when performing a graphical analysis of the uploaded data.

In combination with the *Keysight KS6800A Series Analytics Software*, the Upload Results To Repository feature provides a comprehensive solution to export, view and perform analysis of the measurement results, thereby resulting in qualitative data to ensure that the Device Under Test (DUT) is compliant to the industry standards.

Refer to the *Keysight KS6800A Series Analytics Software Online Help* for more information about the functionality of various features in this software.

To export measurement results to the Repository after the completion of test runs,

1   From the Test Application's main menu, click **File > Export Results... > Repository**.
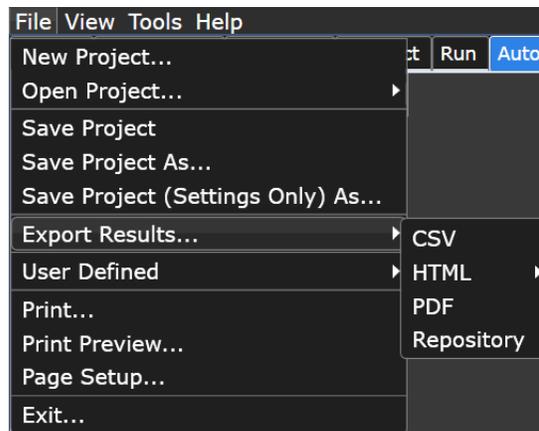
The **Upload Results to Repository** window appears.

2   In the **Connect to Server** pane of the **Datasets** tab, click **Connect...** to login to the Dataset Repository server.
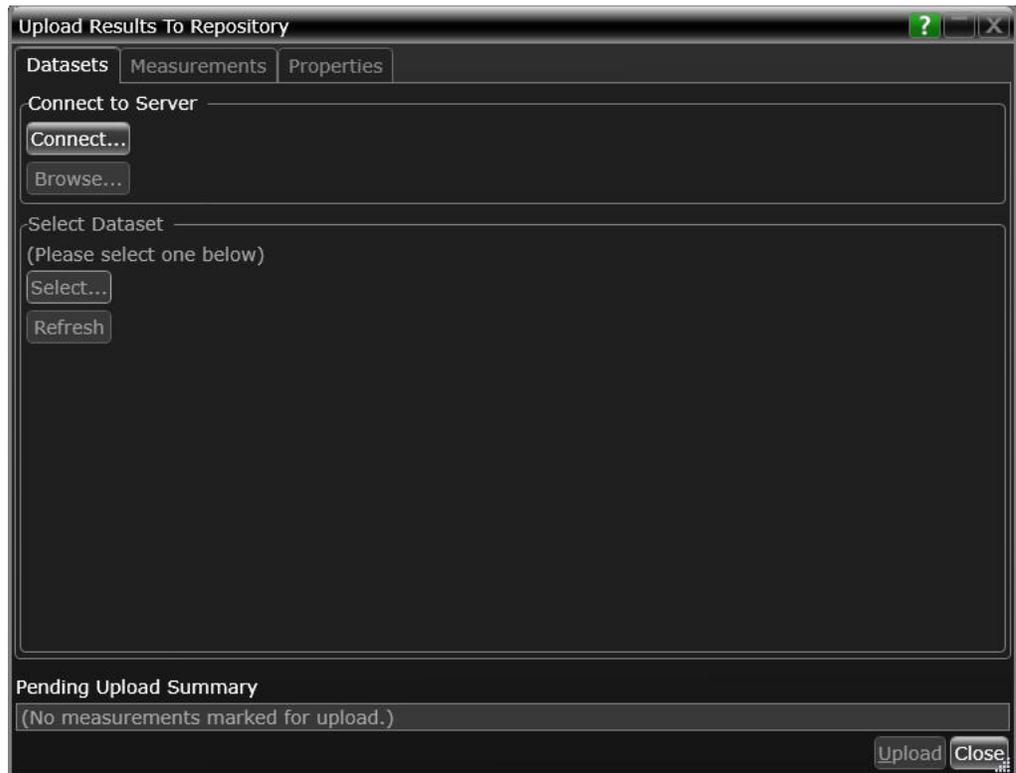
3   In the **URL:** drop-down text field that appears, replace the default text with the actual IP address or the URL along with the port number, if applicable.

You may enter the URL of the Web Repository server, which may be a self-hosted server on your machine (http://localhost:5000/), a remote server or an authentication server. Note that all such URLs accessed via this window appear as a drop-down list in the **URL:** field.

4   Click the **Check** button to verify that the KS6800A Series Analytics service is available on the specified web address. Repeat this step each time you edit the web address.
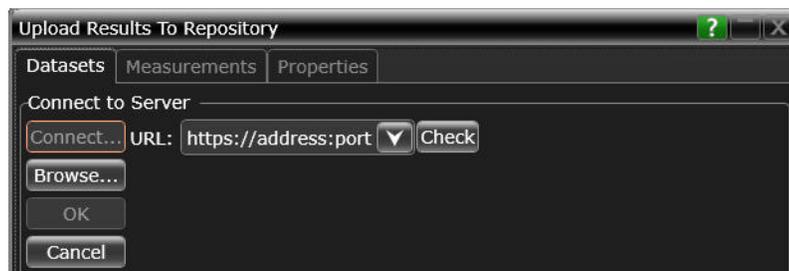
- For unrestricted access to the Repository
  - *a* If the server does not require authentication and the KS6800A Series Analytics service is found on the specified web address, the version information is displayed adjacent to the **Check** button.

  - *b* If you click **OK**, the **Upload Results to Repository** window displays the connectivity status to the Dataset Repository.
  - *c* Click **Browse**... to navigate directly to the URL.
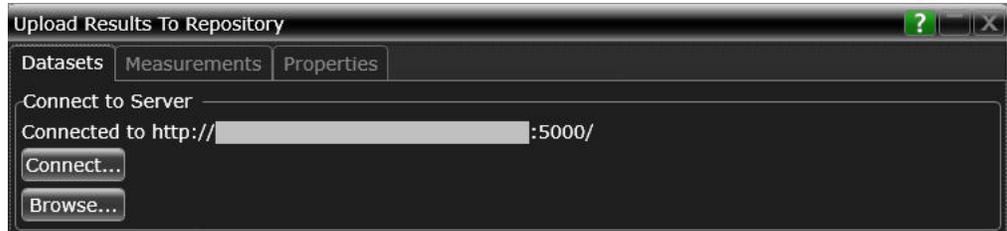
- For restricted access to the Repository
  - *a* If service is found on the specified URL but access to the web server is restricted based on authentication, the version information is displayed along with the text Authentication Required adjacent to the **Check** button. Also, the **Username**: and **Password**: fields appear. The **OK** button remains disabled until the authentication credentials are entered.
  - *b* Enter the user credentials in the respective fields, which are required for authentication to access those Datasets that have been created on the web server you are connecting to. For each URL that you access, the **Username**: drop-down box keeps a record and displays all user names used to access the respective URL.
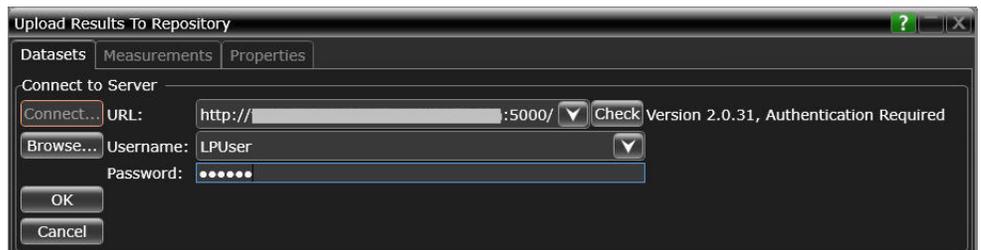
  - *c* Click **OK** to connect to the entered URL/IP address.

   The **Connect to Server** area displays the connection status along with the username.
  - *d* Click **Browse**... to navigate directly to the URL.
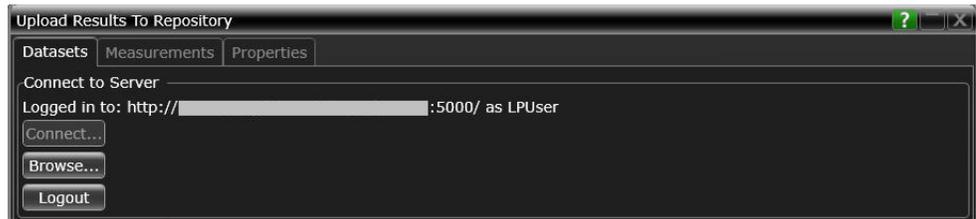
5   In the **Select Dataset** area, click **Select**... to view the list of Datasets created on the connected repository. Click **Refresh** to update the list of Datasets that appear in the Test Application's user interface.

6   Select the Dataset name where you wish to upload measurement results to. Click **OK**.
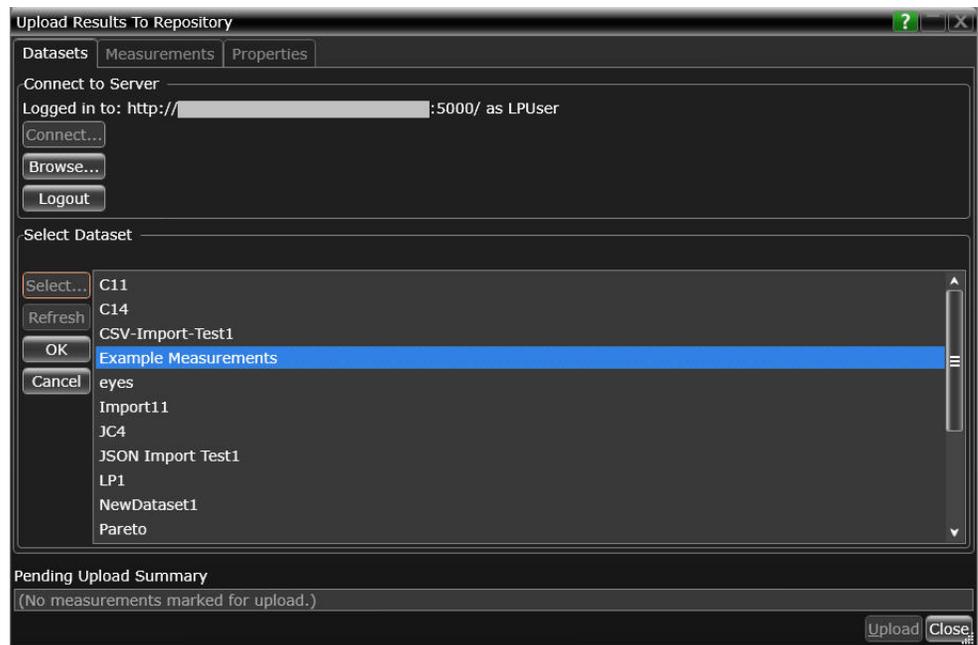
The **Select Dataset** area displays the selected Dataset as Active. The **Measurements** and **Properties** tabs are enabled after a Dataset is selected.
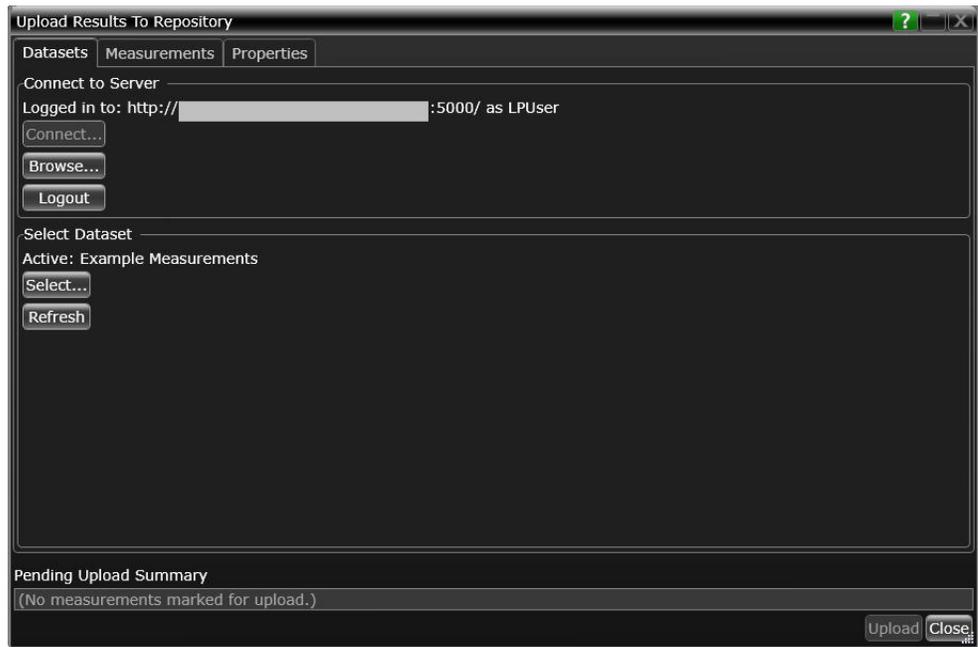
7   Click the **Measurements** tab where the test results from the last test run are displayed.

8   You may select and export multiple test results to the repository. You may change the format for the display of measurement data using the drop-down options in the **Group by:** field.
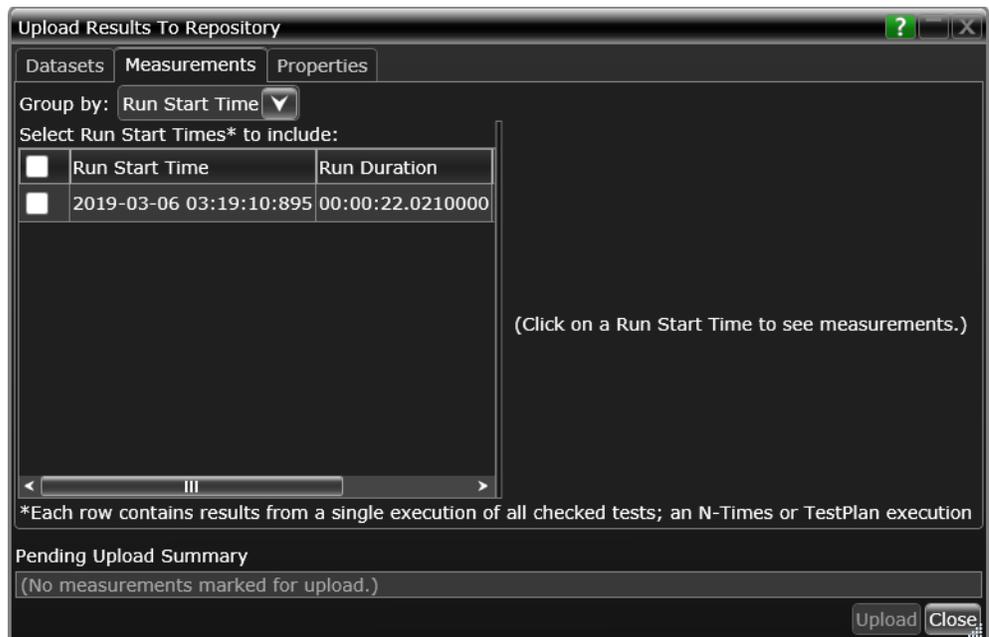
9   After selecting one or more measurements, either click **Upload** or switch to the **Properties** tab to associate one or more properties to the measurements that are being uploaded to the Web Server.

To perform an enhanced analysis on the measurement data using the *KS6800A Series Analytics Service Software*, Keysight recommends assigning properties to the measurements.
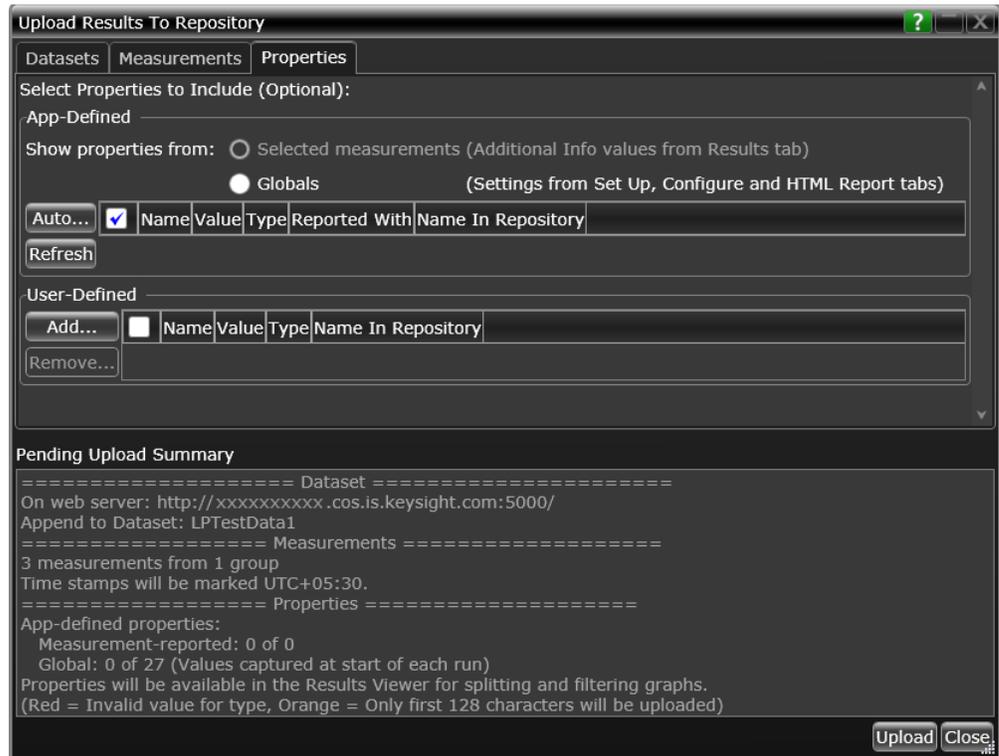
10 Click the **Properties** tab to assign properties for your measurement results that you select to upload. By default, the **App-Defined** properties are selected to be uploaded in association with the measurement data, wherein only certain aspects of the selected measurements are uploaded. However, you may switch to **Globals** to include as properties one or more options configured under the rest of the tabs of the Conformance Test Application or define one or more custom property values to be associated with the selected measurement data.
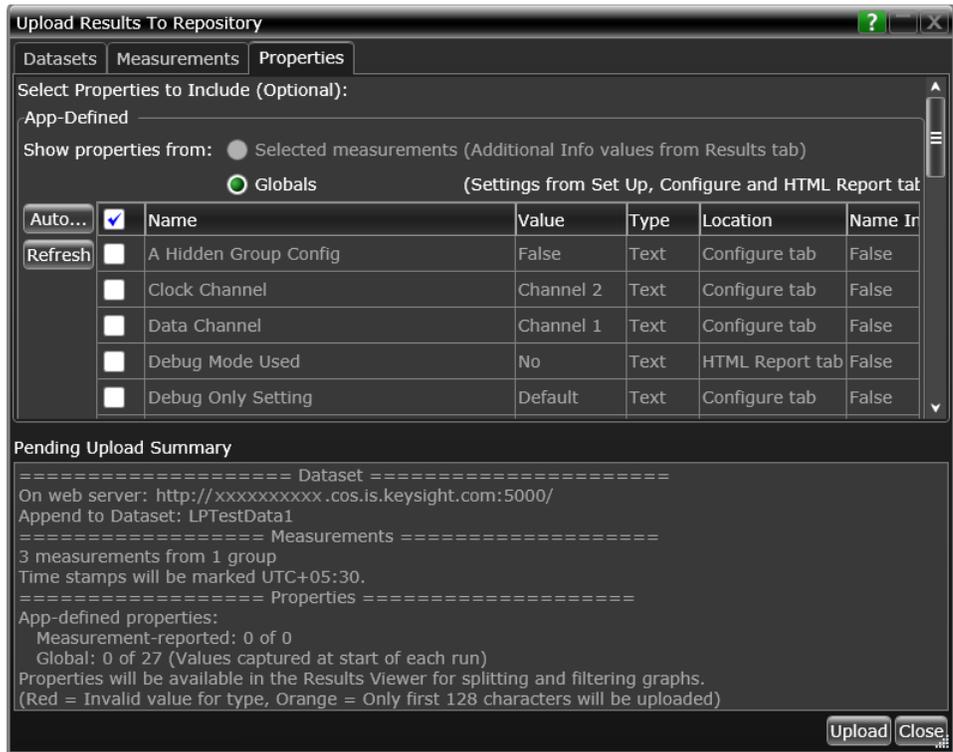
11 Click **Upload** to begin uploading measurement results.

12 Click **Close** to exit the **Upload Results to Repository** window and to return to the Conformance Test Application.

You may access the Dataset Repository using the Internet browser on your machine to view the measurement results graphically on the *KS6800A Series Analytics Service Software*.

KS6800A Series Analytics Service Software

The KS6800A Series Analytics Service software supports multiple data sources and also a wide range of data import clients. This web-based software provides various types of charts, such as Histogram, Box-and-Whisker, Line, Scatter, Eye Diagram and Constellation, each with split capability to enable data analysis. Once you upload the measurement results to a Dataset on the *KS6800A Series Analytics Service Software* via the **Upload Results to Repository** window of the Test Application, the measurement results can be viewed graphically as shown below:
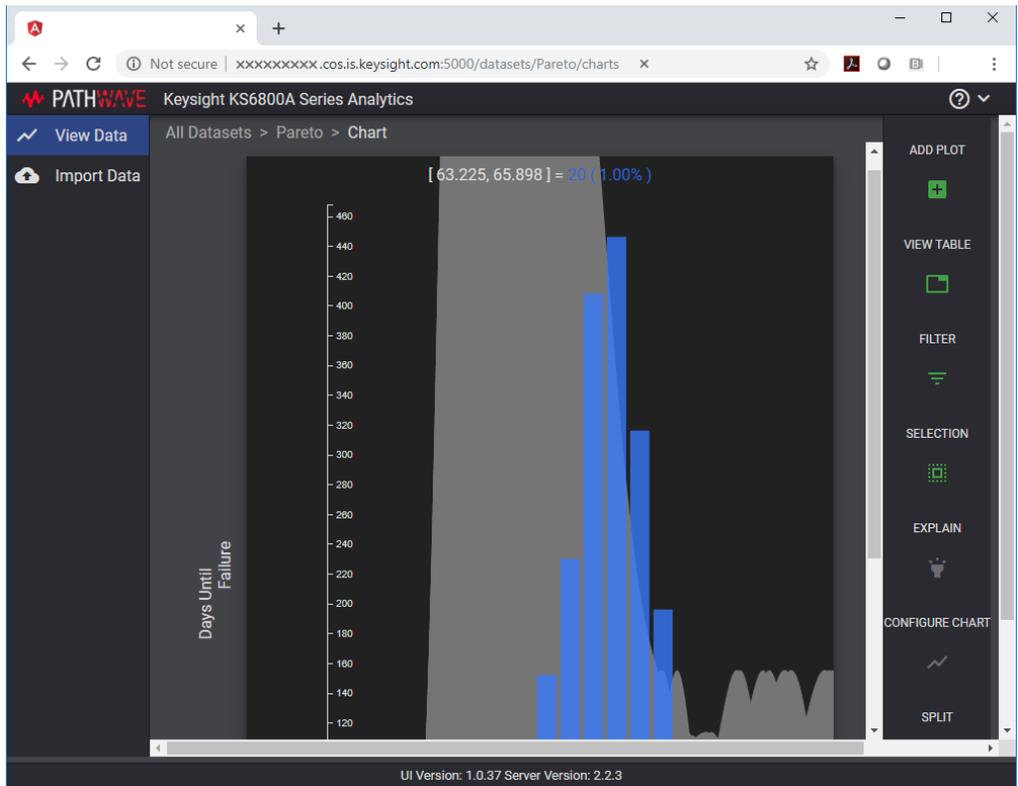
For more information on the Data Analytics Web Service Software, visit KS6800A Series Analytics Service Software page on the Keysight website. You may refer to the Help manual provided within the software to understand the functionality of its features.

3 C2C C2M Tests

This section provides the Methods of Implementation (MOIs) for the IEEE PAM4 Transmitter Characteristics for 100GAUI-1, 200GAUI-2, and 400GGAUI-4 C2C C2M. Measurements are made at test points TP0v, TP1a, and TP4.

NOTE	Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.

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A Note on Crosstalk Calibration for C2M Testing

The N1091CKCA application does not provide calibration procedure for the crosstalk generator in case of C2M host or module testing. As mentioned in the specification, the user must perform crosstalk calibration at TP4 in case of host testing without making use of a reference receiver and with target differential peak-to-peak voltage of 845 mV and transition time of 8.5 ps. Similarly, the crosstalk calibration in case of module testing must be performed at TP1a without making use of a reference receiver and with target differential peak-to-peak voltage of 750mV and transition time of 10 ps for short mode and 15 ps for long mode.

A Note on Difference Measurements (dvf, dRpeak, and dERL)

The difference measurements dVf, dRpeak, and dERL are derived from the measured and the reference values. The measured values are obtained from the actual measurements done at TP0v. Actual measurements include the true transmitter and the fixture. The reference values are calculated using a reference transmitter and the fixture s-parameter. For the test point TP0v, the ERL s-parameter file is the actual package and the fixture (Stp and Sfixt), while the ref s-parameter file is just the fixture (Sfixt). At Test Point TP0v, ref s-parameter is required to find the Tfx Delay using COM tool. For the other test points, the reference s-parameter file is the transmitter package and traces, and what leads to their respective test points.

The difference measurements are defined below:

- dvf is difference steady-state voltage, and is calculated as the difference between the measured steady state voltage and the reference steady state voltage. Refer to Equations 163A-6 and 163A-7 in the specification.
- dRpeak is the difference pulse peak ratio, and is calculated as the difference between the measured pulse peak ratio and the reference pulse peak ratio. Refer to Equations 163A-8, 163A-9, and 163A-10 in the specification.
- dERL is the difference ERL, and is calculated as the difference between the measured ERL and the reference ERL. Refer to Equation 163A-11 in the specification.

The following image illustrates the measurement methods for the difference measurements described above.
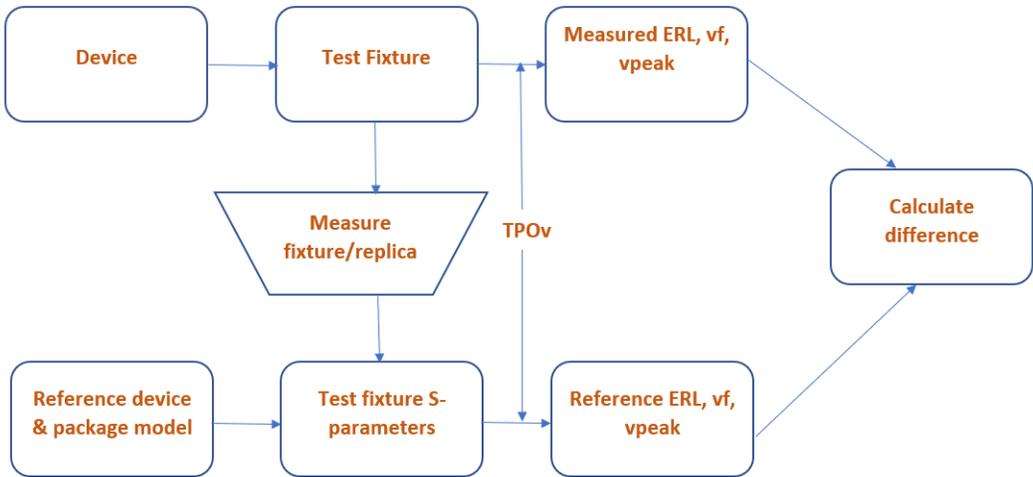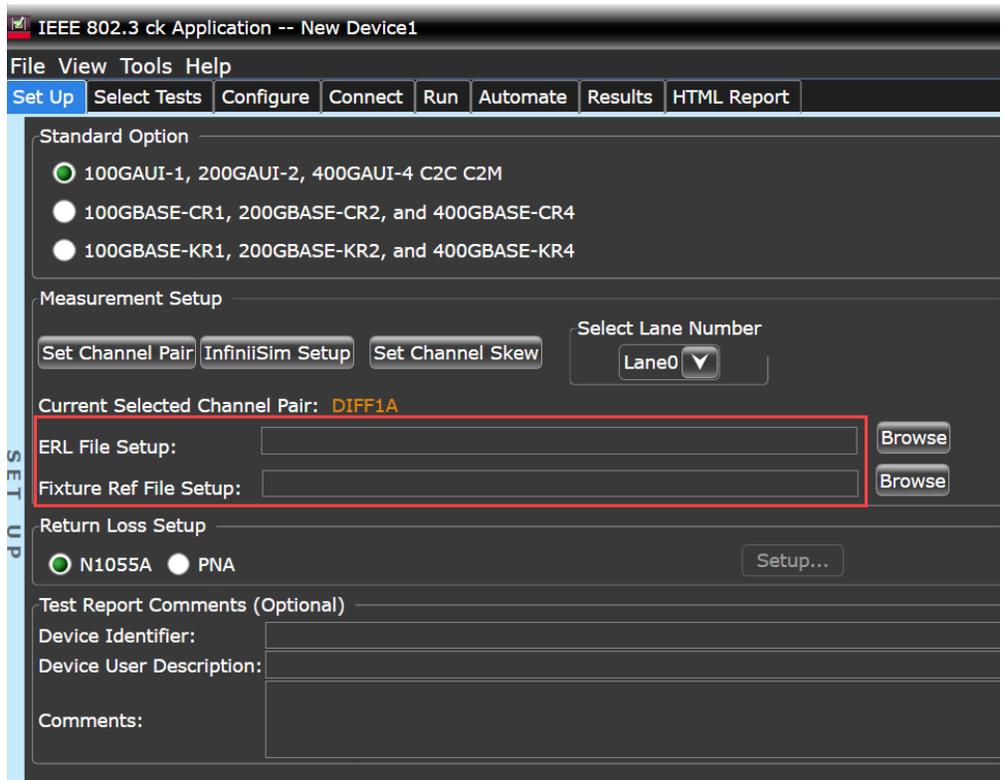
PAM4 Transmitter Characteristics at TP0v

See Table 2 for pass limits pertaining to 100GAUI-1, 200GAUI-2, and 400GAUI-4 C2C C2M tests at TP0v, which are specified in *IEEE P802.3ck^{TM} /D3.3 (Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling) Annexure 120F, Table 120F-1.*

Table 2   100GAUI-1, 200GAUI-2, and 400GGAUI-4 C2C transmitter characteristics at TP0v

Parameter	Reference	Value	Units
Signaling rate per lane (range)		53.125 ± 50 ppm	GBd
Differential peak-to-peak output voltage[a] (max) Transmitter disabled Transmitter enabled	See Sec. 93.8.1.3 of the IEEE specification	35 1200	mV mV
Common-mode voltage[a] (max)	See Sec. 93.8.1.3 of the IEEE specification	1	V
Common-mode voltage[a] (min)	See Sec. 93.8.1.3 of the IEEE specification	0.2	V
Low-frequency peak-to-peak AC common-mode voltage, VCMLF (max)	See Sec. 120F.3.1.1	32	mV
Signal to AC common-mode noise ratio, SCMR (min)	See Sec. 120F.3.1.2	15	dB
Difference effective return loss, dERL (min)	See Sec. 120F.3.1.4	-3	dB
Common-mode to common-mode return loss (min)	See Sec. 162.9.4.9	2	dB
Difference steady-state voltage, dvf (min)	See Sec. 163.9.2.4	0	V
Difference linear fit pulse peak, dRpeak (min)	See Sec. 163A.3.2.1	0	V
Level separation mismatch ratio RLM (min)	See Sec. 162.9.4.2	0.95	–
Output waveform[b] abs. step size for all taps (min) abs. step size for all taps (max) value at min state for c(–3) (max) value at max state for c(–3) (min) value at min state for c(–2) (max) value at max state for c(–2) (min) value at min state for c(–1) (max) value at max state for c(–1) (min) value at min state for c(0) (max) value at min state for c(1) (max) value at max state for c(1) (min)	See Sections 162.9.4.1.4 162.9.4.1.4 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5	0.005 0.025 –0.05 0 0 0.1 –0.3 0 0.5 –0.1 0	- - - - - - - - - - -
Signal-to-noise-and-distortion ratio SNDR (min)	See Sec.162.9.4.6	32.5	dB
Signal-to-residual-intersymbol-interference ratio, SNRISI (min)	See Sec.120F.3.1.3	28	dB
Output jitter JRMS (max) J4u (max) J4u03 (max) Even-odd jitter (max)	See Sections 120F.3.1.6 120F.3.1.6 120F.3.1.6 120F.3.1.6	0.023 0.128 0.118 0.025	UI UI UI UI

a. Measurement uses the method described in section 93.8.1.3 of IEEE specification with the exception that the PRBS13Q test pattern is used.

b. The state of the transmit equalizer is controlled by management interface.

Main Voltage Measurements TP0v (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 9   Selecting Main Voltage Measurement Tests

Refer to Table 2 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Main Voltage Measurements TP0v (pattern: PRBS13Q) tests, see:

- "Differential Peak-to-Peak Output Voltage Test with TX Disabled" on page 36
- "Low Frequency Peak to Peak AC Common Mode Voltage, VCM-LF" on page 37
- "DC Common Mode Output Voltage Test" on page 37
- "Differential Peak-to-Peak Output Voltage Test" on page 37

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 meets the specified standards.

Pass Condition   Refer to Table 2.

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 the specified standards.

Low Frequency Peak to Peak AC Common Mode Voltage, VCM-LF

Test Overview The purpose of this test is to verify that the low frequency peak to peak AC common mode voltage of the signal meets the specified standards.

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

Pass Condition Refer to Table 2.

Measurement Algorithm
1. Set the frame trigger to free run and obtain 131072 pts/wfm.
2. Verify that there is a signal and that the connection is dual single-ended with low-pass filter.
3. Set common mode signal using the common mode function.
4. AC Common Mode voltage range includes all but 10-5 of the measured distribution, from 0.000005 to 0.999995 of the cumulative distribution.
5. Measure the Pk-Pk voltage of the common mode signal.
6. Compare the voltage measurement to the specified standards.

DC Common Mode Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal meets the specified standards.

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

Pass Condition Refer to Table 2.

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. Set common mode signal using the common mode function.
4. Measure minimum and maximum voltage of the common mode signal.
5. Compare the voltage measurement to the specified standards.

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 PRBS13Q pattern meets the specified standards.

Pass Condition Refer to Table 2.

Measurement Algorithm
1. Obtain sample or acquire signal data.
2. Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
3. Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
4. Compare the maximum peak-to-peak voltage to the specified standards.

Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 10   Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 38
- "JRMS" on page 38
- "J4u" on page 39
- "Even-Odd Jitter" on page 39
- "J4u03" on page 40

Signaling Rate

Test Overview   The purpose of this test is to verify that the signaling rate meets the specified standards.

Pass Condition   Refer to Table 2.

Measurement Algorithm
1   Obtain sample or acquire signal data.
2   Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
3   In the **Configure** tab, set **Signaling Rate** to 53.125 GBd.
4   Measure minimum and maximum data rate.
5   Report minimum and maximum values.
6   Compare the mean data rate value with the specified standards. Report the resulting value.

JRMS

Test Overview   The purpose of this test is to verify that differential signal's JRMS meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 2.

Measurement Algorithm	1 Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

   a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

   b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the JRMS value to the specified standards.

J4u

Test Overview   The purpose of this test is to verify that differential signal's J4u meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 2.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

   a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

   b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the J4u value meets the specified standards.

Even-Odd Jitter

Test Overview   The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 2.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

 a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

 b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the Even-Odd Jitter value to the specified standards.

J4u03

Test Overview   The purpose of this test is to verify that differential signal's J4u03 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 2.

Measurement Algorithm   1   Obtain sample or acquire signal data.

> **NOTE**   Signal must be of PRBS13Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

 a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

 b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report if the J4u03 value meets the specified standards.

Jitter Measurement TP0v (pattern: PRBS9Q)

The Jitter Measurement procedure described in this section is performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
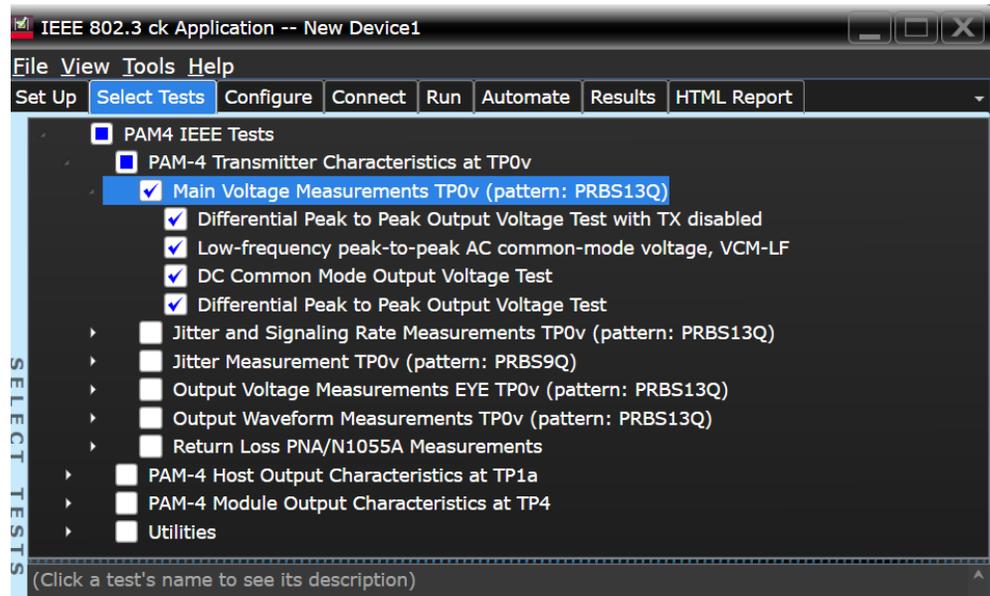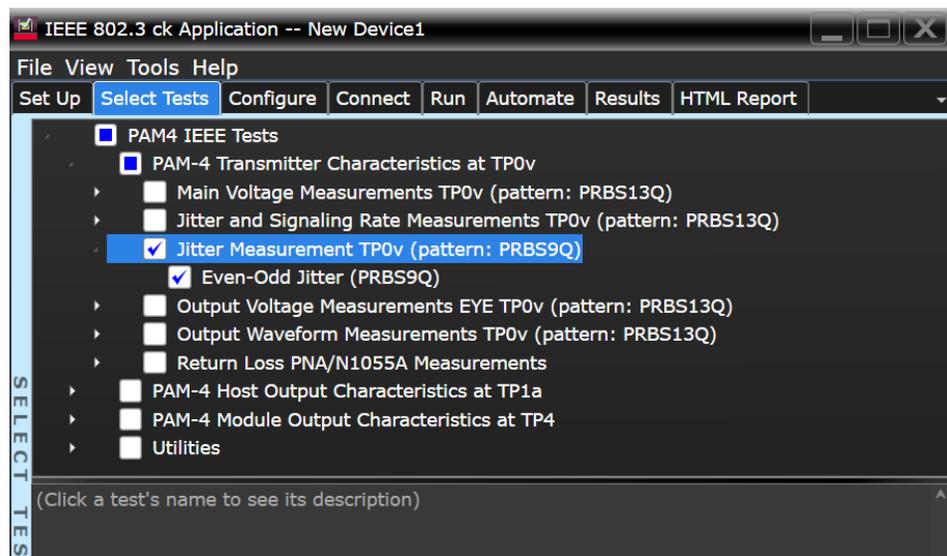

Figure 11   Selecting Jitter and Signaling Rate Measurement Tests

Refer to Table 2 for information on the pass limits for each test that is displayed for the selected standard option.

Even-Odd Jitter (PRBS9Q)

Test Overview   The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards.

Pass Conditions   Refer to Table 2.

Measurement Algorithm   1   Obtain sample or acquire signal data.

> **NOTE**   Signal must be of PRBS9Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

    a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the Even-Odd Jitter value to the specified standards.

Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)

The Output Voltage Measurement EYE procedures for a signal with PRBS13Q pattern that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
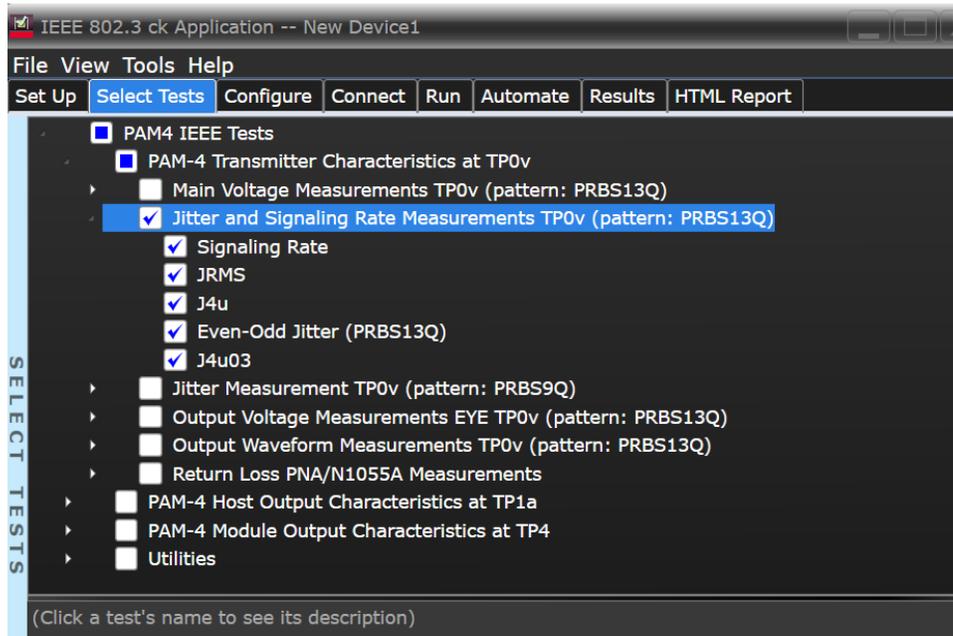

Figure 12   Selecting Output Voltage Measurements EYE Tests

Refer to Table 2 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Voltage Measurements EYE TP0v (pattern: PRBS13Q) tests, see:

-
-
-

> **NOTE**   The tests Level - PRBS pattern and Level RMS - PRBS pattern are considered as "Information-Only" tests and cannot be used for conformance validation.

Level - PRBS Pattern

Test Overview   The purpose of this test is to obtain the mean voltage of each level of the signal with PRBS13Q pattern.

Pass Condition   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm
1. Check that signal is connected and proper data pattern exists (PRBS13Q pattern must be used for this test).
2. V_0, V_1, V_2 and V_3 are the mean signal levels of the symbols corresponding to the PAM4 symbol levels 0, 1, 2 and 3 respectively, as defined in IEEE P802.3bs^{TM} /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2. The calculation of mean signal levels is also defined in section 120D.3.1.2.1.
3. The mean level V_{mid} is defined by equation (120D-3), which is,

$$V_{mid} = (V_0 + V_3) / 2$$

4. Report this value for information-only purpose.

Level RMS - PRBS Pattern

Test Overview   The purpose of this test is to obtain the of the RMS level of the signal with PRBS13Q pattern.

Pass Condition   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm
1. Run the Level - PRBS Pattern test as a prerequisite to this test.
2. The minimum signal level RMS is calculated, as defined in IEEE P802.3bs^{TM} /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.
3. Report this value for information-only purpose.

Level Separation Mismatch Ratio - RLM

Test Overview   The purpose of this test is to obtain the of the Separation Mismatch Ratio level (RLM) of the signal with PRBS13Q pattern.

Pass Condition   Refer to Table 2.

Measurement Algorithm
1. Run the Level - PRBS Pattern as a prerequisite to this test to calculate the mid-range level.
2. The mean signal levels are normalized so that V_0 corresponds to -1, V_1 to -ES1, V_2 to ES2 and V_3 to 1.
3. ES1 and ES2 are calculated using equations (120D-4) and (120D-5), respectively of the IEEE P802.3bs^{TM} /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.

$$ES1 = (V_1 - V_{mid}) / (V_0 - V_{mid})$$

$$ES2 = (V_2 - V_{mid}) / (V_3 - V_{mid})$$

4   The level separation mismatch ratio R_{LM} is defined by equation (120D-5).

$$R_{LM} = min [(3 \times ES1), (3 \times ES2), (2 - 3 \times ES1), (2 - 3 \times ES2)]$$

5   Report this value for information-only purpose.

Output Waveform Measurements TP0v (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 13   Selecting Transmitter Output Waveform Measurement Tests

Refer to Table 2 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Waveform Measurements TP0v (pattern: PRBS13Q) tests, see:

· "Steady State Voltage Vf" on page 44
· "Linear Fit Pulse Peak" on page 44
· "dVf" on page 44
· "dRpeak" on page 44
· "Signal-to-noise-and-distortion ratio" on page 45
· "Signal to AC Common Mode Noise Ratio, SCMR" on page 45
· "dERL" on page 45
· "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 46

- "abs Step Size Tests" on page 46

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 Table 2.

Measurement Algorithm
1. Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).
2. Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
3. Calculate V_f using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of p(k)/M. $N_p = 200$, $D_p = 4$.
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 Table 2.

Measurement Algorithm
1. Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).
2. Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q 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). $N_p = 200$, $D_p = 4$.
4. Compare the specified standards to the resulting value.

dVf

Test Overview   The purpose of this test is to verify that dVf meets the specified standards.

Pass Conditions   Refer to Table 2.

Measurement Algorithm
1. The user enters the fixture s-parameter (S0) file in the **Fixture Ref File Setup** field under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.
2. Calculate the reference transfer function using equation 163A-2.
3. Calculate Vref(peak) as max of h(t).
4. Calculate Vf(ref) using equation 163A-3.
5. Calculate dVf using equation 163A-6.

See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.

dRpeak

Test Overview   The purpose of this test is to verify that dRpeak meets the specified standards.

Pass Conditions   Refer to Table 2.

Measurement Algorithm	1 The user enters the fixture s-parameter (S0) file in the **Fixture Ref File Setup** field under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.
	2 Calculate the reference transfer function using equation 163A-2.
	3 Calculate Vref(peak) as max of h(t).
	4 Calculate Vf(ref) using equation 163A-3.
	5 Calculate dRpeak using equation 163A-7.
	See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.

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 Table 2.
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.

Signal to AC Common Mode Noise Ratio, SCMR

Test Overview	The purpose of this test is to verify that the Signal to AC Common Mode Noise Ratio (SCMR) meets the specified standards.
Pass Condition	Refer to Table 2.
Measurement Algorithm	1 Calculate SCMR using measurement from Linear Fit Pulse peak and Full Band Pk-Pk AC Common mode voltage. The formula is 20log(Vpeak/VcmFB).
	2 Compare the resulting value of SCMR to the specified standards.

ERL

Test Overview	The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.
Pass Condition	Not applicable as the test result is considered as "Information Only".
Measurement Algorithm	1 In the **Set Up** tab of the Compliance Test Application,
	a In the **ERL File Setup** field, specify the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters).
	b In the **Fixture Ref File Setup** field, specify the fixture s-parameter file to calculate the Tfx Delay.
	2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
	3 Specify appropriate values for the **ERL Settings** configuration variables under the **Configure** tab.
	4 Click **Run** under the **Run** tab. The Compliance Test Application automatically calculates the effective return loss by using the COM tool (downloadable from IEEE org website).

dERL

Test Overview	The purpose of this test is to verify that dERL meets the specified standards.
Pass Conditions	Refer to Table 2.

Measurement Algorithm   The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and helps in the ERL computation.

1   The user enters the initial ERL channel file in the **ERL File Setup** field under the Setup tab.

2   The user enters the fixture s-parameter (S0) file in the **Fixture Ref File Setup** field under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.

3   Under the Configure tab, specify values for the following configuration variables:

   a   ERL Settings configuration variables (in the Compliance mode)

   b   Reference ERL Settings configuration variables (in the Debug mode)

4   Enable user to select if they want to apply Tfx Delay when calculating the Reference ERL.

5   The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.

6   The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TP0v measurement to compute ERL at TP0v.

7   The difference between ERL TP0v and ERL ref is reported as the result.

See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.

Signal-to-residual-intersymbol-interference ratio, SNRISI

Test Overview   The purpose of this test is to verify that the highest value of the Signal to residual intersymbol interference ratios (SNRISI) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards:

0 dB through -20 dB gDC and - 4 dB through 0 dB gDC2.

Pass Conditions   Refer to Table 2.

Measurement Algorithm

1   Select a test that pertains to a specific Output Gain value combination.

2   Calculate SNRISI for each test using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test. A time offset is added to tp (index of the linear fit pulse where p(tp) equals Pmax) whose value is swept from -0.5 UI to 0.5 UI when calculating ISIcursor. SNRISI is the lowest value found across the time offset sweep.

3   The highest SNRISI value will be reported based on the equalizer setting.

4   Compare the resulting value to the specified standards.

abs Step Size Tests

Test Overview   The purpose of this test is to verify the abs Step Size.

To know about the measurement algorithm for each abs Step Size test, see:

- "abs Step Size for c(-3)" on page 47
- "abs Step Size for c(-2)" on page 47
- "abs Step Size for c(-1)" on page 47
- "abs Step Size for c(0)" on page 48
- "abs Step Size for c(1)" on page 48
- "value at min. state for c(-3)" on page 49
- "value at max. state for c(-3)" on page 49
- "value at max. state for c(-2)" on page 49
- "value at min. state for c(-2)" on page 50
- "value at min. state for c(-1)" on page 50
- "value at max. state for c(-1)" on page 50
- "value at min. state for c(0)" on page 51

abs Step Size for c(-3)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-3) is within limits.

Pass Condition   When abs Coefficient Step Size c(-3) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1 Request Transmitter to be set to "PRESET" condition.
2 Capture full pattern of PRBS13Q at 32 points per UI.
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4 Define r(m) from "PRESET" as per equation 136-1.
5 Request to change c(-3) to the first step.
6 Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7 Calculate coefficients c(i) using equation 136-2.
8 Save coefficient c(-3) as base step value.
9 Request next c(-3) step.
10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11 Calculate coefficients c(i) using equation 136-2.
12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(-2)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-2) is within limits.

Pass Condition   When abs Coefficient Step Size c(-2) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1 Request Transmitter to be set to "PRESET" condition.
2 Capture full pattern of PRBS13Q at 32 points per UI.
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4 Define r(m) from "PRESET" as per equation 136-1.
5 Request to change c(-2) to the first step.
6 Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7 Calculate coefficients c(i) using equation 136-2.
8 Save coefficient c(-2) as base step value.
9 Request next c(-2) step.
10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11 Calculate coefficients c(i) using equation 136-2.
12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(-1)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-1) is within limits.

Pass Condition   When abs Coefficient Step Size c(-1) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define $r(m)$ from "PRESET" as per equation 136-1.
	5	Request to change $c(-1)$ to the first step.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	7	Calculate coefficients $c(i)$ using equation 136-2.
	8	Save coefficient $c(-1)$ as base step value.
	9	Request next $c(-1)$ step.
	10	Calculate linear fit pulse response as per section 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	11	Calculate coefficients $c(i)$ using equation 136-2.
	12	Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
	13	Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(0)

Test Overview   The purpose of this test is to verify that the abs Step Size for $c(0)$ is within limits.

Pass Condition   When abs Coefficient Step Size $c(0)$ is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define $r(m)$ from "PRESET" as per equation 136-1.
	5	Request to change $c(0)$ to the first step.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	7	Calculate coefficients $c(i)$ using equation 136-2.
	8	Save coefficient $c(0)$ as base step value.
	9	Request next $c(0)$ step.
	10	Calculate linear fit pulse response as per section 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	11	Calculate coefficients $c(i)$ using equation 136-2.
	12	Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
	13	Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(1)

Test Overview   The purpose of this test is to verify that the abs Step Size for $c(1)$ is within limits.

Pass Condition   When abs Coefficient Step Size $c(1)$ is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define $r(m)$ from "PRESET" as per equation 136-1.
	5	Request to change $c(1)$ to the first step.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Save coefficient c(1) as base step value.

9   Request next c(1) step.

10   Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.

11   Calculate coefficients c(i) using equation 136-2.

12   Calculate the step size as coefficient value from step 11 – coefficient value from step 7.

13   Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

value at min. state for c(-3)

Test Overview   The purpose of this test is to verify that the value at min. state for c(-3) is within limits.

Pass Condition   When value at min. state for c(-3) is less than or equal to -50 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(-3) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-3) value from step 7.

value at max. state for c(-3)

Test Overview   The purpose of this test is to verify that the value at max. state for c(-3) is within limits.

Pass Condition   When value at max. state for c(-3) is greater than or equal to 0 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-2), c(-1), and c(1) to zero. Increment both c(0) and c(-3) to their maximum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-3) value from step 7.

value at max. state for c(-2)

Test Overview   The purpose of this test is to verify that the value at max. state for c(-2) is within limits.

Pass Condition   When value at max. state for c(-2) is greater than or equal to 100 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-1), and c(1) to zero. Increment both c(0) and c(-2) to their maximum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-2) value from step 7.

value at min. state for c(-2)

Test Overview   The purpose of this test is to verify that the value at min. state for c(-2) is within limits.

Pass Condition   When value at min. state for c(-2) is less than or equal to 0 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-1), and c(1) to zero. Decrement both c(0) and c(-2) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-2) value from step 7.

value at min. state for c(-1)

Test Overview   The purpose of this test is to verify that the value at min. state for c(-1) is within limits.

Pass Condition   When value at min. state for c(-1) is less than or equal to -300 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-2), and c(1) to zero. Decrement both c(0) and c(-1) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-1) value from step 7.

value at max. state for c(-1)

Test Overview   The purpose of this test is to verify that the value at max. state for c(-1) is within limits.

Pass Condition   When value at max. state for c(-1) is greater than or equal to 0 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-2), and c(1) to zero. Increment both c(0) and c(-1) to their maximum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-1) value from step 7.

value at min. state for c(0)

Test Overview   The purpose of this test is to verify that the value at min. state for c(0) is within limits.

Pass Condition   When value at min. state for c(0) is less than or equal to 500 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to decrement c(0) to minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(0) value from step 7.

value at min. state for c(1)

Test Overview   The purpose of this test is to verify that the value at min. state for c(1) is within limits.

Pass Condition   When value at min. state for c(1) is less than or equal to -100 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(1) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(1) value from step 7.

value at max. state for c(1)

Test Overview   The purpose of this test is to verify that the value at max. state for c(1) is within limits.

Pass Condition   When value at max. state for c(1) is greater than or equal to 0 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-2), c(-1), and c(1) to zero. Increment both c(0) and c(1) to their maximum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(1) value from step 7.

Return Loss PNA/N1055A Measurements

The Return Loss PNA/N1055A Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope along with either a PNA or an N1055A and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. The Conformance Test Application controls the PNA/N1055A to set the test limits and run the tests. You must ensure that the connected device is calibrated.

Figure 14   Selecting Return Loss PNA/N1055A Measurements Tests

Refer to Table 2 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Return Loss PNA/N1055A Measurements tests, see:

- "Common-mode to Common-mode Output Return Loss" on page 52

Common-mode to Common-mode Output Return Loss

Measurement Algorithm

1 Ensure that the PNA/N1055A is physically connected and calibrated.

2 In the **Set Up** tab of the Conformance Test Application, click **PNA** to establish connectivity to the connected equipment. For N1055A, select **N1055A**.

3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.

4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.

5 Compare the reported values with the specification to check for conformance.

PAM4 Host Output Characteristics at TP1a

This section provides the Methods of Implementation (MOIs) for the 100GAUI-1, 200GAUI-2, and 400GAUI-4 C2M tests at TP1a as specified in IEEE P802.3ck[TM] /D3.3 Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling), Annex 120G, Table 120G-1. Measurements are made at TP1a.

NOTE	Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.

Table 3   C2M Host output characteristics at TP1a

Parameter	Reference	Value	Units
Signaling rate per lane (range)		53.125 ± 50 ppm	GBd
DC common-mode output voltage (max)	Sec. 120G.5.1	2.8	V
DC common-mode output voltage (min)	Sec. 120G.5.1	-0.3	V
Single-ended output voltage (max)	Sec. 120G.5.1	3.3	V
Single-ended output voltage (min)	Sec. 120G.5.1	-0.4	V

Peak-to-peak AC common-mode voltage (max)
    ·   Low-frequency, VCM_{LF}
    ·   Full-band, VCM_{FB}
	Sec. 120G.5.1	
		32
		80
			
			mV
			mV

Differential peak-to-peak output voltage (max)
    ·   Transmitter disabled
    ·   Transmitter enabled
	Sec. 120G.5.1	
		35
		750
			
			mV

Steady-state voltage	Sec. 120G.5.3	375	mV
Eye height (min)	Sec. 120G.3.1.5	10	mV
Vertical eye closure (max)	Sec. 120G.3.1.5	12	dB
Common-mode to differential-mode return loss (min)	Sec. 120G.3.1.1	See Equation (120G-1)	dB
Effective return loss, ERL (min)	Sec. 120G.3.1.2	7.3	dB

Transition time (min, 20% to 80%)
    ·   Host is requesting short mode
    ·   Host is requesting long mode
	Sec. 120G.3.1.4	
		10
		15
			
			ps
			ps

Main Voltage Measurements TP1a (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 15   Selecting Main Voltage Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Main Voltage Measurements TP1a (pattern: PRBS13Q) tests, see:

- "Differential Peak-to-Peak Output Voltage Test with TX Disabled" on page 54
- "DC Common Mode Output Voltage Test" on page 54
- "Low-Frequency Peak-to-Peak AC Common Mode Voltage, VCM-LF" on page 55
- "Full-Band Peak-to-Peak AC Common Mode Voltage, VCM-FB" on page 55
- "Differential Peak-to-Peak Output Voltage Test" on page 56
- "Single-ended Output Voltage Test" on page 56

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 or equal to 35mV.

Pass Condition   Refer to Table 3.

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.

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 Table 3.

Measurement Algorithm

1   Obtain sample or acquire signal data.
2   Set common mode signal using the common mode function.
3   Measure minimum and maximum voltage of the common mode signal.
4   Compare the voltage measurement to the range between -300mV and 2.8V.

Low-Frequency Peak-to-Peak AC Common Mode Voltage, VCM-LF

Test Overview   The purpose of this test is to verify that the low-frequency peak-to-peak AC common mode voltage of the signal conforms to the specification.

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

Pass Condition   Refer to Table 3.

Measurement Algorithm

1   Set the frame trigger to free run and obtain 131072 pts/wfm.
2   Verify that there is a signal and that the connection is dual single-ended with low-pass filter.
3   Set common mode signal using the common mode function.
4   AC Common Mode voltage range includes all but 10-5 of the measured distribution, from 0.000005 to 0.999995 of the cumulative distribution.
5   Measure peak-to-peak voltage of the common mode signal.
6   Compare the voltage measurement with specification.

Full-Band Peak-to-Peak AC Common Mode Voltage, VCM-FB

Test Overview   The purpose of this test is to verify that the full-band peak-to-peak AC common mode voltage of the signal conforms to the specification.

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

Pass Condition   Refer to Table 3.

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   Set common mode signal using the common mode function.
4   AC Common Mode voltage range includes all but 10-5 of the measured distribution, from 0.000005 to 0.999995 of the cumulative distribution.
5   Measure peak-to-peak voltage of the common mode signal.
6   Compare the voltage measurement with specification.

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 PRBS13Q pattern is less than or equal to 750 mV.

Pass Condition   Refer to Table 3.

Measurement Algorithm

1   Obtain sample or acquire signal data.
2   Verify that the signal is connected, has TX enabled and has a PRBS13Q 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 750 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 or equal to -400mV and that the maximum voltage is less than or equal to 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 Table 3.

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 TP1a (pattern: PRBS13Q)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits vary in both the modes.
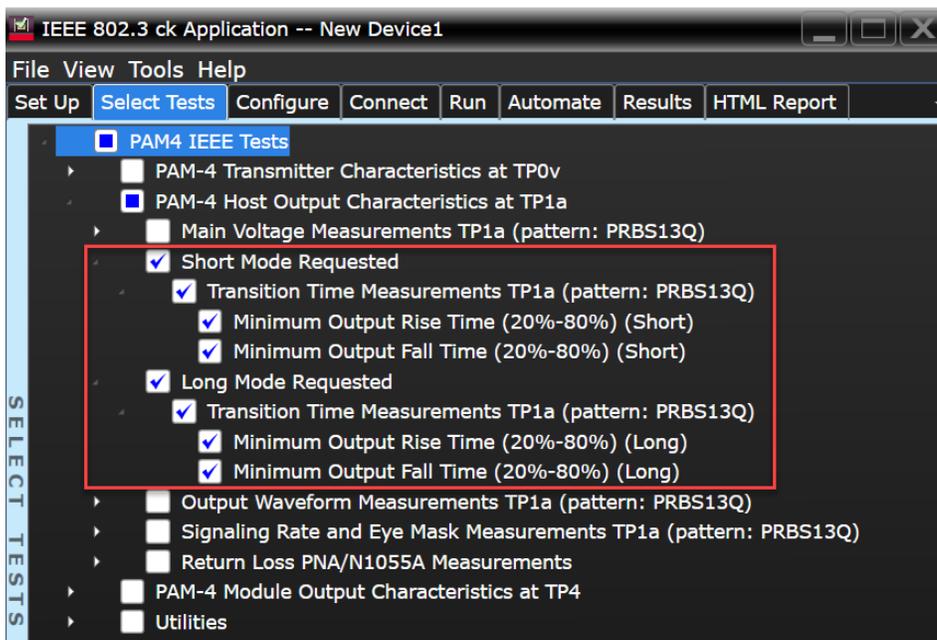
Figure 16   Selecting Transition Time Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Transition Time Measurements TP1a (pattern: PRBS13Q) tests, see:

· "Minimum Output Rise Time (20%-80%)" on page 57
· "Minimum Output Fall Time (20%-80%)" on page 57

Minimum Output Rise Time (20%-80%)

Test Overview   The purpose of this test is to verify that the minimum rise time is 10ps for short mode and 15ps for long mode.

Pass Condition   Refer to Table 3.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is PRBS13Q.
3 Find pattern 000333 for the rising edge.
4 Measure rise time from 20% to 80% of the signal amplitude.
5 Compare the minimum rise time with 10ps for short mode and 15ps for long mode.

Minimum Output Fall Time (20%-80%)

Test Overview   The purpose of this test is to verify that the minimum fall time is 10ps for short mode and 15ps for long mode.

Pass Condition   Refer to Table 3.

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Verify that the signal is PRBS13Q.
3 Find pattern 333000 for the falling edge.
4 Measure fall time from 20% to 80% of the signal amplitude.
5 Compare the minimum rise time with 10ps for short mode and 15ps for long mode.

Output Waveform Measurements TP1a (pattern: PRBS13Q)

The Output Waveform Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
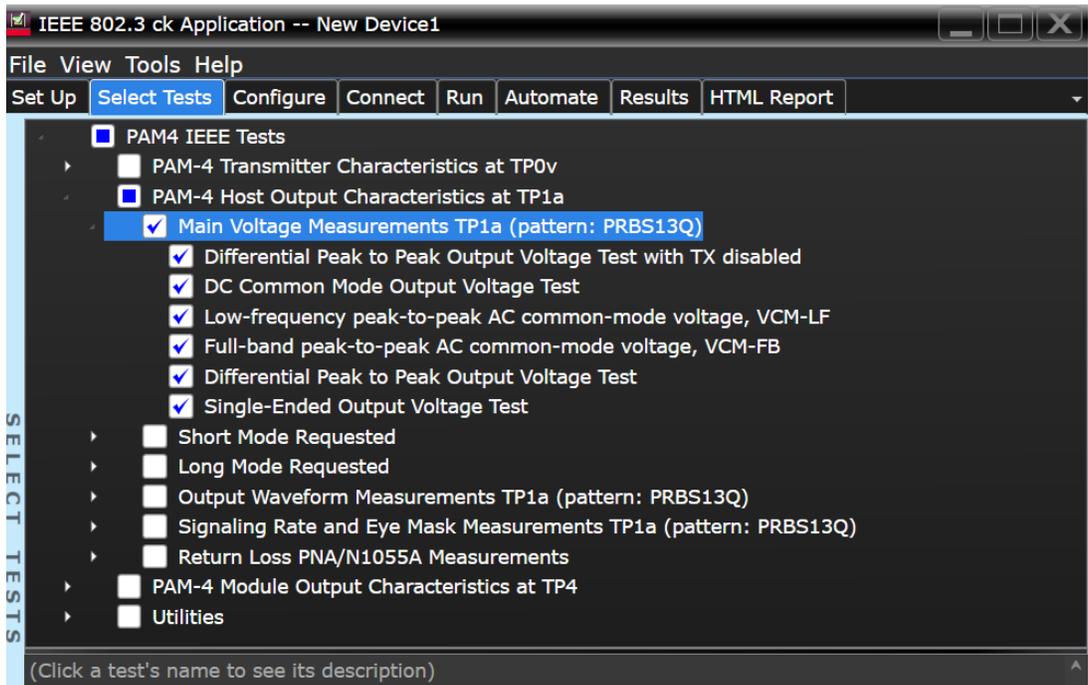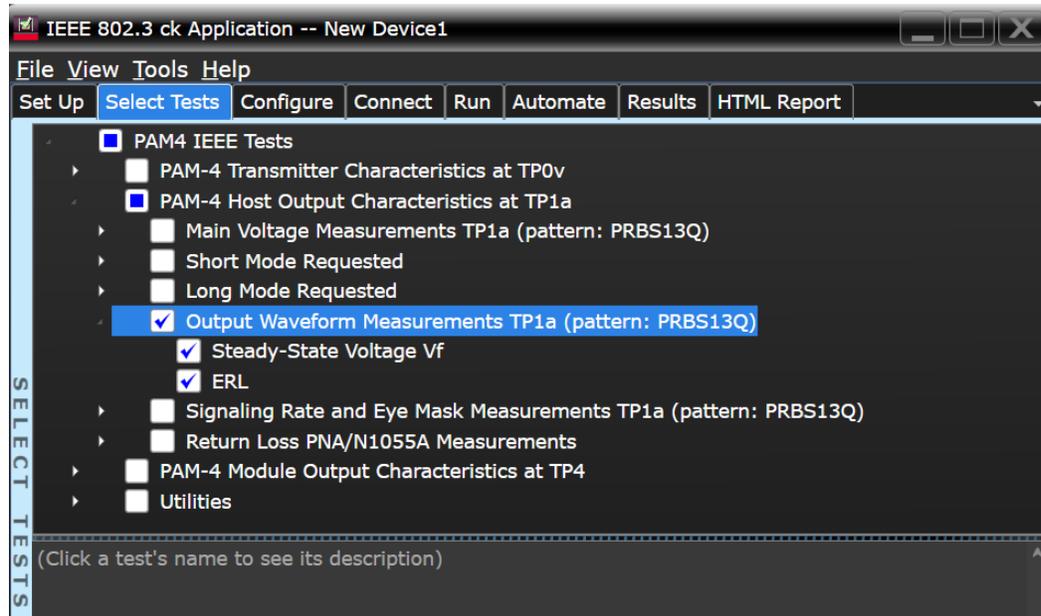

Figure 17   Selecting Transition Time Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm, see:
- "Steady State Voltage Vf" on page 58
- "ERL" on page 58

Steady State Voltage Vf

Test Overview   The purpose of this test is to verify that the Steady State Voltage does not exceed 375 mV.

Pass Condition   Refer to Table 3 for the pass limits pertaining to each standard option.

Measurement Algorithm
1   Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).
2   Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
3   Calculate V_f using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of p(k)/M. $N_p = 200$, $D_p = 4$.
4   Compare and report the resulting value.

ERL

Test Overview   The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.

Pass Condition   Refer to Table 3 for the pass limits pertaining to each standard option.

Measurement Algorithm The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and helps in the ERL computation.

1 In the **Set Up** tab of the Compliance Test Application, specify the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters) in the **ERL File Setup** field.

2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.

3 Specify appropriate values for the **ERL Settings** configuration variables under the **Configure** tab.

4 Click **Run** under the **Run** tab.

5 The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120G-2) and the user-specified S-parameter file for return loss at TP0v measurement to compute ERL at TP1a. The computed ERL at TP1a is reported as the result.

Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q)

The Signaling Rate and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
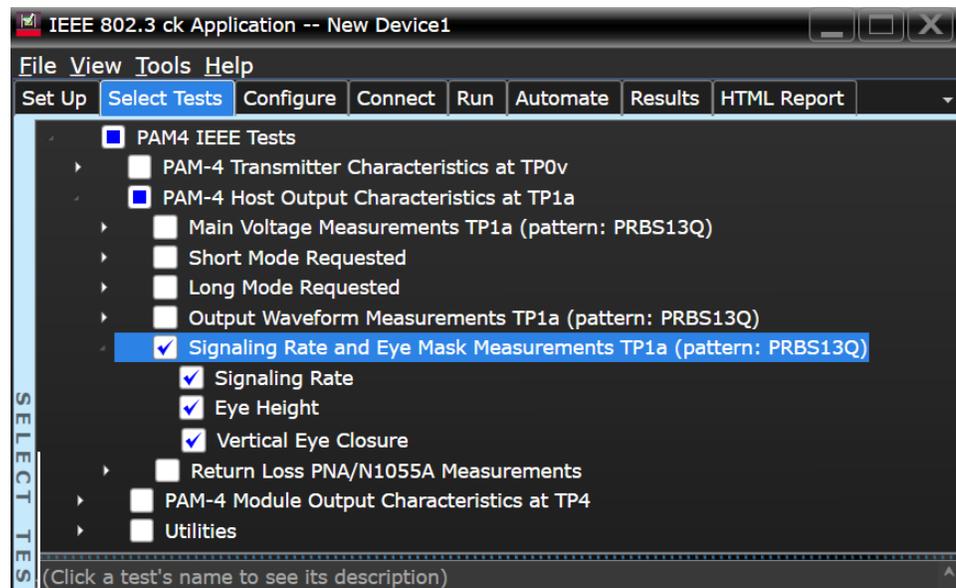
Figure 18   Selecting Signaling Rate and Eye Mask Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Signaling Rate and Eye Mask Measurements TP1a (pattern: PRBS13Q) tests, see:

· "Signaling Rate" on page 59
· "Eye Height" on page 60
· "Vertical Eye Closure" on page 60

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate mean is between 53.125 ±50ppm GBd.

Pass Condition Refer to Table 3.

Measurement Algorithm
1   Obtain sample or acquire signal data.
2   Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
3   In the **Configure** tab, set **Signaling Rate** to 53.125 GBd.
4   Measure minimum, maximum and mean data rate.
5   Report minimum and maximum values.
6   Compare the mean data rate value with 53.125 ±50ppm GBd.
7   Report the resulting value.

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 or equal to 10 mV.

Pass Conditions   Refer to Table 3.

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 **Auto-tune CTLE, DFE Eye Opening** 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'. See IEEE P802.3ck D2.1, Section 120G, Table 120G-12.
2   Obtain sample or acquire signal data.
3   Measure the Eye Height at an **Eye Height/Width Probability** setting of 1E-5.
4   On the Oscilloscope,
   a   set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4MHz.
   b   Set 4th Order Butterworth filter to 40 GHz with 3 dB gain.
5   Compare the Eye Height with 10 mV. Report the resulting value.

Vertical Eye Closure

Test Overview   The purpose of this test is to measure the Vertical Eye Closure at EH5 (1E-5).

Pass Conditions   Refer to Table 3.

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 **Auto-tune CTLE, DFE Eye Opening** 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 (53.125 GBd) and Loop Bandwidth to 4 MHz.
   b   Set 4th Order Butterworth filter to 40 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   Report the resulting value of Vertical Eye Closure.

Return Loss PNA/N1055A Measurements

The Return Loss PNA/N1055A Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope along with either a PNA or an N1055A and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. The Conformance Test Application controls the PNA/N1055A to set the test limits and run the tests. You must ensure that the connected device is calibrated.
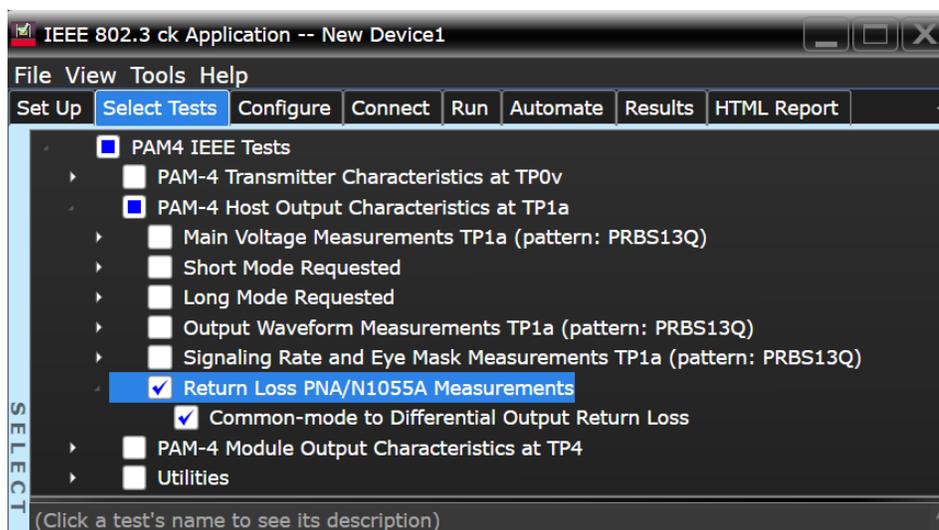
Figure 19   Selecting Return Loss Measurement Tests

Refer to Table 3 for information on the pass limits for each test.

To know about the measurement algorithm for each Return Loss PNA/N1055A Measurements tests, see:

- "Common-mode to Differential Output Return Loss" on page 61

Common-mode to Differential Output Return Loss

Measurement Algorithm

1 Ensure that the PNA/N1055A is physically connected and calibrated.

2 In the **Set Up** tab of the Conformance Test Application, click **PNA** to establish connectivity to the connected equipment. For N1055A, select **N1055A**.

3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.

4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.

5 Compare the reported values with the specification to check for conformance.

PAM4 Module Output Characteristics at TP4

This section provides the Methods of Implementation (MOIs) for the PAM4 100GAUI-1, 200GAUI-2, and 400GAUI-4 IEEE PAM4 Module Output Characteristics at TP4 as specified in *IEEE P802.3ck^{TM}* *...*

This section provides the Methods of Implementation (MOIs) for the PAM4 100GAUI-1, 200GAUI-2, and 400GAUI-4 IEEE PAM4 Module Output Characteristics at TP4 as specified in *IEEE P802.3ck^{TM} /D3.3 (Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling) section 120G, Table 120G-3*. Measurements are made at TP4.

> **NOTE** Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.

Table 4   Module output characteristics at TP4

Parameter	Reference	Value	Units
Signaling rate per lane (range)		53.125	GBd
Peak-to-peak AC common-mode voltage (max) · Low-frequency, VCM_{LF} · Full-band, VCM_{FB}	Sec. 120G.5.1	 32 80	 mV mV
Differential peak-to-peak output voltage (max) · Short mode · Long mode	Sec. 120G.5.1	 600 845	 mV mV
Eye height (min)	Sec. 120G.3.2.2	15	mV
Vertical Eye Closure, VEC (max)	Sec. 120G.3.2.2	12	dB
Common-mode to differential-mode return loss (min)	Sec. 120G.3.1.1	Equation (120G–1)	dB
Effective Return Loss, ERL (min.)	Sec. 120G.3.2.3	8.5	dB
Transition time (min, 20% to 80%)	Sec. 120G.3.1.4	8.5	ps
DC common mode voltage tolerance (min)	Sec. 120G.3.2.4	-350	mV
DC common mode voltage tolerance (max)	Sec. 120G.3.2.4	2850	mV

Main Voltage Measurements TP4 (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits might vary in both the modes.

Figure 20   Selecting Main Voltage Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Main Voltage Measurements TP4 (pattern: PRBS13Q) tests, see:

· "Low-Frequency Peak-to-Peak AC Common Mode Voltage, VCM-LF" on page 63
· "Full-Band Peak-to-Peak AC Common Mode Voltage, VCM-FB" on page 64
· "Differential Output Voltage Test" on page 64
· "DC Common Mode Voltage Test" on page 64

Low-Frequency Peak-to-Peak AC Common Mode Voltage, VCM-LF

Test Overview   The purpose of this test is to verify that the low-frequency peak-to-peak AC common mode voltage of the signal conforms with the specification.

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

Pass Condition   Refer to Table 4.

Measurement Algorithm

1   Set the frame trigger to free run and obtain 131072 pts/wfm.
2   Verify that there is a signal and that the connection is dual single-ended with low-pass filter.
3   Set common mode signal using the common mode function.

4   AC Common Mode voltage range includes all but 10-5 of the measured distribution, from 0.000005 to 0.999995 of the cumulative distribution.

5   Measure peak-to-peak voltage of the common mode signal.

6   Compare the voltage measurement with specification.

Full-Band Peak-to-Peak AC Common Mode Voltage, VCM-FB

Test Overview   The purpose of this test is to verify that the full-band peak-to-peak AC common-mode voltage of the signal conforms to the specification.

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

Pass Condition   Refer to Table 4.

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   Set common mode signal using the common mode function.

4   AC Common Mode voltage range includes all but 10-5 of the measured distribution, from 0.000005 to 0.999995 of the cumulative distribution.

5   Measure peak-to-peak voltage of the common mode signal.

6   Compare the voltage measurement with specification.

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 PRBS13Q pattern is less than or equal to 600mV for short output mode and 845mV for long output mode.

Pass Condition   Refer to Table 4.

Measurement Algorithm
1   Obtain sample or acquire signal data.

2   Verify that the signal is connected, has TX enabled and has a PRBS13Q 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 600mV for short output mode and 845mV for long output mode.

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 Table 4.

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   Set common mode signal using the common mode function.

4   Measure minimum and maximum voltage of the common mode signal.

5   Compare the voltage measurement to the range between –350mV and 2.85V.

Transition Time Measurements TP4 (pattern: PRBS13Q)

The Transition Time Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits do not vary in both the modes.
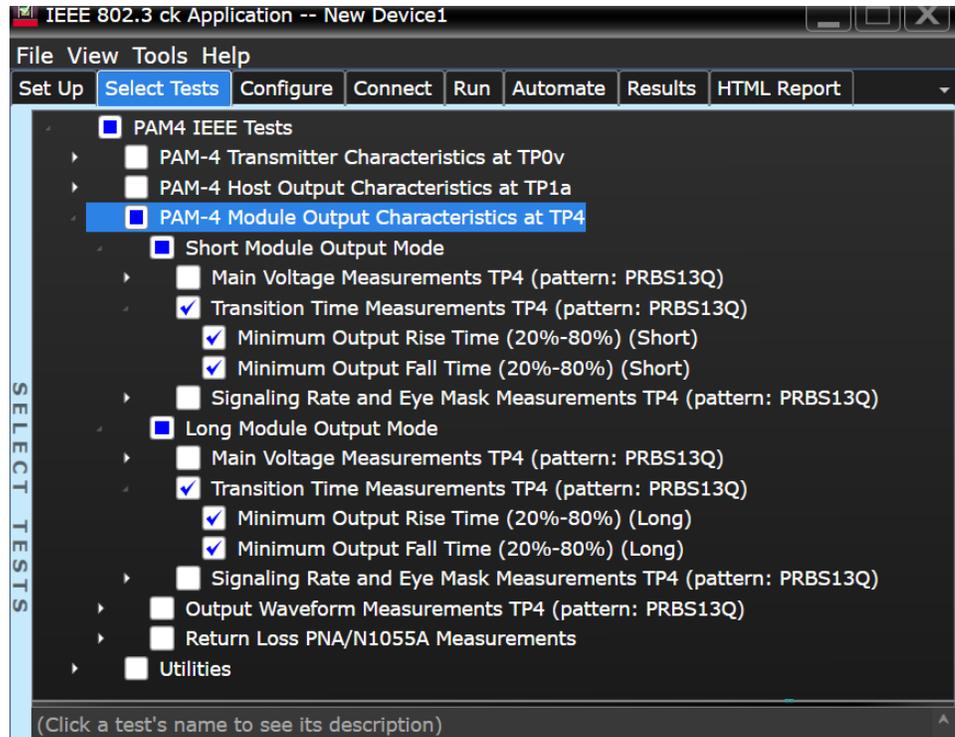
Figure 21   Selecting Transition Time Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Transition Time Measurements TP4 (pattern: PRBS13Q) tests, see:

- "Minimum Output Rise Time (20%-80%)" on page 65
- "Minimum Output Fall Time (20%-80%)" on page 66

Minimum Output Rise Time (20%-80%)

Test Overview   The purpose of this test is to verify that the minimum rise time is 8.5ps.

Pass Condition   Refer to Table 4.

Measurement Algorithm
1   Obtain sample or acquire signal data.
2   Verify that the signal is PRBS13Q.
3   Find pattern 000333 for rising edge.
4   Measure rise time from 20% to 80% of the signal amplitude.
5   Compare the minimum rise time with 8.5ps.

Minimum Output Fall Time (20%-80%)

Test Overview   The purpose of this test is to verify that the minimum fall time is 8.5ps.

Pass Condition   Refer to Table 4.

Measurement   1   Obtain sample or acquire signal data.
Algorithm
2   Verify that the signal is PRBS13Q.

3   Find pattern 333000 for the falling edge.

4   Measure fall time from 20% to 80% of the signal amplitude.

5   Compare the minimum fall time with 8.5ps.

Signaling Rate and Eye Mask Measurements TP4 (pattern: PRBS13Q)

The Signaling Rate and Eye Mask Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. These measurements can be made in short module output mode and long module output mode. The pass limits do not vary in both the modes.
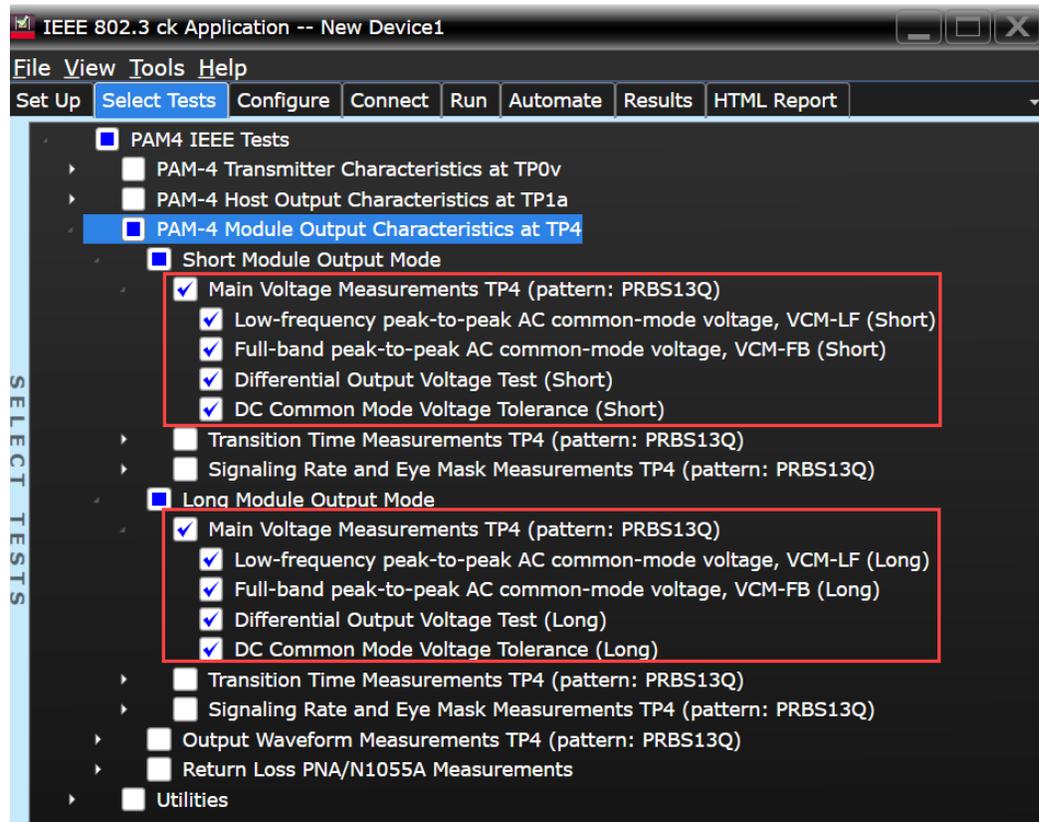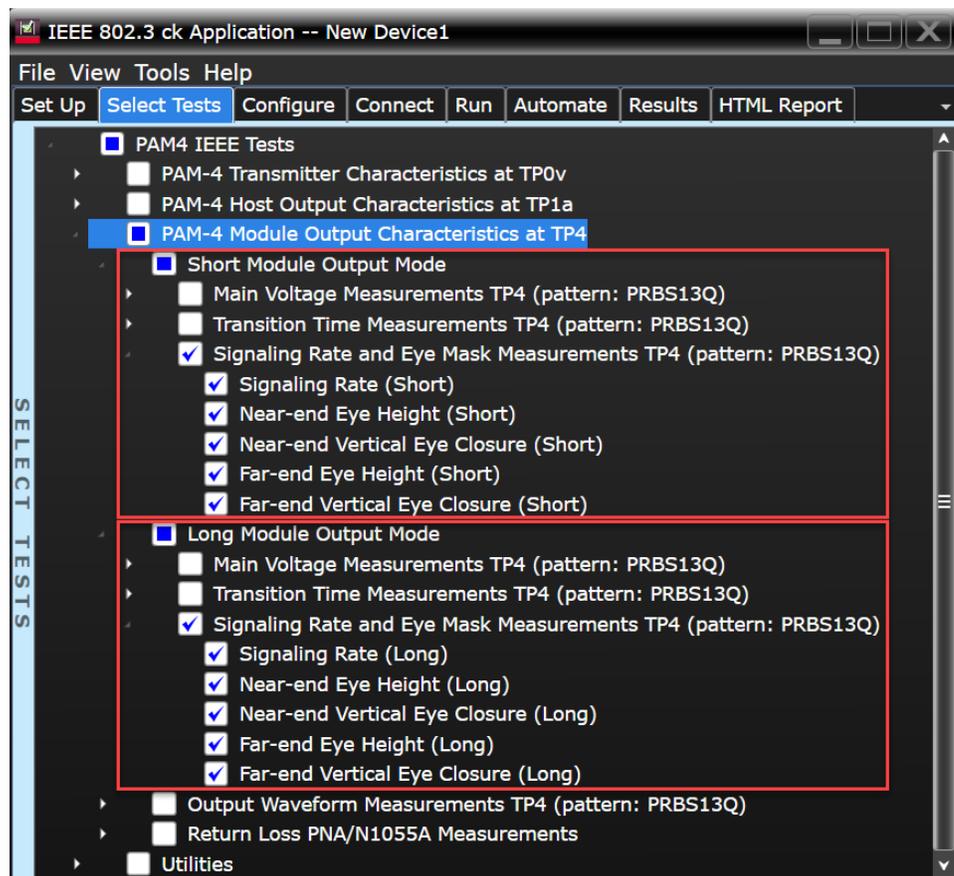

Figure 22   Selecting Signaling Rate and Eye Mask Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Signaling Rate and Eye Mask Measurements TP4 (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 67

Signaling Rate

Test Overview   The purpose of this test is to verify that the signaling rate mean is conformant with the specification.

Pass Condition   Refer to Table 4.

Measurement Algorithm
1. Obtain sample or acquire signal data.
2. Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
3. In the **Configure** tab, set **Signaling Rate** to 53.125 GBd.
4. Measure minimum, maximum and mean data rate.
5. Report minimum and maximum values.
6. Compare the mean data rate value with 53.125 GBd.
7. Report the resulting value.

Near-end Eye Height

Test Overview   The purpose of this test is to verify that for a defined range of CTLE settings, the Near-end Eye Height is greater than or equal to 15mV.

Pass Conditions   Refer to Table 4.

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 **Auto-tune Near-end CTLE Eye Opening TP4 (Short)** or **Auto-tune Near-end CTLE Eye Opening TP4 (Long)** under the **Utilities** in the **Select Tests** tab.
   - Manually select the optimal CTLE settings from the **Use Optimized CTLE gDC for Near-end Eye Opening (Short)** and **Use Optimized CTLE gDC2 for Near-end Eye Opening (Short)** or **Use Optimized CTLE gDC for Near-end Eye Opening (Long)** and **Use Optimized CTLE gDC2 for Near-end Eye Opening (Long)** 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 Near-end Eye Height at an **Eye Height/Width Probability** setting of 1E-5.
4. On the Oscilloscope,
   a. Set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4MHz.
   b. Set 4th Order Butterworth filter to 40 GHz with 3 dB gain.
5. Compare the Near-end Eye Height with the specified limit. Report the resulting value.

Near-end Vertical Eye Closure

Test Overview   The purpose of this test is to measure the Near-end Vertical Eye Closure at EH5 (1E-5).

Pass Conditions   Refer to Table 4.

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 **Auto-tune Near-end CTLE Eye Opening TP4 (Short)** or **Auto-tune Near-end CTLE Eye Opening TP4 (Long)** under the **Utilities** in the **Select Tests** tab.

- Manually select the optimal CTLE settings from the **Use Optimized CTLE gDC for Near-end Eye Opening (Short)** and **Use Optimized CTLE gDC2 for Near-end Eye Opening (Short)** or **Use Optimized CTLE gDC for Near-end Eye Opening (Long)** and **Use Optimized CTLE gDC2 for Near-end Eye Opening (Long)** 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 (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Butterworth filter to 40 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   Report the resulting value of Vertical Eye Closure.

Far-end Eye Height

Test Overview   The purpose of this test is to verify that for a defined range of CTLE settings, the Far-end Eye Height is greater than or equal to 15mV.

Pass Conditions   Refer to Table 4.

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 **Auto-tune Far-end CTLE Eye Opening TP4 (Short)** or **Auto-tune Far-end CTLE Eye Opening TP4 (Long)** under the **Utilities** in the **Select Tests** tab.
- Manually select the optimal CTLE settings from the **Use Optimized CTLE gDC for Far-end Eye Opening (Short)** and **Use Optimized CTLE gDC2 for Far-end Eye Opening (Short)** or **Use Optimized CTLE gDC for Far-end Eye Opening (Long)** and **Use Optimized CTLE gDC2 for Far-end Eye Opening (Long)** 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 Far-end Eye Height at an **Eye Height/Width Probability** setting of 1E-5.

4   On the Oscilloscope,

    a   Set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Butterworth filter to 40 GHz with 3 dB gain.

5   Compare the Far-end Eye Height with 15mV. Report the resulting value.

Far-end Vertical Eye Closure

Test Overview   The purpose of this test is to measure the Far-end Vertical Eye Closure at EH5 (1E-5).

Pass Conditions   Refer to Table 4.

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 **Auto-tune Far-end CTLE Eye Opening TP4 (Short)** or **Auto-tune Far-end CTLE Eye Opening TP4 (Long)** under the **Utilities** in the **Select Tests** tab.
- Manually select the optimal CTLE settings from the **Use Optimized CTLE gDC for Far-end Eye Opening (Short)** and **Use Optimized CTLE gDC2 for Far-end Eye Opening (Short)** or **Use Optimized CTLE gDC for Far-end Eye Opening (Long)** and **Use Optimized CTLE gDC2 for Far-end Eye Opening (Long)** 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 (53.125 GBd) and Loop Bandwidth to 4 MHz.

　　b   Set 4th Order Butterworth filter to 40 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   Report the resulting value of Vertical Eye Closure.

Output Waveform Measurements TP4 (pattern: PRBS13Q)

The Output Waveform Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
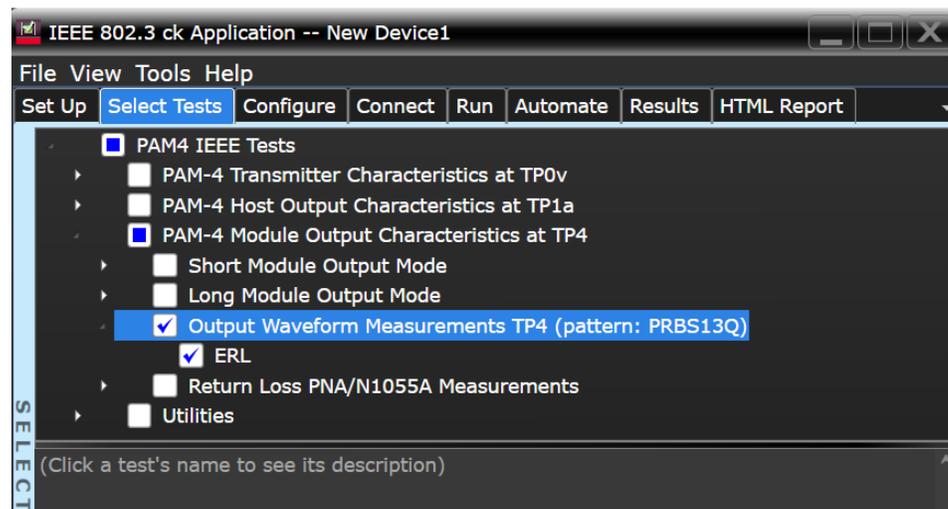
Figure 23　　　Selecting Transition Time Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm, see:

· "ERL" on page 69

ERL

Test Overview　　The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.

Pass Condition　　Refer to Table 4 for the pass limits pertaining to each standard option.

Measurement Algorithm　　The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and help in the ERL computation.

1   In the **Set Up** tab of the Compliance Test Application, specify the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters) in the **ERL File Setup** field.

2   Click the **Select Tests** tab and check the ERL test to measure the effective return loss.

3   Specify appropriate values for the **ERL Settings** configuration variables under the **Configure** tab.

4   Click **Run** under the **Run** tab.

5   The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120G-6) and the user-specified S-parameter file for return loss at TP0v measurement to compute ERL at TP4. The computed ERL at TP4 is reported as the result.

Return Loss PNA/N1055A Measurements

The Return Loss PNA/N1055A Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope along with either a PNA or an N1055A and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. The Conformance Test Application controls the PNA/N1055A to set the test limits and run the tests. You must ensure that the connected device is calibrated.
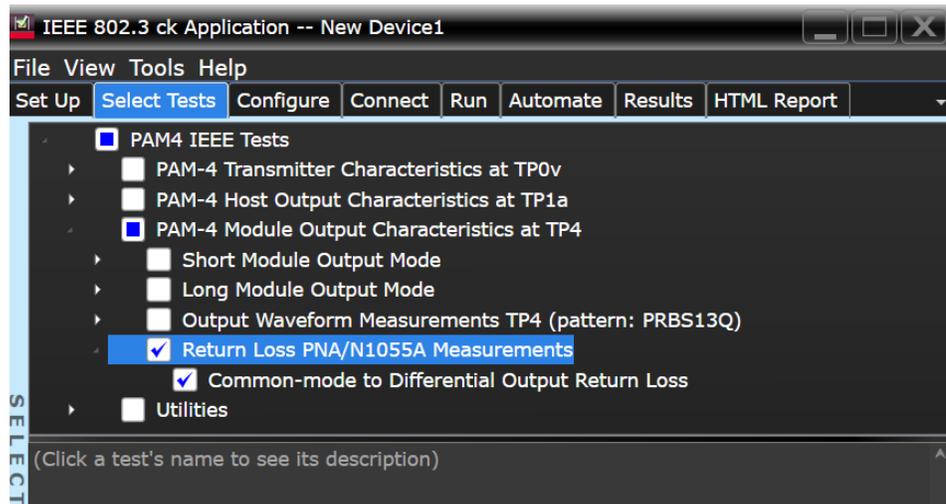
Figure 24   Selecting Return Loss Measurement Tests

Refer to Table 4 for information on the pass limits for each test.

To know about the measurement algorithm for each Return Loss PNA/N1055A Measurements tests, see:

- "Common-mode to Differential Output Return Loss" on page 70

Common-mode to Differential Output Return Loss

Measurement Algorithm

1   Ensure that the PNA/N1055A is physically connected and calibrated.

2   In the **Set Up** tab of the Conformance Test Application, click **PNA** to establish connectivity to the connected equipment. For N1055A, select **N1055A**.

3   Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.

4   Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.

5   Compare the reported values with the specification to check for conformance.

Utilities

This section provides the Methods of Implementation (MOIs) for the Utilities tests to find the optimal CTLE Eye Opening.

Run the CTLE utility tests documented in this section before running the corresponding Eye Height tests. The following is the general sequence of steps to be followed:

1   Run the Utility called "Auto-tune CTLE, DFE Eye Opening TP1a" or "Auto-tune Near-end CTLE Eye Opening TP4" (for Near-end tests) or "Auto-tune Far-end CTLE Eye Opening TP4" (for Far-end tests) to determine the correct CTLE value to use in subsequent eye measurement tests. The Near-end and Far-end utilities can be run either in short or long module output mode. Run the Utility standalone (do not run with other tests).
    After running the utility, the applicable ones out of the following settings on the Configure tab will be set with the optimal values:

    · Use Optimized CTLE gDC for Eye Opening
    · Use Optimized CTLE gDC2 for Eye Opening
    · Use Optimized CTLE gDC for Near-end Eye Opening (Short)
    · Use Optimized CTLE gDC2 for Near-end Eye Opening (Short)
    · Use Optimized CTLE gDC for Near-end Eye Opening (Long)
    · Use Optimized CTLE gDC2 for Near-end Eye Opening (Long)
    · Use Optimized CTLE gDC for Far-end Eye Opening (Short)
    · Use Optimized CTLE gDC2 for Far-end Eye Opening (Short)
    · Use Optimized CTLE gDC for Far-end Eye Opening (Long)
    · Use Optimized CTLE gDC2 for Far-end Eye Opening (Long)

    The following two methods can be used to find the optimum CTLE gDC and gDC2:

    · Optimize CTLE using COM Method - FFE is calculated and included in the measurement to find the optimized CTLE settings.
    · Auto-Tune - The measurement does not use FFE.

    Configure appropriate settings using the COM tool settings and General settings configuration variables under the Utilities category in the Configure tab.

2   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 Conformance Test Application matches the frequency of the acquired input signal.

Utilities in IEEE Tests

The procedure described in this section to find Optimal CTLE Eye Opening are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
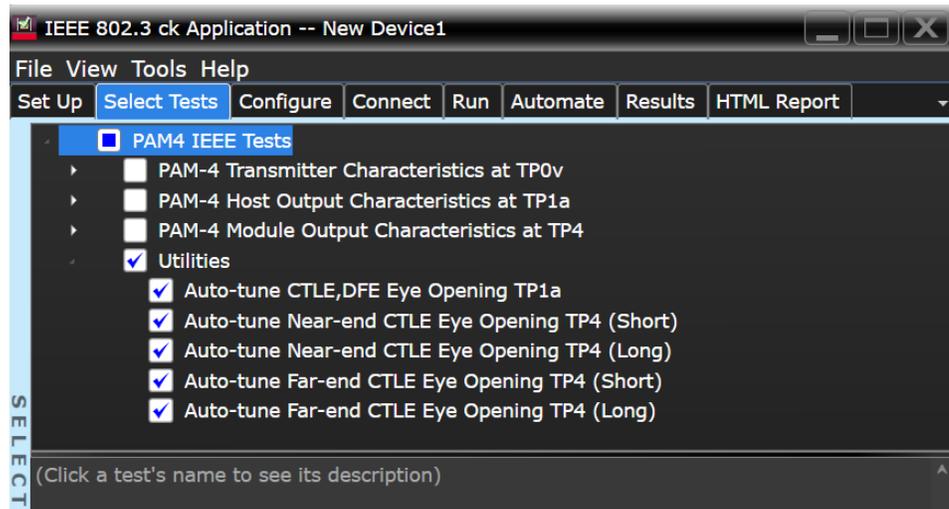
Figure 25   Selecting Utilities under the Select Tests tab

Auto-tune CTLE, DFE Eye Opening TP1a

Test Overview   The purpose of this test is to measure the eye height and VEC with CTLE and DFE settings at TP1a and report the optimal settings to use in Eye measurements. The optimal values are automatically set in the Configure tab after this test has run.

Measurement Algorithm

1 Obtain sample or acquire signal data.

2 Apply the Start CTLE gDC.

3 Apply the Start CTLE gDC2 that corresponds to the current gDC setting.

4 Set DFE to pulse response method and 4 taps.

5 Auto find the optimal DFE taps.

6 Measure eye height and VEC.

7 Step to next CTLE gDC2 value.

8 Auto find the optimal DFE taps.

9 Measure eye height and VEC.

10 Compare eye height and VEC results. Optimal eye is where eye height is greater than 10mV and the minimum VEC of any eye height greater than 15mV. (User can select if these comparison values are min/max or average in the Configure tab.)

11 Repeat steps 7-10 for the rest of the gDC2 settings available for the gDC setting.

12 Set to next gDC setting.

13 Repeat steps 7-10 for each gDC2 setting.

14 Repeat step 12-13 for each gDC setting – If eye height and VEC are not improving after three more steps, app will stop loop and report the optimal CTLE gDC and gDC2 and DFE settings. (User can select to run all the gDC/gDC2 options in the Configure tab).

Auto-tune Far-end CTLE Eye Opening TP4

Test Overview   The purpose of this test is to measure the far-end eye height and far-end VEC with each CTLE setting at TP4 and report the optimal setting to use in the Far-end Eye measurements. The optimal value is automatically set in the Configure tab after this test has run. The measurement is made either in short module output mode or long module output mode.

Measurement Algorithm The measurement algorithm for this test is same as for the previous test with the difference that the far-end channel response is applied to the eye.

Auto-tune Near-end CTLE Eye Opening TP4

Test Overview The purpose of this test is to measure the near-end eye height and near-end VEC with each CTLE setting at TP4 and report the optimal setting to use in the Near-end Eye measurements. The optimal value is automatically set in the Configure tab after this test has run. The measurement is made either in short module output mode or long module output mode.

Measurement Algorithm The measurement algorithm for this test is same as for the previous test except that the gDC and gDC2 combinations and options are different.

4 CR Tests

This section provides the Methods of Implementation (MOIs) for the tests for IEEE PAM4 Transmitter Characteristics for 100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4. Measurements are made at test point TP2.

| NOTE | Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application matches the frequency of the acquired input signal. |

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Transmitter characteristics for CR tests

See Table 5 for pass limits pertaining to 100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4 PAM4 tests, which are specified in *IEEE P802.3ck^{TM} /D3.3 (Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling) section 162.9.4, Table 162-11.*

Table 5   100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4 transmitter characteristics at TP2

Parameter	Reference	Value	Units
Differential pk-to-pk output voltage (max) with TX disabled[a]	See Sec. 93.8.1.3 of the IEEE specification	30	mV
DC common-mode voltage (min)[a] DC common-mode voltage (max)[a]	See Sec. 93.8.1.3 of the IEEE specification	0 1.9	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM-LF Full-band, VCM-FB	162.9.4.4	 30 80	 mV mV
Differential pk-to-pk, v_{di} (max)[a]	See Sec. 93.8.1.3 of the IEEE specification	1200	mV
Effective return loss, ERL (min)	See Sec. 162.9.4.8 of the IEEE specification	7.3	dB
Common-mode to differential mode return loss (min)	See Sec. 162.9.4.10 of the IEEE specification	See Eq. 162-7	dB
Common-mode to common-mode return loss (min)	See Sec. 162.9.4.9 of the IEEE specification	2	dB
Transmitter steady-state voltage, vf (min) Transmitter steady-state voltage, vf (max)	See Sec. 162.9.4.1.2 of the IEEE specification	0.387 0.6	V V
Linear fit pulse peak ratio (min)	See Sec. 162.9.4.1.2 of the IEEE specification	0.397	-
Level separation mismatch ratio R_{LM} (min)	See Sec.162.9.4.2 of the IEEE specification	0.95	-
Transmitter output waveform abs step size for all taps (min) abs step size for all taps (max) value at minimum state for c(–3) (max) value at maximum state for c(–2) (min) value at minimum state for c(–1) (max) value at minimum state for c(0) (max) value at minimum state for c(1) (max)	See Sections 162.9.4.1.4 162.9.4.1.4 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5	 0.005 0.025 −0.06 0.12 −0.34 0.5 −0.2	 - - - - - - -
Signal-to-noise-and-distortion ratio SNDR (min)	See Sec.162.9.4.6 of the IEEE specification	31.5	dB
Signal-to-residual-intersymbol-interference ratio, SNRISI (min)	See Sec.162.9.4.3 of the IEEE specification	26.7	dB
Output jitter (max.) JRMS J3u03 J3u Even-odd jitter, pk-pk	See Sections 162.9.4.7 162.9.4.7 162.9.4.7 162.9.4.7	 0.023 0.115 0.125 0.025	 UI UI UI UI
Signaling rate per lane (range)	162.9.4.1	53.125 ± 50 ppm	GBd

a. Measurement uses the method described in section 93.8.1.3 of IEEE specification with the exception that the PRBS13Q test pattern is used.

Main Voltage Measurements TP2 (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.


Figure 26   Selecting Main Voltage Measurement Tests

Refer to Table 5 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Main Voltage Measurements TP2 (pattern: PRBS13Q) tests, see:

· "Differential Peak to Peak Output Voltage Test with TX Disabled" on page 78
· "Low-Frequency Peak to Peak AC Common-Mode Voltage, VCM-LF" on page 78
· "Full-Band Peak to Peak AC Common-Mode Voltage, VCM-FB" on page 79
· "DC Common Mode Output Voltage Test" on page 79
· "Differential Peak-to-Peak Output Voltage Test" on page 80

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 meets the specified standards.

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

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 the specified standards.

Low-Frequency Peak to Peak AC Common-Mode Voltage, VCM-LF

Test Overview   The purpose of this test is to verify that the low-frequency peak to peak AC common mode voltage of the signal meets the specified standards.

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

Pass Condition Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm
1 Set the frame trigger to free run and obtain 131072 pts/wfm.
2 Verify that there is a signal and that the connection is dual single-ended with low-pass filter.
3 Set common mode signal using the common mode function.
4 AC Common Mode voltage range includes all but 10-4 of the measured distribution, from 0.00005 to 0.99995 of the cumulative distribution.
5 Measure the peak-to-peak voltage of the common mode signal.
6 Compare the voltage measurement to the specified standards.

Full-Band Peak to Peak AC Common-Mode Voltage, VCM-FB

Test Overview The purpose of this test is to verify that the full-band peak to peak AC common mode voltage of the signal meets the specified standards.

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

Pass Condition Refer to Table 5 for the pass limits pertaining to each standard option.

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 Set common mode signal using the common mode function.
4 AC Common Mode voltage range includes all but 10-4 of the measured distribution, from 0.00005 to 0.99995 of the cumulative distribution.
5 Measure the peak-to-peak voltage of the common mode signal.
6 Compare the voltage measurement to the specified standards.

DC Common Mode Output Voltage Test

Test Overview The purpose of this test is to verify that the common mode signal meets the specified standards.

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

Pass Condition Refer to Table 5 for the pass limits pertaining to each standard option.

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 Set common mode signal using the common mode function.
4 Measure minimum and maximum voltage of the common mode signal.
5 Compare the voltage measurement to the specified standards.

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 PRBS13Q pattern meets the specified standards.

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Obtain sample or acquire signal data.

2   Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.

3   Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.

4   Compare the maximum peak-to-peak voltage to the specified standards.

Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
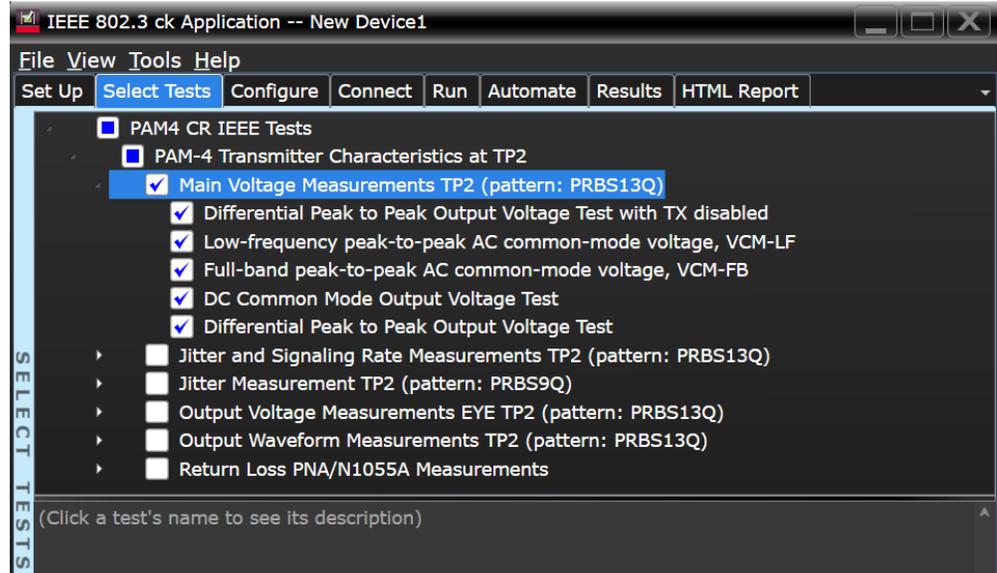

Figure 27   Selecting Jitter and Signaling Rate Measurement Tests

Refer to Table 5 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 81
- "JRMS" on page 82
- "J3u" on page 82
- "Even-Odd Jitter (PRBS13Q)" on page 82
- "J3u03" on page 83

Signaling Rate

Test Overview   The purpose of this test is to verify that the signaling rate meets the specified standards.

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Obtain sample or acquire signal data.
2   Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
3   In the **Configure** tab, set **Signaling Rate** to 53.125 GBd.
4   Measure minimum and maximum data rate.
5   Report minimum and maximum values.
6   Compare the mean data rate value with the specified standards. Report the resulting value.

JRMS

Test Overview   The purpose of this test is to verify that differential signal's JRMS meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

    a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the JRMS value to the specified standards.

J3u

Test Overview   The purpose of this test is to verify that differential signal's J3u meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

    a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the J3u value meets the specified standards.

Even-Odd Jitter (PRBS13Q)

Test Overview   The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the Even-Odd Jitter value to the specified standards.

J3u03

Test Overview   The purpose of this test is to verify that differential signal's J3u03 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the J3u03 value meets the specified standards.

Jitter Measurement TP2 (pattern: PRBS9Q)

The Jitter Measurement procedure described in this section is performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
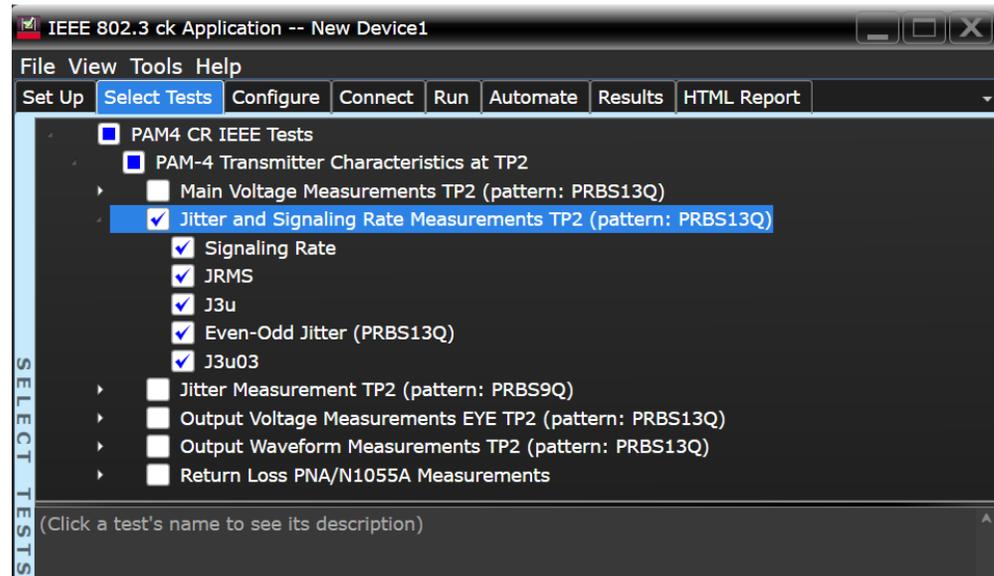

Figure 28   Selecting Jitter and Signaling Rate Measurement Tests

Refer to Table 5 for information on the pass limits for each test that is displayed for the selected standard option.

Even-Odd Jitter (PRBS9Q)

Test Overview   The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS9Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

    a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the Even-Odd Jitter value to the specified standards.

Output Voltage Measurements EYE TP2 (pattern: PRBS13Q)

The Output Voltage Measurement EYE procedures for a signal with PRBS13Q pattern that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 29   Selecting Output Voltage Measurements EYE Tests

Refer to Table 5 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Voltage Measurements EYE TP2 (pattern: PRBS13Q) tests, see:

· "Level – PRBS Pattern" on page 85
· "Level RMS – PRBS Pattern" on page 86
· "Level Separation Mismatch Ratio – RLM" on page 86

NOTE	The tests Level - PRBS pattern and Level RMS - PRBS pattern are considered as "Information-Only" tests and cannot be used for conformance validation.

Level – PRBS Pattern

Test Overview   The purpose of this test is to obtain the mean voltage of each level of the signal with PRBS13Q pattern.

Pass Condition   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm

1   Check that signal is connected and proper data pattern exists (PRBS13Q pattern must be used for this test).

2   V_0, V_1, V_2 and V_3 are the mean signal levels of the symbols corresponding to the PAM4 symbol levels 0, 1, 2 and 3 respectively, as defined in IEEE P802.3bs^{TM} /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2. The calculation of mean signal levels is also defined in section 120D.3.1.2.1.

3   The mean level V_{mid} is defined by equation (120D-3), which is,

$$V_{mid} = (V_0 + V_3) / 2$$

4   Report this value for information-only purpose.

Level RMS - PRBS Pattern

Test Overview   The purpose of this test is to obtain the of the RMS level of the signal with PRBS13Q pattern.

Pass Condition   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm

1   Run the Level - PRBS Pattern test as a prerequisite to this test.

2   The minimum signal level RMS is calculated, as defined in IEEE P802.3bs[TM] /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.

3   Report this value for information-only purpose.

Level Separation Mismatch Ratio - RLM

Test Overview   The purpose of this test is to obtain the of the Separation Mismatch Ratio level (RLM) of the signal with PRBS13Q pattern.

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Run the Level - PRBS Pattern as a prerequisite to this test to calculate the mid-range level.

2   The mean signal levels are normalized so that V_0 corresponds to -1, V_1 to -ES1, V_2 to ES2 and V_3 to 1.

3   ES1 and ES2 are calculated using equations (120D-4) and (120D-5), respectively of the IEEE P802.3bs[TM] /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.

$$ES1 = (V_1 - V_{mid}) / (V_0 - V_{mid})$$

$$ES2 = (V_2 - V_{mid}) / (V_3 - V_{mid})$$

4   The level separation mismatch ratio R_{LM} is defined by equation (120D-5).

$$R_{LM} = min [(3 \times ES1), (3 \times ES2), (2 - 3 \times ES1), (2 - 3 \times ES2)]$$

5   Report this value for information-only purpose.

Output Waveform Measurements TP2 (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
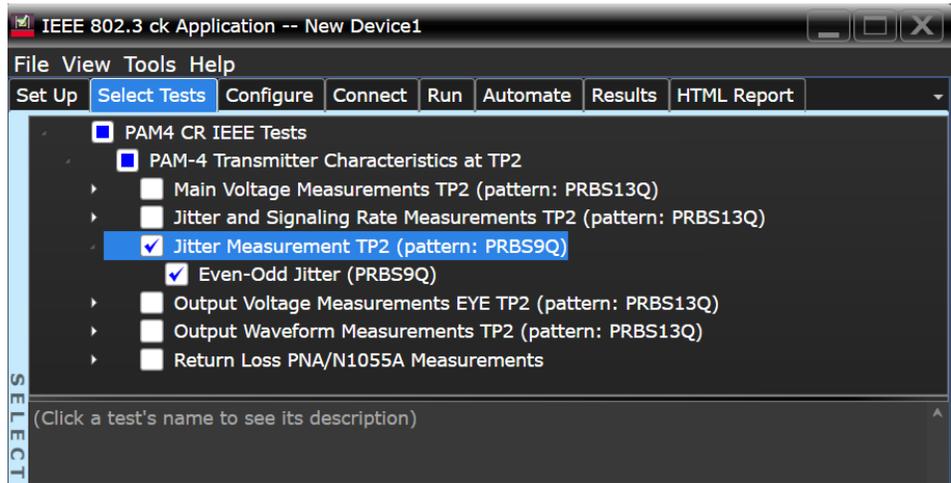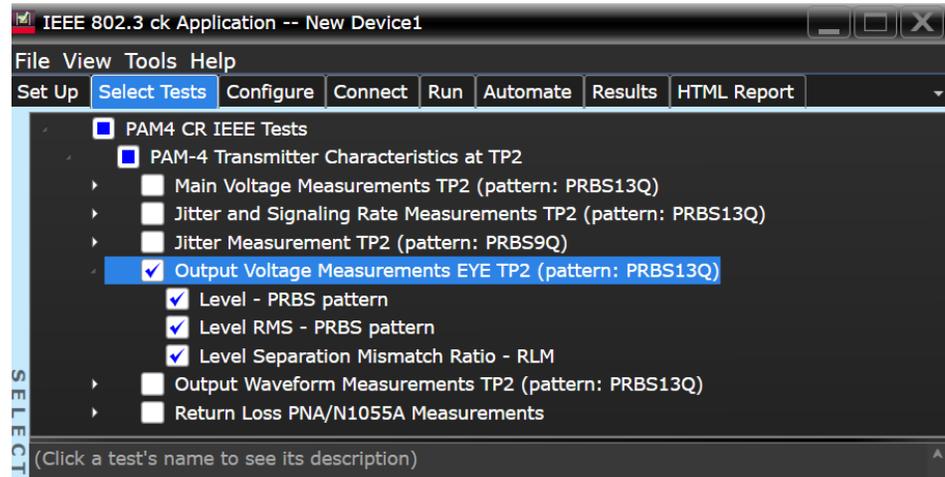

Figure 30   Selecting Transmitter Output Waveform Measurement Tests

Refer to Table 5 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Waveform Measurements TP2 (pattern: PRBS13Q) tests, see:

· "Steady State Voltage Vf" on page 87
· "Linear Fit Pulse Peak Ratio" on page 88
· "Signal-to-noise-and-distortion ratio" on page 88
· "ERL" on page 88
· "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 89
· "abs Step Size Tests" on page 89
· "Coefficient Initialization" on page 94

Steady State Voltage V_f

Test Overview   The purpose of this test is to verify that the Steady State Voltage is between 0.387V and 0.6V.

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).

2   Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.

3   Calculate V_f using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of p(k)/M. $N_p = 200$, $D_p = 4$.

4   Compare and report the resulting value in the range between 0.387V and 0.6V.

Linear Fit Pulse Peak Ratio

Test Overview   The purpose of this test is to verify that the Linear Fit Pulse Ratio meets the specified standards.

NOTE   Run the Steady-State Voltage Vf test as a prerequisite to running the Linear Fit Pulse Peak Ratio test.

Pass Conditions   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm
1   Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).
2   Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
3   Calculate the transmitter output steady-state voltage, Vf and linear fit pulse response peak voltage, Vpeak.
4   Calculate the Linear Fit Pulse Peak Ratio by dividing Vpeak with Vf.
5   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 Table 5 for the pass limits pertaining to each standard option.

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.

ERL

Test Overview   The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm   The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and help in the ERL computation.
1   In the **Set Up** tab of the Compliance Test Application, specify the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters) in the **ERL File Setup** field.
2   Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
3   Specify appropriate values for the **ERL Settings** configuration variables under the Configure tab.
4   Click **Run** under the **Run** tab.
5   The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 162-13) and the user-specified S-parameter file for return loss at TP0v measurement to compute ERL at TP2. The computed ERL at TP2 is reported as the result.

Signal-to-residual-intersymbol-interference ratio, SNRISI

Test Overview   The purpose of this test is to verify that the highest value of the Signal to residual intersymbol interference ratios (SNRISI) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards:

0 dB through -20 dB gDC and - 6 dB through 0 dB gDC2

Pass Condition   Refer to Table 5 for the pass limits pertaining to each standard option.

Measurement Algorithm
1   Select a test that pertains to a specific Output Gain value combination.
2   Calculate SNRISI for each test using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test. A time offset is added to tp (index of the linear fit pulse where p(tp) equals Pmax) whose value is swept from -0.5 UI to 0.5 UI when calculating ISIcursor. SNRISI is the lowest value found across the time offset sweep.
3   The highest SNRISI value will be reported based on the equalizer setting.
4   Compare the resulting value to the specified standards.

abs Step Size Tests

Test Overview   The purpose of this test is to verify the abs Step Size.

To know about the measurement algorithm for each abs Step Size test, see:
- "abs Step Size for c(-3)" on page 89
- "abs Step Size for c(-2)" on page 90
- "abs Step Size for c(-1)" on page 90
- "abs Step Size for c(0)" on page 90
- "abs Step Size for c(1)" on page 91
- "value at min. state for c(-3)" on page 91
- "value at max. state for c(-2)" on page 92
- "value at min. state for c(-1)" on page 92
- "value at min. state for c(0)" on page 92
- "value at min. state for c(1)" on page 92

abs Step Size for c(-3)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-3) is within limits.

Pass Condition   When abs Coefficient Step Size c(-3) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1   Request Transmitter to be set to "PRESET" condition.
2   Capture full pattern of PRBS13Q at 32 points per UI.
3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4   Define r(m) from "PRESET" as per equation 136-1.
5   Request to change c(-3) to the first step.
6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7   Calculate coefficients c(i) using equation 136-2.
8   Save coefficient c(-3) as base step value.
9   Request next c(-3) step.
10   Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11   Calculate coefficients c(i) using equation 136-2.
12   Calculate the step size as coefficient value from step 11 – coefficient value from step 7.

13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(-2)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-2) is within limits.

Pass Condition   When abs Coefficient Step Size c(-2) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1   Request Transmitter to be set to "PRESET" condition.
2   Capture full pattern of PRBS13Q at 32 points per UI.
3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4   Define r(m) from "PRESET" as per equation 136-1.
5   Request to change c(-2) to the first step.
6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7   Calculate coefficients c(i) using equation 136-2.
8   Save coefficient c(-2) as base step value.
9   Request next c(-2) step.
10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11 Calculate coefficients c(i) using equation 136-2.
12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(-1)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-1) is within limits.

Pass Condition   When abs Coefficient Step Size c(-1) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1   Request Transmitter to be set to "PRESET" condition.
2   Capture full pattern of PRBS13Q at 32 points per UI.
3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4   Define r(m) from "PRESET" as per equation 136-1.
5   Request to change c(-1) to the first step.
6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7   Calculate coefficients c(i) using equation 136-2.
8   Save coefficient c(-1) as base step value.
9   Request next c(-1) step.
10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11 Calculate coefficients c(i) using equation 136-2.
12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(0)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(0) is within limits.

Pass Condition   When abs Coefficient Step Size c(0) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define r(m) from "PRESET" as per equation 136-1.
	5	Request to change c(0) to the first step.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	7	Calculate coefficients c(i) using equation 136-2.
	8	Save coefficient c(0) as base step value.
	9	Request next c(0) step.
	10	Calculate linear fit pulse response as per section 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	11	Calculate coefficients c(i) using equation 136-2.
	12	Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
	13	Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(1)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(1) is within limits.

Pass Condition   When abs Coefficient Step Size c(1) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define r(m) from "PRESET" as per equation 136-1.
	5	Request to change c(1) to the first step.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	7	Calculate coefficients c(i) using equation 136-2.
	8	Save coefficient c(1) as base step value.
	9	Request next c(1) step.
	10	Calculate linear fit pulse response as per section 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.
	11	Calculate coefficients c(i) using equation 136-2.
	12	Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
	13	Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

value at min. state for c(-3)

Test Overview   The purpose of this test is to verify that the value at min. state for c(-3) is within limits.

Pass Condition   When value at min. state for c(-3) is less than or equal to -60 m.

Measurement Algorithm	1	Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
	2	Capture full pattern of PRBS13Q at 32 points per UI.
	3	Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
	4	Define r(m) from "PRESET" as per equation 136-1.
	5	Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(-3) to their minimum value.
	6	Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-3) value from step 7.

value at max. state for c(-2)

Test Overview   The purpose of this test is to verify that the value at max. state for c(-2) is within limits.

Pass Condition   When value at max. state for c(-2) is greater than or equal to 120 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-1), and c(1) to zero. Increment both c(0) and c(-2) to their maximum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-2) value from step 7.

value at min. state for c(-1)

Test Overview   The purpose of this test is to verify that the value at min. state for c(-1) is within limits.

Pass Condition   When value at min. state for c(-1) is less than or equal to -340 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-2), and c(1) to zero. Decrement both c(0) and c(-1) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-1) value from step 7.

value at min. state for c(0)

Test Overview   The purpose of this test is to verify that the value at min. state for c(0) is within limits.

Pass Condition   When value at min. state for c(0) is less than or equal to 500 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to decrement c(0) to minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(0) value from step 7.

value at min. state for c(1)

Test Overview   The purpose of this test is to verify that the value at min. state for c(1) is within limits.

Pass Condition   When value at min. state for c(1) is less than or equal to -200 m.

Measurement Algorithm

1. Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
2. Capture full pattern of PRBS13Q at 32 points per UI.
3. Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4. Define r(m) from "PRESET" as per equation 136-1.
5. Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(1) to their minimum value.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7. Calculate coefficients c(i) using equation 136-2.
8. Report c(1) value from step 7.

Coefficient Initialization

Test Overview   This test group consists of the following tests:

- Coefficient Initialization Preset 1
- Coefficient Initialization Preset 2 c(-3)
- Coefficient Initialization Preset 2 c(-2)
- Coefficient Initialization Preset 2 c(-1)
- Coefficient Initialization Preset 2 c(0)
- Coefficient Initialization Preset 2 c(1)
- Coefficient Initialization Preset 3 c(-3)
- Coefficient Initialization Preset 3 c(-2)
- Coefficient Initialization Preset 3 c(-1)
- Coefficient Initialization Preset 3 c(0)
- Coefficient Initialization Preset 3 c(1)
- Coefficient Initialization Preset 4 c(-3)
- Coefficient Initialization Preset 4 c(-2)
- Coefficient Initialization Preset 4 c(-1)
- Coefficient Initialization Preset 4 c(0)
- Coefficient Initialization Preset 4 c(1)
- Coefficient Initialization Preset 5 c(-3)
- Coefficient Initialization Preset 5 c(-2)
- Coefficient Initialization Preset 5 c(-1)
- Coefficient Initialization Preset 5 c(0)
- Coefficient Initialization Preset 5 c(1)

Pass Condition

Coefficient Update State	Preset	c(-3)	c(-2)	c(-1)	c(0)	c(1)
OUT_OF_SYNC[a]	N/A	0	0	0	1	0
NEW_IC	Preset 1[a]	0	0	0	1	0
	Preset 2	0 ±0.0125	0 ±0.0125	0 ±0.0125	0.5 ±0.0125	0 ±0.0125
	Preset 3	0 ±0.0125	0 ±0.0125	-0.075 ±0.0125	0.75 ±0.0125	0 ±0.0125
	Preset 4	0 ±0.0125	0.05 ±0.0125	-0.2 ±0.0125	0.75 ±0.0125	0 ±0.0125
	Preset 5	-0.025 ±0.0125	0.075 ±0.0125	-0.25 ±0.0125	0.65 ±0.0125	0 ±0.0125

a. PRESET1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 162.9.4.1.1). As a result the normalized coefficients for PRESET1 and OUT_OF_SYNC do not include any tolerances.

Measurement Algorithm (Preset 1)

1   Request Transmitter to be set to "PRESET 1" condition.
2   Capture full pattern of PRBS13Q at 32 points per UI.
3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4   Define r(m) from "PRESET" as per equation 136-1.
5   Request "Out of Sync" state.
6   Calculate linear fit pulse response as per 85.8.3.3.5 with Np = 200, Dp = 4.
7   Calculate coefficients c(-3) , c(-2), c(-1), c(0), and c(1) using equation 136-2.
8   Report c(-3) , c(-2), c(-1), c(0) and c(1) values from step 7.
9   Request "Preset 1" state.
10 Calculate linear fit pulse response as per 85.8.3.3.5 with Np = 200, Dp = 4.
11 Calculate coefficients c(-3) , c(-2), c(-1), c(0) and c(1) using equation 136-2.
12 Report c(-3), c(-2), c(-1), c(0), and c(1) values from step 11.

Measurement Algorithm (Preset 2 to Preset 5)

1   Request Transmitter to be set to "PRESET 1" condition.
2   Capture full pattern of PRBS13Q at 32 points per UI.
3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4   Define r(m) from "PRESET" as per equation 136-1.
5   Request preset # (for each test).
6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7   Calculate coefficients c(i) using equation 136-2.
8   Report c(#) value from step 7.

Return Loss PNA/N1055A Measurements

The Return Loss PNA/N1055A measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope along with either a PNA or an N1055A and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. The Conformance Test Application controls the PNA/N1055A to set the test limits and run the tests. You must ensure that the connected device is calibrated.

Figure 31   Selecting Return Loss PNA/N1055A Measurements Tests

Refer to Table 5 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Return Loss PNA/N1055A Measurements tests, see:

· "Common-mode to Common-mode Output Return Loss" on page 96
· "Common-mode to Differential Output Return Loss" on page 96

Common-mode to Common-mode Output Return Loss

Measurement Algorithm
1 Ensure that the PNA/N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Conformance Test Application, select **PNA** to establish connectivity to the connected equipment. For N1055A, select **N1055A**.
3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.
5 Compare the reported values with the specification to check for conformance.

Common-mode to Differential Output Return Loss

Measurement Algorithm
1 Ensure that the PNA/N1055A is physically connected and calibrated.
2 In the **Set Up** tab of the Conformance Test Application, select **PNA** to establish connectivity to the connected equipment. For N1055A, select **N1055A**.
3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.

5   Compare the reported values with the specification to check for conformance.

5 KR Tests

This section provides the Methods of Implementation (MOIs) for the tests for IEEE PAM4 Transmitter Characteristics for 100GBASE-KR, 200GBASE-KR2, and 400GBASE-KR4. Measurements are made at test point TP0v.

NOTE   Ensure that the **Signaling Rate** setting in the **Configure** tab of the Conformance Test Application must match the frequency of the acquired input signal.

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Transmitter characteristics for KR tests

See Table 6 for pass limits pertaining to 100GBASE-KR, 200GBASE-KR2, and 400GBASE-KR4 PAM4 tests, which are specified in *IEEE P802.3ck^{TM} /D3.3 (Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 100Gb/s, 200Gb/s, and 400Gb/s Electrical Interfaces Based on 100 Gb/s Signaling) section 163.9.2, Table 163-5*.

Table 6   100GBASE-KR, 200GBASE-KR2, and 400GBASE-KR4 transmitter characteristics at TP0v

Parameter	Reference	Value	Units
Signaling rate per lane (range)		53.125 ± 50 ppm	GBd
Differential peak-to-peak voltage[a] (max) Transmitter disabled Transmitter enabled	See Sec. 93.8.1.3 of the IEEE specification	30 1200	mV mV
DC Common-mode voltage[a] (max)	See Sec. 93.8.1.3 of the IEEE specification	1.0	V
DC Common-mode voltage[a] (min)	See Sec. 93.8.1.3 of the IEEE specification	0.2	V
Low frequency peak-to-peak AC common mode voltage, VCM_{LF} (max)	162.9.4.4	30	mV
Signal to AC common-mode noise ratio, SCMR (min)	163.9.2.6	15	dB
Difference effective return loss (min), dERL	163.9.2.2	-3	dB
Common-mode to common-mode output return loss, RLcc(max)	163.9.2.3	-3.25	dB
Difference steady-state voltage (min), dvf	163.9.2.4	0	V
Difference linear fit pulse peak ratio (min), dRpeak	163.9.2.5	0	V
Level separation mismatch ratio RLM (min.)	162.9.4.2	0.95	-
Transmitter waveform abs step size for c(–3), c(–2), c(–1), c(0), and c(1) (min.) abs step size for c(–3), c(–2), c(–1), c(0), and c(1) (max.) value at minimum state for c(–3) (max.) value at maximum state for c(–2) (min.) value at minimum state for c(–1) (max.) value at minimum state for c(0) (max.) value at minimum state for c(1) (max.)	See Sections 162.9.4.1.4 162.9.4.1.4 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5 162.9.4.1.5	0.005 0.025 −0.06 0.12 −0.34 0.5 −0.2	- - - - - - -
Signal-to-noise-and-distortion ratio SNDR (min)	162.9.4.6	32.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	162.9.4.3	28	dB
Jitter[b] JRMS (max) J3u03 J3u (max) Even-odd jitter, pk-pk (max)[e]	See Sections 162.9.4.7 162.9.4.7 162.9.4.7 162.9.4.7	0.023 0.106 0.115 0.025	UI UI UI UI

a. Measurement uses the method described in section 93.8.1.3 of IEEE specification with the exception that the PRBS13Q test pattern is used.

b. J3u, JRMS, and even-odd jitter measurements are made with a single transmit equalizer setting selected to compensate for the loss of the transmitter package and TP0 to TP0v test fixture.

Main Voltage Measurements TP0v (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 32   Selecting Main Voltage Measurement Tests

Refer to Table 6 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Main Voltage Measurements TP0v (pattern: PRBS13Q) tests, see:

· "Differential Peak-to-Peak Output Voltage Test with TX Disabled" on page 99
· "Low-frequency peak-to-peak AC Common Mode Voltage, VCM-LF" on page 99
· "DC Common Mode Output Voltage Test" on page 100
· "Differential Peak-to-Peak Output Voltage Test" on page 100

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 meets the specified standards.

Pass Condition   Refer to Table 6 for the pass limits pertaining to each standard option.

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 the specified standards.

Low-frequency peak-to-peak AC Common Mode Voltage, VCM-LF

Test Overview   The purpose of this test is to verify that the low-frequency peak-to-peak AC common mode voltage of the signal meets the specified standards.

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

Pass Condition   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm
1. Set the frame trigger to free run and obtain 131072 pts/wfm.
2. Verify that there is a signal and that the connection is dual single-ended with low-pass filter.
3. Set common mode signal using the common mode function.
4. AC Common Mode voltage range includes all but 10-4 of the measured distribution, from 0.00005 to 0.99995 of the cumulative distribution.
5. Measure the peak-to-peak voltage of the common mode signal.
6. Compare the voltage measurement to the specified standards.

DC Common Mode Output Voltage Test

Test Overview   The purpose of this test is to verify that the common mode signal meets the specified standards.

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

Pass Condition   Refer to Table 6 for the pass limits pertaining to each standard option.

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. Set common mode signal using the common mode function.
4. Measure minimum and maximum voltage of the common mode signal.
5. Compare the voltage measurement to the specified standards.

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 PRBS13Q pattern meets the specified standards.

Pass Condition   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm
1. Obtain sample or acquire signal data.
2. Verify that the signal is connected, has TX enabled and has a PRBS13Q pattern.
3. Measure the peak-to-peak voltage of the differential signal on DUT+ and DUT-.
4. Compare the maximum peak-to-peak voltage to the specified standards.

Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.
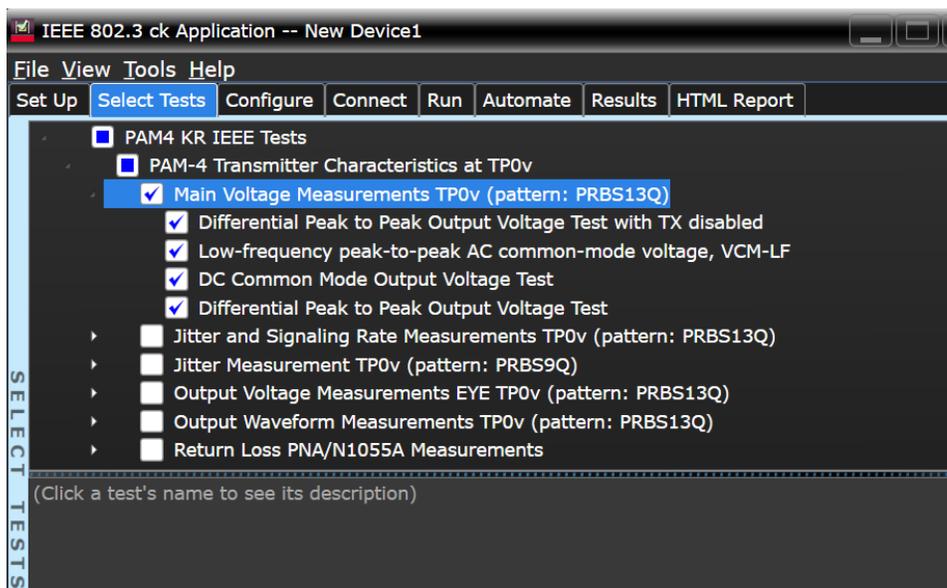

Figure 33   Selecting Jitter and Signaling Rate Measurement Tests

Refer to Table 6 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q) tests, see:

- "Signaling Rate" on page 101
- "JRMS" on page 102
- "J3u" on page 102
- "Even-Odd Jitter (PRBS13Q)" on page 102
- "J3u03" on page 103

Signaling Rate

Test Overview The purpose of this test is to verify that the signaling rate meets the specified standards.

Pass Condition Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm
1 Obtain sample or acquire signal data.
2 Check that the signal is connected, has a bit-rate of 53.125 GHz and that data pattern exists (PRBS13Q must be used for this test).
3 In the **Configure** tab, set **Signaling Rate** to 53.125 GBd.
4 Measure minimum and maximum data rate.
5 Report minimum and maximum values.
6 Compare the mean data rate value with the specified standards. Report the resulting value.

JRMS

Test Overview   The purpose of this test is to verify that differential signal's JRMS meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

   a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

   b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the JRMS value to the specified standards.

J3u

Test Overview   The purpose of this test is to verify that differential signal's J3u meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

NOTE   Signal must be of PRBS13Q pattern.

---

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

   a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

   b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report whether the J3u value meets the specified standards.

Even-Odd Jitter (PRBS13Q)

Test Overview   The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm	1 Obtain sample or acquire signal data.

> **NOTE**   Signal must be of PRBS13Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

  a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

  b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the Even-Odd Jitter value to the specified standards.

J3u03

Test Overview   The purpose of this test is to verify that differential signal's J3u03 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

> **NOTE**   Signal must be of PRBS13Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

  a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

  b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report whether the J3u value meets the specified standards.

Jitter Measurement TP0v (pattern: PRBS9Q)

The Jitter Measurement procedure described in this section is performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 34   Selecting Jitter Measurement Test

Refer to Table 6 for information on the pass limits for each test that is displayed for the selected standard option.

Even-Odd Jitter (PRBS9Q)

Test Overview   The purpose of this test is to verify that differential signal's Even-Odd Jitter meets the specified standards.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm   1   Obtain sample or acquire signal data.

> **NOTE**   Signal must be of PRBS9Q pattern.

2   In the **Configure** tab, set the value for the Signaling Rate as that of the Symbol Rate of the acquired signal.

3   On the Oscilloscope,

    a   Set Clock Recovery to OJTF First Order PLL with Nominal Data Rate (53.125 GBd) and Loop Bandwidth to 4 MHz.

    b   Set 4th Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4   Compare and report the Even-Odd Jitter value to the specified standards.

Output Voltage Measurements EYE TP0v (pattern: PRBS13Q)

The Output Voltage Measurement EYE procedures for a signal with PRBS13Q pattern that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

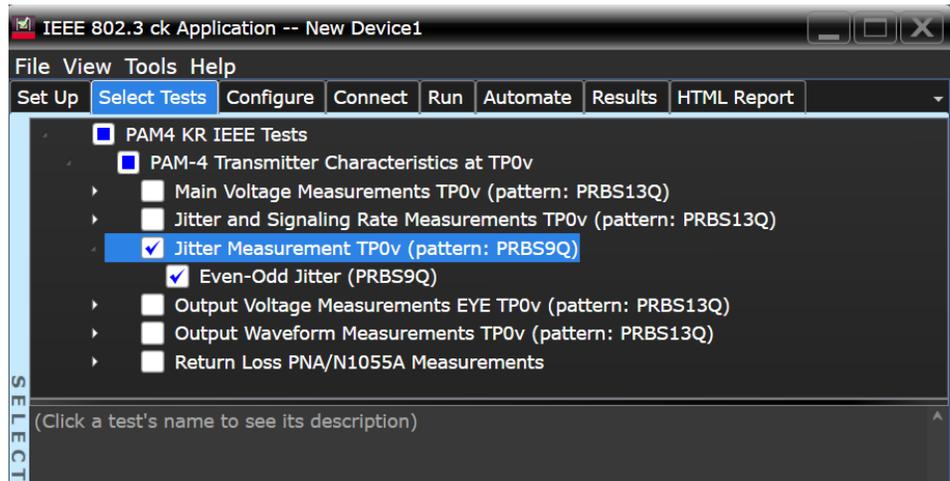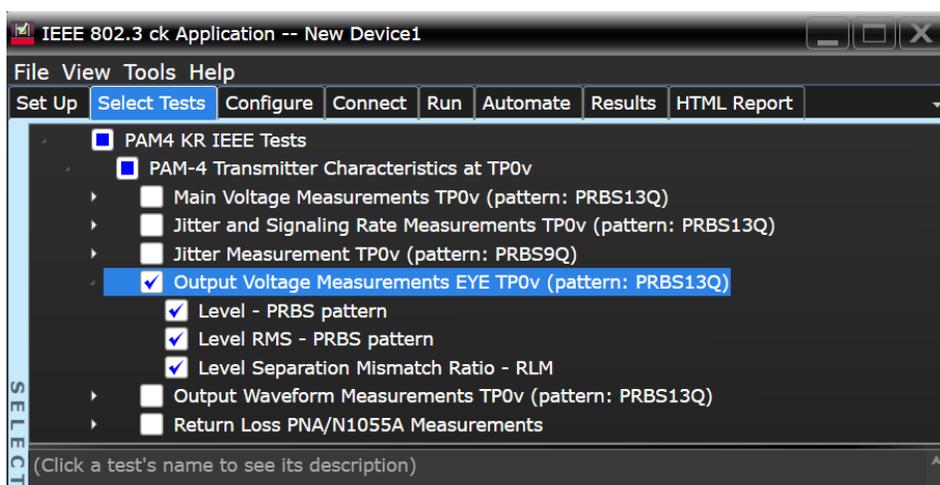Figure 35   Selecting Output Voltage Measurements EYE Tests

Refer to Table 6 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Voltage Measurements EYE TP0v (pattern: PRBS13Q) tests, see:

- "Level - PRBS Pattern" on page 105
- "Level RMS - PRBS Pattern" on page 106
- "Level Separation Mismatch Ratio - RLM" on page 106

> **NOTE** The tests Level - PRBS pattern and Level RMS - PRBS pattern are considered as "Information-Only" tests and cannot be used for conformance validation.

Level - PRBS Pattern

Test Overview The purpose of this test is to obtain the mean voltage of each level of the signal with PRBS13Q pattern.

Pass Condition Not applicable as the test result is considered as "Information Only".

Measurement Algorithm

1 Check that signal is connected and proper data pattern exists (PRBS13Q pattern must be used for this test).

2 V_0, V_1, V_2 and V_3 are the mean signal levels of the symbols corresponding to the PAM4 symbol levels 0, 1, 2 and 3 respectively, as defined in IEEE P802.3bs[TM] /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2. The calculation of mean signal levels is also defined in section 120D.3.1.2.1.

3 The mean level V_{mid} is defined by equation (120D-3), which is,

$$V_{mid} = (V_0 + V_3) / 2$$

4   Report this value for information-only purpose.

Level RMS - PRBS Pattern

Test Overview   The purpose of this test is to obtain the of the RMS level of the signal with PRBS13Q pattern.

Pass Condition   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm

1   Run the Level - PRBS Pattern test as a prerequisite to this test.

2   The minimum signal level RMS is calculated, as defined in IEEE P802.3bs[TM] /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.

3   Report this value for information-only purpose.

Level Separation Mismatch Ratio - RLM

Test Overview   The purpose of this test is to obtain the of the Separation Mismatch Ratio level (RLM) of the signal with PRBS13Q pattern.

Pass Condition   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Run the Level - PRBS Pattern as a prerequisite to this test to calculate the mid-range level.

2   The mean signal levels are normalized so that V_0 corresponds to -1, V_1 to -ES1, V_2 to ES2 and V_3 to 1.

3   ES1 and ES2 are calculated using equations (120D-4) and (120D-5), respectively of the IEEE P802.3bs[TM] /D3.5 (Draft Standard for Ethernet Amendment 10: Media Access Control Parameters, Physical Layers and Management Parameters for 200Gb/s and 400Gb/s Operation), Annex 120D.3.1.2.

$$ES1 = (V_1 - V_{mid}) / (V_0 - V_{mid})$$

$$ES2 = (V_2 - V_{mid}) / (V_3 - V_{mid})$$

4   The level separation mismatch ratio R_{LM} is defined by equation (120D-5).

$$R_{LM} = min [(3 \times ES1), (3 \times ES2), (2 - 3 \times ES1), (2 - 3 \times ES2)]$$

5   Report this value for information-only purpose.

Output Waveform Measurements TP0v (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application.

Figure 36   Selecting Transmitter Output Waveform Measurement Tests

Refer to Table 6 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Output Waveform Measurements TP0v (pattern: PRBS13Q) tests, see:

- "Steady State Voltage Vf" on page 107
- "Linear Fit Pulse Peak" on page 108
- "dVf" on page 108
- "dRpeak" on page 108
- "Signal-to-noise-and-distortion ratio" on page 109
- "Signal to AC common-mode noise ratio, SCMR" on page 109
- "ERL" on page 109
- "dERL" on page 109
- "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 110
- "abs Step Size Tests" on page 110

Steady State Voltage V_f

Test Overview   The purpose of this test is to determine the Steady State Voltage.

Pass Condition   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm	1	Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).
	2	Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q pattern.
	3	Calculate V_f using the equations in section 85.8.3.3.5. The resulting value is the sum of columns of p(k)/M. N_p = 200, D_p = 4.

Linear Fit Pulse Peak

Test Overview   The purpose of this test is to determine the Linear Fit Pulse value.

> **NOTE**   Run the Steady-State Voltage Vf test as a prerequisite to running the Linear Fit Pulse Peak test.

Pass Conditions   Not applicable as the test result is considered as "Information Only".

Measurement Algorithm	1	Check that signal is connected and proper data pattern exists (PRBS13Q must be used for this test).
	2	Set memory depth and sample rate to capture the 8191 bits of the PRBS13Q 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 = 4.

dVf

Test Overview   The purpose of this test is to verify that dVf meets the specified standards.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm	1	The user enters the fixture s-parameter (S0) file in the **Fixture Ref File Setup** field under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.
	2	Calculate the reference transfer function using equation 163A-2.
	3	Calculate Vref(peak) as max of h(t).
	4	Calculate Vf(ref) using equation 163A-3.
	5	Calculate dVf using equation 163A-6.

See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.

dRpeak

Test Overview   The purpose of this test is to verify that dRpeak meets the specified standards.

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm	1	The user enters the fixture s-parameter (S0) file in the **Fixture Ref File Setup** field under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.
	2	Calculate the reference transfer function using equation 163A-2.
	3	Calculate Vref(peak) as max of h(t).
	4	Calculate Vf(ref) using equation 163A-3.
	5	Calculate dRpeak using equation 163A-7.

See also "A Note on Difference Measurements (dvf, dRpeak, and dERL)" on page 33.

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 Table 6 for the pass limits pertaining to each standard option.

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.

Signal to AC common-mode noise ratio, SCMR

Test Overview The purpose of this test is to verify that the Signal to AC common-mode noise ratio (SCMR) meets the specified standards.

Pass Condition Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm
1 Calculate SCMR using measurement from Linear Fit Pulse peak and Full Band Pk-Pk AC Common mode voltage. The formula is 20log(Vpeak/VcmFB).

2 Compare the resulting value of SCMR to the specified standards.

ERL

Test Overview The purpose of this test is to verify that the Effective Return Loss (ERL) meets the specified standards.

Pass Condition Not applicable as the test result is considered as "Information Only".

Measurement Algorithm
1 In the **Set Up** tab of the Compliance Test Application,
   a In the **ERL File Setup** field, specify the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters).
   b In the **Fixture Ref File Setup** field, specify the fixture s-parameter file to calculate the Tfx Delay.

2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.

3 Specify appropriate values for the **ERL Settings** configuration variables under the **Configure** tab.

4 Click **Run** under the **Run** tab. The Compliance Test Application automatically calculates the effective return loss by using the COM tool (downloadable from IEEE org website).

dERL

Test Overview The purpose of this test is to verify that dERL meets the specified standards.

Pass Conditions Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm The COM MATLAB script takes the user-specified s-parameter files and the configuration spreadsheets (available with the COM tool) as the input and help in the ERL computation.

1 The user enters the initial ERL channel file in the **ERL File Setup** field under the Setup tab.

2 The user enters the fixture s-parameter (S0) file in the **Fixture Ref File Setup** field under the Setup tab. Refer to Annex 163A.4.1 for information about the standards defined to create the s-parameters file for reference fixture.

3 Under the Configure tab, specify values for the following configuration variables:
   a ERL Settings configuration variables (in the Compliance mode)
   b Reference ERL Settings configuration variables (in the Debug mode)

4 Enable the user to select if they want to apply Tfx Delay when calculating the Reference ERL.

5 The COM tool uses the spreadsheet for ERL (with COM parameter values from Table 120F-8) and the s-parameter file for test fixture (s4p file) to compute reference ERL or ERL ref.

6   The COM tool uses the spreadsheet for ERL (with the ERL parameter values in the Table 120F-2) and the user-specified s4p for return loss at TP0v measurement to compute ERL at TP0v.

7   The difference between ERL TP0v and ERL ref is reported as the result.

See also

Signal-to-residual-intersymbol-interference ratio, SNRISI

Test Overview   The purpose of this test is to verify that the highest value of the Signal to residual intersymbol interference ratios (SNRISI) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards:

0 dB through -20 dB gDC and - 6 dB through 0 dB gDC2

Pass Conditions   Refer to Table 6 for the pass limits pertaining to each standard option.

Measurement Algorithm

1   Select a test that pertains to a specific Output Gain value combination.

2   Calculate SNRISI for each test using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test. A time offset is added to tp (index of the linear fit pulse where p(tp) equals Pmax) whose value is swept from -0.5 UI to 0.5 UI when calculating ISIcursor. SNRISI is the lowest value found across the time offset sweep.

3   The highest SNRISI value will be reported based on the equalizer setting.

4   Compare the resulting value to the specified standards.

abs Step Size Tests

Test Overview   The purpose of this test is to verify the abs Step Size.

To know about the measurement algorithm for each abs Step Size test, see:

abs Step Size for c(-3)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-3) is within limits.

Pass Condition   When abs Coefficient Step Size c(-3) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request to change c(-3) to the first step.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Save coefficient c(-3) as base step value.

9   Request next c(-3) step.

10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.

11 Calculate coefficients c(i) using equation 136-2.

12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.

13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(-2)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-2) is within limits.

Pass Condition   When abs Coefficient Step Size c(-2) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request to change c(-2) to the first step.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Save coefficient c(-2) as base step value.

9   Request next c(-2) step.

10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.

11 Calculate coefficients c(i) using equation 136-2.

12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.

13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(-1)

Test Overview   The purpose of this test is to verify that the abs Step Size for c(-1) is within limits.

Pass Condition   When abs Coefficient Step Size c(-1) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request to change c(-1) to the first step.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Save coefficient c(-1) as base step value.

9   Request next c(-1) step.

10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.

11 Calculate coefficients c(i) using equation 136-2.

12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.

13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(0)

Test Overview The purpose of this test is to verify that the abs Step Size for c(0) is within limits.

Pass Condition When abs Coefficient Step Size c(0) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1 Request Transmitter to be set to "PRESET" condition.
2 Capture full pattern of PRBS13Q at 32 points per UI.
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4 Define r(m) from "PRESET" as per equation 136-1.
5 Request to change c(0) to the first step.
6 Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7 Calculate coefficients c(i) using equation 136-2.
8 Save coefficient c(0) as base step value.
9 Request next c(0) step.
10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11 Calculate coefficients c(i) using equation 136-2.
12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

abs Step Size for c(1)

Test Overview The purpose of this test is to verify that the abs Step Size for c(1) is within limits.

Pass Condition When abs Coefficient Step Size c(1) is greater than or equal to 5 m and less than or equal to 25 m, and when other Coefficient Step Sizes are less than or equal to 5 m.

Measurement Algorithm
1 Request Transmitter to be set to "PRESET" condition.
2 Capture full pattern of PRBS13Q at 32 points per UI.
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4 Define r(m) from "PRESET" as per equation 136-1.
5 Request to change c(1) to the first step.
6 Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7 Calculate coefficients c(i) using equation 136-2.
8 Save coefficient c(1) as base step value.
9 Request next c(1) step.
10 Calculate linear fit pulse response as per section 85.8.3.3.5 with N_p = 200, D_p = 4.
11 Calculate coefficients c(i) using equation 136-2.
12 Calculate the step size as coefficient value from step 11 – coefficient value from step 7.
13 Repeat steps 9-12 for as many steps as user requests. Each of these step sizes is calculated as coefficient value from step 11 – previous coefficient value from step 11.

value at min. state for c(-3)

Test Overview The purpose of this test is to verify that the value at min. state for c(-3) is within limits.

Pass Condition When value at min. state for c(-3) is less than or equal to -60 m.

Measurement Algorithm
1 Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.
2 Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(-3) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-3) value from step 7.

value at max. state for c(-2)

Test Overview   The purpose of this test is to verify that the value at max. state for c(-2) is within limits.

Pass Condition   When value at max. state for c(-2) is greater than or equal to 120 m.

Measurement Algorithm   1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-1), and c(1) to zero. Increment both c(0) and c(-2) to their maximum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-2) value from step 7.

value at min. state for c(-1)

Test Overview   The purpose of this test is to verify that the value at min. state for c(-1) is within limits.

Pass Condition   When value at min. state for c(-1) is less than or equal to -340 m.

Measurement Algorithm   1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-3), c(-2), and c(1) to zero. Decrement both c(0) and c(-1) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 200$, $D_p = 4$.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-1) value from step 7.

value at min. state for c(0)

Test Overview   The purpose of this test is to verify that the value at min. state for c(0) is within limits.

Pass Condition   When value at min. state for c(0) is less than or equal to 500 m.

Measurement Algorithm   1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to decrement c(0) to minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(0) value from step 7.

value at min. state for c(1)

Test Overview   The purpose of this test is to verify that the value at min. state for c(1) is within limits.

Pass Condition   When value at min. state for c(1) is less than or equal to -200 m.

Measurement Algorithm

1   Request Transmitter to be set to "PRESET" condition. If preset has already been calculated during trial, steps 1-4 are skipped.

2   Capture full pattern of PRBS13Q at 32 points per UI.

3   Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.

4   Define r(m) from "PRESET" as per equation 136-1.

5   Request user to set c(-2), c(-1), and c(1) to zero. Decrement both c(0) and c(1) to their minimum value.

6   Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.

7   Calculate coefficients c(i) using equation 136-2.

8   Report c(-3) value from step 7.

Coefficient Initialization

Test Overview   This test group consists of the following tests:

- Coefficient Initialization Preset 1
- Coefficient Initialization Preset 2 c(-3)
- Coefficient Initialization Preset 2 c(-2)
- Coefficient Initialization Preset 2 c(-1)
- Coefficient Initialization Preset 2 c(0)
- Coefficient Initialization Preset 2 c(1)
- Coefficient Initialization Preset 3 c(-3)
- Coefficient Initialization Preset 3 c(-2)
- Coefficient Initialization Preset 3 c(-1)
- Coefficient Initialization Preset 3 c(0)
- Coefficient Initialization Preset 3 c(1)
- Coefficient Initialization Preset 4 c(-3)
- Coefficient Initialization Preset 4 c(-2)
- Coefficient Initialization Preset 4 c(-1)
- Coefficient Initialization Preset 4 c(0)
- Coefficient Initialization Preset 4 c(1)
- Coefficient Initialization Preset 5 c(-3)
- Coefficient Initialization Preset 5 c(-2)
- Coefficient Initialization Preset 5 c(-1)
- Coefficient Initialization Preset 5 c(0)
- Coefficient Initialization Preset 5 c(1)

Pass Condition

Coefficient Update State	Preset	c(-3)	c(-2)	c(-1)	c(0)	c(1)
OUT_OF_SYNC[a]	N/A	0	0	0	1	0
NEW_IC	Preset 1[a]	0	0	0	1	0
	Preset 2	0 ±0.0125	0 ±0.0125	0 ±0.0125	0.5 ±0.0125	0 ±0.0125
	Preset 3	0 ±0.0125	0 ±0.0125	-0.075 ±0.0125	0.75 ±0.0125	0 ±0.0125
	Preset 4	0 ±0.0125	0.05 ±0.0125	-0.2 ±0.0125	0.75 ±0.0125	0 ±0.0125
	Preset 5	-0.025 ±0.0125	0.075 ±0.0125	-0.25 ±0.0125	0.65 ±0.0125	0 ±0.0125

a. PRESET1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 162.9.4.1.1). As a result the normalized coefficients for PRESET1 and OUT_OF_SYNC do not include any tolerances.

Measurement Algorithm (Preset 1)

1 Request Transmitter to be set to "PRESET 1" condition.
2 Capture full pattern of PRBS13Q at 32 points per UI.
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4 Define r(m) from "PRESET" as per equation 136-1.
5 Request "Out of Sync" state.
6 Calculate linear fit pulse response as per 85.8.3.3.5 with Np = 200, Dp = 4.
7 Calculate coefficients c(-3) , c(-2), c(-1), c(0), and c(1) using equation 136-2.
8 Report c(-3) , c(-2), c(-1), c(0) and c(1) values from step 7.
9 Request "Preset 1" state.
10 Calculate linear fit pulse response as per 85.8.3.3.5 with Np = 200, Dp = 4.
11 Calculate coefficients c(-3) , c(-2), c(-1), c(0) and c(1) using equation 136-2.
12 Report c(-3), c(-2), c(-1), c(0), and c(1) values from step 11.

Measurement Algorithm (Preset 2 to Preset 5)

1 Request Transmitter to be set to "PRESET 1" condition.
2 Capture full pattern of PRBS13Q at 32 points per UI.
3 Calculate linear fit pulse response at "PRESET" condition as per section 85.8.3.3.5.
4 Define r(m) from "PRESET" as per equation 136-1.
5 Request preset # (for each test).
6 Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 200, D_p = 4.
7 Calculate coefficients c(i) using equation 136-2.
8 Report c(#) value from step 7.

Return Loss PNA/N1055A Measurements

The Return Loss PNA/N1055A Measurement procedures that are described in this section are performed using a Keysight DCA oscilloscope along with either a PNA or an N1055A and the N1091CKCA IEEE802.3ck FlexDCA Conformance Application. The Conformance Test Application controls the PNA/N1055A to set the test limits and run the tests. You must ensure that the connected device is calibrated.
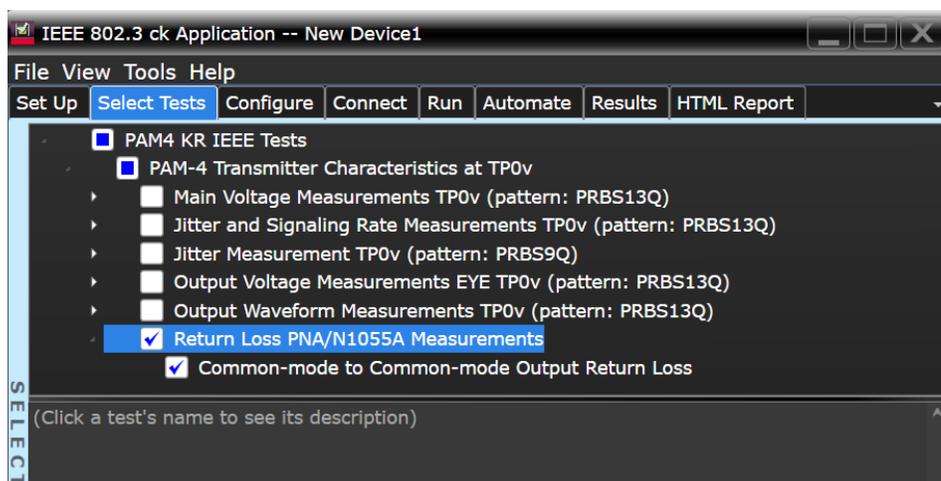

Figure 37   Selecting Return Loss PNA/N1055A Measurements Tests

Refer to Table 6 for information on the pass limits for each test that is displayed for the selected standard option.

To know about the measurement algorithm for each Return Loss PNA/N1055A Measurements tests, see:

- "Common-mode to Common-mode Output Return Loss" on page 117

Common-mode to Common-mode Output Return Loss

Measurement Algorithm

1 Ensure that the PNA/N1055A is physically connected and calibrated.

2 In the **Set Up** tab of the Conformance Test Application, click **PNA** to establish connectivity to the connected equipment. For N1055A, select **N1055A**.

3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.

4 Click **Run** under the **Run** tab. The Conformance Test Application automatically calculates the return loss.

5 Compare the reported values with the specification to check for conformance.