D90203UAC UALink 2.0 Conformance Test Application

KEYSIGHT

METHODS OF IMPLEMENTATION

Notices

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Product Software Updates

Keysight releases periodic software updates to fix known defects, incorporate product enhancements, and address cybersecurity vulnerabilities, if any. Please ensure that your product software is always up to date.

To search for software updates for your product, please visit the Keysight Technical Support website at: https://www.keysight.com/us/en/support/D90203UAC

User Documentation

Our user documentation includes comprehensive information on features that may impact the secure deployment, use, and decommissioning of our products. This includes details on exposed network ports, the use of cryptography and authentication, and firmware security settings, if necessary.

Additional Resources

- Network Security Solutions: Learn how Keysight helps protect your network from threats.
- Creating a More Connected and Secure World: Discover Keysight's commitment to cybersecurity.

D90203UAC UALink 2.0 Conformance Test Application—At a Glance

The Keysight D90203UAC UALink 2.0 Conformance Test Application is a high-speed serial interface test solution designed to verify the electrical and timing parameters based on PAM4 signaling.

The main features of the D90203UAC UALink 2.0 Conformance Test Application are:

- Complete coverage of specification-based CR and KR tests.
- Data Analytics

The D90203UAC UALink 2.0 Conformance Test Application:

- Lets you select individual or multiple tests to run.
- Lets you identify the device being tested and its configuration.
- Shows you how to make oscilloscope 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 D90203UAC UALink 2.0 Conformance Test Application, you need the following hardware and software:

Hardware:

- Keysight UXR series Real-Time Infiniium Oscilloscope (Bandwidth 90 GHz and above)
- Keysight PNA Network Analyzer
- 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 D90203UAC release notes)
- Keysight D90203UAC UALink 2.0 Conformance Application

Licenses:

- For the required licenses for the D90203UAC UALink 2.0 Conformance Test Application, refer to the Data Sheet.

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If you purchased the D90203UAC UALink 2.0 Conformance Test 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 D90203UAC release notes) by selecting **Help > About Infiniium...** from the main menu.
2. To obtain the D90203UAC Conformance Test Application, go to Keysight website: http://www.keysight.com/find/D90203UAC.
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

To procure a license, you require the Ethernet Address information that is displayed in the Keysight Software Manager Utility application installed on the same machine where you wish to install the license.

Using Keysight Software Manager Utility

To view and copy the Ethernet Address from Keysight Software Manager Utility:

1 Launch **Keysight Software Manager Utility** on the machine where you wish to run the Test Application and its features.

2 Copy the **Ethernet Address**, which is a set of alphanumeric values (as highlighted in Figure 1) that appears in the **Add License** tab of the application.

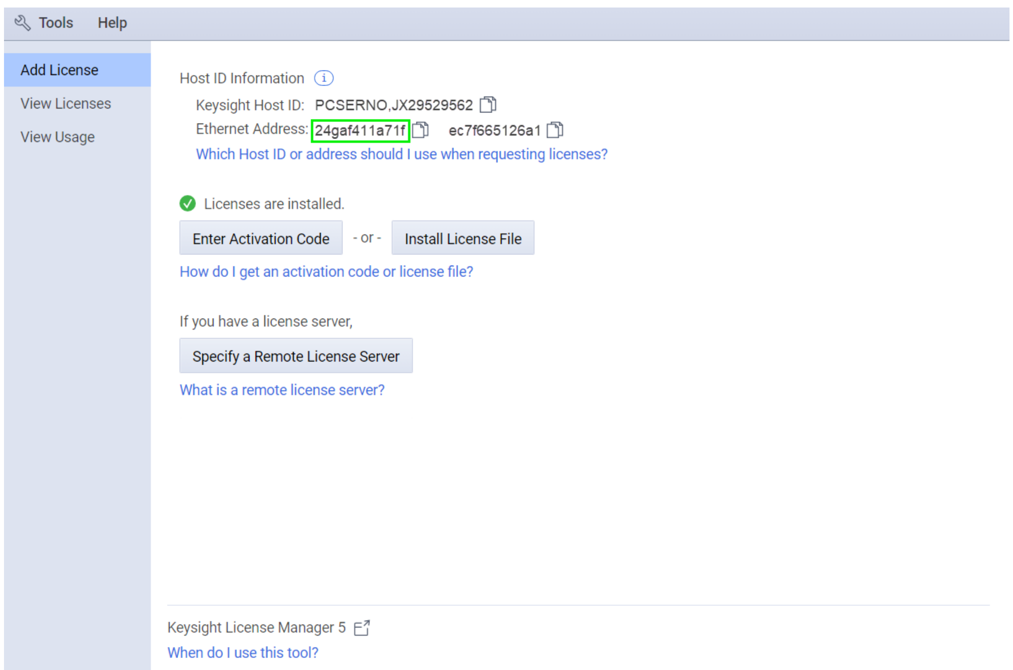

Figure 1 Viewing the Ethernet Address

To install one of the procured licenses using the Keysight Software Manager Utility application:

1. Save the license files on the machine where you wish to run the Test Application and its features.
2. Launch Keysight Software Manager Utility.
3. In the **Add License** tab (Figure 2), use one of the options to install the license file.

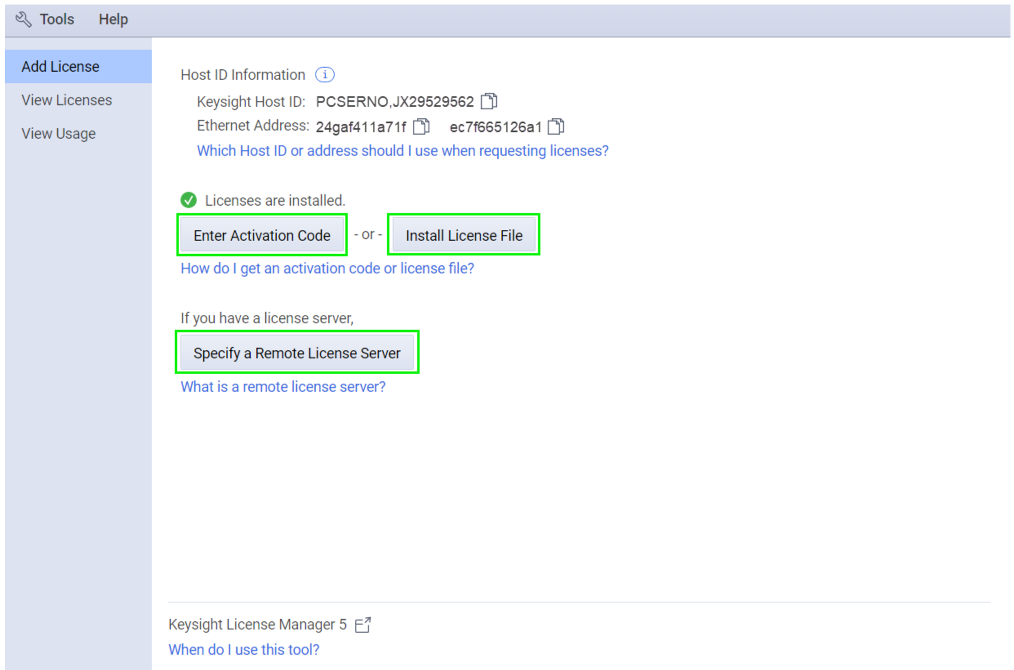

Figure 2 License installation options

- For more information regarding installation of procured licenses in Keysight Software Manager Utility, refer to **Supporting Documentation** section on the Keysight Software Manager Utility web page.

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 D90203UAC UALink 2.0 Conformance Test 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 > D90203UAC Oscilloscope Transmitter Compliance Test for UALink 2.0 Devices**.

3 The Keysight D90203UAC UALink 2.0 Conformance Test Application appears.

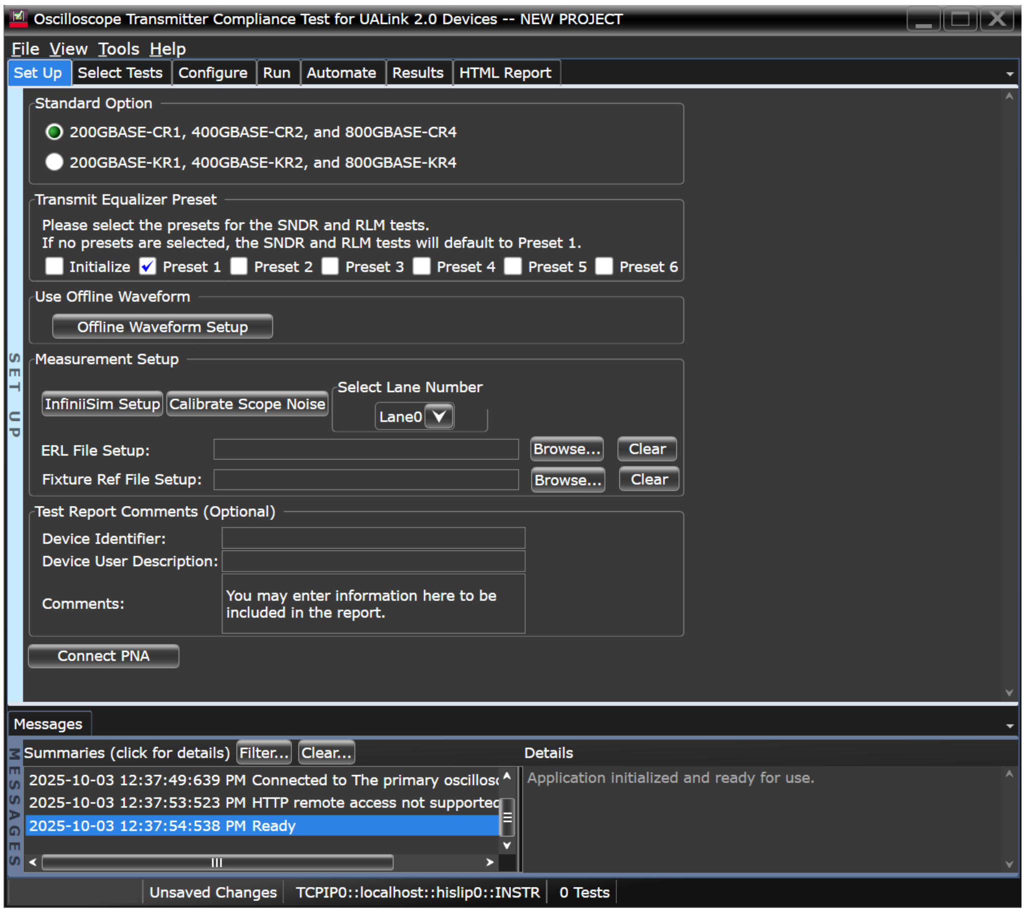

Figure 3 The D90203UAC UALink 2.0 Conformance Test Application Main Window

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. ▪ Select the **Standard Option** against which the DUT should be tested. ▪ In the **Instrument Setup** section, select the channel pair for performing measurement. In case of offline mode, **Instrument Setup** option changes to **Offline Waveform Setup**. Use this option to select the required waveform files. ▪ 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 **Calibrate Scope Noise** button, the scope noise calibration process can be started. ▪ 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 fixture can be specified. ▪ The **Select Lane Number** enables you to choose a lane for testing. ▪ Use the **Connect PNA** button to connect to a PNA device. ▪ The **Device Identifier**, **User Description**, and **Comments** are all printed in the final HTML report.
Select Tests	Lets you select the tests you want to run. The tests are organized hierarchically so you can select all tests in a group. After tests are run, status indicators show which tests have passed, failed, or not been run, and there are indicators for the test groups.
Configure	Lets you configure test parameters (for example, channels used in test, 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 3), 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 16.

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 D90203UAC UALink 2.0 Conformance Test Application sets optimum values for each configuration parameter.

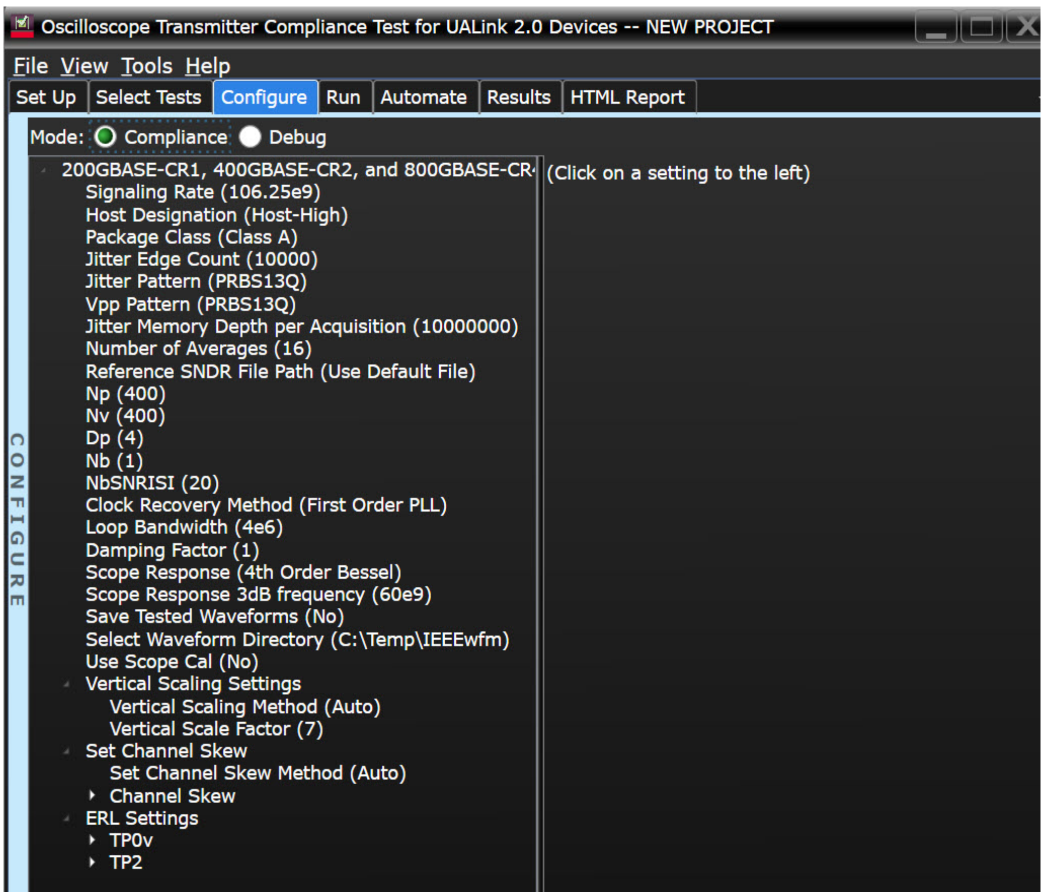

Figure 4 Configure Tab in the D90203UAC UALink 2.0 Conformance Application

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 5. 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.

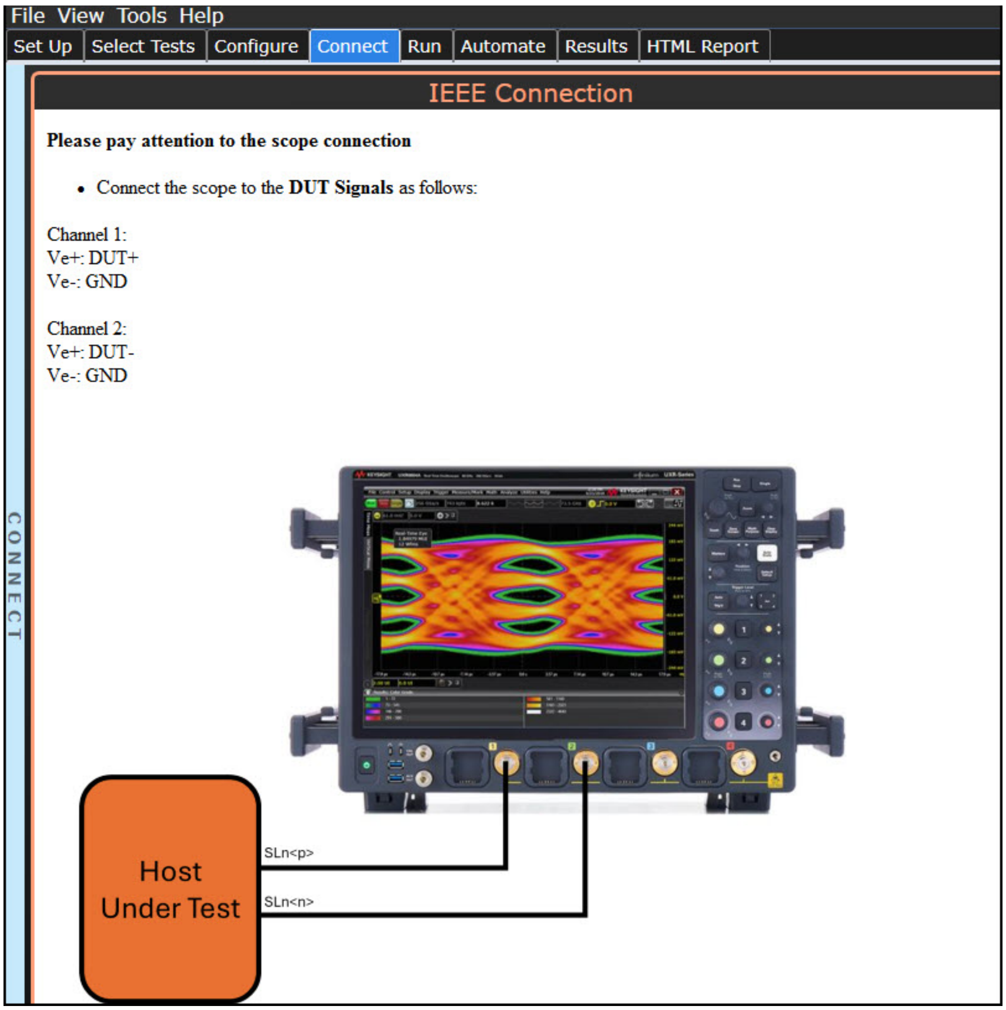

Figure 5 Connect Tab in the D90203UAC UALink 2.0 Conformance Application

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.

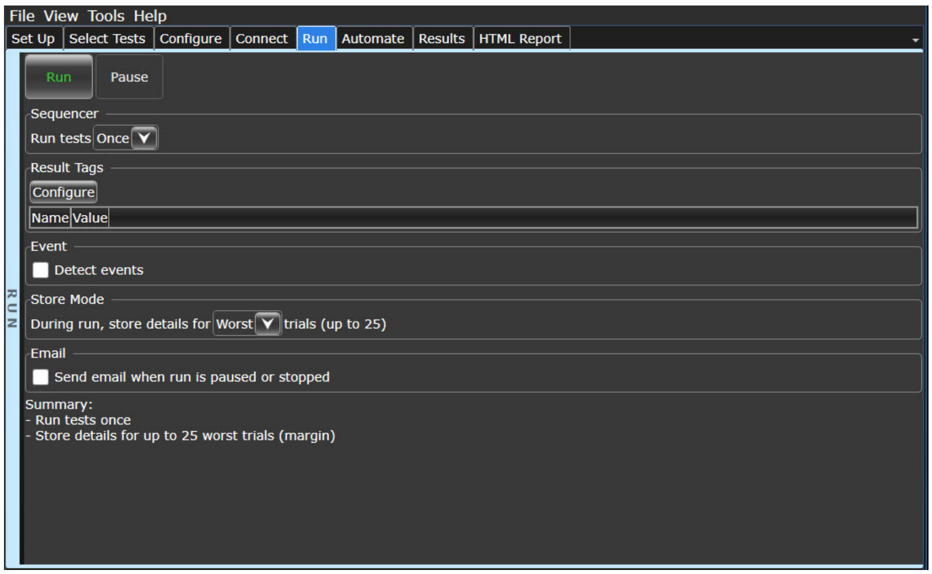

Figure 6 Run Tab in the D90203UAC UALink 2.0 Conformance Application

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 KS6800B Series Analytics Software.

3 CR Tests

PAM-4 Transmitter Characteristics at TP2 for CR tests 22

This section provides the Methods of Implementation (MOIs) for the tests for IEEE PAM4 Transmitter Characteristics for 200GBASE-CR1, 400GBASE-CR2, and 800GBASE-CR4 tests. 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.

PAM-4 Transmitter Characteristics at TP2 for CR tests

See Table 2 for pass limits pertaining to 200GBASE-CR1, 400GBASE-CR2, and 800GBASE-CR4 PAM4 tests, which are specified in *IEEE P802.3dj™ /D2.0 (Draft Standard for Ethernet* Amendment: Media Access Control Parameters for 1.6 Tb/s and Physical Layers and Management Parameters for 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Operation) Section 179.9.4, *Table 179-7*.

Table 2 Summary of transmitter specifications at TP2 (Spec Table 179-7)

Parameter	Reference	Value	Units
Signaling rate, each lane (range)		106.25 ± 50 ppm[a]	GBd
Differential pk-to-pk voltage (max) Transmitter disabled Transmitter enabled	176D.8.1	 30 1000	mV
DC common-mode voltage (max)	176D.8.1	1	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}	176D.8.1	 30 80	 mV mV
Effective return loss, ERL (min)	179.9.4.7	7.3	dB
Common-mode to common-mode return loss, RLcc (min)	179.9.4.8	See Equation (179–19)	dB
Common-mode to differential-mode return loss, RLdc (min)	179.9.4.9	See Equation (179–20)	dB
Transmitter steady-state voltage, v_f (range)	179.9.4.1.2	0.4 to 0.5	V
Linear fit pulse peak ratio, R_{peak} (min) Host class HL Host class HN Host class HH	179.9.4.1.2	 0.456 0.345 0.234	 - - -
Level separation mismatch ratio R_{LM} (min)	179.9.4.2	0.95	-
Transmitter waveform 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)	 179.9.4.1.4 179.9.4.1.4 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5	 0.005 0.025 −0.06 0.12 −0.34 0.5 −0.2	 - - - - - - -
Difference Signal-to-noise-and-distortion ratio, dSNDR (min)	179.9.4.5	0	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	26.7	dB
Output jitter (max.) J_{RMS03} EOJ_{03} $J3u_{03}$, Host class HL Host class HN Host class HH	179.9.4.6	 0.023 0.025 0.120 0.124 0.128	 UI UI UI UI UI

Main Voltage Measurements TP2 (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90203UAC UALink 2.0 Conformance Test Application.

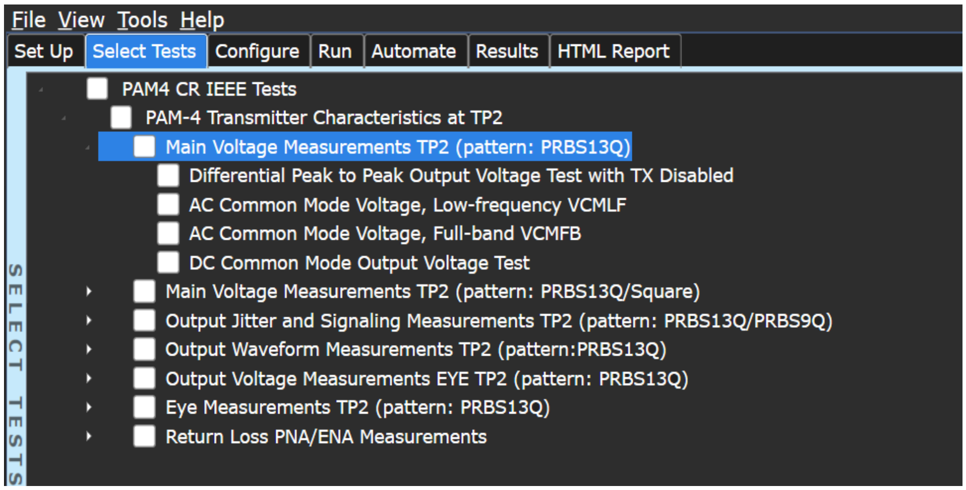

Figure 7 Selecting Main Voltage Measurement Tests

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

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

- "Differential Peak to Peak Output Voltage Test with TX Disabled" on page 23
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 24
- "AC Common Mode Voltage, Full-band VCMFB" on page 24
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 24

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 Table 2 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.

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 Table 2 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 Table 2 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.

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 Table 2 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.

Main Voltage Measurements TP2 (pattern: PRBS13Q/Square)

The Main Voltage measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90203UAC UALink 2.0 Conformance Test Application.

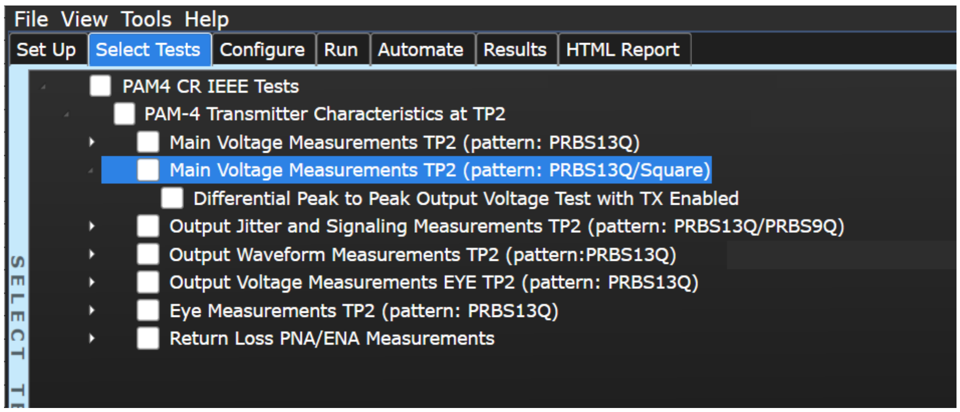

Figure 8 Selecting Main Voltage Measurement Tests

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

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

- "Differential Peak to Peak Output Voltage Test with TX Enabled" on page 26

Differential Peak to Peak Output Voltage Test with TX Enabled

Test Overview The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q/Square pattern meets the specified standards.

Pass Condition Refer to the section Table 2 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/Square pattern.
3 Measure the peak-to-peak voltage range of the differential signal on DUT+ and DUT- that includes all but 10^{-7} of the measurement distribution.
4 Compare the maximum peak-to-peak voltage to the specified standards.

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

The Output Jitter and Signaling Measurement procedures described in this section are performed using a Keysight Infiniium oscilloscope and the D90203UAC UALink 2.0 Conformance Test Application.

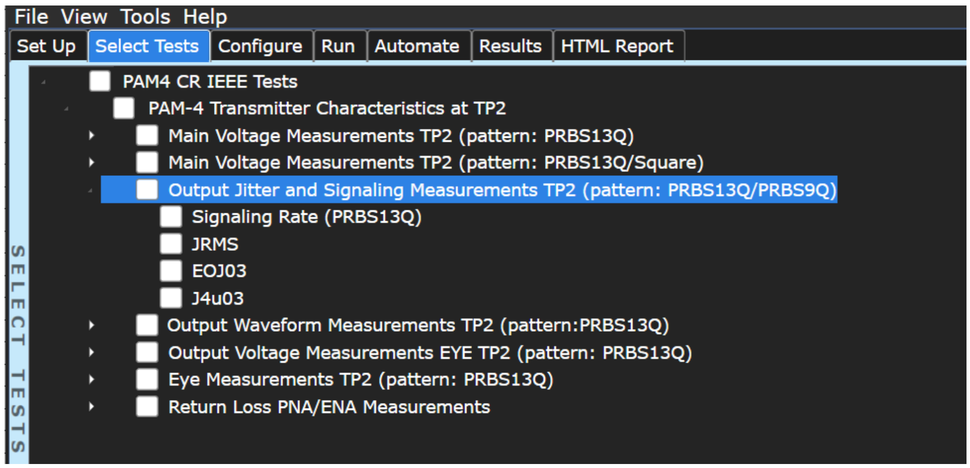

Figure 9 Selecting Output Jitter and Signaling Measurement Tests

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

To know about the measurement algorithm for each Output Jitter and Signaling Measurements TP2 (pattern: PRBS13Q/PRBS9Q) tests, see:

- "Signaling Rate" on page 27
- "JRMS" on page 28
- "EOJ03" on page 28
- "J4u03" on page 29

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 Table 2 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 symbol rate of 106.25 GBd and that data pattern exists (PRBS13Q or PRBS9Q must be used for this test).
3. In the **Configure** tab, set **Signaling Rate** to 106.25 GBd.
4. Measure minimum and maximum data rate.
5. Report minimum and maximum values.
6. Compare the mean data rate value with the specified standards. Report the resulting value.

JRMS

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

Pass Conditions Refer to the section Table 2 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 2 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 (106.25 Gb/s) 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 60 GHz with 3 dB gain.
4 Compare and report the JRMS value to the specified standards.

EOJ03

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 Table 2 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 2 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 (106.25 Gb/s 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 60 GHz with 3 dB gain.
   d Compare and report the Even-Odd Jitter value to the specified standards.

J4u03

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

Pass Conditions Refer to the section Table 2 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 2 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 (106.25 Gb/s) 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 60 GHz with 3 dB gain.

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

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 D90203UAC UALink 2.0 Conformance Test Application.

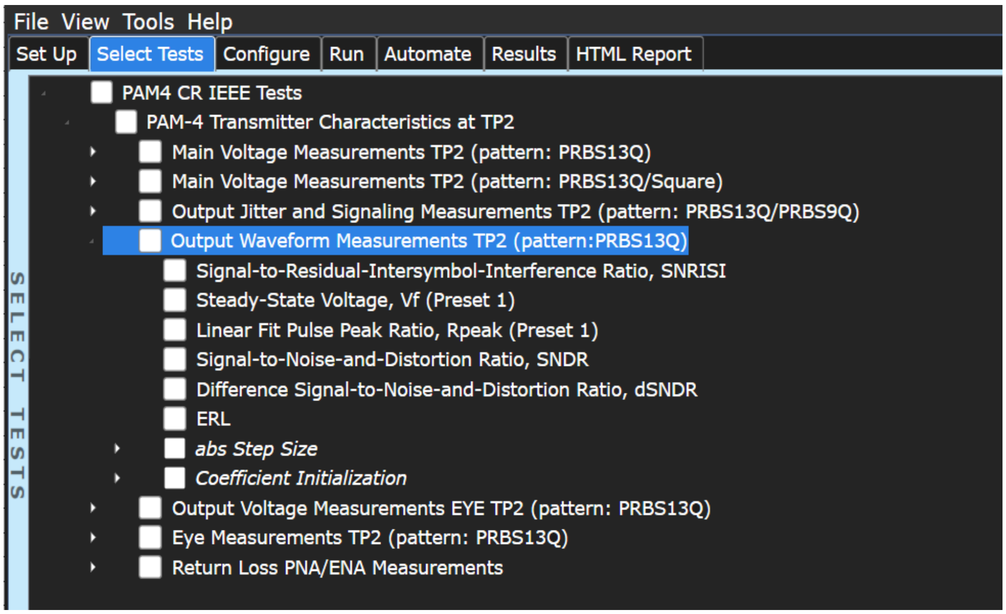

Figure 10 Selecting Transmitter Output Waveform Measurement Tests

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

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

- "Signal-to-Residual-Intersymbol-Interference Ratio, SNRISI" on page 31
- "Steady State Voltage Vf" on page 31
- "Linear Fit Pulse Peak Ratio, Rpeak" on page 31
- "Signal-to-Noise-and-Distortion Ratio, SNDR (Information Only)" on page 32
- "Difference Signal-to-Noise-and-Distortion Ratio, dSNDR" on page 32
- "ERL" on page 32
- "abs Step Size Tests" on page 33
- "Coefficient Initialization" on page 38

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 (SNR_{ISI}) for the following pairs of Output Gain, gDC and gDC2 (in Decibels) meets the specified standards:

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

Pass Condition Refer to the section Table 2 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.
3 With Nb=20, sweep tp from -0.5 UI to 0.5 UI to calculate ISI cursors for each gain.
4 Using the min ISI cursor calculation from step 3 for each gain, calculate SNRISI.
5 The results is the highest SNR_{ISI} value.

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 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 = 400, D_p = 4.
4 Compare the resulting value to the specified standards.

Linear Fit Pulse Peak Ratio, Rpeak

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

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 the transmitter output steady-state voltage, V_f and linear fit pulse response peak voltage, V_{peak}.
4 Calculate the Linear Fit Pulse Ratio by dividing V_{peak} with V_f.
5 Compare the resulting value to the specified standards.

Signal-to-Noise-and-Distortion Ratio, SNDR (Information Only)

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 N/A

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.

Difference Signal-to-Noise-and-Distortion Ratio, dSNDR

Test Overview The purpose of this test is to verify that the Difference Signal-to-noise-and-distortion ratio (dSNDR) meets the specified standards.

Pass Condition Refer to the section Table 2 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. From the SNDR value, subtract the user provided SNDR reference value.
   User will provide SNDR reference value in a csv file in C:\ProgramData\Keysight\Infiniium\Apps\UALink Test\dSNDR\ folder

$$dSNDR(i) = SNDR_i^{(meas)} - SNDR^{(ref)}(c_i)$$

3. Compare the resulting value of dSNDR to the specified standards.

NOTE

Specify the source of the reference SNDR values. If "Use Default File" is selected, the application will use the default CSV file located at "C:\Program Files\Keysight\Infiniium\Apps\UALinkTest\app\dSNDR\SNDR_ref_evaluation_and_data.csv".

Alternatively, selecting "Use Editable File" will point to a custom CSV file located at "C:\ProgramData\Keysight\Infiniium\Apps\UALink Test\dSNDR\SNDR_ref_evaluation_and_data.csv", which users can modify to define their own SNDR reference values for evaluation.

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 Table 2 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, use **ERL File Setup** option to set up the s-parameter file.
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).
4. Compare the effective return loss to the specified standards.

abs Step Size Tests

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

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

- "abs Step Size for c(-3)" on page 33
- "abs Step Size for c(-2)" on page 34
- "abs Step Size for c(-1)" on page 34
- "abs Step Size for c(0)" on page 35
- "abs Step Size for c(1)" on page 35
- "value at min. state for c(-3)" on page 36
- "value at max. state for c(-2)" on page 36
- "value at min. state for c(-1)" on page 36
- "value at min. state for c(0)" on page 37
- "value at min. state for c(1)" on page 37

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 179-1.
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 = 400, D_p = 4.
7. Calculate coefficients c(i) using equation 179-2.
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 = 400, D_p = 4.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request to change c(-2) to the first step.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 $N_p = 400$, $D_p = 4$.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request to change c(-1) to the first step.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 $N_p = 400$, $D_p = 4$.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request to change c(0) to the first step.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 $N_p = 400$, $D_p = 4$.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request to change c(1) to the first step.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 $N_p = 400$, $D_p = 4$.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7. Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7. Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7. Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
8 Report c(1) value from step 7.

Coefficient Initialization

Test Overview This test group consists of the following tests:

- Coefficient Initialization Preset Initialize c(-3) (Information Only)
- Coefficient Initialization Preset Initialize c(-2) (Information Only)
- Coefficient Initialization Preset Initialize c(-1) (Information Only)
- Coefficient Initialization Preset Initialize c(0) (Information Only)
- Coefficient Initialization Preset Initialize c(1) (Information Only)
- 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)
- Coefficient Initialization Preset 6 c(-3)
- Coefficient Initialization Preset 6 c(-2)
- Coefficient Initialization Preset 6 c(-1)
- Coefficient Initialization Preset 6 c(0)
- Coefficient Initialization Preset 6 c(1)

Pass Condition

Table 3 Coefficient initial conditions (Spec Table 179-8)

Preset\Coefficient	c(-3)	c(-2)	c(-1)	c(0)	c(1)
initialize	0	0	0	1	0
Preset 1[a]	0	0	0	1	0
Preset 2	0 ±0.025	0 ±0.025	0 ±0.025	0.5 ±0.025	0 ±0.025
Preset 3	0 ±0.025	0 ±0.025	-0.075 ±0.025	0.75 ±0.025	0 ±0.025
Preset 4	0 ±0.025	0.05 ±0.025	-0.2 ±0.025	0.75 ±0.025	0 ±0.025
Preset 5	-0.025 ±0.025	0.075 ±0.025	-0.25 ±0.025	0.65 ±0.025	0 ±0.025
Preset 5	0 ±0.025	0.075 ±0.025	-0.25 ±0.025	0.75 ±0.025	0 ±0.025

[a] Preset 1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 179.9.4.1.1). As a result, the normalized coefficients for preset 1 and initialize do not include any tolerances.

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 179-1.
5 Request preset # (for each test).
6 Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7 Calculate coefficients c(i) using equation 179-2.
8 Report c(#) value from step 7.

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 D90203UAC UALink 2.0 Conformance Test Application.

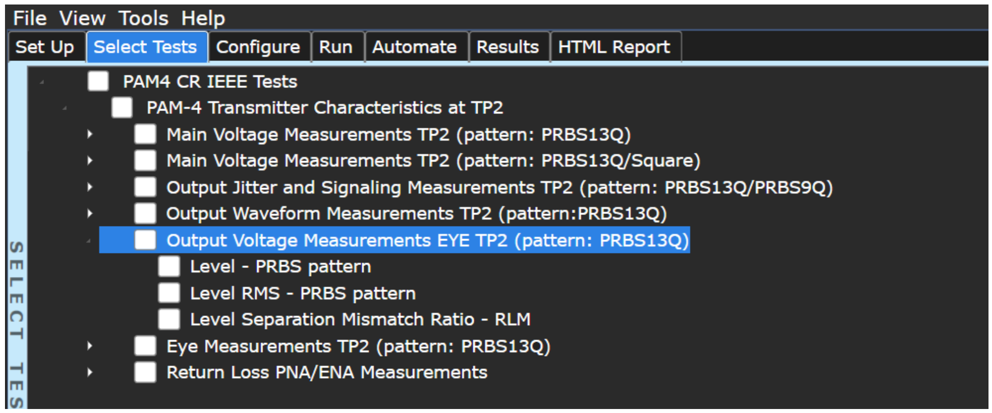

Figure 11 Selecting Output Voltage Measurements EYE Tests

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

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

- “Level - PRBS Pattern (Information Only)” on page 41
- “Level RMS - PRBS Pattern (Information Only)” on page 41
- “Level Separation Mismatch Ratio - RLM” on page 41

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 (Information Only)

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

Pass Condition N/A

Measurement Algorithm

1 Check that signal is connected and proper data pattern exists (PRBS13Q/PRBS9Q 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 Std 802.3^{TM}-2022, section 120D.3.1.2. The calculation of mean signal levels is 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 (Information Only)

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

Pass Condition N/A

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 Std 802.3^{TM}-2022, section 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 Table 2 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 Std 802.3^{TM}-2022, section 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-6).

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

5 Report the calculated value.

Eye Measurements TP2 (pattern: PRBS13Q)

The Eye Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90203UAC UALink 2.0 Conformance Test Application.

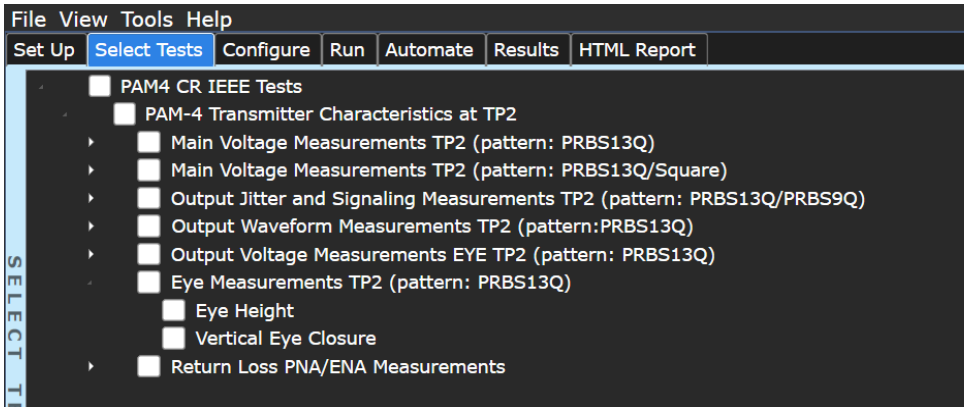

Figure 12 Selecting Signaling Rate and Eye Measurement Tests

Refer to Table 2 for information on the pass limits for each test.

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

- "Eye Height (Information Only)" on page 42
- "Vertical Eye Closure (Information Only)" on page 43

Eye Height (Information Only)

Test Overview The purpose of this test is to measure the eye height at user defined CTLE.

Pass Conditions N/A

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Measure the Eye Height at an **Eye Height/Width Probability** setting of 1E-5.
3 On the Oscilloscope,
   a set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (106.25 GBd) and Loop Bandwidth to 4 MHz.
   b Set 4th Order Bessel Thomson filter to 60 GHz with 3 dB gain.
   c Perform eye measurement using 60 GHz Butterworth filter.
4 Report the eye height value.

Vertical Eye Closure (Information Only)

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

Pass Conditions N/A

Measurement Algorithm

1 Obtain sample or acquire signal data.
2 Measure the Vertical Eye Closure at an **Eye Height/Width Probability** setting of 1E-5 (EH5).
3 On the Oscilloscope,
   a set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (106.25 GBd) and Loop Bandwidth to 4 MHz.
   b Set 4^{th} Order Bessel Thomson filter to 60 GHz with 3 dB gain.
   c Perform eye measurement using 60 GHz Butterworth filter.
4 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.
5 Calculate Vertical Eye Closure (VEC) using the equation:

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

6 Report the resulting value of Vertical Eye Closure.

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 a PNA and the D90203UAC UALink 2.0 Conformance Test Application. The Conformance Test Application controls the PNA to set the test limits and run the tests. You must ensure that the connected device is calibrated.

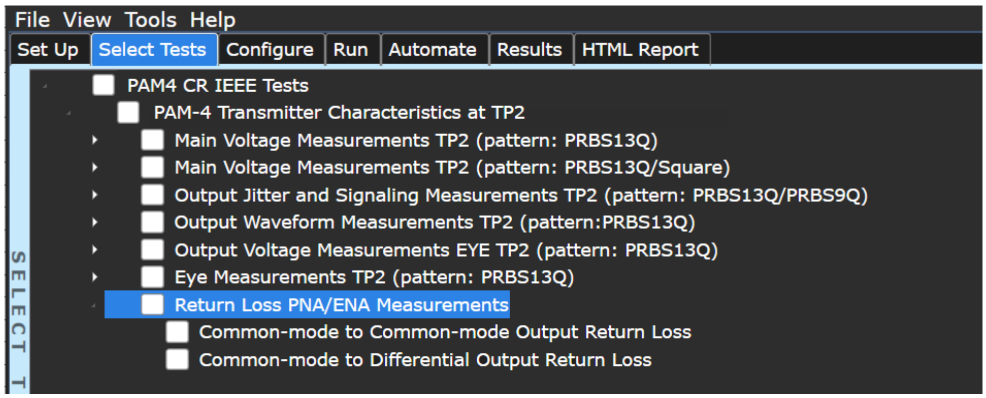

Figure 13 Selecting Return Loss PNA Measurements Tests

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

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

- "Common-mode to Common-mode Output Return Loss" on page 45
- "Common-mode to Differential Output Return Loss" on page 45

Common-mode to Common-mode Output Return Loss

Measurement Algorithm

1 Ensure that the PNA is physically connected and calibrated.
2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** 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 is physically connected and calibrated.
2 In the **Set Up** tab of the Conformance Test Application, click **Connect PNA** 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.

4 KR Tests

PAM-4 Transmitter Characteristics at TP0v for KR tests 48

This section provides the Methods of Implementation (MOIs) for the tests for IEEE PAM4 Transmitter Characteristics for 200GBASE-KR1, 400GBASE-KR2, and 800GBASE-KR4 tests. 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.

PAM-4 Transmitter Characteristics at TP0v for KR tests

See Table 4 for pass limits pertaining to 200GBASE-KR1, 400GBASE-KR2, and 800GBASE-KR4 tests, which are specified in *IEEE P802.3dj™ /D2.0 (Draft Standard for Ethernet* Amendment: Media Access Control Parameters for 1.6 Tb/s and Physical Layers and Management Parameters for 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Operation) Section 178.9.2 Table 178-6.

Table 4 200GBASE-KR1, 400GBASE-KR2, and 800GBASE-KR4 transmitter characteristics at TP0v (Spec Table 178-6)

Parameter	Reference	Value	Units
Signaling rate (range)		106.25 ± 50 ppm	GBd
Differential peak-to-peak voltage (max) Transmitter disabled Transmitter enabled	176D.8.1	 30 1000	 mV mV
DC Common-mode voltage (range)	176D.8.1	0.2 to 1	V
Low-frequency peak-to-peak AC common-mode voltage, VCM_{LF} (max)	179.9.4.1	30	mV
Signal to AC common-mode noise ratio, SCMR (min)	178.9.2.6	15	dB
Difference effective return loss, dERL (min)	178.9.2.2	-3	dB
Common-mode to common-mode return loss, RLcc (min)	178.9.2.3	3.25	dB
Difference steady-state voltage, dv_f (range)	178.9.2.4	0 to 0.1	V
Difference linear fit pulse peak ratio, dR_{peak} (min)	178.9.2.5	0	V
Level separation mismatch ratio, R_{LM} (min)	179.9.4.2	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 179.9.4.1.4 179.9.4.1.4 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5	 0.005 0.025 −0.06 0.12 −0.34 0.5 −0.2	 - - - - - - -
Difference Signal-to-noise-and-distortion ratio, dSNDR (min)	178.9.2.7	0	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	28	dB
Output jitter (max) J_{RMS} EOJ_{03} $J4u_{03}$ Tx package Class A Tx package Class B	179.9.4.6	 0.023 0.025 0.118 0.12	 UI UI UI UI

Main Voltage Measurements TP0v (pattern: PRBS13Q)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the D90203UAC UALink 2.0 Conformance Application.

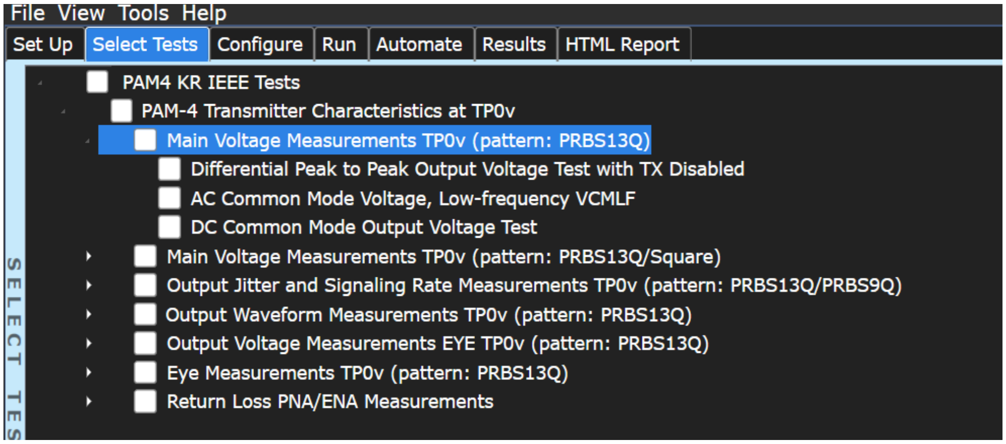

Figure 14 Selecting Main Voltage Measurement TP0v Tests

Refer to the section PAM-4 Transmitter Characteristics at TP0v 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 49
- "AC Common Mode Voltage, Low-frequency VCMLF" on page 50
- "DC Common Mode Output Voltage Test" on page 50

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 Table 4 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.

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 Table 4 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^{-7} of the measurement distribution.
6. Compare the voltage measurement to the specified standards.

DC Common Mode Output Voltage Test

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

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

Pass Condition Refer to the Table 4 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.

Main Voltage Measurements TP0v (pattern: PRBS13Q/Square)

The Main Voltage measurement procedures described in this section are performed using a Keysight DCA oscilloscope and the D90203UAC UALink 2.0 Conformance Application.

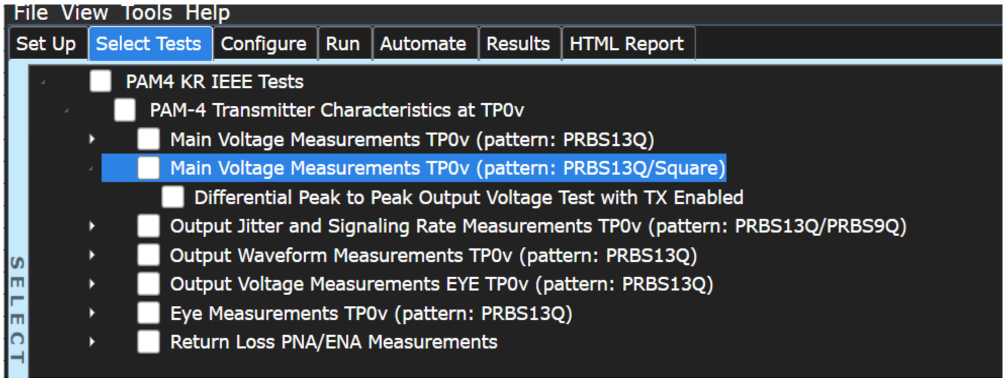

Figure 15 Selecting Main Voltage Measurement Tests

Refer to the section PAM-4 Transmitter Characteristics at TP0v 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 Enabled" on page 51

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

Test Overview The purpose of this test is to verify that the peak-to-peak voltage of the differential signal on a PRBS13Q/Square pattern meets the specified standards.

Pass Condition Refer to the Table 4 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/Square pattern.
3. Measure the peak-to-peak voltage range of the differential signal on DUT+ and DUT- that includes all but 10^{-7} of the measurement distribution.
4. Compare the maximum peak-to-peak voltage to the specified standards.

Output 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 D90203UAC UALink 2.0 Conformance Application.

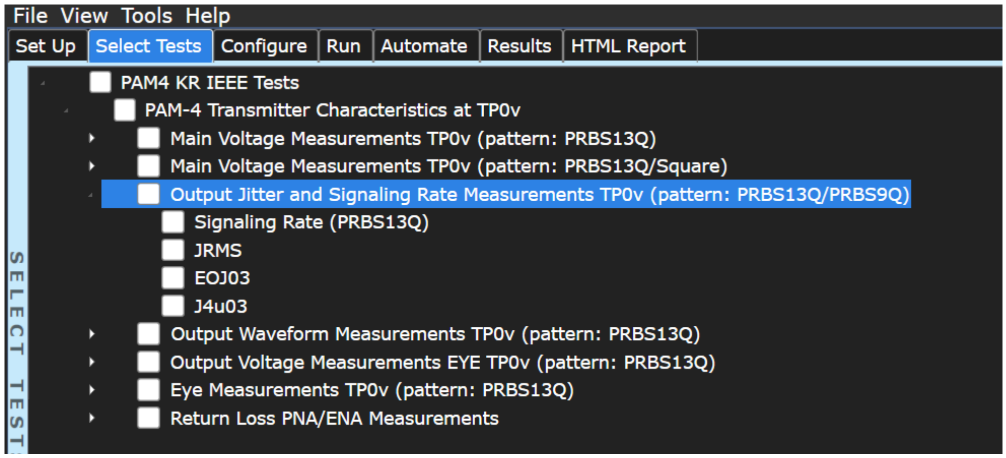

Figure 16 Selecting Jitter and Signaling Rate Measurement Tests

Refer to the section PAM-4 Transmitter Characteristics at TP0v 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 (PRBS13Q)” on page 52
- “JRMS” on page 53
- “EOJ03” on page 53
- “J4u03” on page 54

Signaling Rate (PRBS13Q)

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

Pass Condition Refer to the Table 4 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 Table 4 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 2 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 (106.25 GBd) and Loop Bandwidth to 4 MHz.

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

   c Set 4^{th} Order Bessel Thomson filter to 60 GHz with 3 dB gain.

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

EOJ03

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 Table 4 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 2 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 (106.25 GBd) and Loop Bandwidth to 4 MHz.

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

   c Set 4^{th} Order Bessel Thomson filter to 60 GHz with 3 dB gain.

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

J4u03

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

Pass Conditions Refer to the Table 4 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 2 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 (106.25 GBd) and Loop Bandwidth to 4 MHz.

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

   c Set 4^{th} Order Bessel Thomson filter to 60 GHz with 3 dB gain.

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

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 D90203UAC UALink 2.0 Conformance Application.

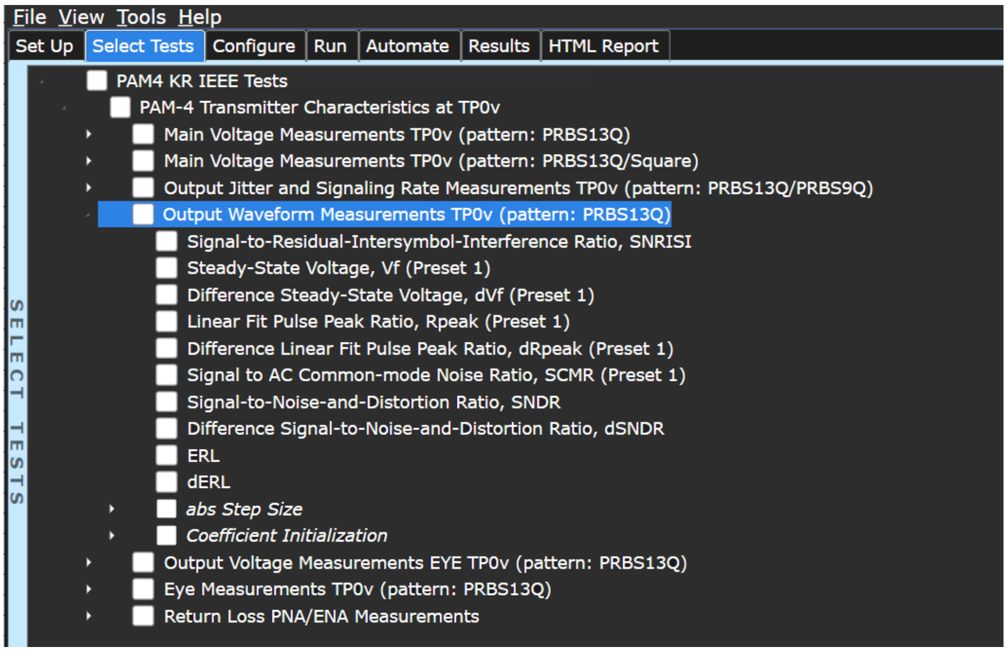

Figure 17 Selecting Transmitter Output Waveform Measurement Tests

Refer to the section PAM-4 Transmitter Characteristics at TP0v 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:

- "Signal-to-Residual-Intersymbol-Interference Ratio, SNRISI" on page 56
- "Steady State Voltage Vf (Information Only)" on page 56
- "Difference Steady-State Voltage, dVf" on page 56
- "Linear Fit Pulse Peak Ratio, Rpeak (Information Only)" on page 57
- "Difference Linear Fit Pulse Peak Ratio, dRpeak" on page 57
- "Signal to AC common-mode Noise Ratio, SCMR" on page 58
- "Signal-to-Noise-and-Distortion Ratio, SNDR (Information Only)" on page 58
- "Difference Signal-to-Noise-and-Distortion Ratio, dSNDR" on page 58
- "ERL (Information Only)" on page 60
- "dERL" on page 61
- "abs Step Size Tests" on page 61
- "Coefficient Initialization (Information Only)" on page 66

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 Table 4 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.

Steady State Voltage V_f (Information Only)

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

Pass Condition N/A

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 = 400, D_p = 4.

Difference Steady-State Voltage, dVf

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

Pass Conditions Refer to the Table 4 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.

Linear Fit Pulse Peak Ratio, Rpeak (Information Only)

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

Pass Conditions N/A

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). $N_p = 200$, $D_p = 2$.

Difference Linear Fit Pulse Peak Ratio, dRpeak

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

Pass Conditions Refer to the Table 4 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.

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

Measurement Algorithm

1. Calculate SCMR using measurements from Level RMS - PRBS pattern test and error from Linear Fit Pulse Peak test.
2. Compute the VCM_{FB} with 10^{-7} probability.
3. Compute SCMR using the following equation:

$$\mathrm{SCMR} = 20\log_{10}\left(\frac{v_{peak}}{VCM_{FB}}\right)$$

where

$SCMR$	is the signal to AC common-mode noise ratio in dB
v_{peak}	is defined in 179.9.4.1.2
VCM_{FB}	is the full-band peak-to-peak AC common-mode voltage defined by the method specified in 179.9.4.1 and measured with the transmitter equalization set to “no equalization”

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

Signal-to-Noise-and-Distortion Ratio, SNDR (Information Only)

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 N/A

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.

Difference Signal-to-Noise-and-Distortion Ratio, dSNDR

Test Overview The purpose of this test is to verify that the Difference Signal-to-Noise-and-Distortion Ratio (dSNDR) meets the specified standards.

Pass Condition Refer to the Table 4 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. From the SNDR value, subtract the user provided SNDR reference value.
   User will provide SNDR reference value in a csv file in C:\ProgramData\Keysight\Infiniium\Apps\

UALink Test\dSNDR\ folder

$$dSNDR(i) = SNDR_i^{(meas)} - SNDR^{(ref)}(\mathbf{c}_i)$$

3 Compare the resulting value of dSNDR to the specified standards.

NOTE

Specify the source of the reference SNDR values. If "Use Default File" is selected, the application will use the default CSV file located at "C:\Program Files\Keysight\Infiniium\Apps\UALink Test\app\dSNDR\SNDR_ref_evaluation_and_data.csv".

Alternatively, selecting "Use Editable File" will point to a custom CSV file located at "C:\ProgramData\Keysight\Infiniium\Apps\UALink Test\dSNDR\SNDR_ref_evaluation_and_data.csv", which users can modify to define their own SNDR reference values for evaluation.

ERL (Information Only)

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

Pass Condition N/A

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™ 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 Table 4 for the pass limits pertaining to each standard option.

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

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 61
- "abs Step Size for c(-2)" on page 62
- "abs Step Size for c(-1)" on page 62
- "abs Step Size for c(0)" on page 63
- "abs Step Size for c(1)" on page 63
- "value at min. state for c(-3)" on page 64
- "value at max. state for c(-2)" on page 64
- "value at min. state for c(-1)" on page 64
- "value at min. state for c(0)" on page 65
- "value at min. state for c(1)" on page 65

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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 = 400, D_p = 4.
11 Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 = 400, D_p = 4.
11 Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 = 400, D_p = 4.
11 Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request to change c(0) to the first step.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 $N_p = 400$, $D_p = 4$.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request to change c(1) to the first step.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 $N_p = 400$, $D_p = 4$.
11. Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
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 179-1.
5. Request user to decrement c(0) to minimum value.
6. Calculate linear fit pulse response as per 85.8.3.3.5 with $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
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 179-1.
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 $N_p = 400$, $D_p = 4$.
7. Calculate coefficients c(i) using equation 179-2.
8. Report c(1) value from step 7.

Coefficient Initialization (Information Only)

Test Overview This test group consists of the following tests:

- Coefficient Initialization Preset Initialize c(-3) (Information Only)
- Coefficient Initialization Preset Initialize c(-2) (Information Only)
- Coefficient Initialization Preset Initialize c(-1) (Information Only)
- Coefficient Initialization Preset Initialize c(0) (Information Only)
- Coefficient Initialization Preset Initialize c(1) (Information Only)
- 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

Table 5 Coefficient initial conditions (Spec Table 179-8)

Preset\Coefficient	c(-3)	c(-2)	c(-1)	c(0)	c(1)
initialize	0	0	0	1	0
Preset 1[a]	0	0	0	1	0
Preset 2	0 ±0.025	0 ±0.025	0 ±0.025	0.5 ±0.025	0 ±0.025
Preset 3	0 ±0.025	0 ±0.025	-0.075 ±0.025	0.75 ±0.025	0 ±0.025
Preset 4	0 ±0.025	0.05 ±0.025	-0.2 ±0.025	0.75 ±0.025	0 ±0.025
Preset 5	-0.025 ±0.025	0.075 ±0.025	-0.25 ±0.025	0.65 ±0.025	0 ±0.025
Preset 6	0 ±0.025	0 ±0.025	0 ±0.025	0.75 ±0.025	0 ±0.025

[a] Preset 1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 179.9.4.1.1). As a result, the normalized coefficients for preset 1 and initialize do not include any tolerances.

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 179-1.
5 Request preset # (for each test).
6 Calculate linear fit pulse response as per 85.8.3.3.5 with N_p = 400, D_p = 4.
7 Calculate coefficients c(i) using equation 179-2.
8 Report c(#) value from step 7.

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 D90203UAC UALink 2.0 Conformance Application.

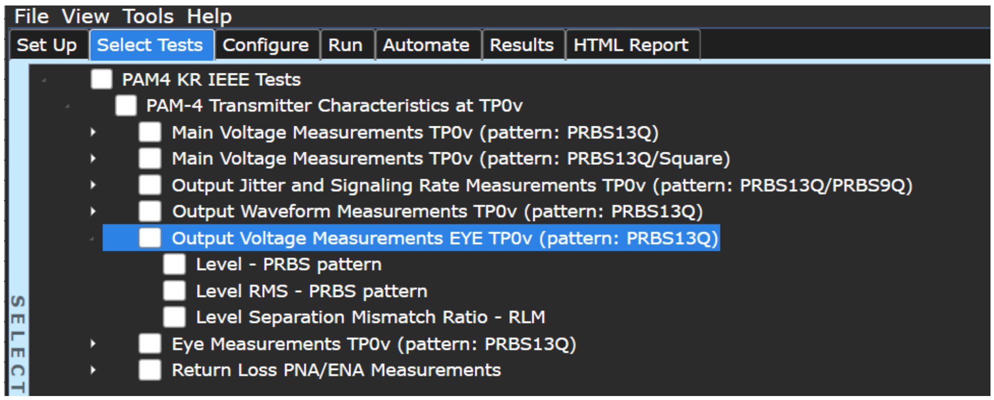

Figure 18 Selecting Output Voltage Measurements EYE Tests

Refer to the section PAM-4 Transmitter Characteristics at TP0v 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 (Information Only)” on page 69
- “Level RMS - PRBS Pattern (Information Only)” on page 69
- “Level Separation Mismatch Ratio - RLM” on page 69

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 (Information Only)

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

Pass Condition N/A

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 Std 802.3TM-2022, section 120D.3.1.2. The calculation of mean signal levels is 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 (Information Only)

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

Pass Condition N/A

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 Std 802.3TM-2022, section 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 Table 4 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 Std 802.3TM-2022, section 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-6).

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

5 Report the calculated value.

Eye Measurements TP0v (pattern: PRBS13Q)

The Eye Measurement procedures that are described in this section are performed using a Keysight Infiniium oscilloscope and the D90203UAC UALink 2.0 Conformance Application.

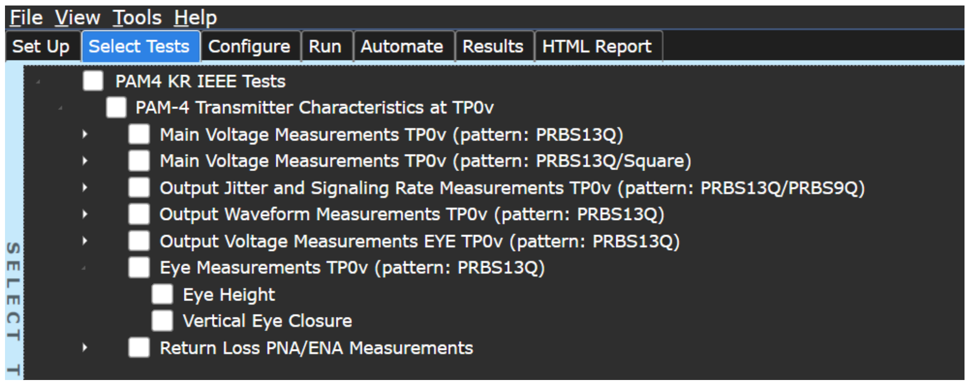

Figure 19 Selecting Signaling Rate and Eye Measurement Tests

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 Measurements TP0v (pattern: PRBS13Q) tests, see:

- "Eye Height (Information Only)" on page 70
- "Vertical Eye Closure (Information Only)" on page 71

Eye Height (Information Only)

Test Overview The purpose of this test is to measure the eye height at user defined CTLE.

Pass Conditions N/A

Measurement Algorithm

1. Obtain sample or acquire signal data.
2. Measure the Eye Height at an **Eye Height/Width Probability** setting of 1E-5.
3. On the Oscilloscope,
   a. set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (106.25 GBd) and Loop Bandwidth to 4 MHz.
   b. Set 4^{th} Order Bessel Thomson filter to 60 GHz with 3 dB gain.
   c. Perform eye measurement using 60 GHz Butterworth filter.
4. Report the eye height value.

Vertical Eye Closure (Information Only)

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

Pass Conditions N/A

Measurement Algorithm.

1 Obtain sample or acquire signal data.
2 Measure the Vertical Eye Closure at an **Eye Height/Width Probability** setting of 1E-5 (EH5).
3 On the Oscilloscope,
   a set the Clock Recovery to OJTF First Order PLL with Nominal Data Rate (106.25 GBd) and Loop Bandwidth to 4 MHz.
   b Set 4^{th} Order Bessel Thomson filter to 60 GHz with 3 dB gain.
   c Perform eye measurement using 60 GHz Butterworth filter.
4 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.
5 Calculate Vertical Eye Closure (VEC) using the equation:

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

6 Report the resulting value of Vertical Eye Closure.

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 D90203UAC UALink 2.0 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.

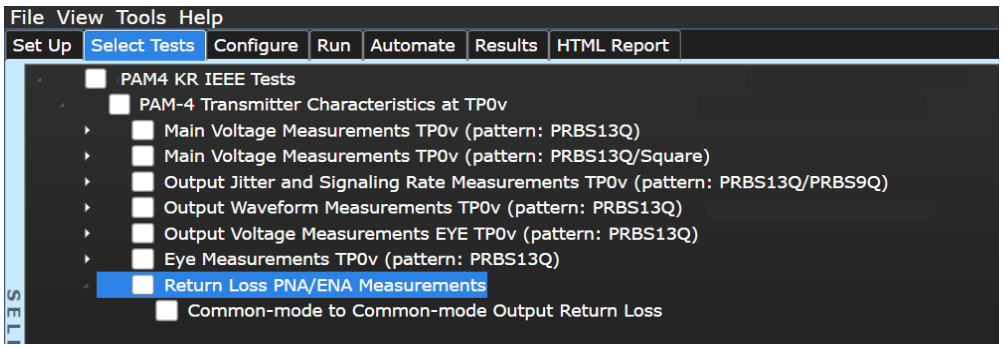

Figure 20 Selecting Return Loss PNA/ENA Measurements Tests

Refer to the section PAM-4 Transmitter Characteristics at TP0v 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 72

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.