D90103CKC IEEE 802.3ck Conformance Application - Methods of Implementation

KEYSIGHT

METHODS OF IMPLEMENTATION

Notices

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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 Conformance Application—At a Glance

The Keysight D90103CKC IEEE 802.3ck 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 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 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 Conformance Application, you need the following hardware and software:

Hardware:

- Keysight UXR series Real-Time Infiniium Oscilloscope (Bandwidth 59 GHz and above)
- Keyboard, qty = 1, (provided with the Keysight Infiniium oscilloscope)
- Mouse, qty = 1, (provided with the Keysight Infiniium oscilloscope)
- Keysight also recommends using a second monitor to view the test application.

Software:

- Infiniium Oscilloscope Software (For the minimum version of oscilloscope software, see the D90103CKC release notes)
- Keysight D90103CKC IEEE802.3ck Conformance Application

Licenses:

- For the required licenses for the D90103CKC IEEE 802.3ck Conformance Application, refer to the Data Sheet.

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If you purchased the D90103CKC IEEE 802.3ck Conformance Application separate from your Infiniium oscilloscope, you must install the software and license key.

Installing the Software

1. Make sure you have the minimum version of oscilloscope software (see the D90103CKC release notes) by selecting **Help > About Infiniium...** from the main menu.
2. To obtain the D90103CKC Conformance Test Application, go to Keysight website: http://www.keysight.com/find/D90103CKC.
3. Navigate to the **Visit Technical Support** section and click the **Drivers, Firmware and Software** tab.
4. Click on the software's current version link and follow the instructions to download and install the latest version of the test application software.

Installing the License Key

Refer to the D90103CKC IEEE 802.3ck Conformance Application Data Sheet to know about the various licenses pertaining to Keysight D90103CKC IEEE 802.3ck 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.

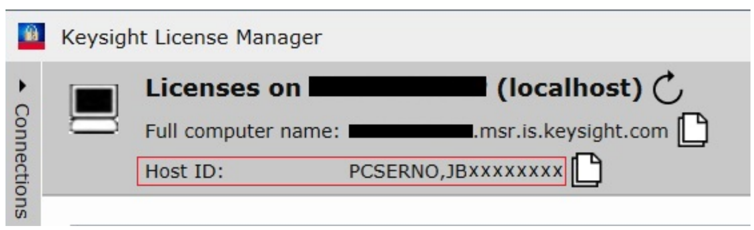

Figure 1 Viewing the Host ID information in Keysight License Manager 5

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.

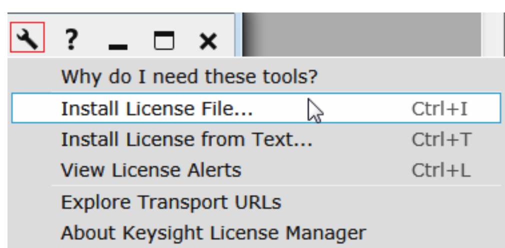

Figure 2 Configuration menu options to install licenses on Keysight License Manager 5

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.

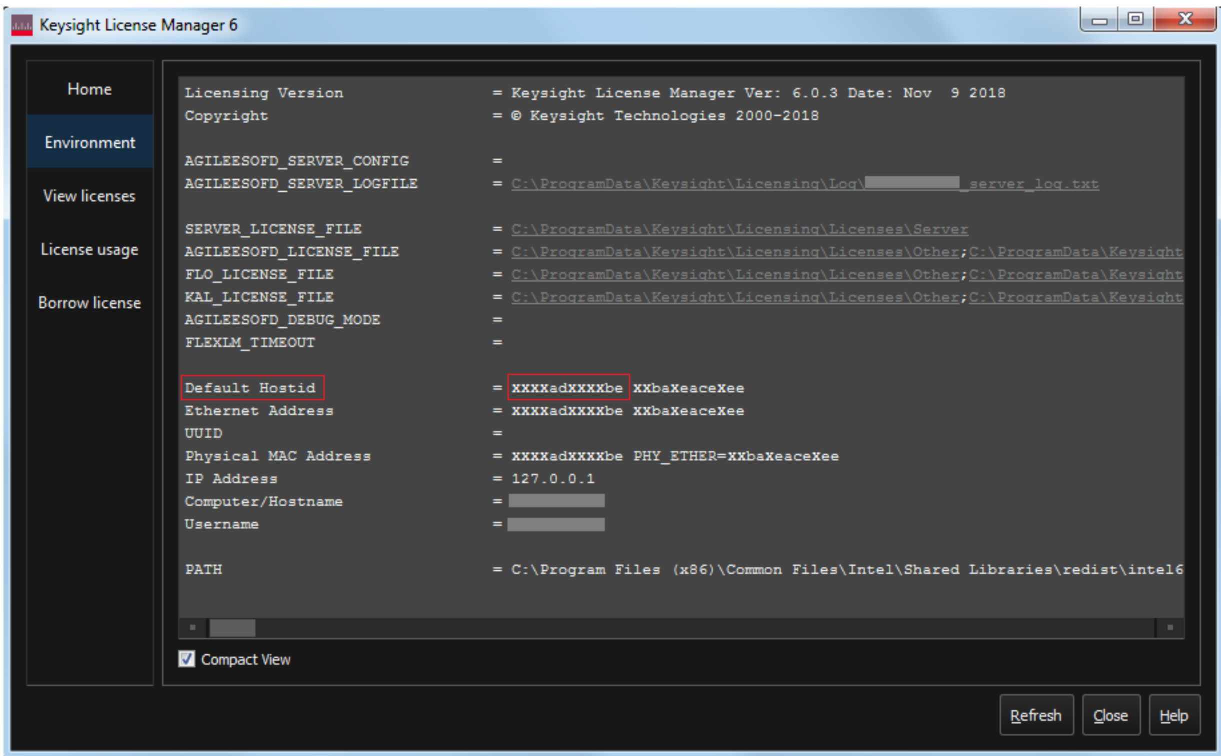

Figure 3 Viewing the Host ID information in Keysight License Manager 6

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.

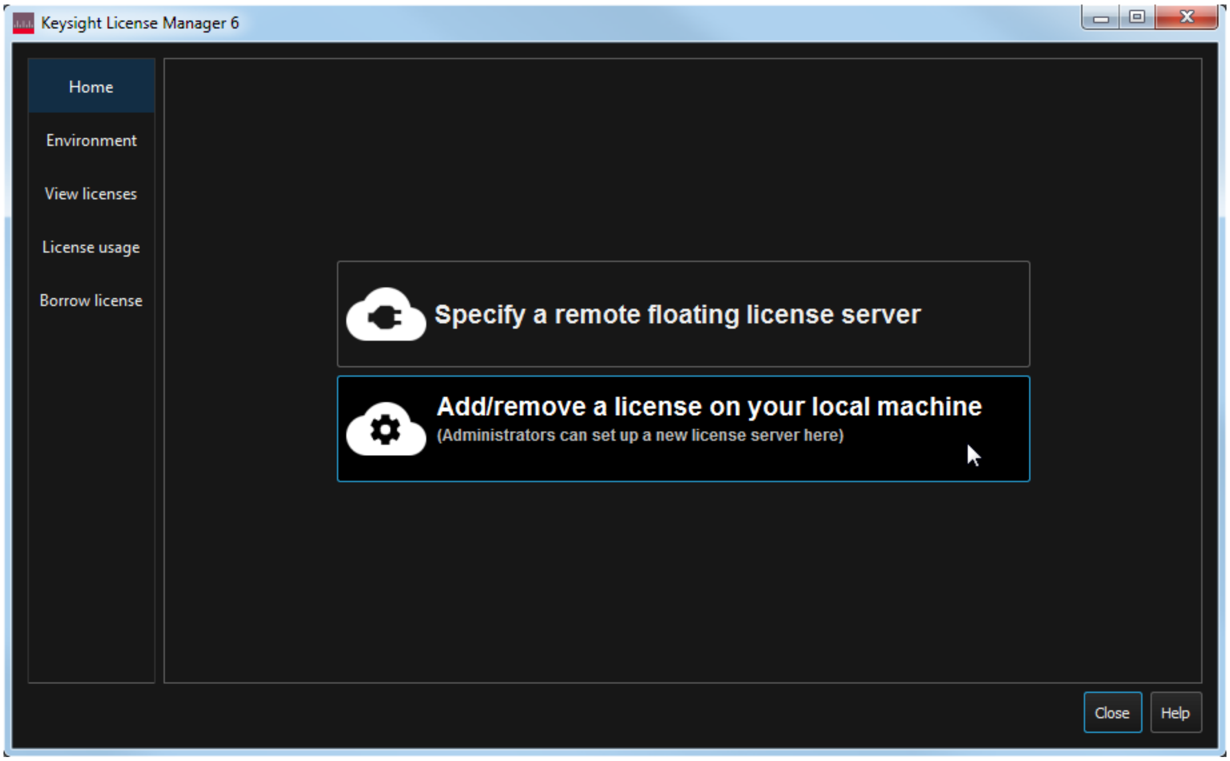

Figure 4 Home menu options to install licenses on Keysight License Manager 6

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

2 Preparing to Take Measurements

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Before running the automated tests, you must calibrate the oscilloscope. After the oscilloscope has been calibrated, you are ready to start the D90103CKC IEEE 802.3ck Conformance Application and perform the measurements.

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 Infiniium software's main menu, select **Analyze > Automated Test Apps > D90103CKC IEEE 802.3ck Electrical Tx Test App**.
3 The Keysight D90103CKC IEEE 802.3ck Conformance Application appears.

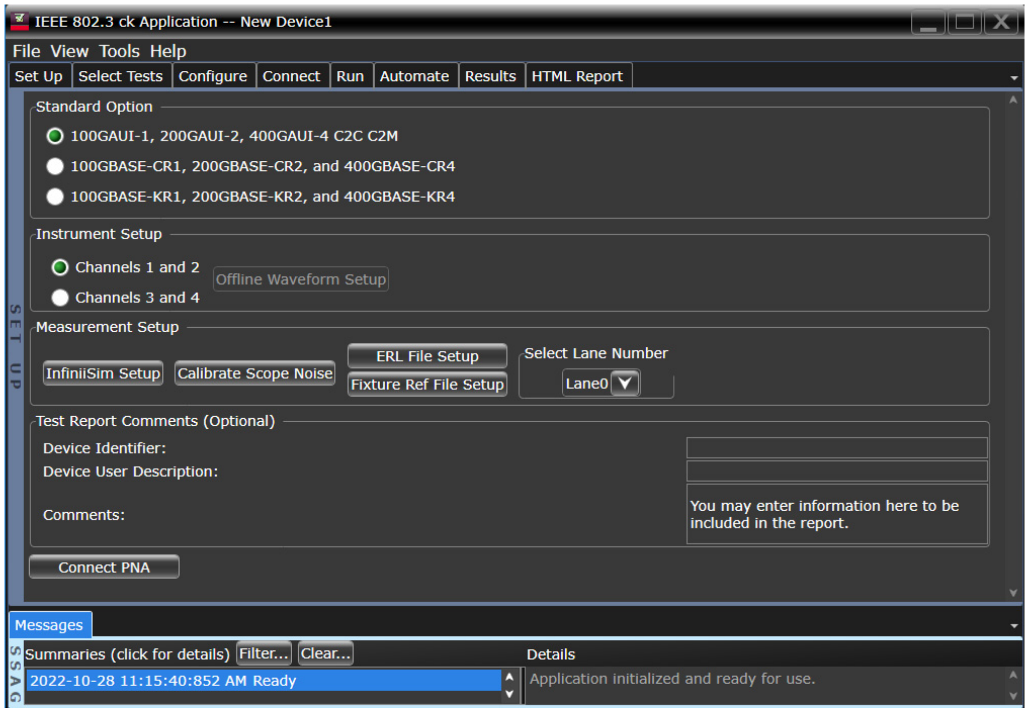


Figure 5 The D90103CKC IEEE 802.3ck Conformance Application Main Window

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. In the **Instrument Setup** section, 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. With the **ERL File Setup** button, the s-parameter file for the effective return loss can be specified. With the **Fixture Ref File Setup** button, the s-parameter file for the fixtures used can be specified. 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. The **Select Lane Number** enables you to choose a lane for testing. Use the **Connect PNA** button to connect to 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 As per your setup, 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 D90103CKC IEEE 802.3ck Conformance Application sets optimum values for each configuration parameter.

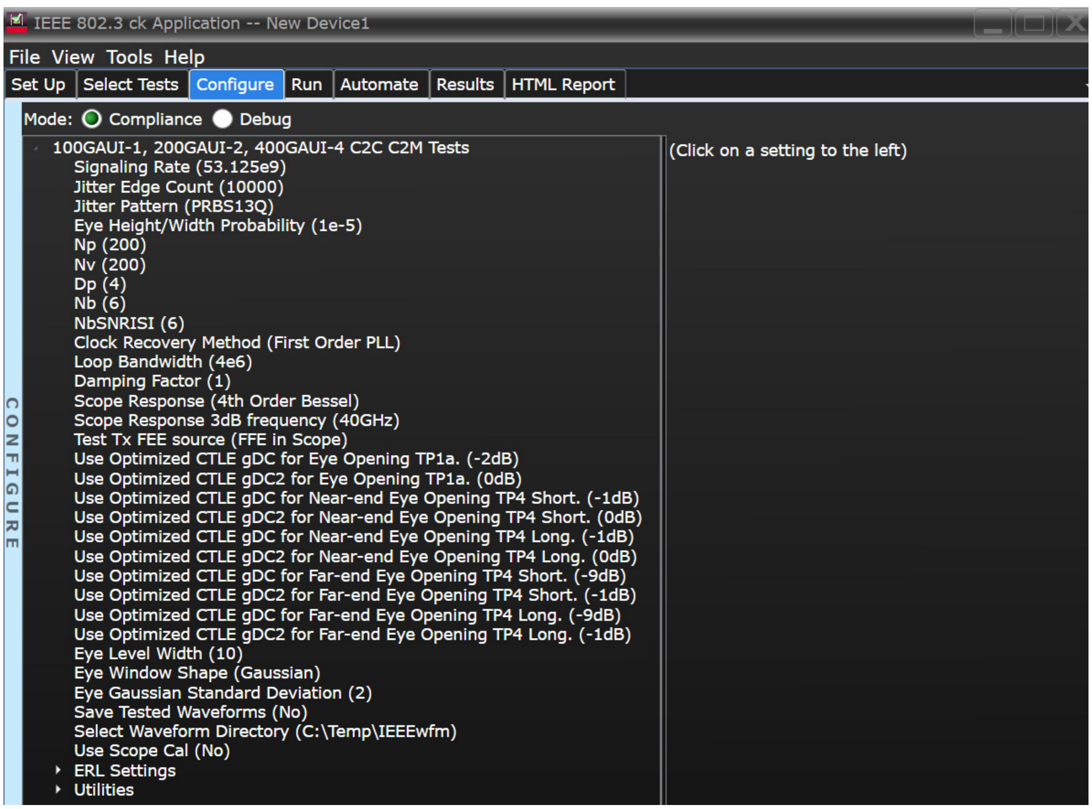


Figure 6 Configure Tab in the D90103CKC IEEE 802.3ck Conformance Application

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.

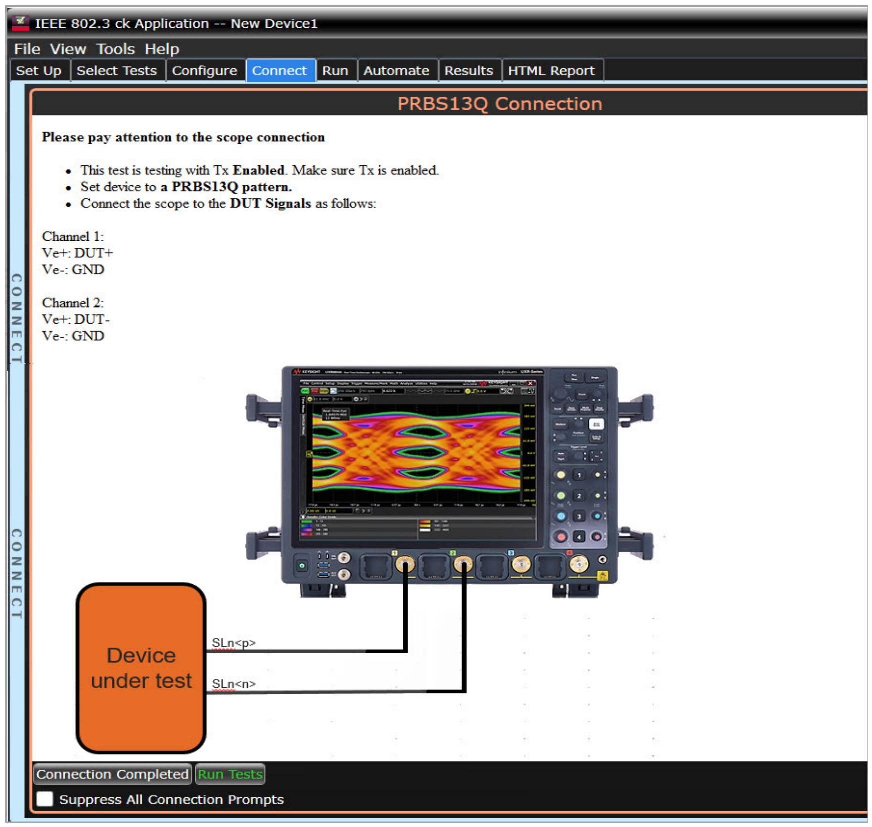


Figure 7 Connect Tab in the D90103CKC IEEE 802.3ck Conformance Application

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.

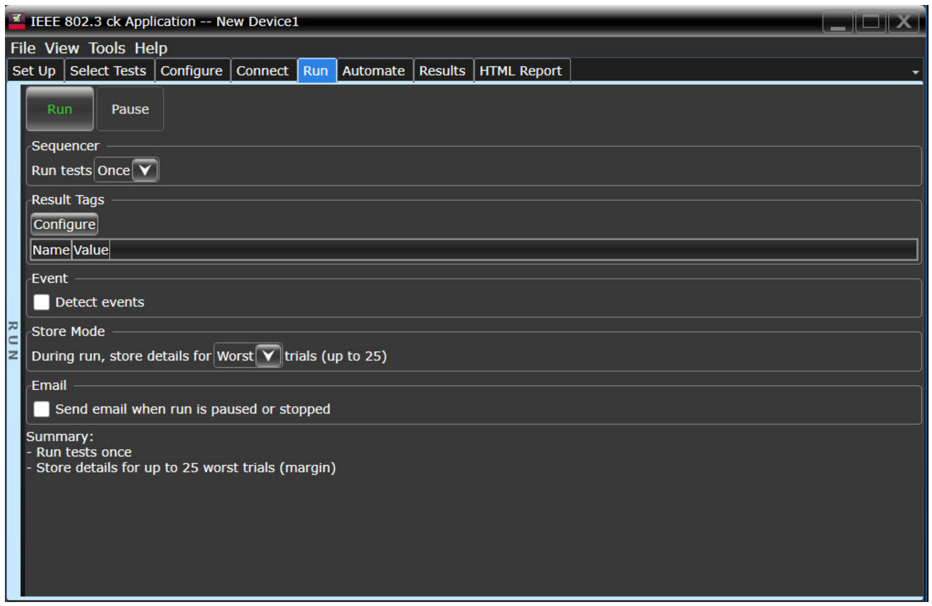


Figure 8 Run Tab in the D90103CKC IEEE 802.3ck Conformance Application

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.

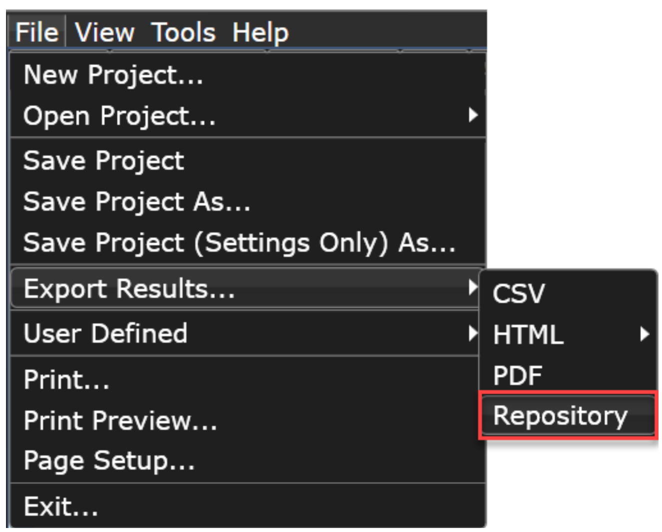
Not only can remote users with an active Internet connection access these Datasets and the corresponding test results on the Web Repository, but they have the option to add and delete Datasets on the Web Server. In the Upload Results To Repository feature, you can even modify the Dataset properties, 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.

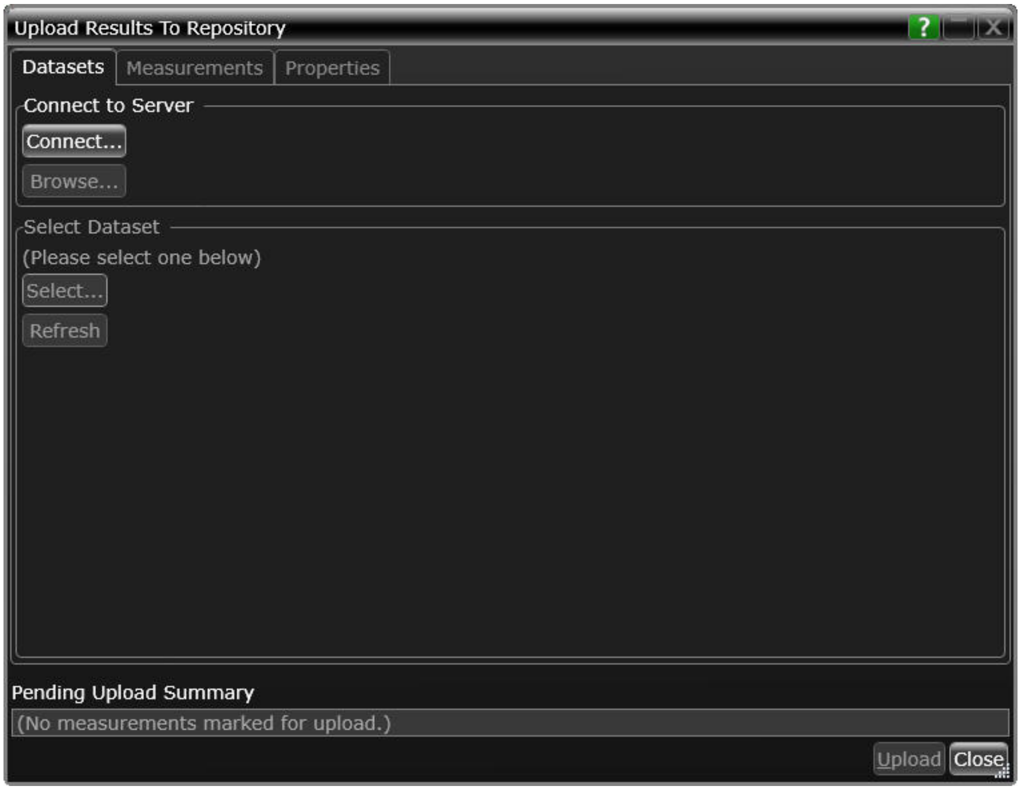
To export measurement results to the Repository after the completion of test runs,

1 From the Test Application's main menu, click **File > Export Results... > Repository**.



The **Upload Results to Repository** window appears.

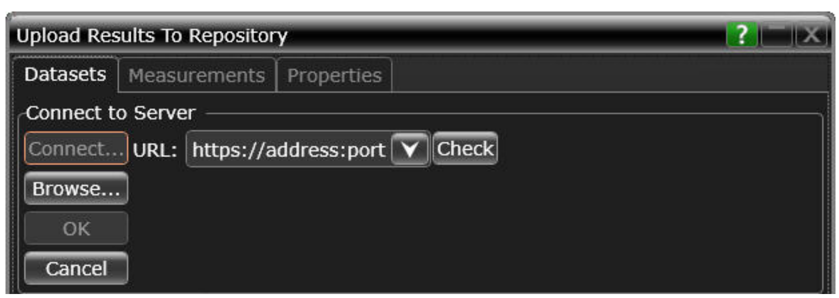
2 In the **Connect to Server** pane of the **Datasets** tab, click **Connect...** to login to the Dataset Repository server.



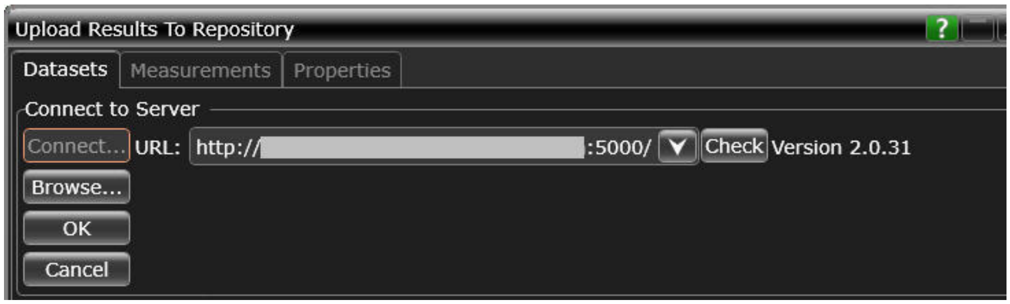
3 In the **URL:** drop-down text field that appears, replace the default text with the actual IP address or the URL along with the port number, if applicable.

   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.

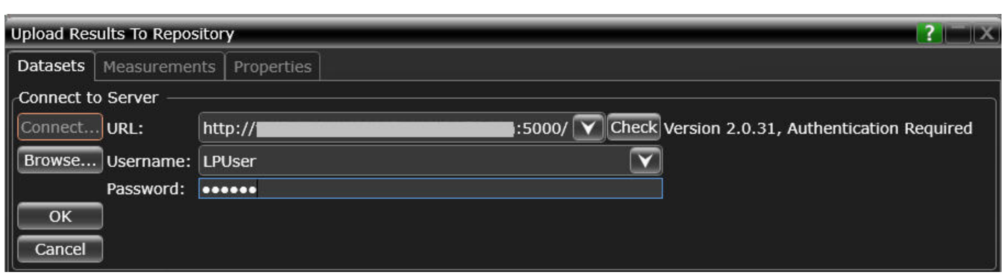


- For unrestricted access to the Repository
  - *a* If the server does not require authentication and the KS6800A Series Analytics service is found on the specified web address, the version information is displayed adjacent to the **Check** button.



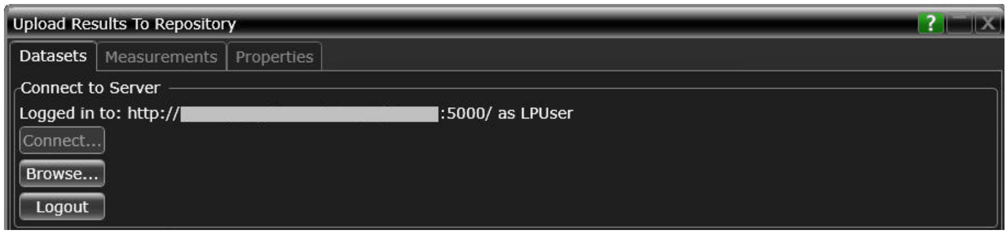
  - *b* If you click **OK**, the **Upload Results to Repository** window displays the connectivity status to the Dataset Repository.
  - *c* Click **Browse**... to navigate directly to the URL.

- 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.



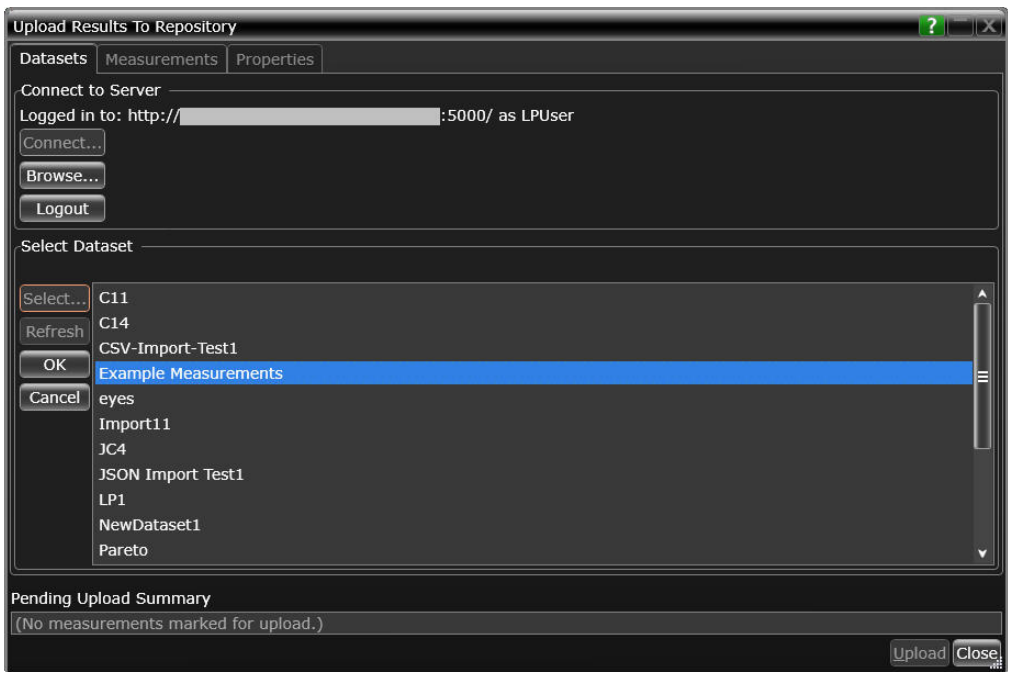
  - *c* Click **OK** to connect to the entered URL/IP address.

  The **Connect to Server** area displays the connection status along with the username.
  - *d* Click **Browse**... to navigate directly to the URL.

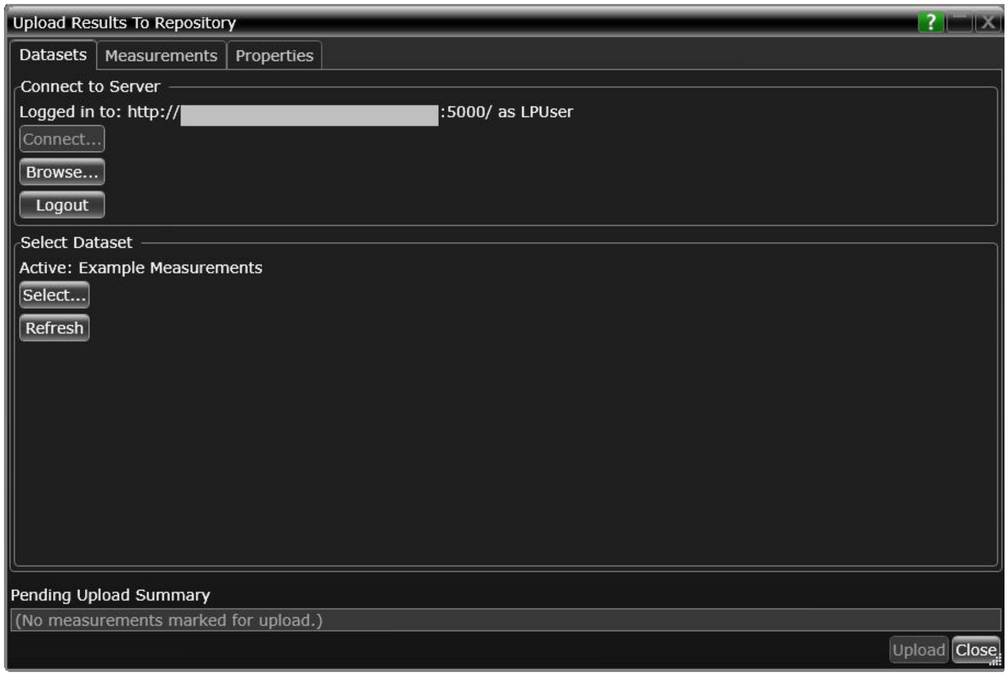


5 In the **Select Dataset** area, click **Select**... to view the list of Datasets created on the connected repository. Click **Refresh** to update the list of Datasets that appear in the Test Application's user interface.

6 Select the Dataset name where you wish to upload measurement results to. Click **OK**.

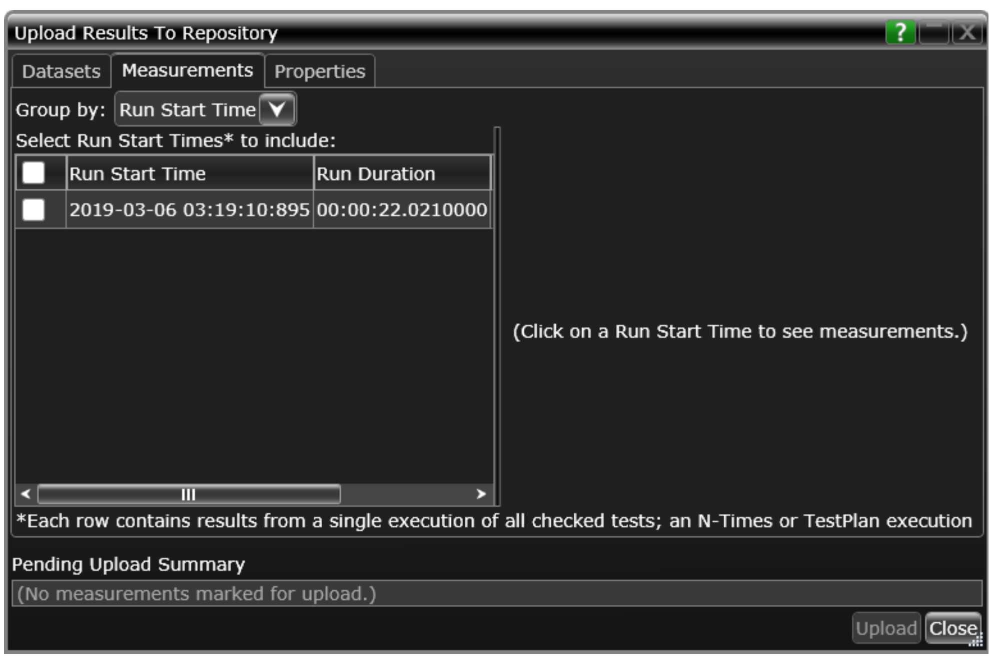


The **Select Dataset** area displays the selected Dataset as Active. The **Measurements** and **Properties** tabs are enabled after a Dataset is selected.



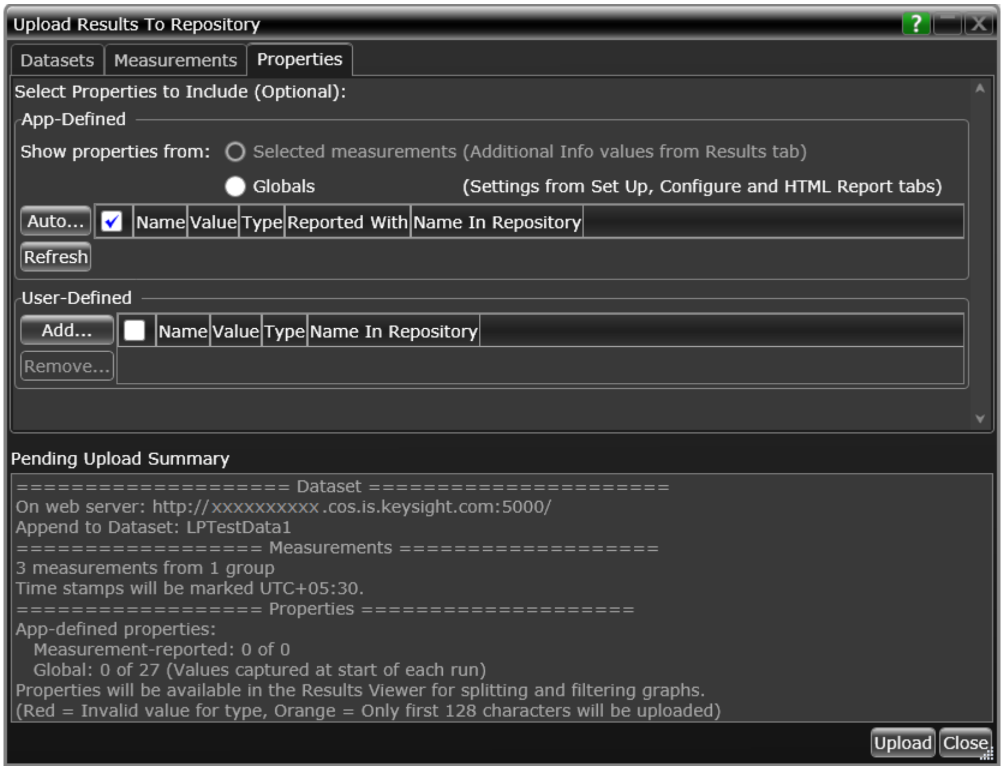
7 Click the **Measurements** tab where the test results from the last test run are displayed.

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.

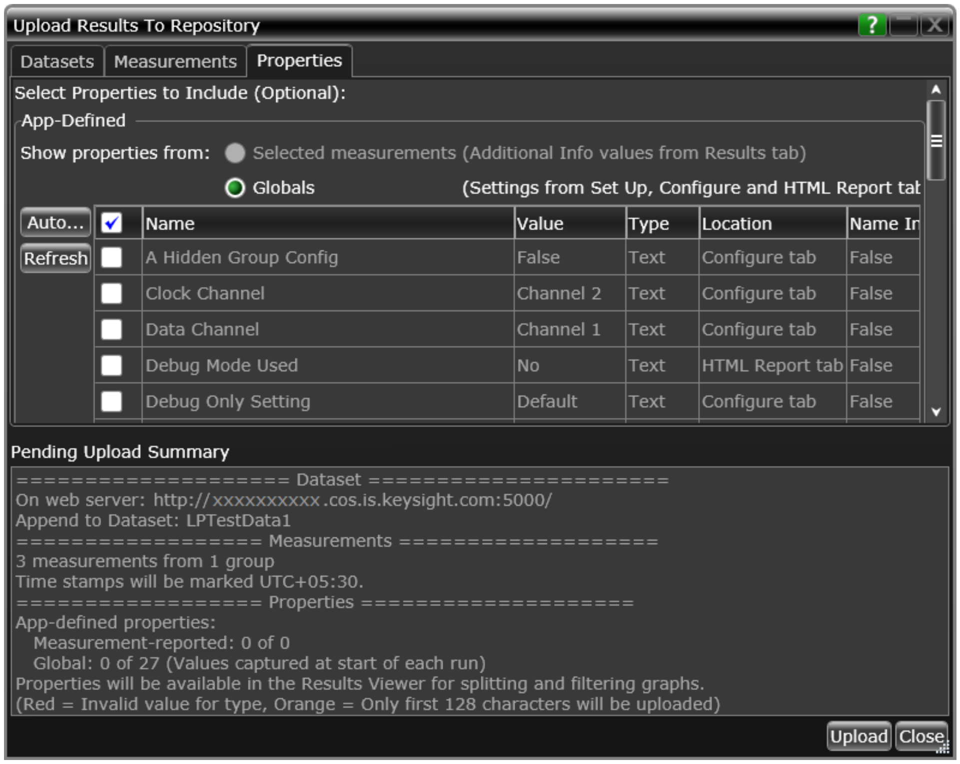


9 After selecting one or more measurements, either click **Upload** or switch to the **Properties** tab to associate one or more properties to the measurements that are being uploaded to the Web Server.

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.



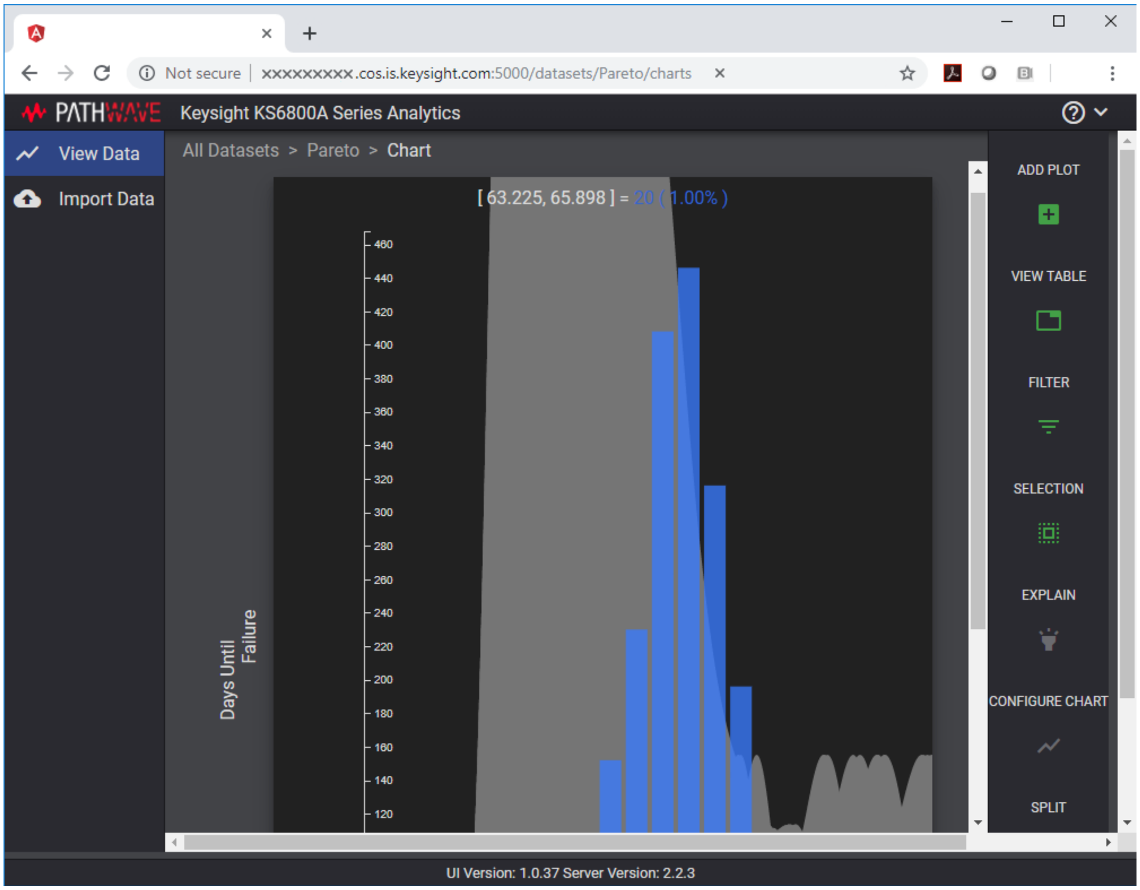
11 Click **Upload** to begin uploading measurement results.

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

PAM4 Transmitter Characteristics at TP0v 35
PAM4 Host Output Characteristics at TP1a 53
PAM4 Module Output Characteristics at TP4 62
Utilities 73

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.

A Note on Crosstalk Calibration for C2M Testing

The D90103CKC 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.

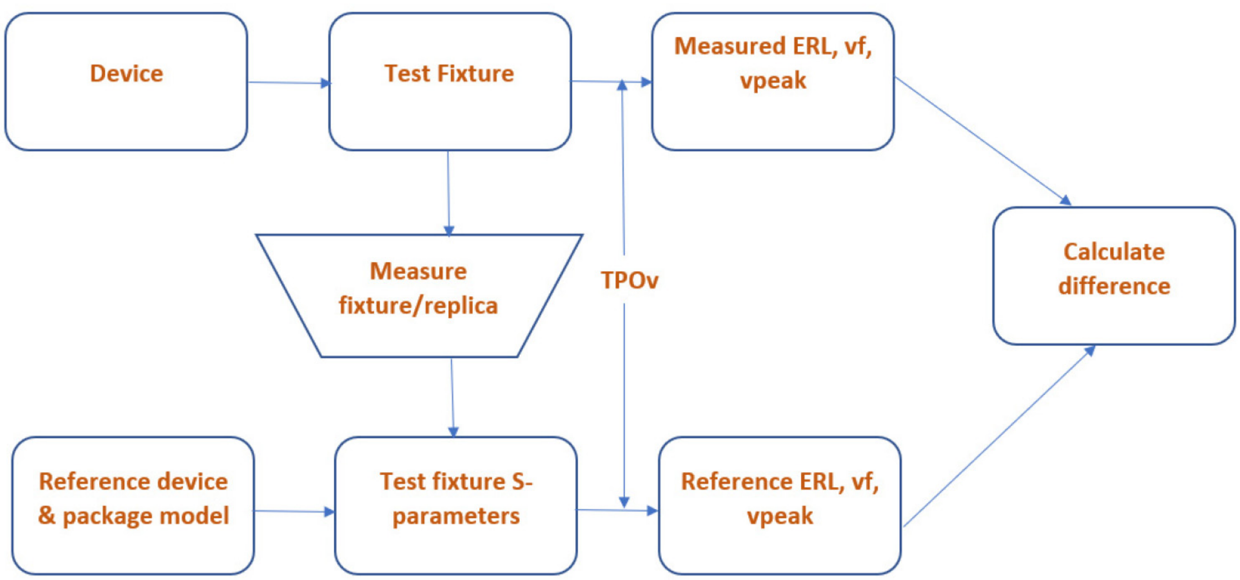
A Note on Difference Measurements (dvf, dRpeak, and dERL)

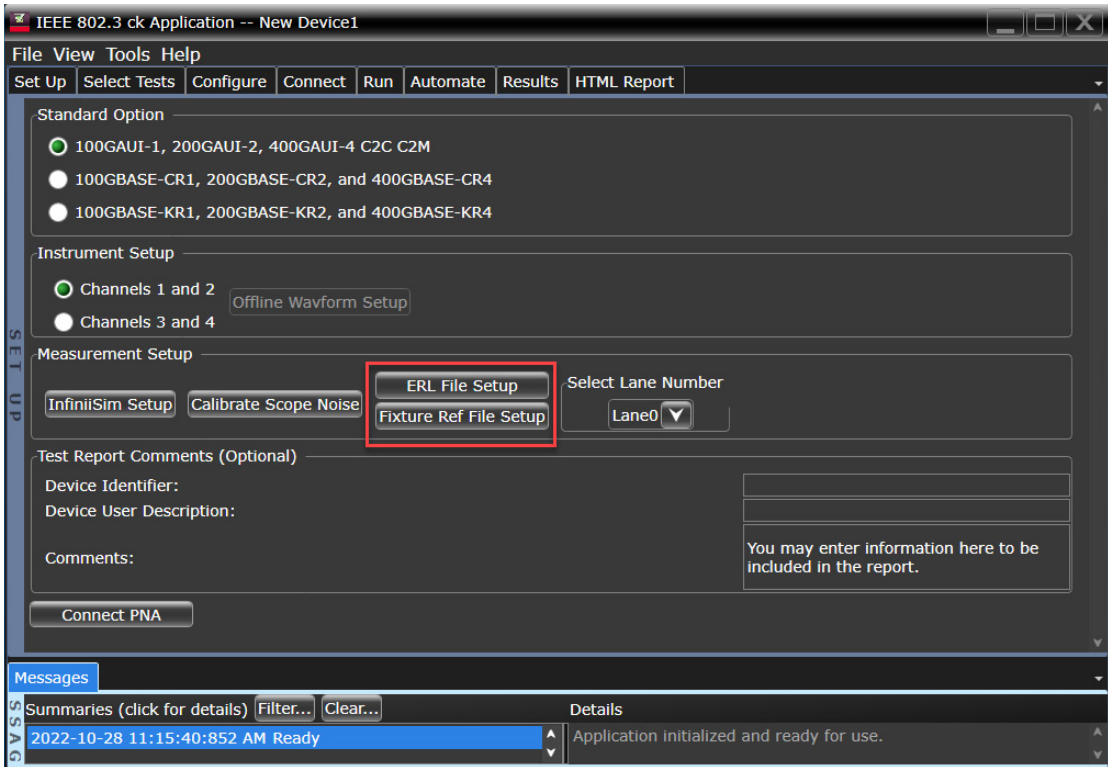
The difference measurements dVf, dRpeak, and dERL are derived from the measured and the reference values. The measured values are obtained from the actual measurements done at TP0v. Actual measurements include the true transmitter and the fixture. The reference values are calculated using a reference 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). 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.




IEEE 802.3 ck Application -- New Device1
File View Tools Help
Set Up
Select Tests
Configure
Connect
Run
Automate
Results
HTML Report
Standard Option
100GAUI-1, 200GAUI-2, 400GAUI-4 C2C C2M
100GBASE-CR1, 200GBASE-CR2, and 400GBASE-CR4
100GBASE-KR1, 200GBASE-KR2, and 400GBASE-KR4
Instrument Setup
Channels 1 and 2
Channels 3 and 4
Offline Wavform Setup
Measurement Setup
InfiniiSim Setup
Calibrate Scope Noise
ERL File Setup
Fixture Ref File Setup
Select Lane Number
Lane0
Test Report Comments (Optional)
Device Identifier:
Device User Description:
Comments:
You may enter information here to be included in the report.
Connect PNA
SET UP
Messages
Summaries (click for details)
Filter...
Clear...
Details
2022-10-28 11:15:40:852 AM Ready
Application initialized and ready for use.

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™ /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 400GAUI-4 C2C transmitter characteristics at TP0v

Parameter	Reference	Value	Units
Signaling rate, each 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, VCM_{LF} (max)	See Sec. 120F.3.1.1 of the IEEE specification	32	mV
Signal to AC common-mode noise ratio, SCMR (min)	See Sec. 120F.3.1.2 of the IEEE specification	15	dB
Difference effective return loss, dERL (min)	See Sec. 120F.3.1.4 of the IEEE specification	-3	dB
Common-mode to common-mode return loss, RLcc (min)	See Sec. 162.9.4.9 of the IEEE specification	2	dB
Difference steady-state voltage, dv_f (min)	See Sec. 163.9.2.4 of the IEEE specification	0	V
Difference linear fit pulse peak, dR_{peak} (min)	See Sec. 163A.3.2.1 of the IEEE specification	0	V
Level separation mismatch ratio, R_{LM} (min)	See Sec. 162.9.4.2 of the IEEE specification	0.95	–
Output waveform[b] absolute value of step size for all taps (min) absolute value of 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	 - - - - - - - - - - -

Parameter	Reference	Value	Units
Signal-to-noise-and-distortion ratio SNDR (min)	See Sec.162.9.4.6 of the IEEE specification	32.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	See Section 120F.3.1.3	28	dB
Output jitter	See Sections		
J_{RMS} (max)	120F.3.1.6	0.023	UI
J4u (max)	120F.3.1.6	0.128	UI
$J4u_{03}$ (max)	120F.3.1.6	0.118	UI
Even-odd jitter (max)	120F.3.1.6	0.025	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.

Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

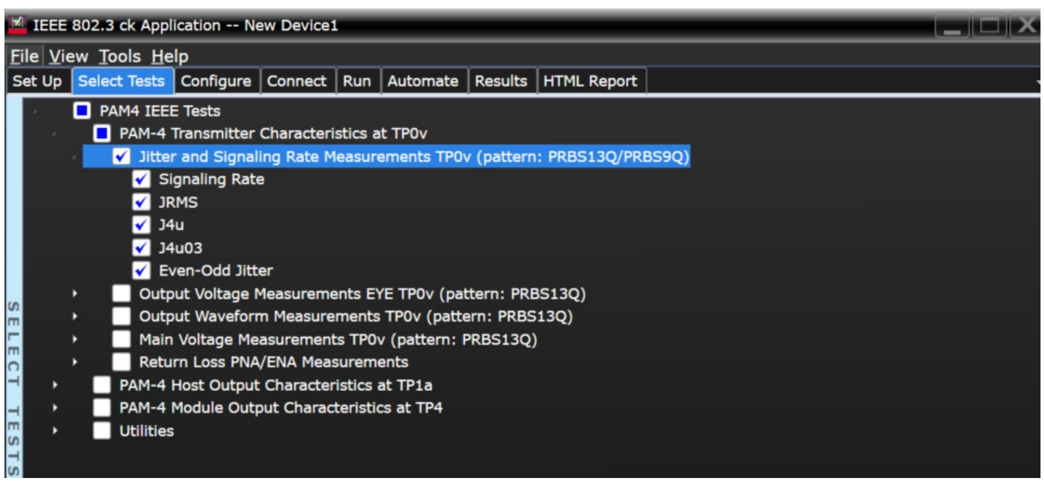


Figure 9 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section PAM4 Transmitter Characteristics at TP0v 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 tests, see:

- "Signaling Rate" on page 36
- "JRMS" on page 37
- "J4u" on page 37
- "J4u03" on page 38
- "Even-Odd Jitter" on page 38

Signaling Rate

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

Pass Condition Refer to the section PAM4 Transmitter Characteristics at TP0v 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 Gb/s.
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 the section PAM4 Transmitter Characteristics at TP0v 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
   c Set 4^{th} 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 J4 meets the specified standards. All jitter tests are run in a single measurement. However, each test can be run individually.

Pass Conditions Refer to the section PAM4 Transmitter Characteristics at TP0v 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
   c Set 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.
4 Compare and report the J4 value meets 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 the section PAM4 Transmitter Characteristics at TP0v 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
   c Set 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.
4 Compare and report the J4u03 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 the section PAM4 Transmitter Characteristics at TP0v for the pass limits pertaining to each standard option.

Measurement Algorithm

1 Obtain sample or acquire signal data.

NOTE **Signal must be of PRBS13Q or PRBS9Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q or PRBS9Q patterns are captured to collect the measurement data of 12 edges.

c 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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

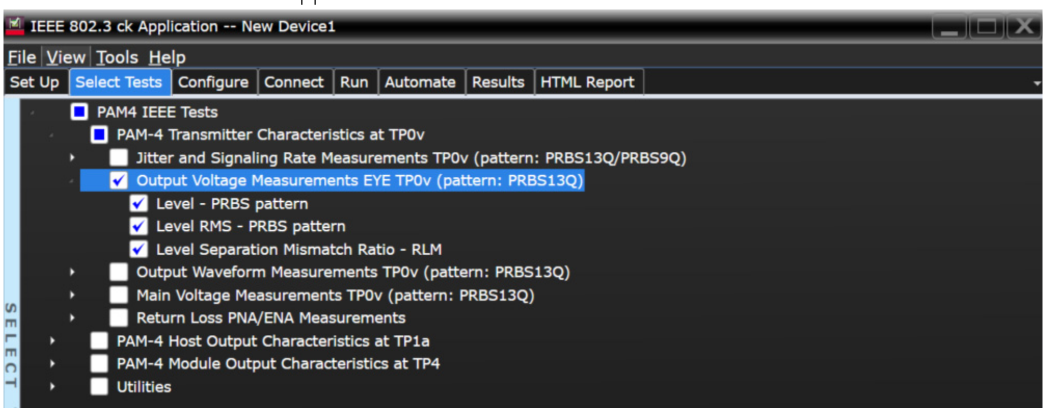


Figure 10 Selecting Output Voltage Measurements EYE Tests

Refer to the section PAM4 Transmitter Characteristics at TP0v 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 39
- “Level RMS - PRBS Pattern” on page 40
- “Level Separation Mismatch Ratio - RLM” on page 40

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™ /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™ /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 the section PAM4 Transmitter Characteristics at TP0v 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™ /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 the calculated value.

Output Waveform Measurements TP0v (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

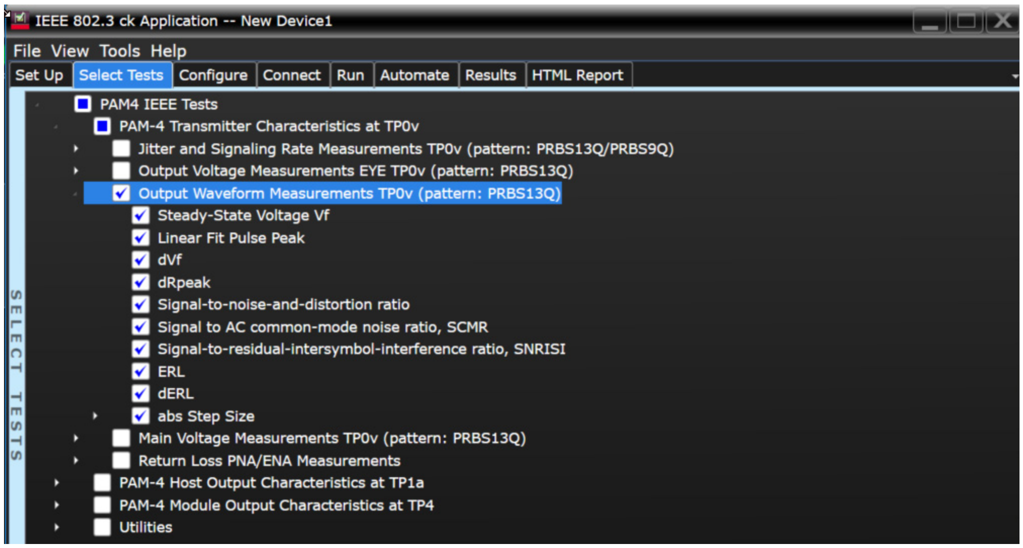


Figure 11 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section PAM4 Transmitter Characteristics at TP0v 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 41
- “Linear Fit Pulse Peak” on page 42
- “dVf” on page 42
- “dRpeak” on page 42
- “Signal-to-noise-and-distortion ratio” on page 43
- “Signal to AC common-mode noise ratio, SCMR” on page 43
- “Signal-to-residual-intersymbol-interference ratio, SNRISI” on page 43
- “ERL” on page 43
- “dERL” on page 44
- “abs Step Size Tests” on page 44

Steady State Voltage V_f

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

Pass Condition Refer to the section PAM4 Transmitter Characteristics at TP0v 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 the specified standards to the resulting value.

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 the section PAM4 Transmitter Characteristics at TP0v 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 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 the section PAM4 Transmitter Characteristics at TP0v for the pass limits pertaining to each standard option.

Measurement Algorithm

1 The user enters the fixture s-parameter (S0) file by clicking the **Fixture Ref File Setup** button 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 the section PAM4 Transmitter Characteristics at TP0v for the pass limits pertaining to each standard option.

Measurement Algorithm

1 The user enters the fixture s-parameter (S0) file by clicking the **Fixture Ref File Setup** button 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 the section PAM4 Transmitter Characteristics at TP0v 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 the section PAM4 Transmitter Characteristics at TP0v 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.

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

Test Overview The purpose of this test is to verify that 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 Condition Refer to the section PAM4 Transmitter Characteristics at TP0v for the pass limits pertaining to each standard option.

Measurement Algorithm

1 Follow the procedure for Linear Fit Pulse peak to calculate p(k).

2 Calculate response for each gDC/gDC2 combination as defined in the Table 162-20.

3 With Nb=6, sweep tp from -0.5UI to 0.5UI to calculate ISI cursors for each gain (EQU 120D-8)

4 Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.

5 The results is the highest SNRISI value.

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 Conformance Test Application, click **ERL File Setup** button to set up the s-parameter file (refer to Annex 93A.5.1 for more information about the standards defined to create the s-parameters).

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

3 Click **Run** under the **Run** tab. The Conformance 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 the section PAM4 Transmitter Characteristics at TP0v 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 The user enters the initial ERL channel file by clicking the **ERL File Setup** button under the Setup tab.
2 The user enters the fixture s-parameter (S0) file by clicking the **Fixture Ref File Setup** button 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 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.
4 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.
5 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.

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 44
- "abs Step Size for c(-2)" on page 45
- "abs Step Size for c(-1)" on page 45
- "abs Step Size for c(0)" on page 46
- "abs Step Size for c(1)" on page 46
- "value at min. state for c(-3)" on page 47
- "value at max. state for c(-3)" on page 47
- "value at max. state for c(-2)" on page 47
- "value at min. state for c(-2)" on page 48
- "value at min. state for c(-1)" on page 48
- "value at max. state for c(-1)" on page 48
- "value at min. state for c(0)" on page 49
- "value at min. state for c(1)" on page 49
- "value at max. state for c(1)" on page 49

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.

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.

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.

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.

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.

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.

Main Voltage Measurements TP0v (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

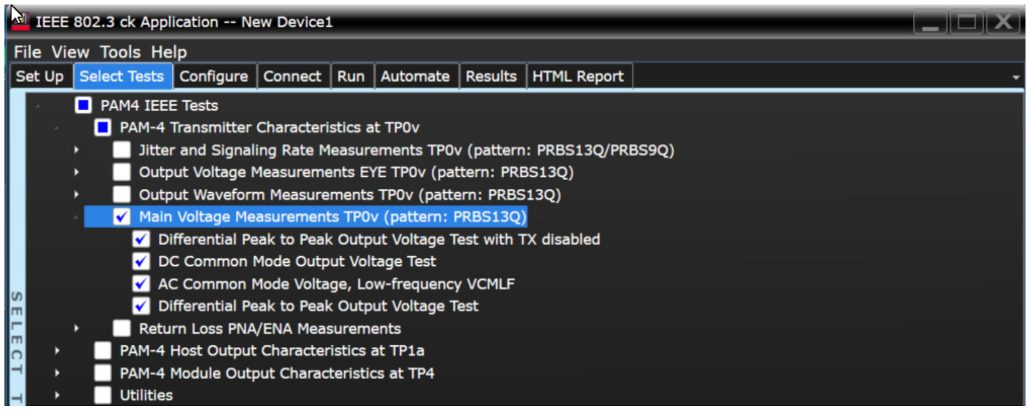


Figure 12 Selecting Main Voltage Measurement Tests

Refer to the section PAM4 Transmitter Characteristics at TP0v 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 50
- “DC Common Mode Output Voltage Test” on page 50
- “AC Common Mode Voltage, Low-Frequency VCMLF” on page 51
- “Differential Peak-to-Peak Output Voltage Test” on page 51

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 the section PAM4 Transmitter Characteristics at TP0v 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.

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 the section PAM4 Transmitter Characteristics at TP0v 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.

AC Common Mode Voltage, Low-Frequency VCMLF

Test Overview The purpose of this test is to verify that the low-frequency 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 the section PAM4 Transmitter Characteristics at TP0v 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 Apply 100 MHz low pass filter.
5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-5} of the measurement distribution.
6 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 the section PAM4 Transmitter Characteristics at TP0v 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.

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

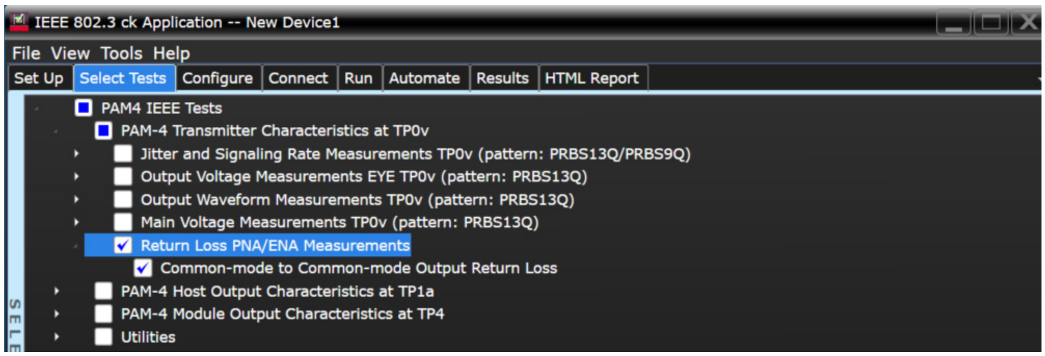


Figure 13 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section PAM4 Transmitter Characteristics at TP0v 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/ENA 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/ENA is physically connected and calibrated.
2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4 Click **Run** under the **Run** tab. The 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.

Host output electrical characteristics at TP1a

Table 3 C2M host output characteristics at TP1a

Parameter	Reference	Value	Units
Signaling rate, each 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
Differential peak-to-peak output voltage (max) Transmitter disabled Transmitter enabled	Sec. 120G.5.1	 35 750	 mV
Steady-state voltage, v_f (max)	Sec. 120G.5.3	375	mV
Eye height (min)	Sec. 120G.3.1.5	10	mV
Vertical eye closure, VEC (max)	Sec. 120G.3.1.5	12	dB
Common-mode to differential-mode return loss, RLDC (min)	Sec. 120G.3.1.1	See Equation (120G-1)	dB
Effective return loss, ERL (min)	Sec. 120G.3.1.2	7.3	dB
Differential termination mismatch (max)	Sec. 120G.3.1.3	10	%
Transition time (min) ▪ 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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

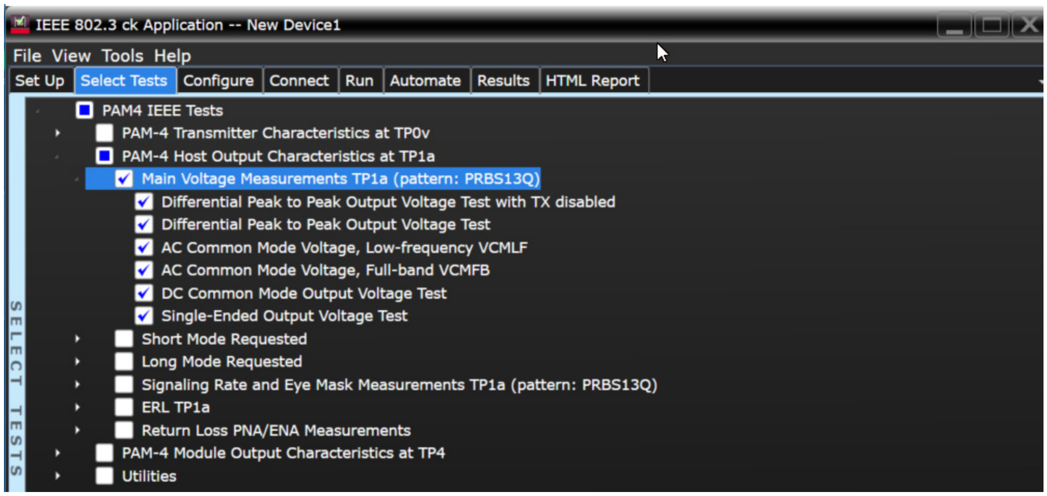


Figure 15 Selecting Main Voltage Measurement Tests

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
- "Differential Peak-to-Peak Output Voltage Test" on page 54
- "AC Common Mode Voltage, Low-Frequency VCMLF" on page 55
- "AC Common Mode Voltage, Full-band VCMFB" on page 55
- "DC Common Mode Output Voltage Test" on page 55
- "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.

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.

AC Common Mode Voltage, Low-Frequency VCMLF

Test Overview The purpose of this test is to verify that the low-frequency AC common mode voltage of the signal is less than or equal to 32mV.

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. Apply 100 MHz low pass filter.
5. Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-5} of the measurement distribution.
6. Compare the voltage measurement with 32mV.

AC Common Mode Voltage, Full-band VCMFB

Test Overview The purpose of this test is to verify that the full-band VCMFB AC common mode voltage of the signal is less than or equal to 80mV.

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. Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-5} of the measurement distribution.
5. Compare the voltage measurement with 80mV.

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.

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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck 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.

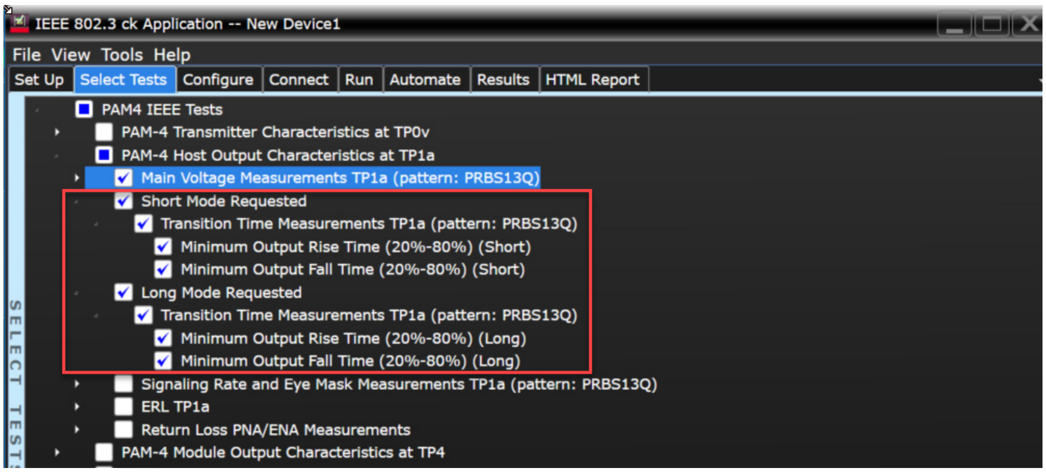


Figure 16 Selecting Transition Time Measurement Tests

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 greater than or equal to 10ps for short mode and greater than or equal to 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 greater than or equal to 10ps for short mode and greater than or equal to 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 fall time with 10ps for short mode and 15ps for long mode.

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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

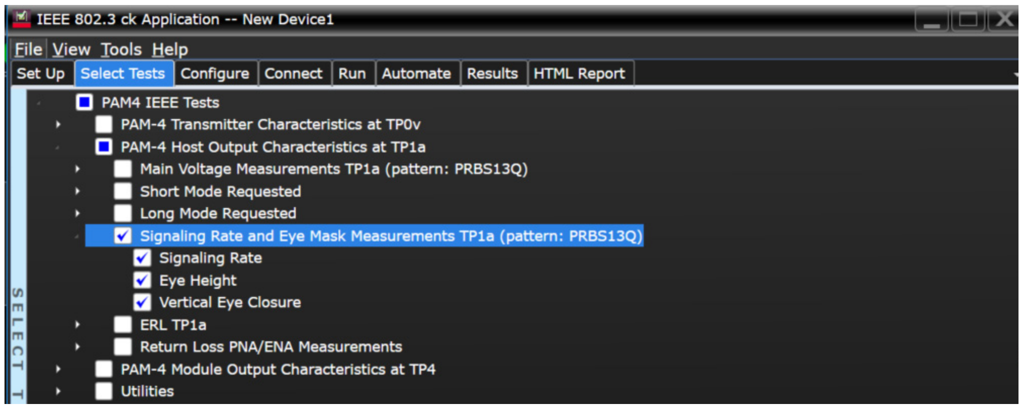


Figure 17 Selecting Signaling Rate and Eye Mask Measurement Tests

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 58
- "Eye Height" on page 58
- "Vertical Eye Closure" on page 59

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 Gb/s.
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 TP1a** 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 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.

5 Compare the Eye Height with 10mV. 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 1a** 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 4^{th} Order Bessel Thomson 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 Calculate Vertical Eye Closure (VEC) using the equation:

$$VEC = 20\log(AV/EH5)$$

7 Report the resulting value of Vertical Eye Closure.

ERL TP1a

The ERL Measurement procedure described in this section is performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

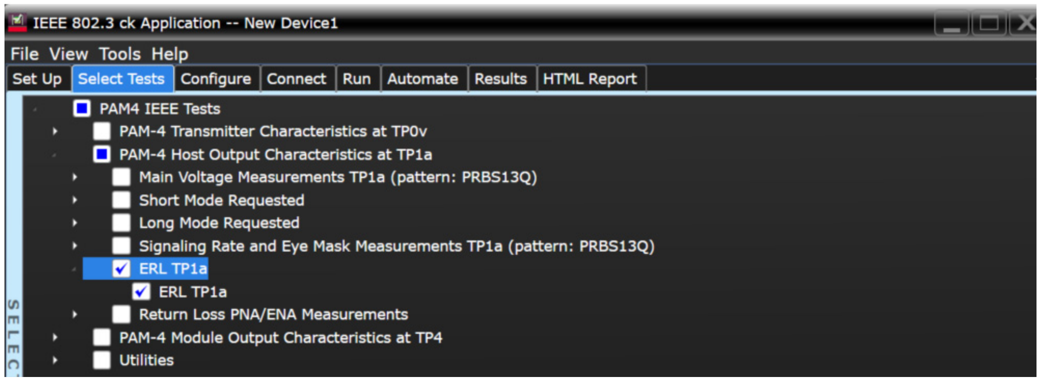


Figure 18 Selecting ERL Test

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

To know about the measurement algorithm, see:

- "ERL TP1a" on page 60

ERL TP1a

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

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

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

3 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).

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

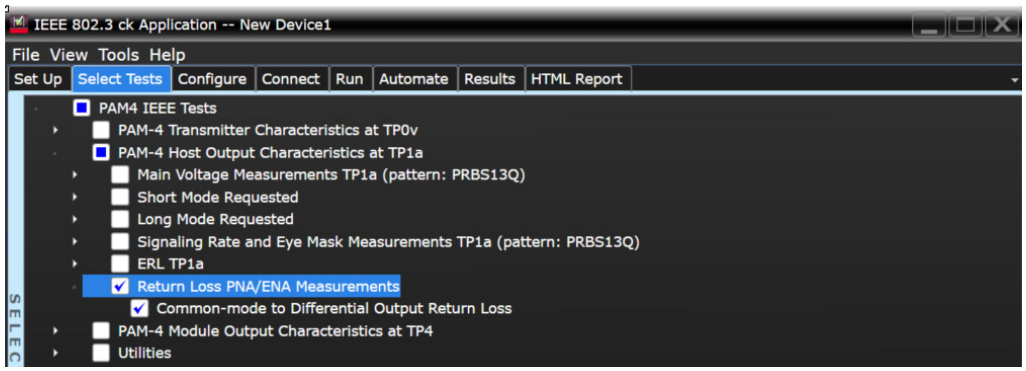


Figure 19 Selecting Return Loss Measurement Tests

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

To know about the measurement algorithm for each Return Loss PNA/ENA 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/ENA is physically connected and calibrated.
2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3 Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4 Click **Run** under the **Run** tab. The 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™ /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.

Module output electrical characteristics at TP4

Table 4 Module output characteristics at TP4

Parameter	Reference	Value	Units
Signaling rate, each lane (nominal)		53.125[a]	GBd
Peak-to-peak AC common-mode voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}	Sec. 120G.5.1	 32 80	 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, RLdc (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 (min)	Sec. 120G.3.2.4	-350	mV
DC common mode voltage (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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck 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.

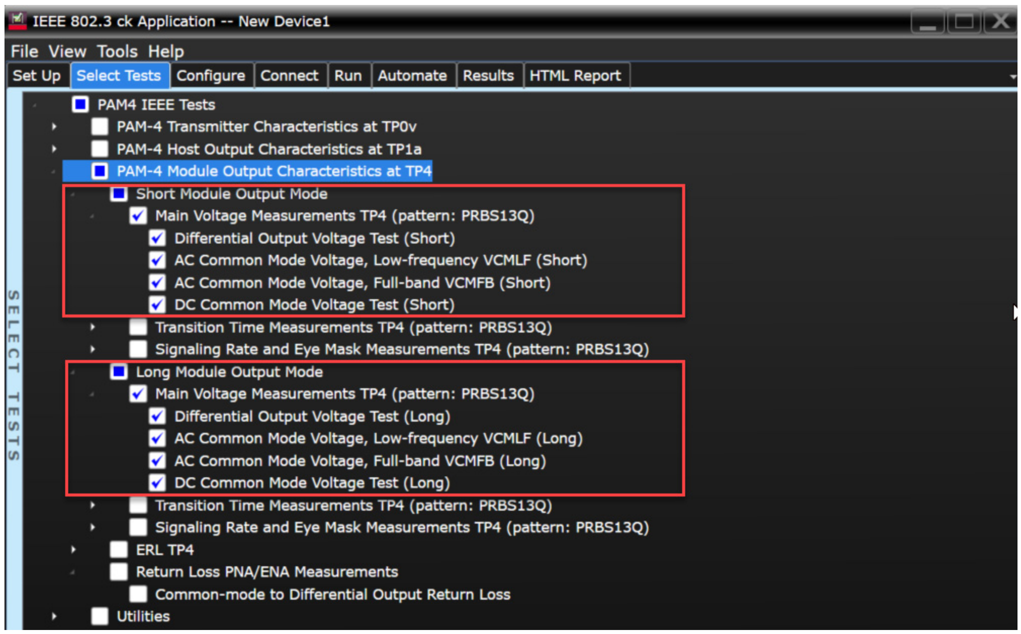


Figure 20 Selecting Main Voltage Measurement Tests

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:

- "Differential Output Voltage Test" on page 63
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 64
- "AC Common Mode Voltage, Full-band VCMFB" on page 64
- "DC Common Mode Voltage Test" on page 64

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.

AC Common Mode Voltage, Low-frequency VCMLF

Test Overview The purpose of this test is to verify that the low-frequency AC common-mode voltage of the signal is less than or equal to 32mV.

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 Apply 100 MHz low pass filter.
5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-5} of the measurement distribution.
6 Compare the voltage measurement with 32mV.

AC Common Mode Voltage, Full-band VCMFB

Test Overview The purpose of this test is to verify that the full-band AC common-mode voltage of the signal is less than or equal to 80mV.

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 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-5} of the measurement distribution.
5 Compare the voltage measurement with 80mV.

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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck 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.

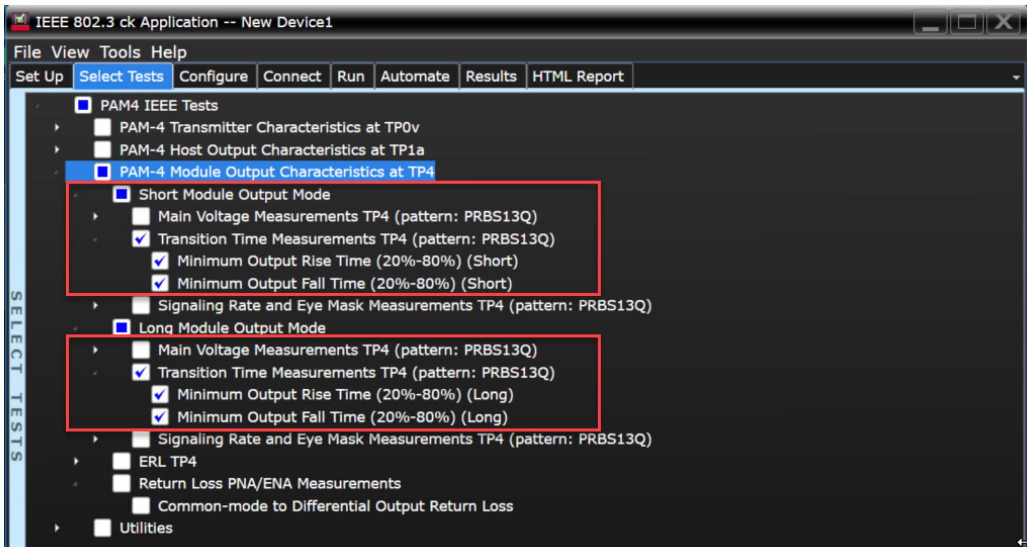


Figure 21 Selecting Transition Time Measurement Tests

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 66
- "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 output rise time is greater than or equal to 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 output fall time is greater than or equal to 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 333000 for the falling edge.
4 Measure fall time from 20% to 80% of the signal amplitude.
5 Compare the minimum output 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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck 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.

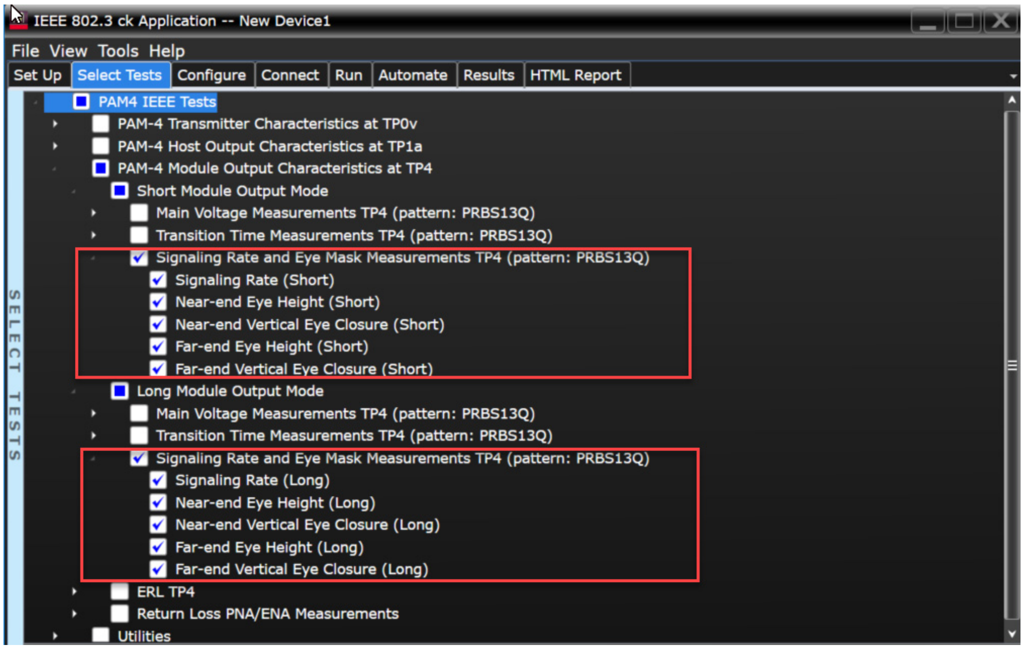


Figure 22 Selecting Signaling Rate and Eye Mask Measurement Tests

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 68
- "Near-end Eye Height" on page 69
- "Near-end Vertical Eye Closure" on page 69
- "Far-end Eye Height" on page 70
- "Far-end Vertical Eye Closure" on page 70

Signaling Rate

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

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. The measurement is made either in short module output mode or long module output mode.

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, DFE Eye Opening TP4 Short** or **Auto-tune Near-end CTLE, DFE 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 TP4 Short** and **Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Short** or **Use Optimized CTLE gDC for Near-end Eye Opening TP4 Long** and **Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 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 4^{th} Order Bessel Thomson 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 Vertical Eye Closure at EH5 (1E-5). The measurement is made either in short module output mode or long module output mode.

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, DFE Eye Opening TP4 Short** or **Auto-tune Near-end CTLE, DFE 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 TP4 Short** and **Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Short** or **Use Optimized CTLE gDC for Near-end Eye Opening TP4 Long** and **Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 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 4^{th} Order Bessel Thomson 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 Calculate Vertical Eye Closure (VEC) using the equation:

$$VEC = 20\log(AV/EH5)$$

7 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. The measurement is made either in short module output mode or long module output mode.

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 TP4 Short** and **Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Short** or **Use Optimized CTLE gDC for Far-end Eye Opening TP4 Long** and **Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 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 4^{th} Order Bessel Thomson 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 Vertical Eye Closure at EH5 (1E-5). The measurement is made either in short module output mode or long module output mode.

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 TP4 Short** and **Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Short** or **Use Optimized CTLE gDC for Far-end Eye Opening TP4 Long** and **Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 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 4^{th} Order Bessel Thomson 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 Calculate Vertical Eye Closure (VEC) using the equation:

$$VEC = 20\log(AV/EH5)$$

7 Report the resulting value of Vertical Eye Closure.

ERL TP4

The ERL Measurement procedure described in this section is performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

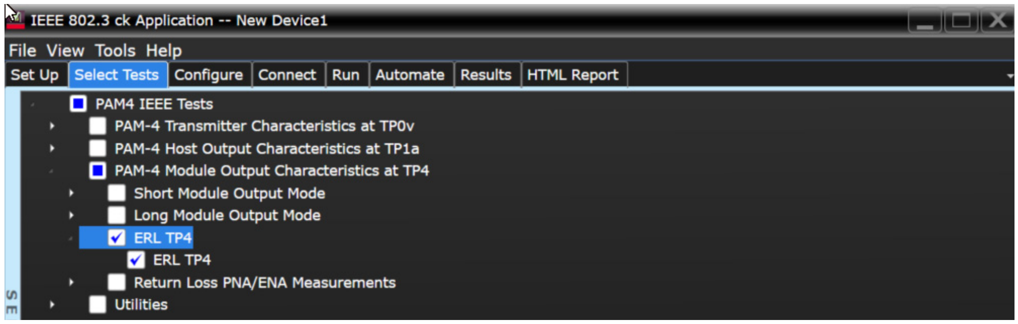


Figure 23 Selecting ERL Test

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

To know about the measurement algorithm, see:

- "ERL TP4" on page 71

ERL TP4

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

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

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

3 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).

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

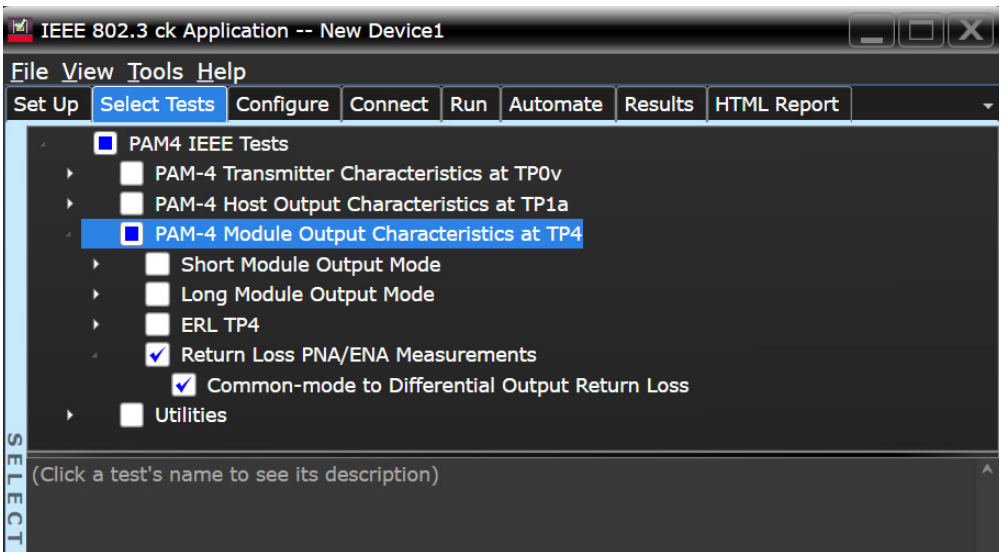


Figure 24 Selecting Return Loss Measurement Tests

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

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

- "Common-mode to Differential Output Return Loss" on page 72

Common-mode to Differential Output Return Loss

Measurement Algorithm

1. Ensure that the PNA/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to measure the Return Loss Measurements.
4. Click **Run** under the **Run** tab. The 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, DFE Eye Opening TP4" (for Near-end tests) or "Auto-tune Far-end CTLE, DFE 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 TP1a
   - Use Optimized CTLE gDC2 for Eye Opening TP1a
   - Use Optimized CTLE gDC for Near-end Eye Opening TP4 Short
   - Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Short
   - Use Optimized CTLE gDC for Near-end Eye Opening TP4 Long
   - Use Optimized CTLE gDC2 for Near-end Eye Opening TP4 Long
   - Use Optimized CTLE gDC for Far-end Eye Opening TP4 Short
   - Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 Short
   - Use Optimized CTLE gDC for Far-end Eye Opening TP4 Long
   - Use Optimized CTLE gDC2 for Far-end Eye Opening TP4 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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application

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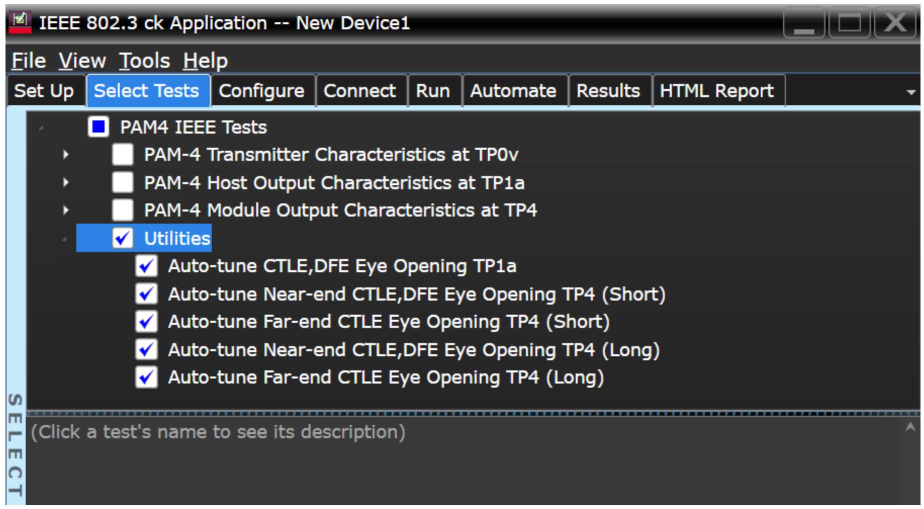

Figure 25 Selecting Utilities under the Select Tests Tab

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. The measurement is made either in short module output mode or long module output mode.

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 Eye Height 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

Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q/PRBS9Q) 80
Output Voltage Measurements EYE TP2 (pattern: PRBS13Q) 83
Output Waveform Measurements TP2 (pattern: PRBS13Q) 85
Main Voltage Measurements TP2 (pattern: PRBS13Q) 93
Return Loss PNA/ENA Measurements 96

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.

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
Signaling rate, each lane (range)	See Sec. 162.9.4.1 f the IEEE specification	53.125 ± 50 ppm	GBd
Differential pk-to-pk voltage with TX disabled[a]	See Sec. 93.8.1.3 of the IEEE specification	30	mV
DC common-mode voltage (max)[a]	See Sec. 93.8.1.3 of the IEEE specification	1.9	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}	See Sec.162.9.4.4 of the IEEE specification	 30 80	 mV mV
Differential pk-to-pk voltage, 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 common-mode return loss, RLcc (min)	See Sec. 162.9.4.9 of the IEEE specification	2	dB
Common-mode to differential-mode return loss, RLdc (min)	See Sec. 162.9.4.10 of the IEEE specification	See Equation (162–7)	dB
Transmitter steady-state voltage, v_f (min) Transmitter steady-state voltage, v_f (max)	See Sec. 162.9.4.1.2 of the IEEE specification	0.387 0.6	V
Linear fit pulse peak ratio, R_{peak} (min)	See Sec. 162.9.4.1.2 of the IEEE specification	0.397	-
Level separation mismatch ratio R_{LM} (min)	See Sec.162.9.4.1.2 of the IEEE specification	0.95	-
Transmitter output waveform[a] absolute value of step size for all taps (min) absolute value of 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)[c]	See Sec.162.9.4.6 of the IEEE specification	31.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	See Sec. 162.9.4.3 of the IEEE specification	26.7	dB
Output jitter (max.) JRMS $J3u_{03}$ 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

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.

Jitter and Signaling Rate Measurements TP2 (pattern: PRBS13Q/PRBS9Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

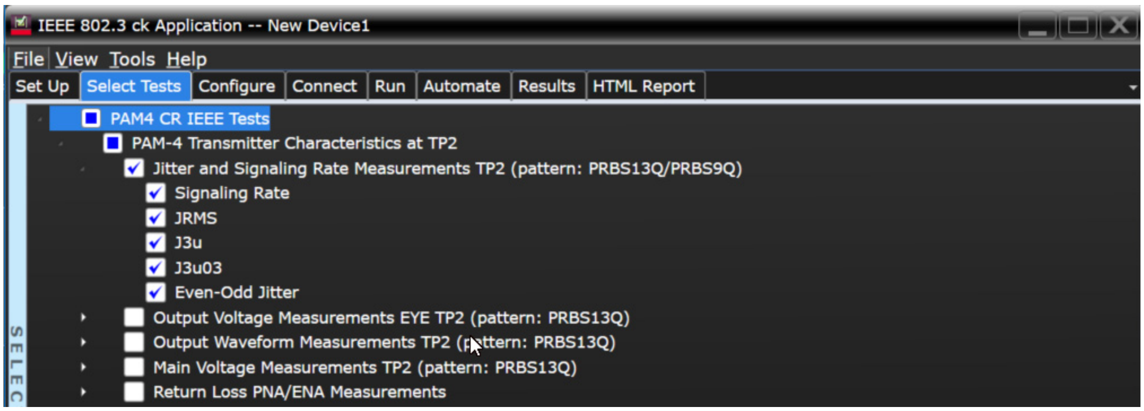

Figure 26 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section Transmitter characteristics for CR tests 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 80
- “JRMS” on page 80
- “J3u” on page 81
- “J3u03” on page 81
- “Even-Odd Jitter” on page 82

Signaling Rate

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

Pass Condition Refer to the section Transmitter characteristics for CR tests 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 Gb/s.
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 the section Transmitter characteristics for CR tests 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
   c Set 4^{th} 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 the section Transmitter characteristics for CR tests 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.
   c Set 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.
4 Compare and report the J3u value meets 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 the section Transmitter characteristics for CR tests 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.

   c Set 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4 Compare and report the J3u03 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 the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.

Measurement Algorithm

1 Obtain sample or acquire signal data.

NOTE **Signal must be of PRBS13Q/PRBS9Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.**

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q or PRBS9Q patterns are captured to collect the measurement data of 12 edges.

   c Set 4^{th} 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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

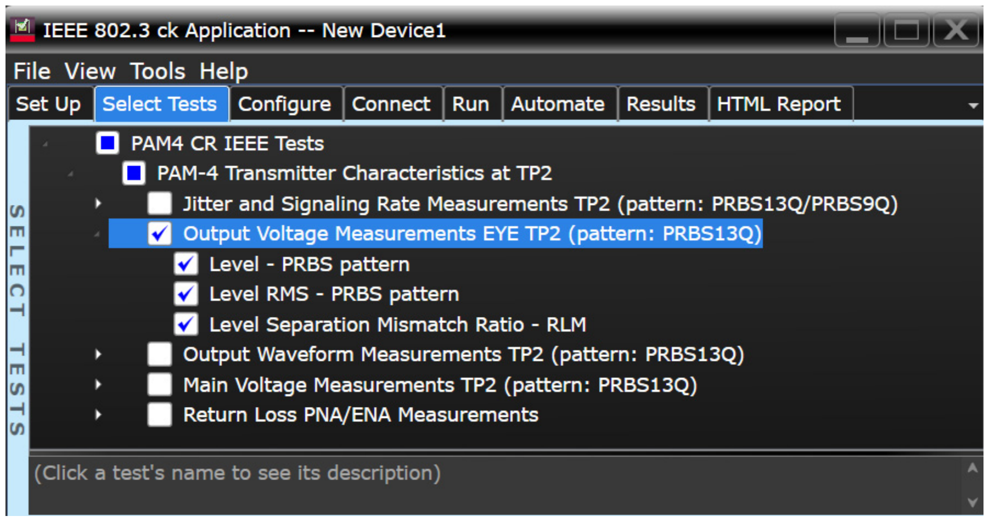

Figure 27 Selecting Output Voltage Measurements EYE Tests

Refer to the section Transmitter characteristics for CR tests 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 83
- "Level RMS - PRBS Pattern" on page 84
- "Level Separation Mismatch Ratio - RLM" on page 84

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 the section Transmitter characteristics for CR tests 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 as the result.

Output Waveform Measurements TP2 (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

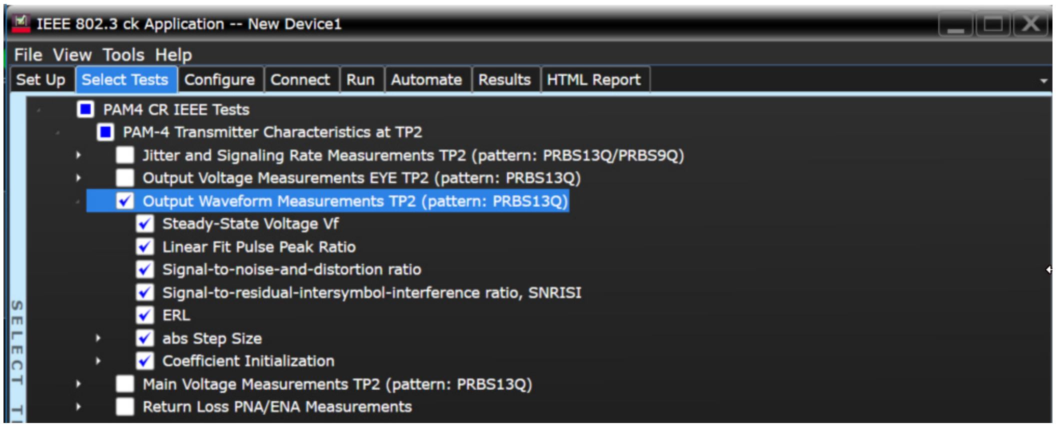

Figure 28 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section Transmitter characteristics for CR tests 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 85
- “Linear Fit Pulse Peak Ratio” on page 85
- “Signal-to-noise-and-distortion ratio” on page 86
- “Signal-to-residual-intersymbol-interference ratio, SNRISI” on page 86
- “ERL” on page 86
- “abs Step Size Tests” on page 87
- “Coefficient Initialization” on page 92

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 the section Transmitter characteristics for CR tests 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 = 2.
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 Peak 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 the section Transmitter characteristics for CR tests 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 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 the section Transmitter characteristics for CR tests 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-residual-intersymbol-interference ratio, SNRISI

Test Overview The purpose of this test is to verify that 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 Condition Refer to the section Transmitter characteristics for CR tests for the pass limits pertaining to each standard option.

Measurement Algorithm

1 Follow the procedure for Linear Fit Pulse peak to calculate p(k).
2 Calculate response for each gDC/gDC2 combination as defined in the Table 162-20.
3 With Nb=6, sweep tp from -0.5UI to 0.5UI to calculate ISI cursors for each gain (EQU 120D-8)
4 Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.
5 The results is the highest SNRISI 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 the section Transmitter characteristics for CR tests 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 Conformance Test Application, click **ERL File Setup** button to set up the s-parameter file (refer to Annex 93A.5.1 of the IEEE P802.3cd^{TM} specification for more information about the standards defined to create the s-parameters).
2 Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
3 Click **Run** under the **Run** tab.
4 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.

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 87
- "abs Step Size for c(-2)" on page 88
- "abs Step Size for c(-1)" on page 88
- "abs Step Size for c(0)" on page 88
- "abs Step Size for c(1)" on page 89
- "value at min. state for c(-3)" on page 89
- "value at max. state for c(-2)" on page 90
- "value at min. state for c(-1)" on page 90
- "value at min. state for c(0)" on page 90
- "value at min. state for c(1)" on page 91

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.

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.

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.

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 25m.

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.

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 = 3.

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 = 3.
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 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

Preset\Coefficient	c(-3)	c(-2)	c(-1)	c(0)	c(1)
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

Measurement Algorithm

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 = 3.
7 Calculate coefficients c(i) using equation 136-2.
8 Report c(#) value from step 7.

Main Voltage Measurements TP2 (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

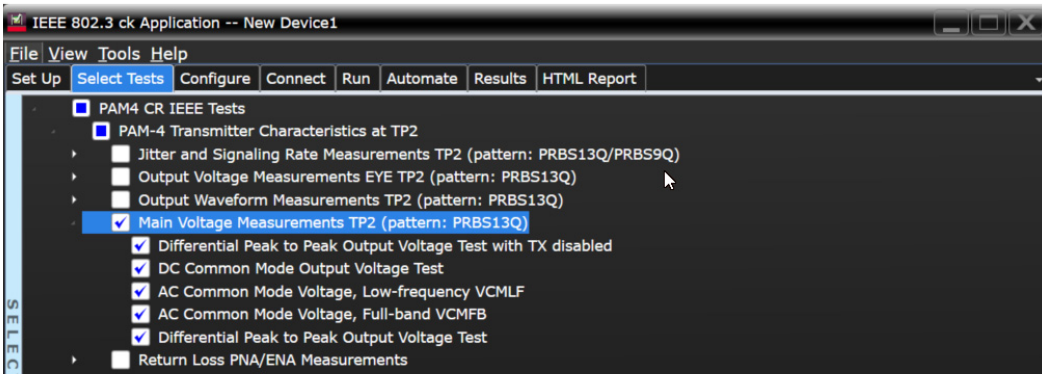

Figure 29 Selecting Main Voltage Measurement Tests

Refer to the section Transmitter characteristics for CR tests 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 93
- "DC Common Mode Output Voltage Test" on page 93
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 94
- "AC Common Mode Voltage, Full-band VCMFB" on page 94
- "Differential Peak-to-Peak Output Voltage Test" on page 95

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 the section Transmitter characteristics for CR tests 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.

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 the section Transmitter characteristics for CR tests 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.

AC Common Mode Voltage, Low-frequency VCMLF

Test Overview The purpose of this test is to verify that the low-frequency 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 the section Transmitter characteristics for CR tests 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 Apply 100 MHz low pass filter.
5 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-4} of the measurement distribution.
6 Compare the voltage measurement to the specified standards.

AC Common Mode Voltage, Full-band VCMFB

Test Overview The purpose of this test is to verify that the full-band 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 the section Transmitter characteristics for CR tests 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 Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-4} of the measurement distribution.
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 the section Transmitter characteristics for CR tests 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.

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or an ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

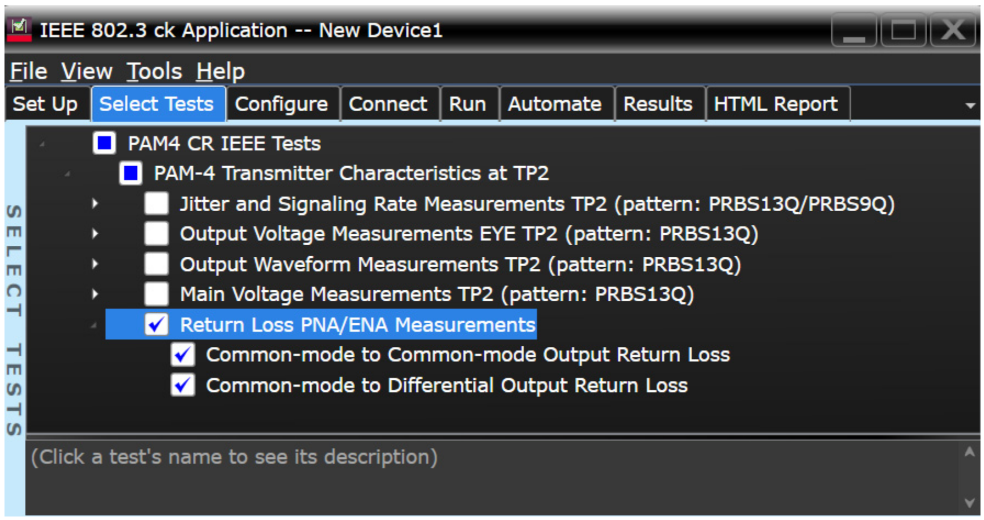

Figure 30 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section Transmitter characteristics for CR tests 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/ENA 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/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to make 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/ENA is physically connected and calibrated.
2. In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** or **Connect ENA** to establish connectivity to the connected equipment.
3. Click the **Select Tests** tab and check the tests to make 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

Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q) 99
Output Voltage Measurements EYE TP0v (pattern: PRBS13Q) 102
Output Waveform Measurements TP0v (pattern: PRBS13Q) 104
Main Voltage Measurements TP0v (pattern: PRBS13Q) 112
Return Loss PNA/ENA Measurements 114

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.

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, VCMLF (max)	See Sec. 162.9.4.4 of the IEEE specification	30	mV
Signal to AC common-mode noise ratio, SCMR (min)	See Sec. 163.9.2.6 of the IEEE specification	15	dB
Difference effective return loss, dERL (min)	163.9.2.2	-3	dB
Common-mode to common-mode return loss, RLcc (min)	162.9.2.3	3.25	dB
Difference steady-state voltage, dv_f (min)	163.9.2.4	0	V
Difference linear fit pulse peak ratio, dR_{peak} (min)	163.9.2.5	0	V
Level separation mismatch ratio, R_{LM} (min)	162.9.4.2	0.95	-
Transmitter waveform[b] absolute value of step size for all taps (min) absolute value of 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)	162.9.4.6	32.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	162.9.4.3	28	dB
Jitter (max)[c] JRMS $J3u_{03}$ 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 0.106 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. Implementations are recommended to use the same step size for all coefficients.

c. 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.

Jitter and Signaling Rate Measurements TP0v (pattern: PRBS13Q/PRBS9Q)

The Jitter and Signaling Rate Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

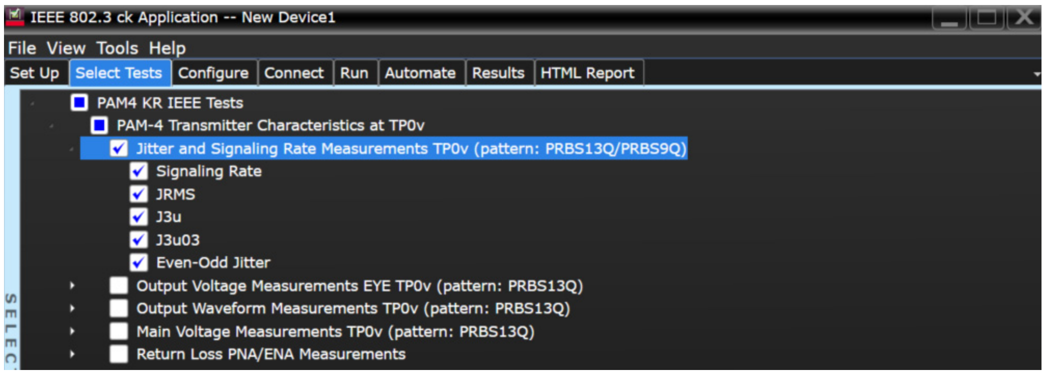

Figure 31 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section Transmitter characteristics for KR tests 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 99
- "JRMS" on page 99
- "J3u" on page 100
- "J3u03" on page 100
- "Even-Odd Jitter" on page 101

Signaling Rate

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

Pass Condition Refer to the section Transmitter characteristics for KR tests 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 Gb/s.
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 the section Transmitter characteristics for KR tests 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.

c Set 4^{th} 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 the section Transmitter characteristics for KR tests 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.

c Set 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4 Compare and report whether the J3u value meets 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 the section Transmitter characteristics for KR tests 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 and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q patterns are captured to collect the measurement data of 12 edges.

   c Set 4^{th} Order Bessel Thomson filter to 40 GHz with 3 dB gain.

4 Compare and report whether the J3u03 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 the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement Algorithm

1 Obtain sample or acquire signal data.

NOTE

Signal must be of PRBS13Q or PRBS9Q pattern and connections must be established between Data+ to Channel 1 and Data- to Channel 3 to measure the defined 12 edges.

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 Using PAM4 jitter measurements, at least 10,000 PRBS13Q or PRBS9Q patterns are captured to collect the measurement data of 12 edges.

   c Set 4^{th} 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 Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

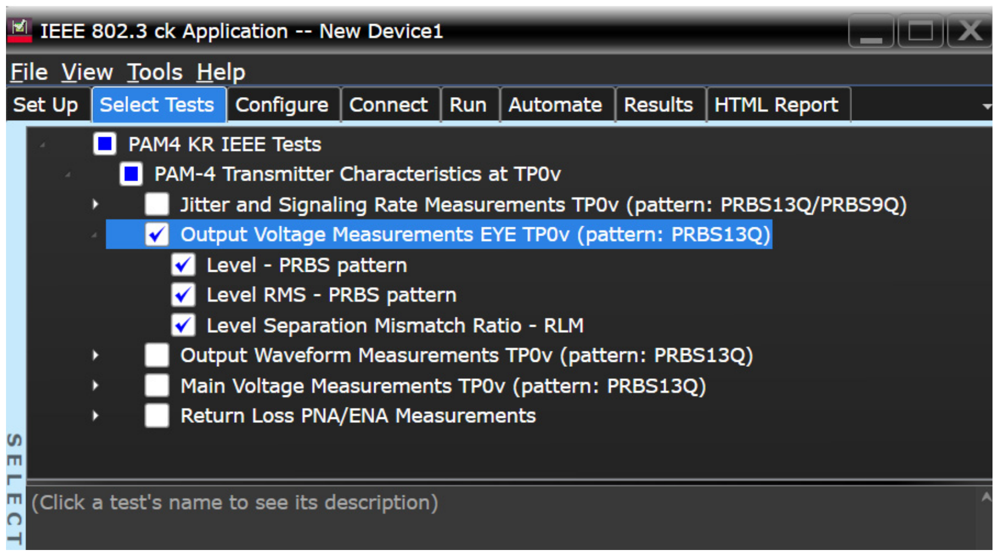

Figure 32 Selecting Output Voltage Measurements EYE Tests

Refer to the section Transmitter characteristics for KR tests 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 102
- "Level RMS - PRBS Pattern" on page 103
- "Level Separation Mismatch Ratio - RLM" on page 103

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 the section Transmitter characteristics for KR tests 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.

Output Waveform Measurements TP0v (pattern: PRBS13Q)

The Output Waveform Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

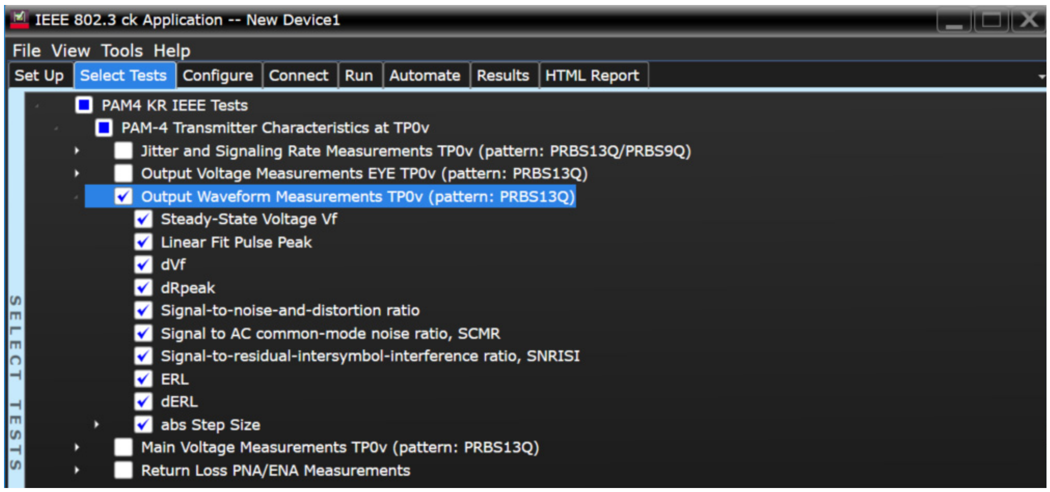

Figure 33 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section Transmitter characteristics for KR tests 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 104
- "Linear Fit Pulse Peak" on page 105
- "dVf" on page 105
- "dRpeak" on page 105
- "Signal-to-noise-and-distortion ratio" on page 106
- "Signal to AC common-mode noise ratio, SCMR" on page 106
- "Signal-to-residual-intersymbol-interference ratio, SNRISI" on page 106
- "ERL" on page 106
- "dERL" on page 107
- "abs Step Size Tests" on page 107

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 = 2.

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 = 2.

dVf

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

Pass Conditions Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement Algorithm

1. The user enters the fixture s-parameter (S0) file by clicking the **Fixture Ref File Setup** button 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 the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement Algorithm

1. The user enters the fixture s-parameter (S0) file by clicking the **Fixture Ref File Setup** button 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 the section Transmitter characteristics for KR tests 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 the section Transmitter characteristics for KR tests 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.

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

Test Overview The purpose of this test is to verify that 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 Condition Refer to the section Transmitter characteristics for KR tests for the pass limits pertaining to each standard option.

Measurement Algorithm

1. Follow the procedure for Linear Fit Pulse peak to calculate p(k).
2. Calculate response for each gDC/gDC2 combination as defined in the Table 162-20.
3. With Nb=6, sweep tp from -0.5UI to 0.5UI to calculate ISI cursors for each gain (EQU 120D-8)
4. Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.
5. The results is the highest SNRISI value.

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 Conformance Test Application, click **ERL File Setup** button to set up the s-parameter file (refer to Annex 93A.5.1 of the IEEE P802.3cd^{TM} specification for more information about the standards defined to create the s-parameters).
2. Click the **Select Tests** tab and check the ERL test to measure the effective return loss.
3. Click **Run** under the **Run** tab. The Conformance 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 the section Transmitter characteristics for KR tests 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 The user enters the initial ERL channel file by clicking the **ERL File Setup** button under the Setup tab.

2 The user enters the fixture s-parameter (S0) file by clicking the **Fixture Ref File Setup** button 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 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.

4 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.

5 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.

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 107
- “abs Step Size for c(-2)” on page 108
- “abs Step Size for c(-1)” on page 108
- “abs Step Size for c(0)” on page 109
- “abs Step Size for c(1)” on page 109
- “value at min. state for c(-3)” on page 109
- “value at max. state for c(-2)” on page 110
- “value at min. state for c(-1)” on page 110
- “value at min. state for c(0)” on page 110
- “value at min. state for c(1)” on page 111

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.

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.

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.

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.

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.

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.

Main Voltage Measurements TP0v (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the D90103CKC IEEE802.3ck Conformance Application.

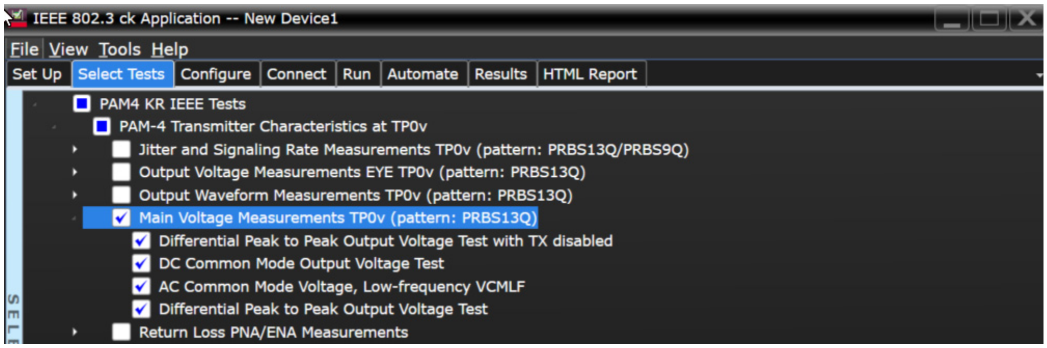

Figure 34 Selecting Main Voltage Measurement Tests

Refer to the section Transmitter characteristics for KR tests 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 112
- "DC Common Mode Output Voltage Test" on page 112
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 113
- "Differential Peak-to-Peak Output Voltage Test" on page 113

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 the section Transmitter characteristics for KR tests 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.

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 the section Transmitter characteristics for KR tests 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.

AC Common Mode Voltage, Low-frequency VCMLF

Test Overview The purpose of this test is to verify that the low-frequency 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 the section Transmitter characteristics for KR tests 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. Apply 100 MHz low pass filter.
5. Calculate the peak-to-peak AC common-mode voltage range that includes all but 10^{-4} of the measurement distribution.
6. 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 the section Transmitter characteristics for KR tests 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.

Return Loss PNA/ENA Measurements

The Return Loss PNA/ENA Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope along with either a PNA or ENA and the D90103CKC IEEE802.3ck Conformance Application. The Conformance Test Application controls the PNA/ENA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

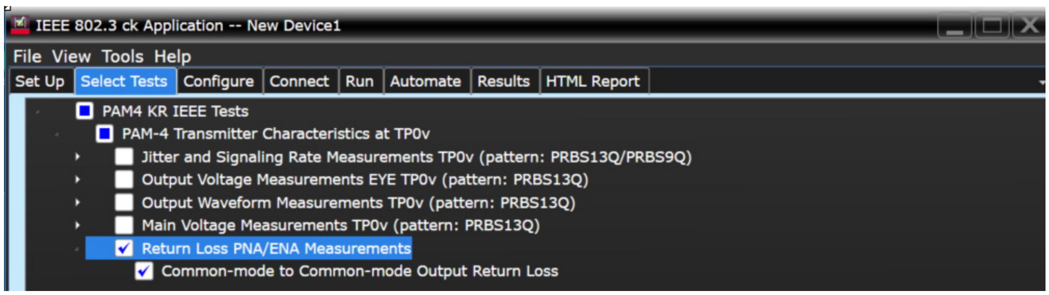

Figure 35 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section Transmitter characteristics for KR tests 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/ENA Measurements tests, see:

- "Common-mode to Common-mode Output Return Loss" on page 114

Common-mode to Common-mode Output Return Loss

Measurement Algorithm

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