# D9050USBC USB4v2 Compliance Test Application

KEYSIGHT

METHODS OF IMPLEMENTATION

# Notices



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# Contents

# 1 Overview

## USB4v2 Automated Testing—At a Glance

The Keysight D9050USBC USB4v2 Compliance Test Application allows the testing of PAM3 devices with the Keysight Infiniium Oscilloscope.

The current version of the USB4v2 Test Application extends support for symbol rates of 25.6 GBd and 26.667 GBd.

The USB4v2 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.
- Provides detailed information for each test that has been run, and lets you specify the thresholds at which marginal or critical warnings appear.
- Creates a printable HTML report of the tests that have been run.

**NOTE** The tests performed by the USB4v2 Test Application are intended to provide a quick check of the electrical health of the DUT. This testing is not a replacement for an exhaustive test validation plan.

## Required Equipment and Software

In order to run the USB4v2 automated tests, you need the following equipment and software:

### Hardware

- D9050USBC USB4v2 Compliance Test Application software
- Matlab Runtime Compiler MCR R2021b (9.11)
  - https://www.mathworks.com/products/compiler/matlab-runtime.html
- USB4 SigTest Tool (minimum required version is 0.75)
  - https://www.usb.org/compliancetools#anchor_sigtest
  - For more info on minimum system requirements for SigTest, please see the SigTest Setup page. Path: **Setting Up the Test Environment** page **> SigTest Setup** page.
- Keysight UXR Oscilloscope
- Keysight VNA (Vector 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

**NOTE** All test equipments require calibration to ensure accurate and repeatable results. The test equipments must be calibrated prior to, and if necessary, during the test procedure.

**NOTE** **Keysight D9050USBC USB4v2 Compliance Test Application** supports **Keysight D9010AGGC Compliance Test Software Measurement Server** for using multiple machines/PCs over a network as acquisition engines and processing engines in order to significantly enhance the test execution speed.

To know more, please see the D9010AGGC product page on keysight.com (http://www.keysight.com/find/d9010aggc).

### Software

- The minimum version of Infiniium Oscilloscope Software (see the Keysight D9050USBC USB4v2 Compliance Test Application Release Notes)
- Keysight D9050USBC USB4v2 Compliance Test Application software

### Licensing information

Refer to the *Data Sheet* pertaining to USB4v2 Test Application to know about the licenses you must install along with other optional licenses. Visit "http://www.keysight.com/find/D9050USBC" and in the web page's **Document Library** tab, you may view the associated Data Sheet.

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

The licensing format for Keysight License Manager 6 differs from its predecessors. See "Installing the License Key" on page 19 to see the difference in installing a license key using either of the applications on your machine.

## In This Book

This manual describes the tests that are performed by the USB4v2 Test Application in more detail.

- Chapter 2, “Installing the Test Application and Licenses” describes how to install the software and licenses for the USB4v2 Test Application software (if it was purchased separately).
- Chapter 3, “Preparing to Take Measurements” describes how to start the USB4v2 Test Application and gives a brief overview of its features.
- Chapter 4, “PAM-3 Signal Integrity Tests” contains the test procedures for PAM-3 physical layer tests.
- Chapter 6, “Appendix” provides detailed information about additional topics.

### See Also

The Keysight D9050USBC USB4v2 Compliance Test Application Methods of Implementation’s Online Help, which describes:

- Starting the USB4v2 Test Application
- Creating or Opening a Test Project
- Setting Up the Test Environment
- Selecting Tests
- Configuring Tests
- Verifying Physical Connections
- Running Tests
- Configuring Automation in the Test Application
- Viewing Results
- Viewing HTML Test Report
- Exiting the Test Application
- Additional Settings in the Test App

# 2 Installing the Test Application and Licenses



If you purchased the Keysight D9050USBC USB4v2 Compliance Test Application separately from your Infiniium oscilloscope, you must install the software and license key.

## Installing the Test Application

1. Make sure you have the minimum version of Infiniium Oscilloscope software (see the D9050USBC USB4v2 Test Application release notes). To ensure that you have the minimum version, select **Help > About Infiniium...** from the main menu.
2. To obtain the USB4v2 Test Application, go to Keysight website: "http://www.keysight.com/find/D9050USBC".
3. In the web page's **Trials & Licenses** tab, click the **Details and Download** button to view instructions for downloading and installing the application software.

## Installing the License Key

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

### Using Keysight License Manager 5

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

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

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

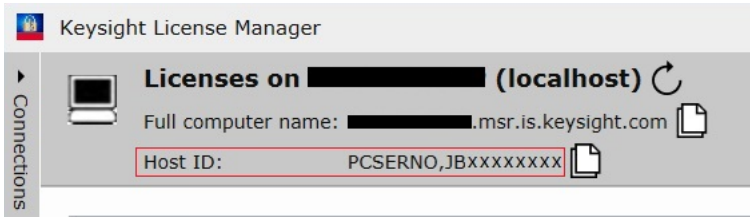



Figure 1 Viewing the Host ID information in Keysight License Manager 5

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

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

2 Launch Keysight License Manager.

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

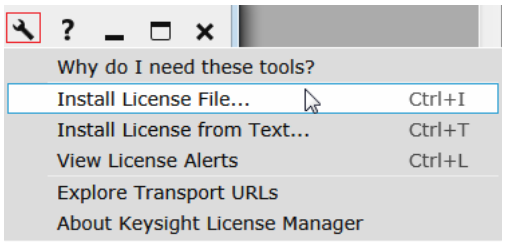



Figure 2 Configuration menu options to install licenses on Keysight License Manager 5

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

### Using Keysight License Manager 6

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

1. Launch Keysight License Manager 6 on your machine, where you wish to run the Test Application and its features.
2. Copy the Host ID, which is the first set of alphanumeric value (as highlighted in Figure 3) that appears in the Environment tab of the application. Note that x indicates numeric values.

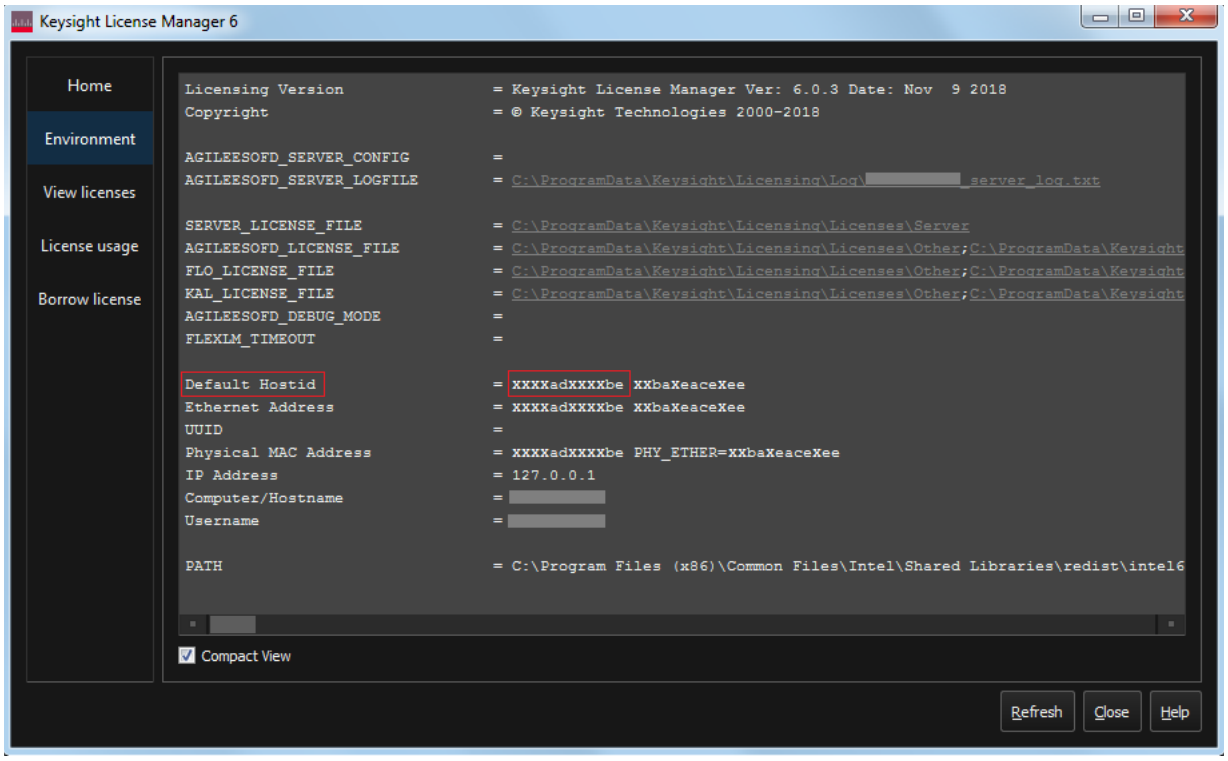



Figure 3 Viewing the Host ID information in Keysight License Manager 6

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

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

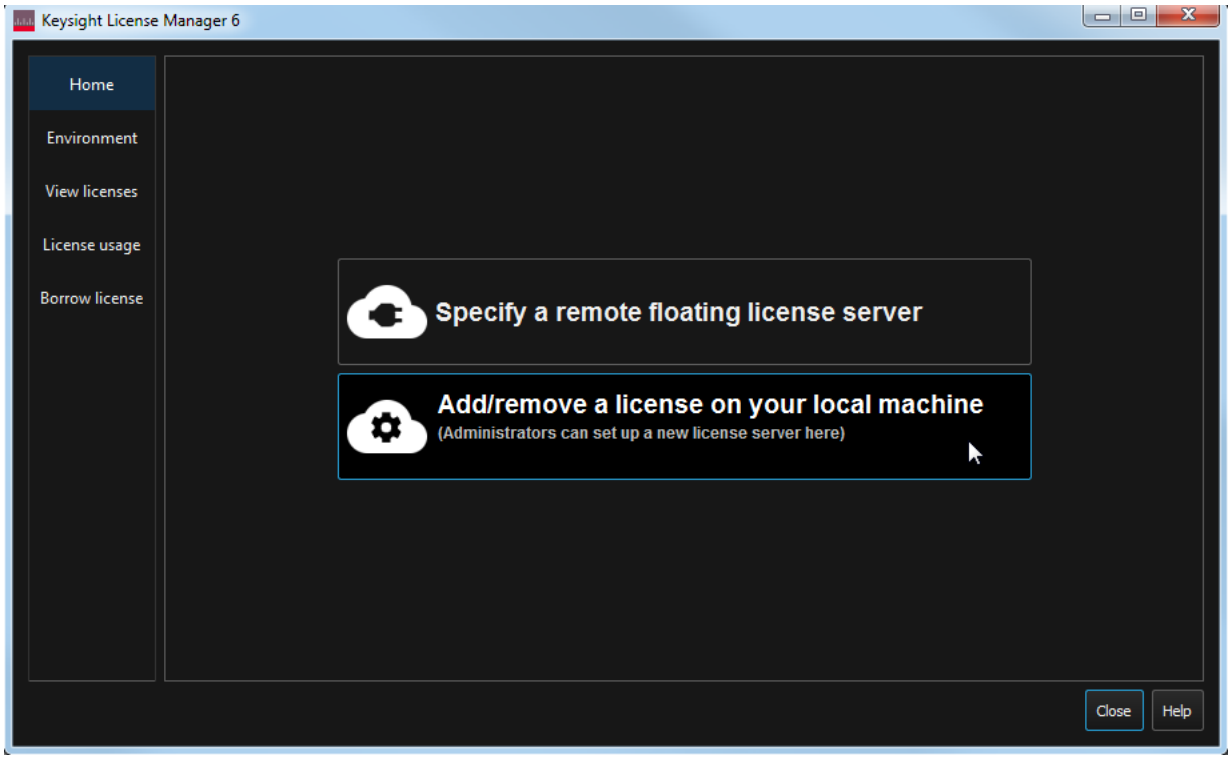



Figure 4 Home menu options to install licenses on Keysight License Manager 6

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

# 3 Preparing to Take Measurements



Before running the automated tests, you should calibrate the oscilloscope and probe. After the oscilloscope and probe have been calibrated, you are ready to start the USB4v2 Test Application and perform the measurements.

**NOTE** Use USB-IF approved test fixtures only.

## Calibrating the Oscilloscope

If you have not already calibrated the oscilloscope, refer to the *User Guide* for the respective 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 USB4v2 Test Application

1 Ensure that the USB4v2 Device Under Test (DUT) is operating and set to desired test modes. To start the USB4v2 Test Application: From the Infiniium Oscilloscope's main menu, select **Analyze > Automated Test Apps > D9050USBC USB4v2 Test App**

**NOTE**

To launch the application on worker PCs in measurement server mode, please use the following Infiniium path: **Analyze > Automated Test Apps > Measurement Server > D9050USBC USB4v2 Test App Measurer**.

**NOTE**

When launching the USB4v2 application for the first time - particularly if Infiniium Offline was launched beforehand, go to the **Configure** tab and set the **Sampling Rate** to the maximum supported rate of the oscilloscope.

For optimal configuration, it is recommended to launch the test application using USB4v2 app shortcut.

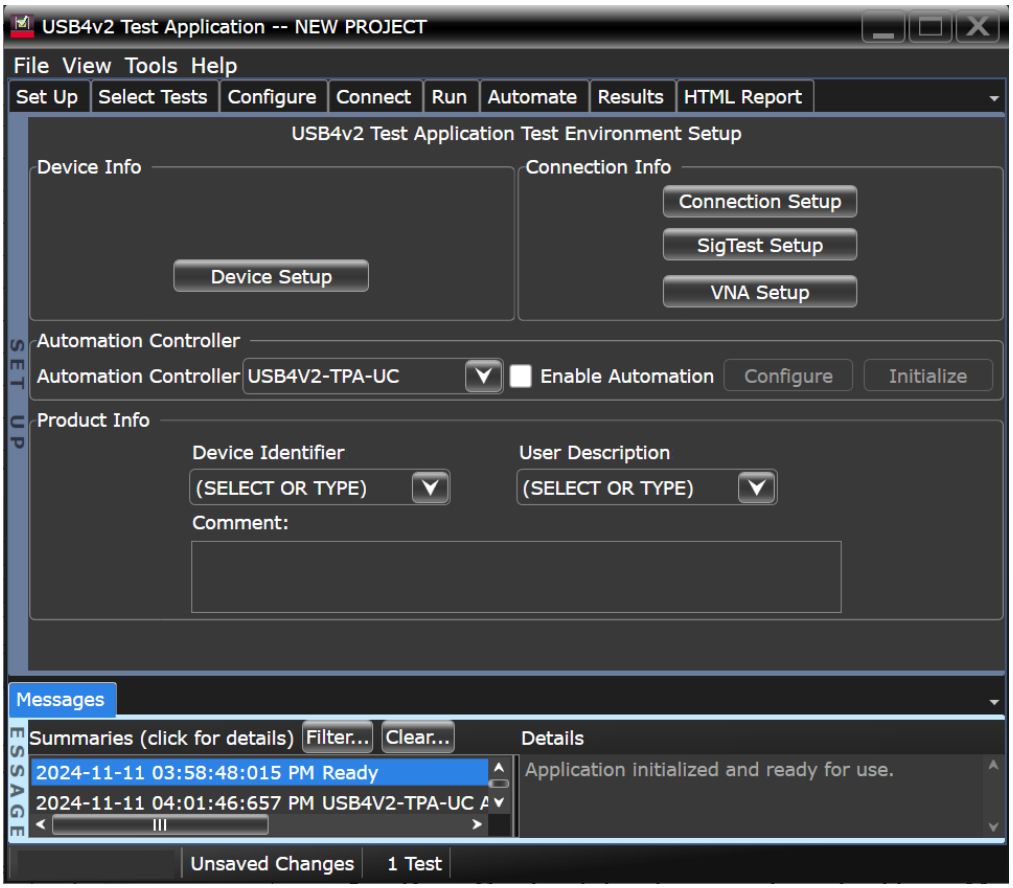



Figure 5 USB4v2 Test Application default window

To understand the functionality of the various features in the user interface of the test application, refer to the *Keysight D9050USBC USB4v2 Compliance Test Application Online Help* available in the Help menu.

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

| | |
|---|---|
| **Set Up** | Lets you identify and set up the test environment, including information about the device under test. The Test App includes relevant information in the final HTML report. |
| **Select Tests** | Lets you select the tests you want to run. The tests are organized hierarchically so you can select all tests in a group. After tests are run, status indicators show which tests have passed, failed, or not been run, and there are indicators for the test groups. |
| **Configure** | Lets you configure test parameters (for example, channels used in test, voltage levels, etc.). |
| **Connect** | Shows you how to connect the oscilloscope to the device under test for the tests that are to be run. |
| **Run** | Starts the automated tests. If the connections to the device under test need to be changed while multiple tests are running, the tests pause, show you how to change the connection, and wait for you to confirm that the connections have been changed before continuing. |
| **Automate** | Lets you construct scripts of commands that drive execution of the application. |
| **Results** | Contains more detailed information about the tests that have been run. You can change the thresholds at which marginal or critical warnings appear. |
| **HTML Report** | Shows a compliance test report that can be printed. |

**NOTE**

In the **Configure** tab, the values for all such configuration parameters that are oscilloscope-dependent, will correspond to the oscilloscope model (DSOs or UXRs), where you are running the test application.

## Setting Up the USB4v2 Test Application

In order to run the electrical compliance tests on a USB4v2 DUT operating at a symbol rate of **25.6 GBd** and Symbol Type **PAM3**, please set up the USB4v2 Test Application to be able to view and select the required tests.

1 Start the USB4v2 Test Application. See "Starting the USB4v2 Test Application" on page 25.By default, the USB4v2 Test Application displays the **Set Up** tab when you start the application or launch a new/existing project.

2 In the **Device Info** section, please click the **Device Setup** button to open the **Device Setup** dialog box.

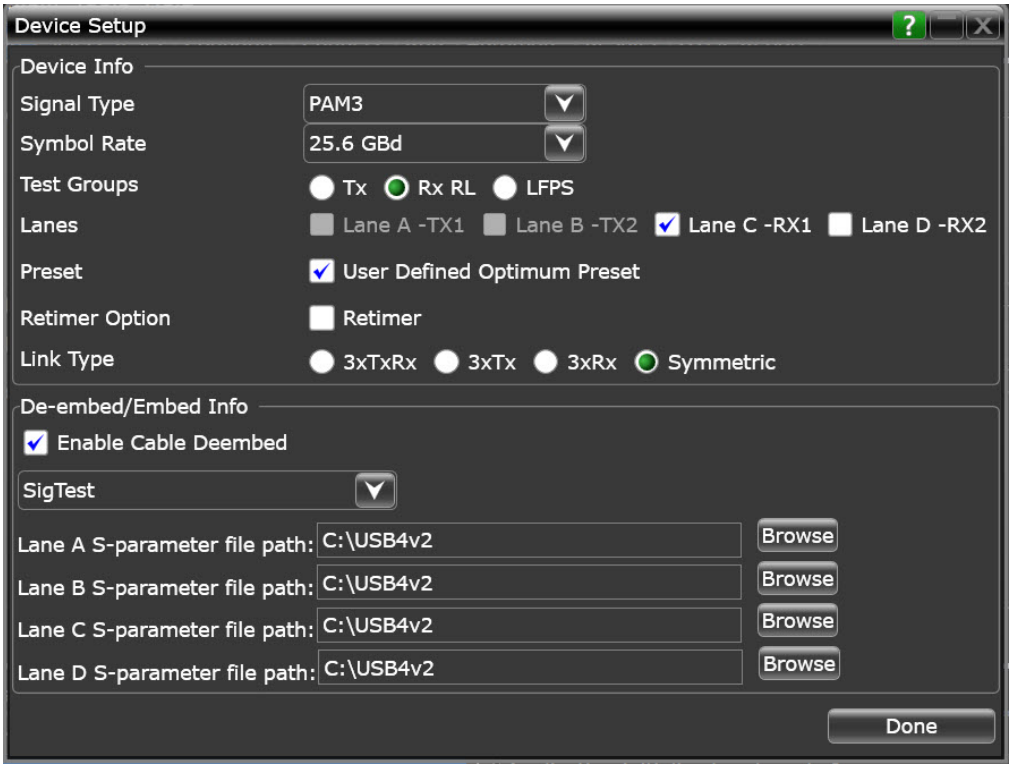



Figure 6 Device Setup dialog box

3 In the **Device Setup** dialog box, please enter the **Device Info** details, and click **OK**.

**Table 1 Device info parameters and description**

| Device Info Parameter | Description |
|---|---|
| **Signal Type** | Select the required signal type. Currently, only **PAM3** signal type is available for selection. |
| **Symbol Rate** | Select the required symbol rate. Currently, only **25.6 GBd** symbol rate is available for selection. |
| **Test Groups** | Select the required test group viz., Tx, Rx RL, or LFPS. |
| **Lanes** | Four lanes are available for selection, i.e., Lane A - TX1, Lane B - TX2, Lane C - RX1, and Lane D - RX2. Please select the lanes that need to be tested. |
| **Preset** | User Defined Preset<br><br>If **Transmitter Equalization** tests are not run, the application will not be able to obtain the best preset automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**. Please select the **User defined Optimum Preset** check box if you do not run the **Transmitter Equalization** tests, and require to use a predefined preset value to run the required **Signal Integrity Tests**. After selecting this check box, please navigate to the **Configure** tab, and manually select the required preset for each lane.<br><br>Auto Best Preset<br><br>In order to configure the application to select the best preset automatically:<br>**1** Clear the **User Defined Optimum Preset** check box.<br>**2** Please select and run all or required **Transmitter Equalization** tests with the **Best Preset** test.<br>**3** Run the required **Signal Integrity Tests**.<br><br>Please note, if all the **PAM-3 Tests** are selected and run together, the application will first run the **Transmitter Equalization** tests, then the **Best Preset** test to select the optimum preset (if the **User Defined Optimum Preset** check box is clear) followed by the **Signal Integrity Tests**. |

| Device Info Parameter | Description |
|---|---|
| **Retimer Option** | If the DUT has a retimer connected, please enable the **Retimer** check box:<br><br>Following tests are enabled:<br><br>▪ Frequency Variation Training Tests:<br>▪ Init Frequency Variation Training<br>▪ Delta Frequency Variation Training 200ns<br>▪ Delta Frequency Variation Training 1000ns<br>▪ Overshoot Frequency Variation Training<br>▪ Steady State Frequency Variation Training |
| **Link Type** | Please select one of the following link types:<br><br>▪ **3xTxRx**: This link type supports three transmit (Tx) and three receive (Rx) channels. It's designed for high-bandwidth applications where both sending and receiving large amounts of data simultaneously is crucial.<br><br>▪ **3xTx**:This configuration focuses on three transmit channels. It's ideal for scenarios where the primary need is to send data out, such as in broadcasting or data upload-heavy applications.<br><br>▪ **3xRx**: This setup features three receive channels, making it suitable for applications that require receiving large volumes of data, like data centers or download-heavy environments.<br><br>▪ **Symmetric**: This link type offers equal bandwidth for both transmitting and receiving data. It's balanced and versatile, suitable for general-purpose applications where data flow in both directions is equally important. |
| **De-embed/Embed Info** | Enable Cable Deembed<br><br>By selecting the **Enable Cable Deembed** check box, losses from fixture or DUT cable could be de-embeded. Use the **Browse** option to provide an S-parameter file for each lane under test. The S-parameter will be applied during waveform acquisition. If a transfer function file has not been generated prior to this, Infiniisim transfer function file will be generated at run time during waveform acquisition and applied to the live waveform. The cable de-embed feature is applicable to all the tests.<br><br>SigTest / Infiniium<br><br>Please select either **SigTest** or **Infiniium** with which you wish to run the tests. |

4 In the **Connection Info** section, please click the **Connection Setup** button to open the **Connection Setup** dialog box.

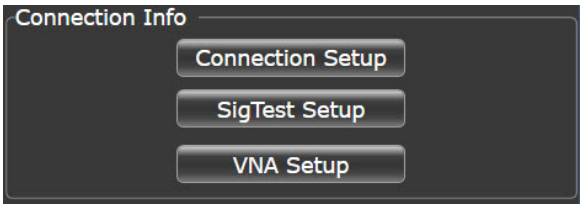



Figure 7 Connection info section of the Set Up tab.

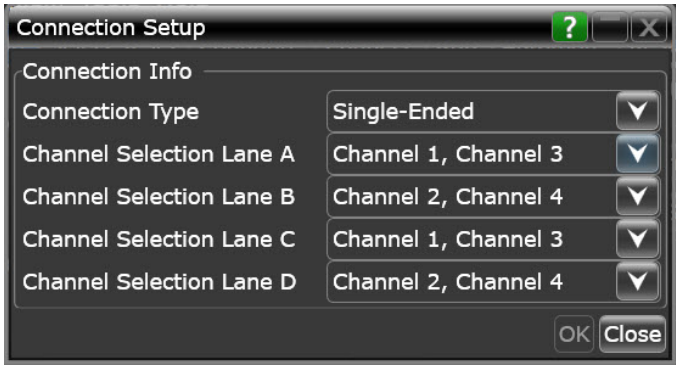



Figure 8 Connection Setup dialog box

5 In the **Connection Setup** dialog box, please select **Connection Type** and Channel Selection for the Device Under Test (DUT) according to which the test list is displayed in the **Select Tests** tab. The available **Connection Type** is **Single-Ended**. The available Channel Selection options are **Channel 1, Channel 3** and **Channel 2, Channel 4**. Click **OK** to save the changes and close the dialog box.

6 In the **Connection Info** section of the **Set Up** tab, please click the **SigTest Setup** button to open the **SigTest Setup** dialog box. Please see the **SigTest Setup** page in the Online Help for more info.
Path: Online Help **>** **Setting Up the Test Environment** page **>** **SigTest Setup** page.

7 In the **Connection Info** section of the **Set Up** tab, please click the **VNA Setup** button to open the **Connect to The Vector Network Analyzer (Keysight VNA)** dialog box. Please see the **Connect VNA** page in the Online Help for more info.
Path: Online Help **>** **Setting Up the Test Environment** page **>** **Connect VNA** page.

8 Based on your choices under the **Set Up** tab, the **Select Tests** tab filters tests into test groups.

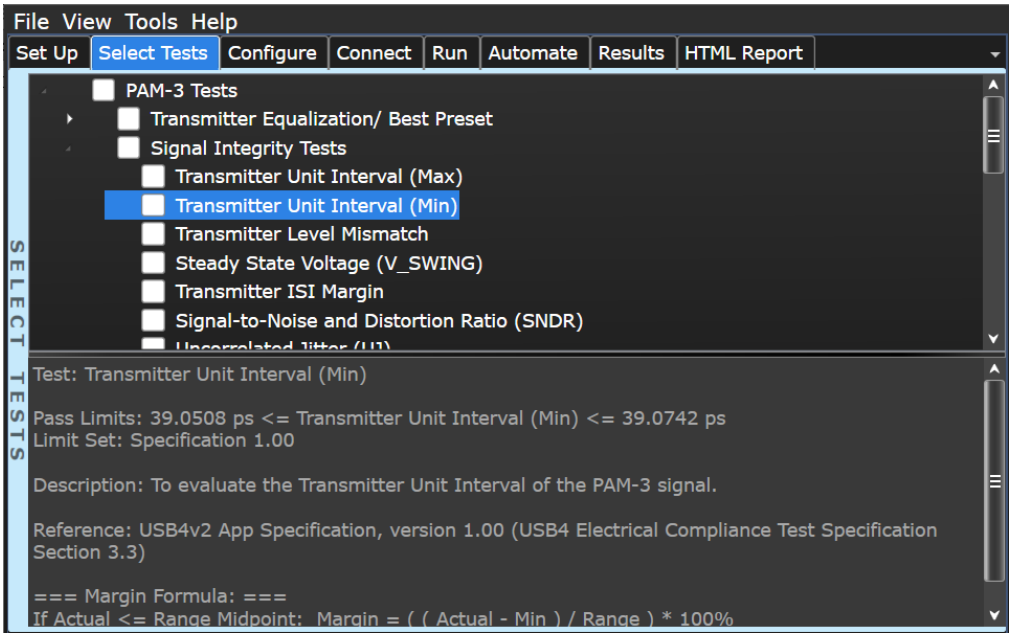



Figure 9 Selecting PAM3 tests for all symbol rates

9 Under the **Configure** tab, you may modify the values for various configurable options associated with the compliance tests. By default, the USB4v2 Test Application sets the values of these options to the optimum value according to the standard specifications.

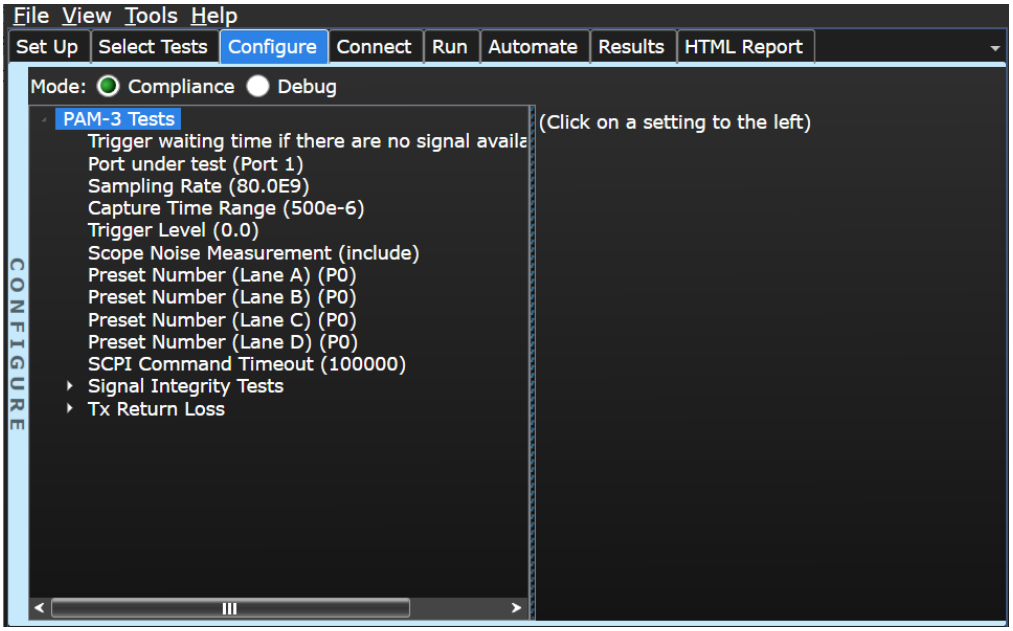



Figure 10 Configure options for USB4v2 tests

10 Under the **Connect** tab, the USB4v2 Test Application displays a Connection Diagram along with a list of instructions. If you have already set up a physical connection, you may verify else connect the DUT with the Oscilloscope as shown under this tab. Note that during some test runs, the application may prompt you for a change in physical connection/setup.

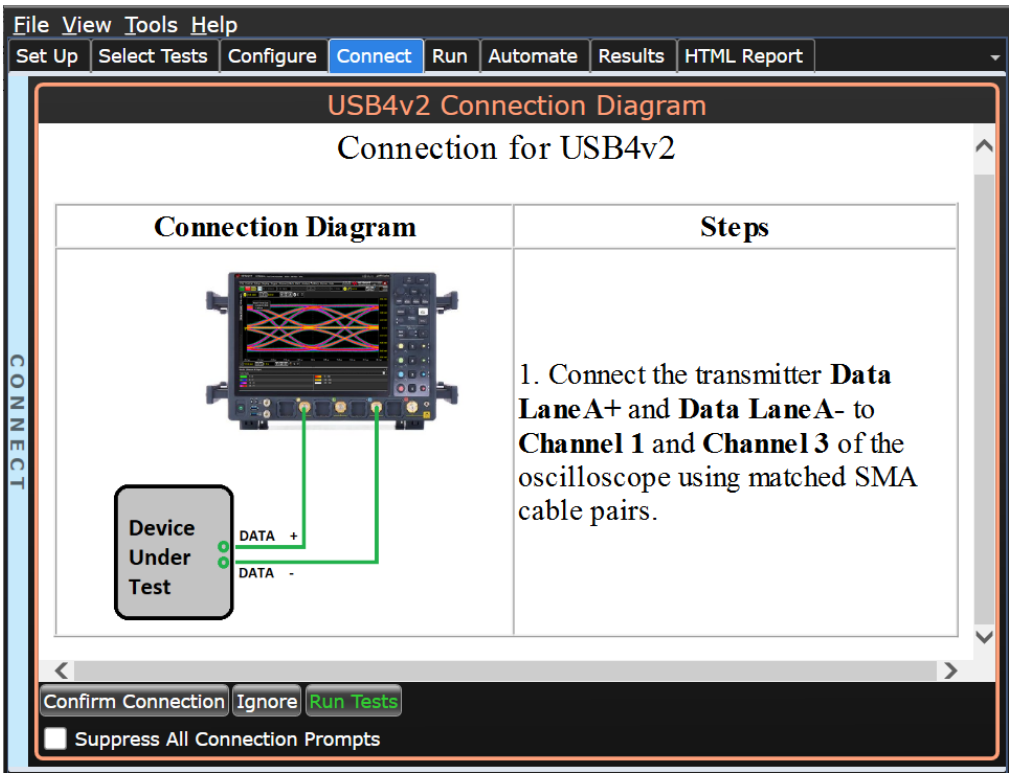



Figure 11 Connection diagram and instructions

11 Once you have performed steps 1 to 9, you are ready to run compliance tests on the USB4v2 DUT. Additionally, you may configure/modify the run settings, automate options in the test application, and view, export, or print the test results and the HTML reports generated by the test application. Refer to the *Keysight D9050USBC USB4v2 Compliance Test Application Online Help* to know more about how to use the test application.

# 4 PAM-3 Signal Integrity Tests



This chapter describes the normative and informative tests for PAM-3 Signal Integrity Tests.

# Best Preset

## Test Overview

This test analyzes the **Transmitter Equalization** tests to identify the best preset for the PAM-3 signal.

**NOTE** **Best Preset** test is available only when **User Defined Optimum Preset** check box in the **Device Setup** dialog box is not selected.

## Pass Limits

N/A (Not Applicable)

## Test Reference

- USB4 Electrical Compliance Test Specification, section 3.3

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

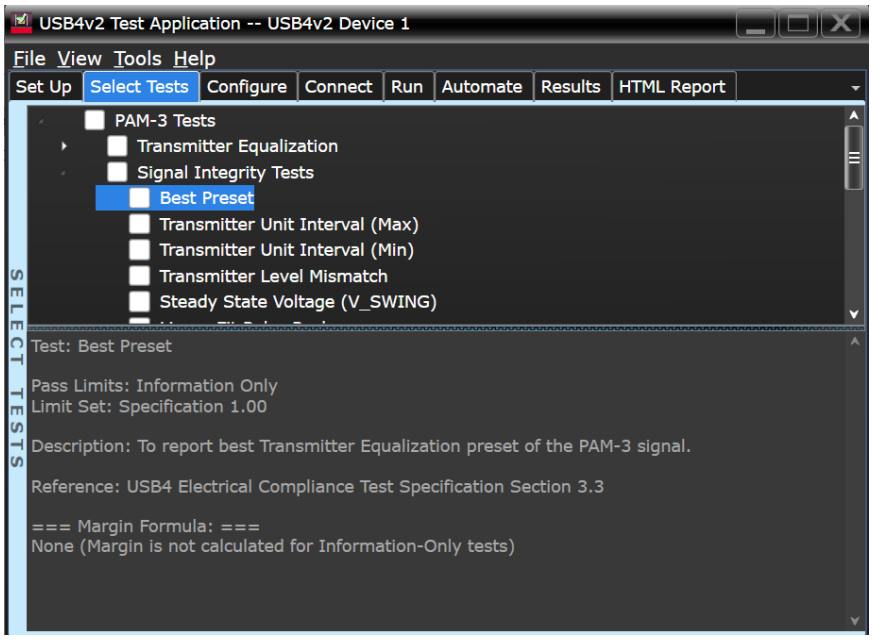



Figure 12 Selecting the best preset test

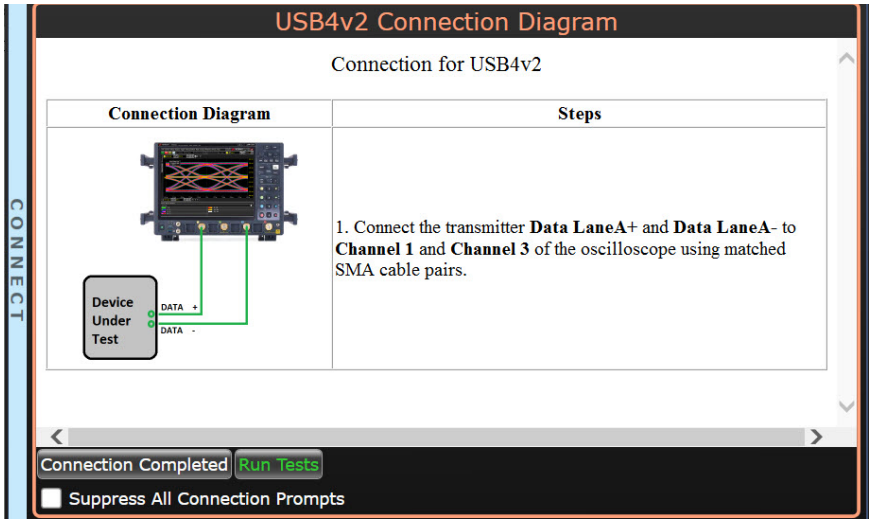



Figure 13 Connection diagram for best preset test

## Measurement Procedure

1 Identify the preset that obtains the lowest DDJ based on the results of the **Transmitter Equalization** tests, and update the info for each lane in the **Configure** tab.

**NOTE** Please select the **Best Preset** test along with the required **Transmitter Equalization Tests** to allows the **Best Preset** tests to analyze and select the best preset for the **Signal Integrity Tests**.

## Pass Condition

NA (Not Applicable)

# Transmitter Unit Interval Min/Max

## Test Overview

This test confirms if the Transmitter Unit Interval of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| Unit Interval Min | 39.0508 ps | 39.0742 ps |
| Unit Interval Max | 39.0508 ps | 39.0742 ps |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

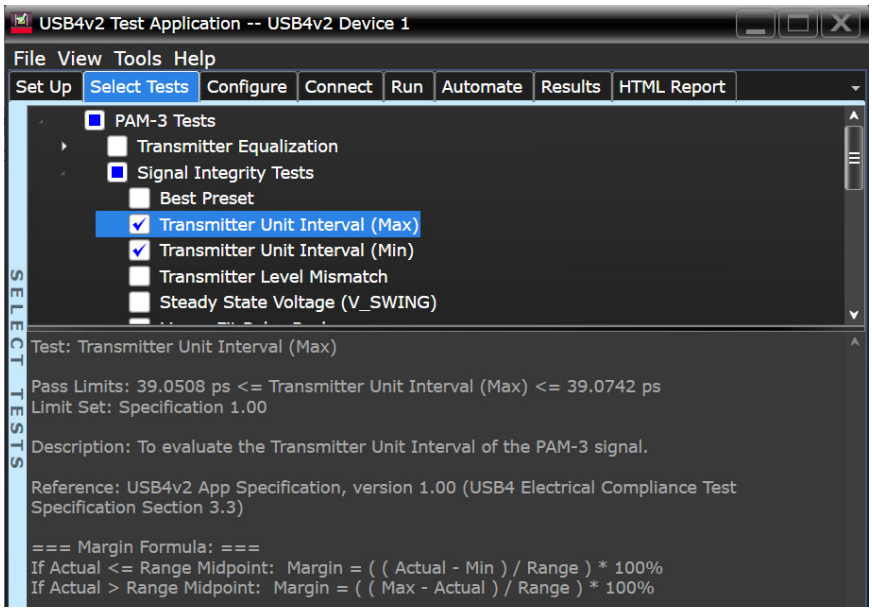



Figure 14 Selecting the unit interval test

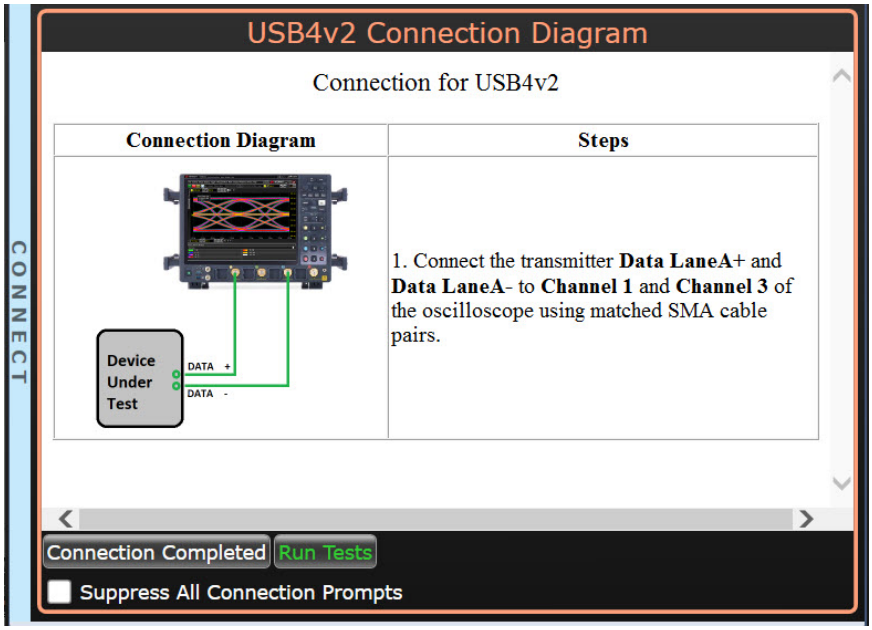



Figure 15 Connection diagram for the transmitter unit interval test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Transmitter Level Mismatch

## Test Overview

This test confirms if the Transmitter Level Mismatch of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit |
|---|---|
| Transmitter Level Mismatch | 975.0 m |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

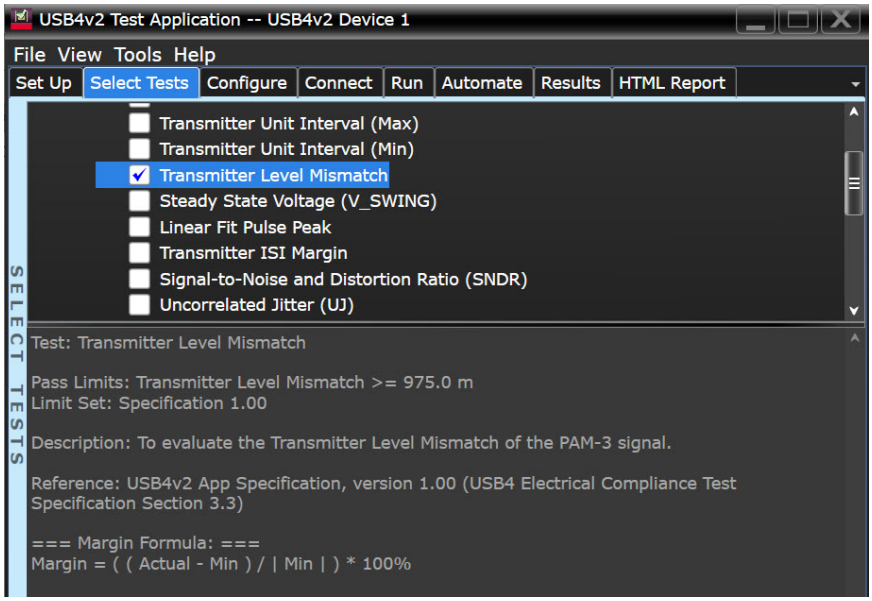



Figure 16 Selecting the transmitter level mismatch test

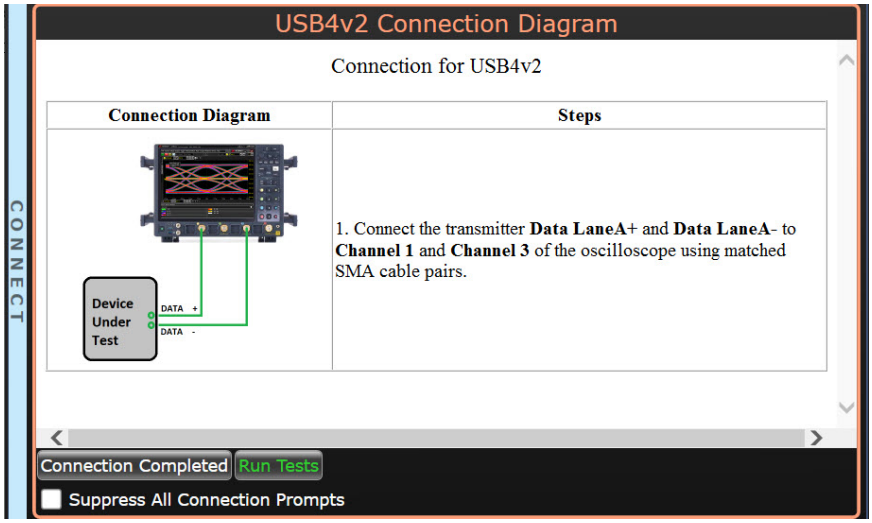



Figure 17 Connection diagram for the transmitter level mismatch test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests.**

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Steady State Voltage (V_SWING)

## Test Overview

This test confirms if the Steady State Voltage (V_SWING) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| Steady State Voltage (V_SWING) | 390.00 mV | 500.00 mV |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

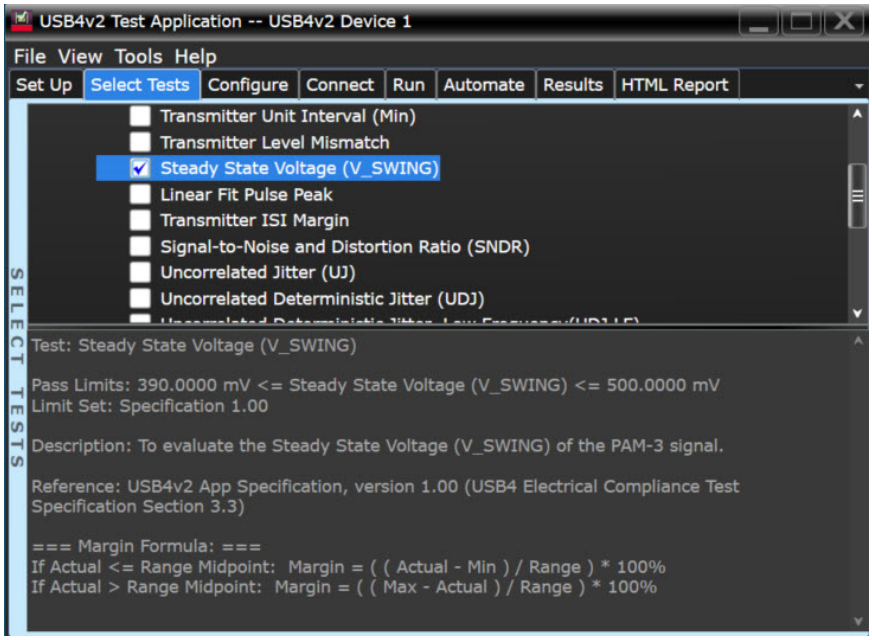



Figure 18 Selecting the transmitter steady state voltage test

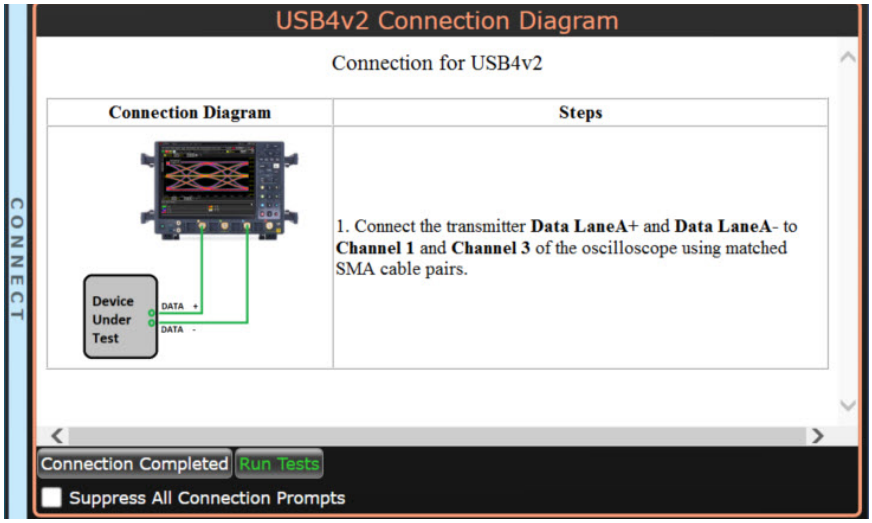



Figure 19 Connection diagram for the transmitter steady state voltage test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests.**

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Transmitter ISI Margin

## Test Overview

This test confirms if the Transmitter ISI Margin of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit |
|---|---|
| Transmitter ISI Margin | 11.50 dB |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

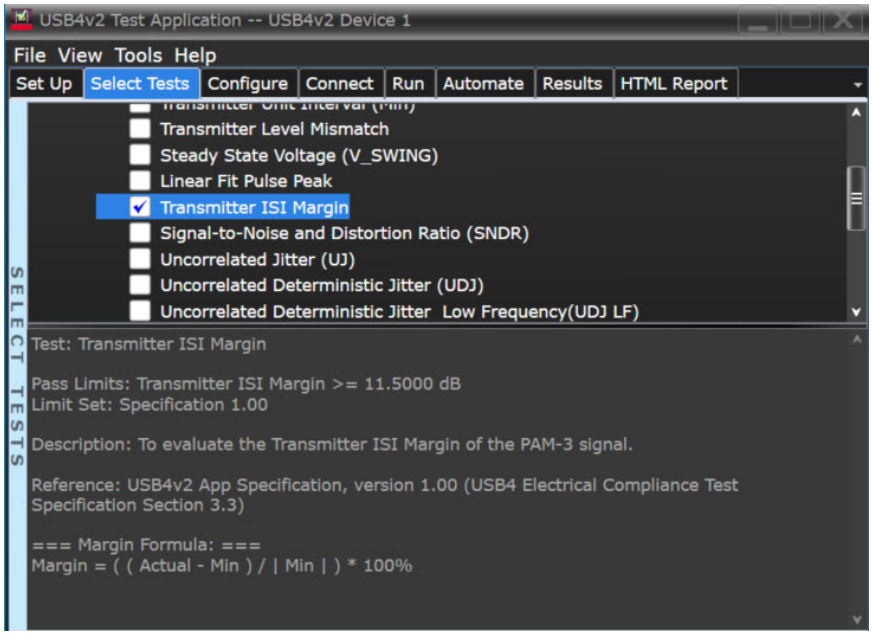



Figure 20 Selecting the transmitter ISI margin test

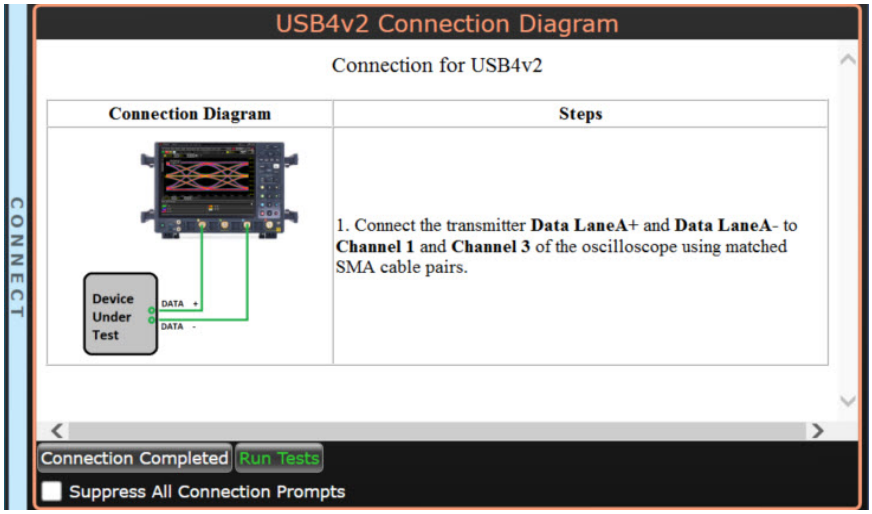



Figure 21 Connection diagram for the transmitter ISI margin test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Signal-to-Noise and Distortion Ratio (SNDR)

## Test Overview

This test confirms if the Signal-to-Noise and Distortion Ratio (SNDR) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit |
|---|---|
| Signal-to-Noise and Distortion Ratio (SNDR) | 32.50 dB |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

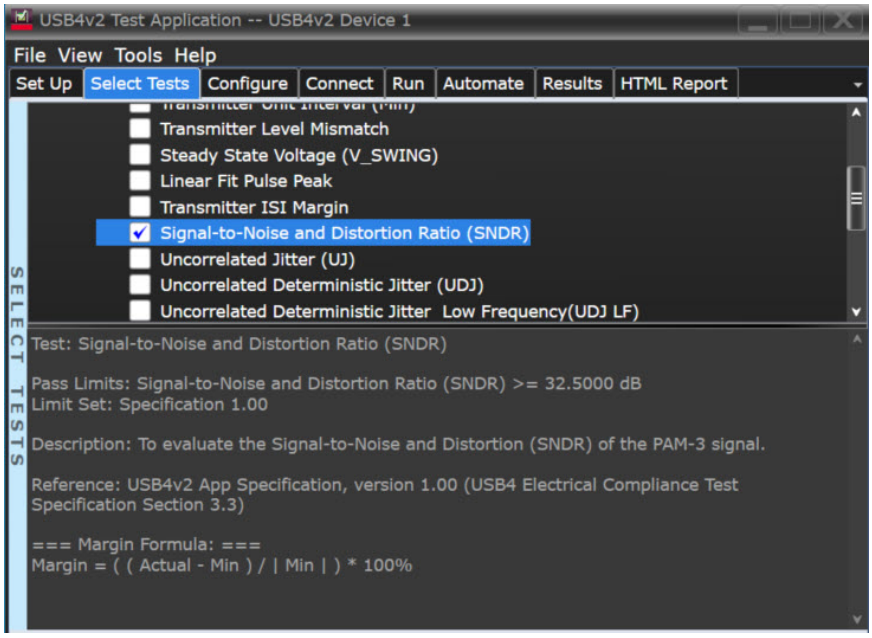



Figure 22 Selecting the transmitter signal-to-noise and distortion ratio test

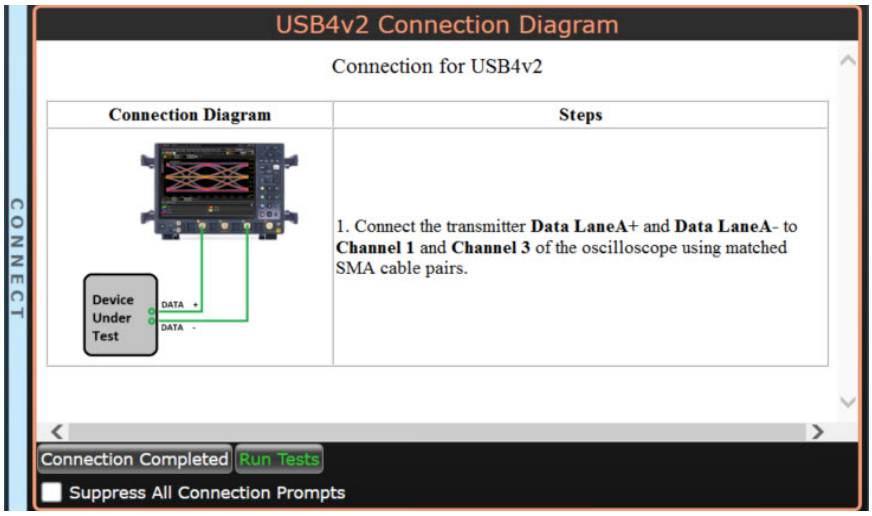



Figure 23 Connection diagram for the transmitter signal-to-noise and distortion ratio test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Uncorrelated Jitter (UJ)

## Test Overview

This test confirms if the Uncorrelated Jitter (UJ) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Uncorrelated Jitter (UJ) | 170.00 mUI pp |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

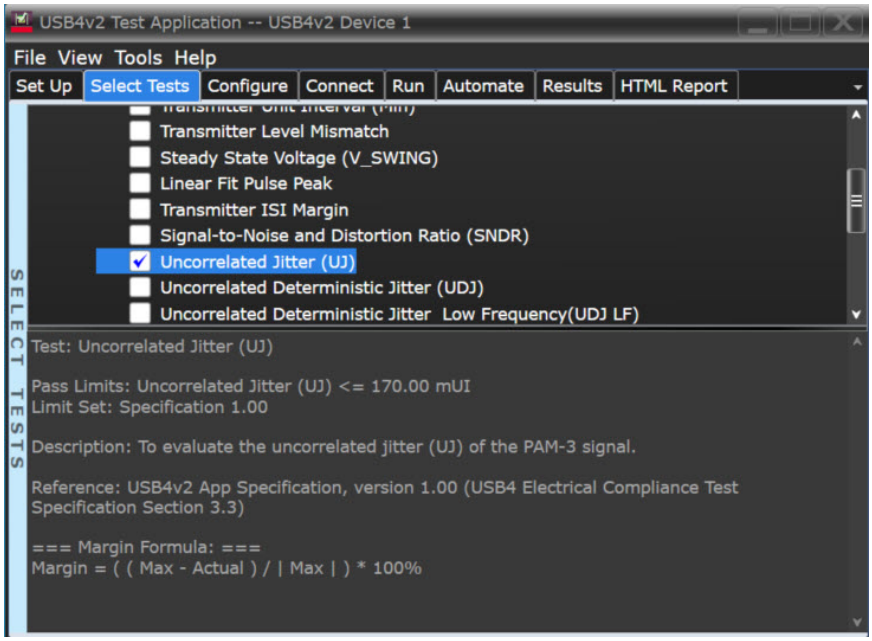



Figure 24 Selecting the transmitter uncorrelated jitter (UJ) test

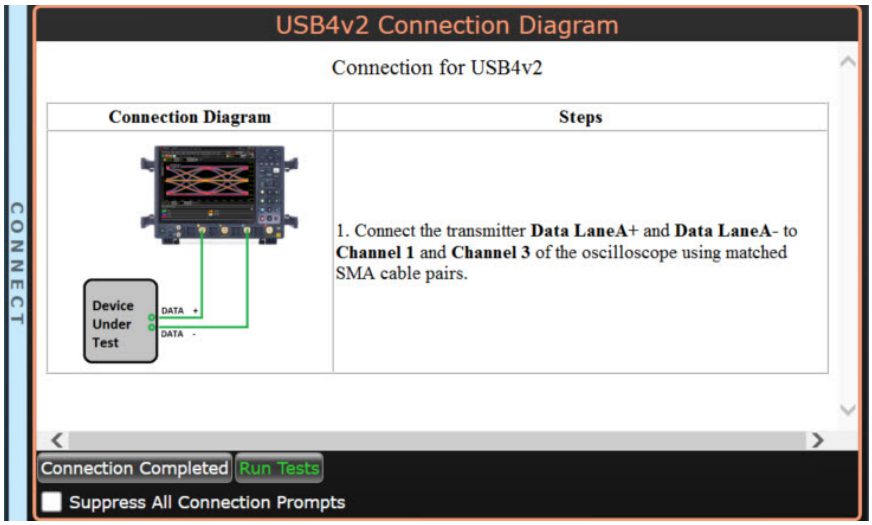



Figure 25 Connection diagram for the transmitter uncorrelated jitter (UJ) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Uncorrelated Deterministic Jitter (UDJ)

## Test Overview

This test confirms if the Uncorrelated Deterministic Jitter (UDJ) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Uncorrelated Deterministic Jitter (UDJ) | 75.00 mUI |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

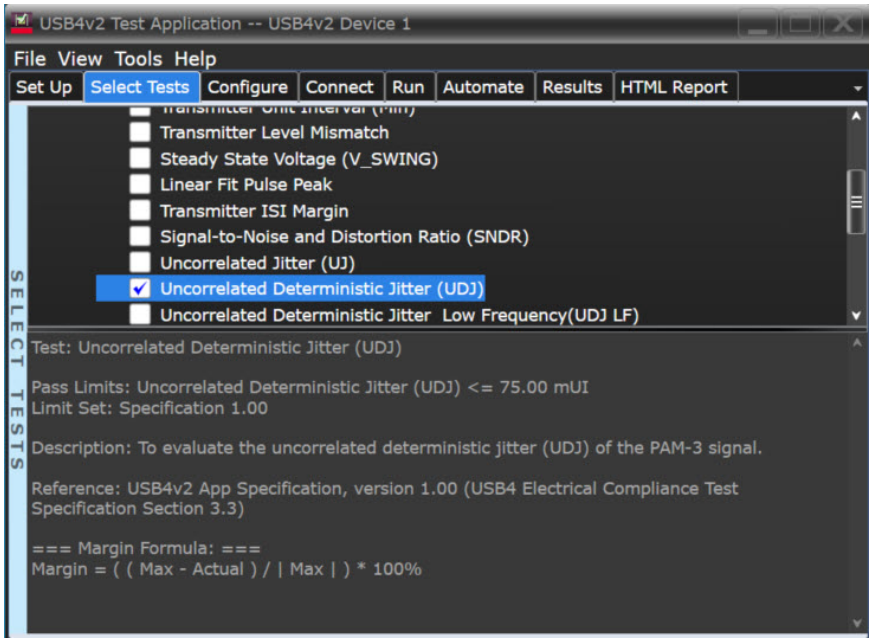



Figure 26 Selecting the transmitter uncorrelated deterministic jitter (UDJ) test

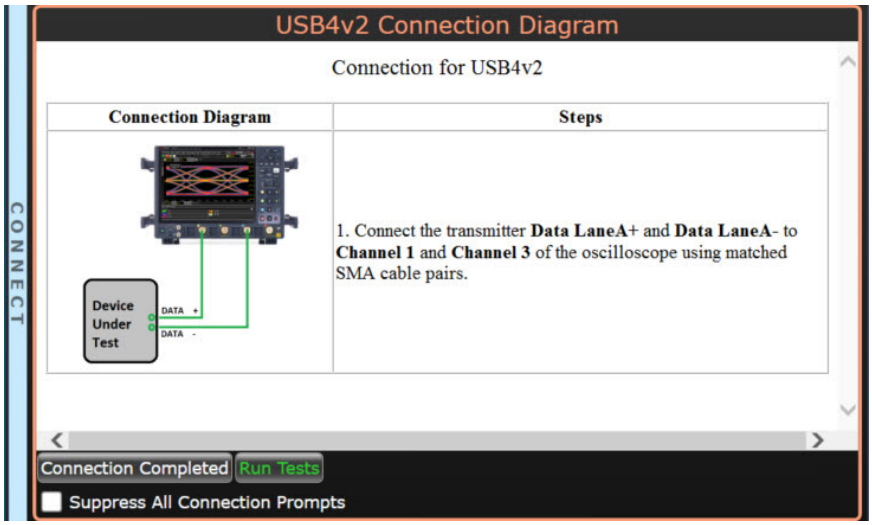



Figure 27 Connection diagram for the transmitter uncorrelated deterministic jitter (UDJ) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Uncorrelated Deterministic Jitter Low Frequency (UDJ LF)

## Test Overview

This test confirms if the Uncorrelated Deterministic Jitter Low Frequency (UDJ LF) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Uncorrelated Deterministic Jitter Low Frequency (UDJ LF) | 30.00 mUI |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

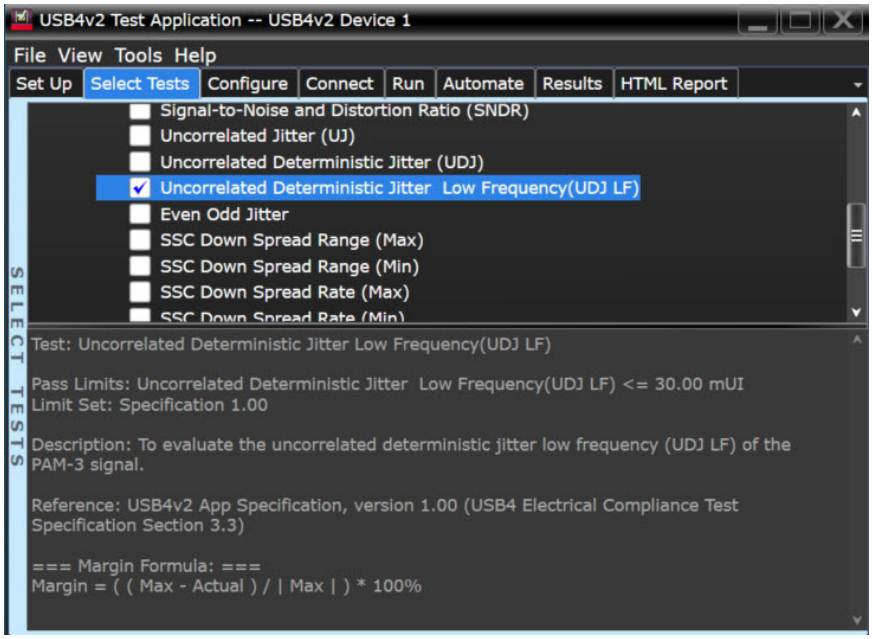



Figure 28 Selecting the transmitter uncorrelated deterministic jitter low frequency (UDJ LF) test

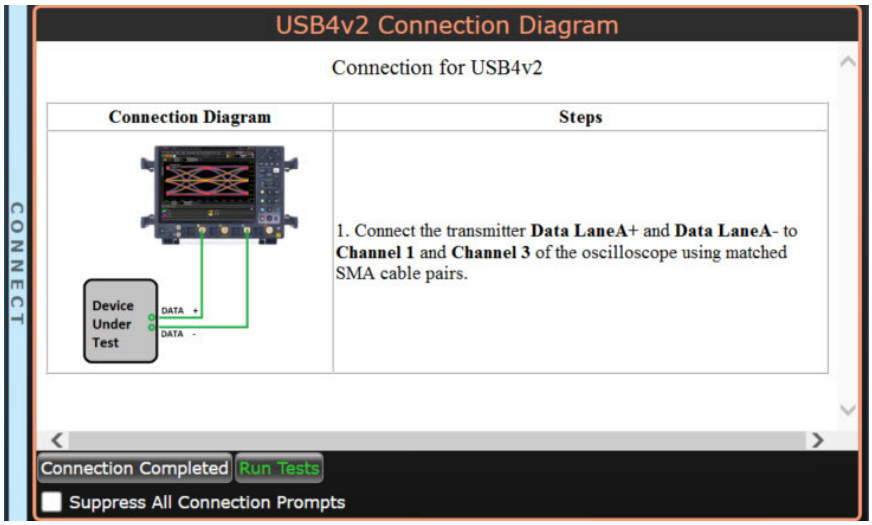



Figure 29 Connection diagram for the transmitter uncorrelated deterministic jitter low frequency (UDJ LF) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Even Odd (DCD) Jitter

## Test Overview

This test confirms if the Even Odd Jitter of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Even Odd Jitter | 20.00 mUI |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

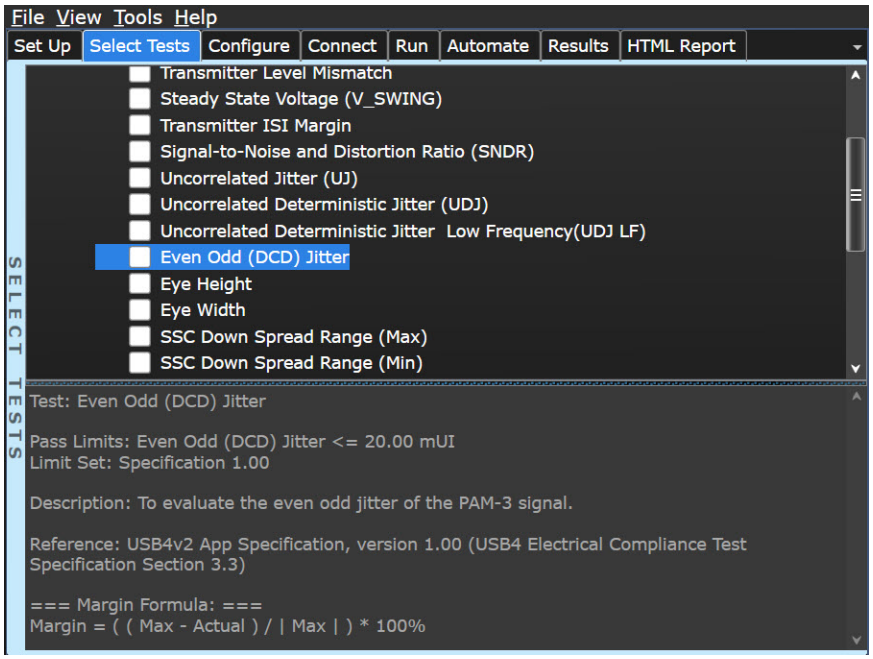



Figure 30 Selecting the transmitter even odd jitter test

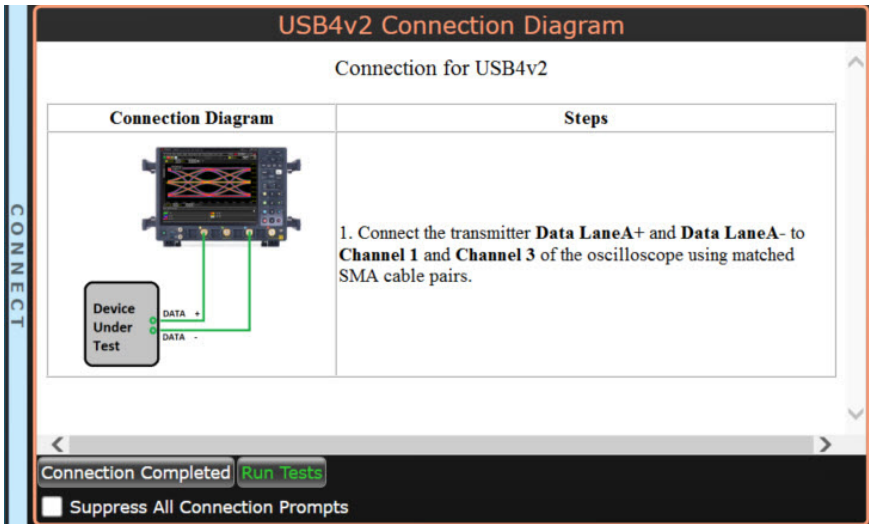



Figure 31 Connection diagram for the transmitter even odd jitter test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# Eye Height (Informative Test)

## Test Overview

This test evaluates the eye height of the PAM-3 signal.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| N/A | N/A |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

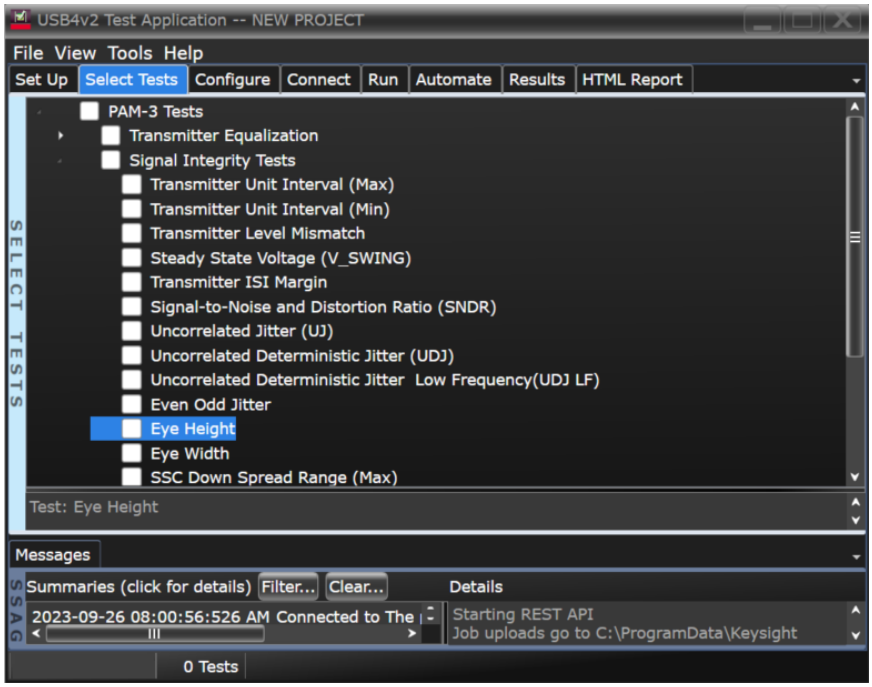



Figure 32 Selecting the eye height test

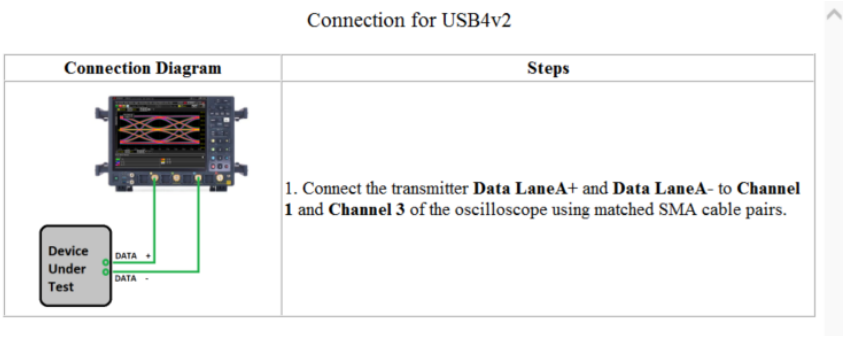



Figure 33 Connection diagram for eye height test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Repeat the test for all remaining USB4 Transmitter Lanes.

4 Obtains the eye-height test results from SigTest.

5 Reports the measured eye-height value as the measurement result.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

N/A - Reports the measured eye-height value as the measurement result.

# Eye Width (Informative Test)

## Test Overview

This test evaluates the eye width of the PAM-3 signal.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| N/A | N/A |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

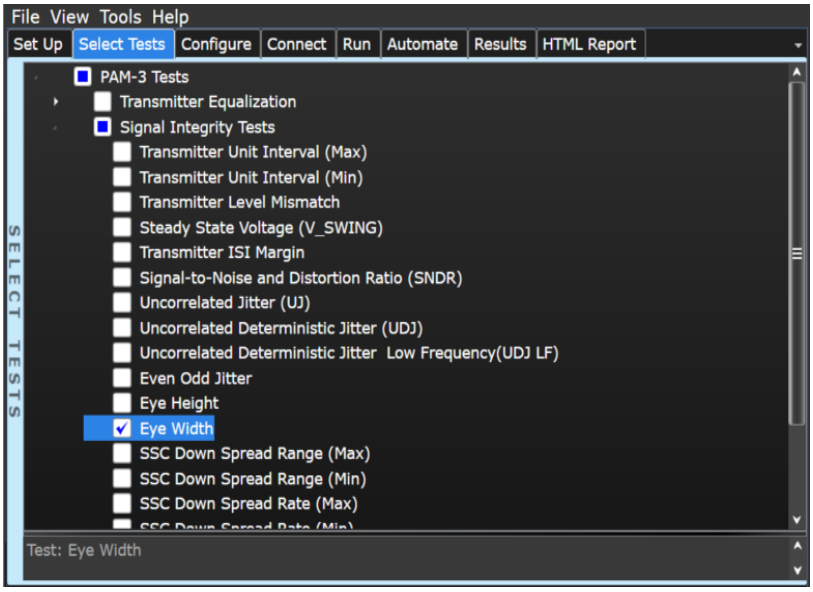



Figure 34 Selecting the eye width test

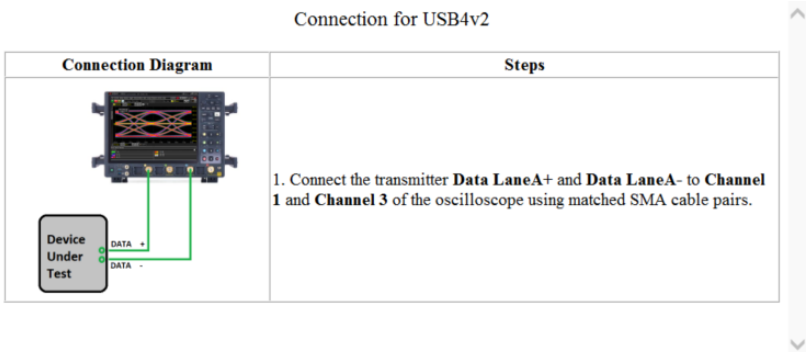



Figure 35 Connection diagram for eye width test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Repeat the test for all remaining USB4 Transmitter Lanes.

4 Obtains the eye-width test results from SigTest.

5 Reports the measured eye-width value as the measurement result.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

N/A - Reports the measured eye-width value as the measurement result.

# SSC Down Spread Range (Max)

## Test Overview

This test confirms if the SSC Down Spread Range (Max) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| SSC Down Spread Range (Max) | 200.00 m% | 300.00 m% |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

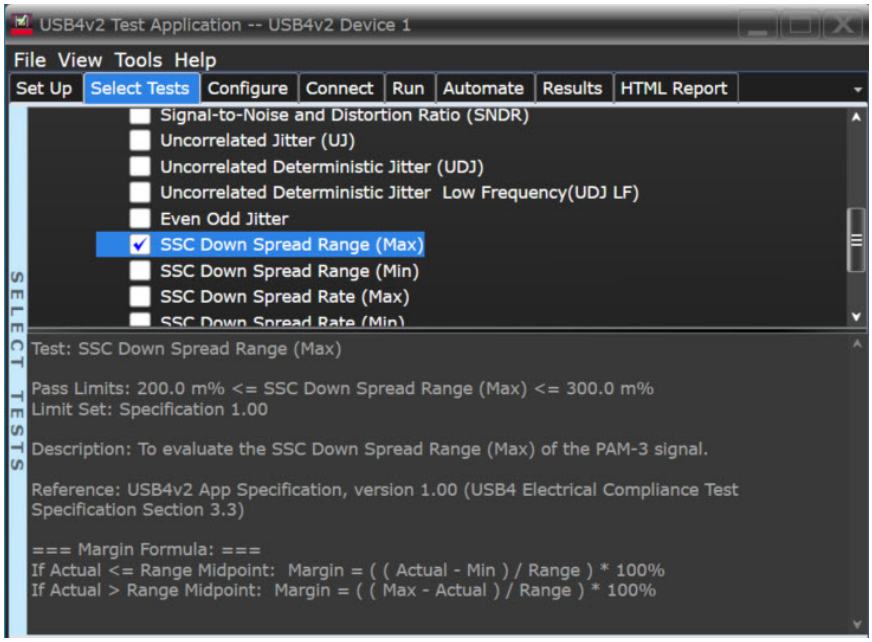



Figure 36 Selecting the transmitter SSC down spread range (max) test

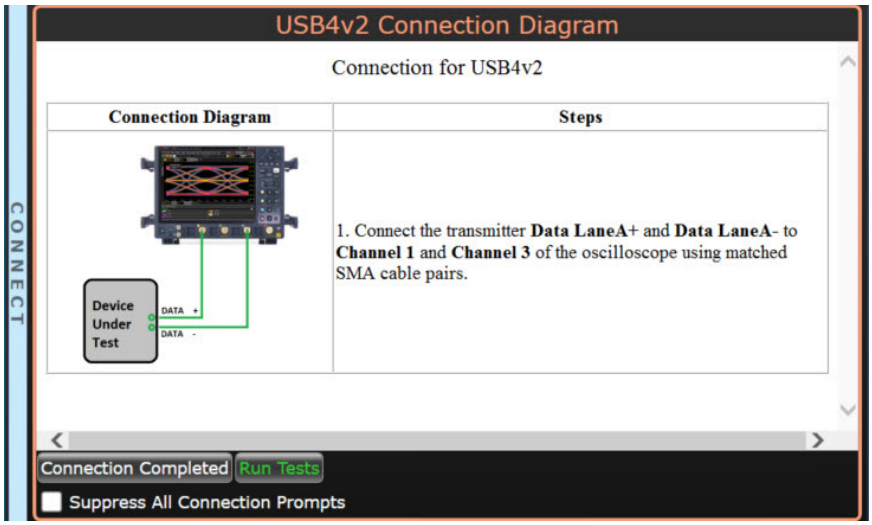



Figure 37 Connection diagram for the transmitter SSC down spread range (max) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# SSC Down Spread Range (Min)

## Test Overview

This test confirms if the SSC Down Spread Range (Min) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| SSC Down Spread Range (Min) | 200.00 m% | 300.00 m% |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

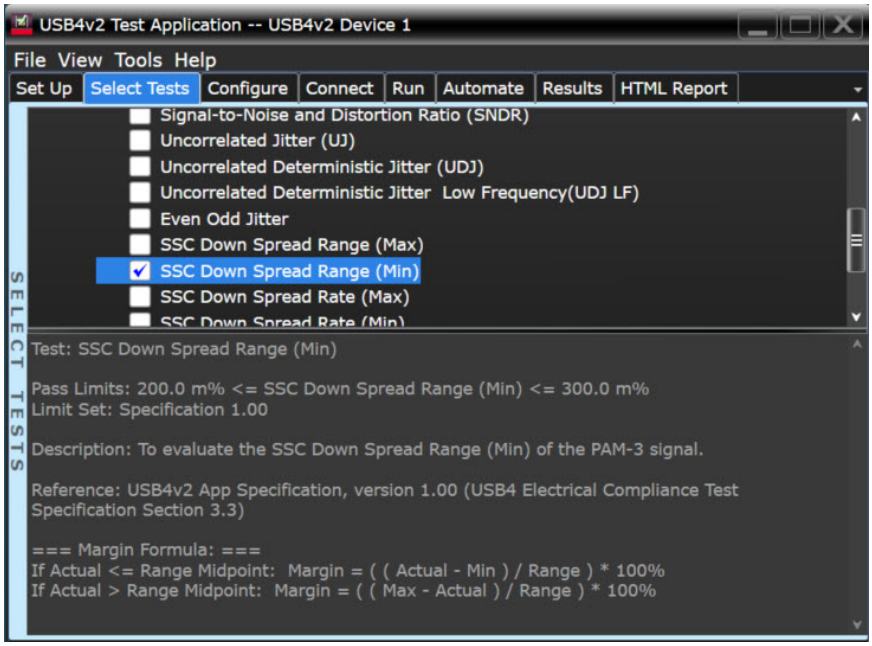



Figure 38 Selecting the transmitter SSC down spread range (min) test

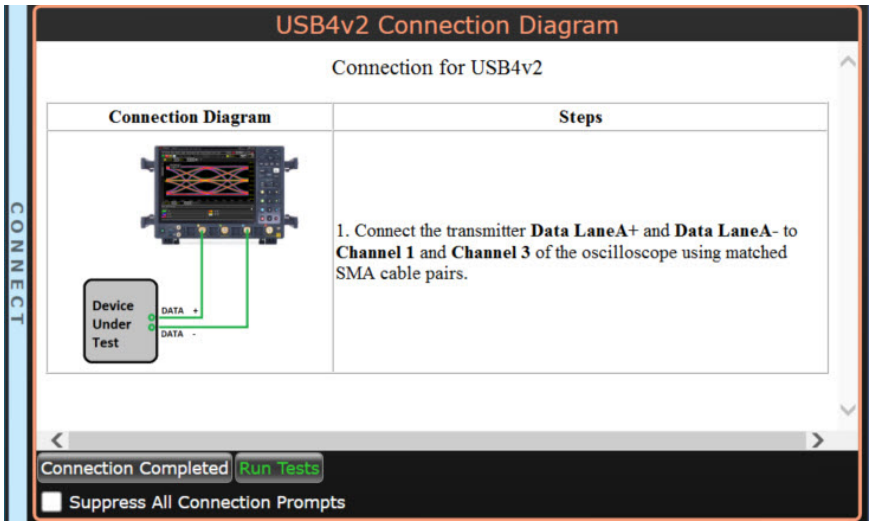



Figure 39 Connection diagram for the transmitter SSC down spread range (min) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# SSC Down Spread Rate (Max)

## Test Overview

This test confirms if the SSC Down Spread Rate (Max) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| SSC Down Spread Rate (Max) | 30.00 kHz | 33.0 kHz |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

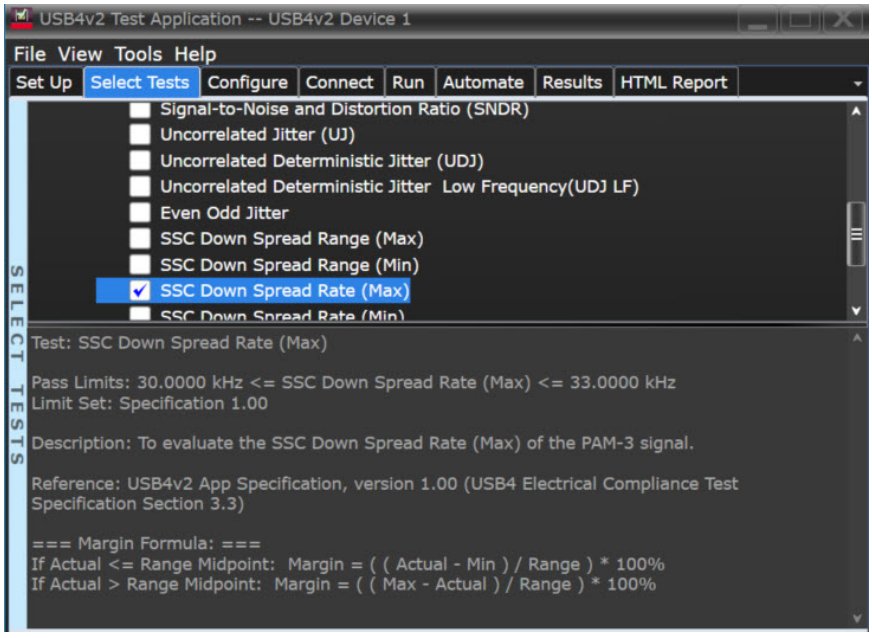



Figure 40 Selecting the transmitter SSC down spread rate (max) test

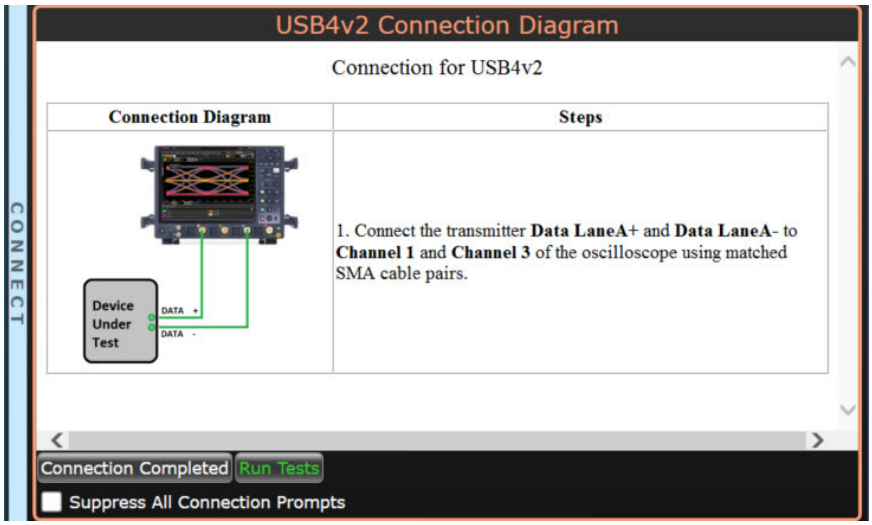



Figure 41 Connection diagram for the transmitter SSC down spread rate (max) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# SSC Down Spread Rate (Min)

## Test Overview

This test confirms if the SSC Down Spread Rate (Min) of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| SSC Down Spread Rate (Min) | 30.00 kHz | 33.0 kHz |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

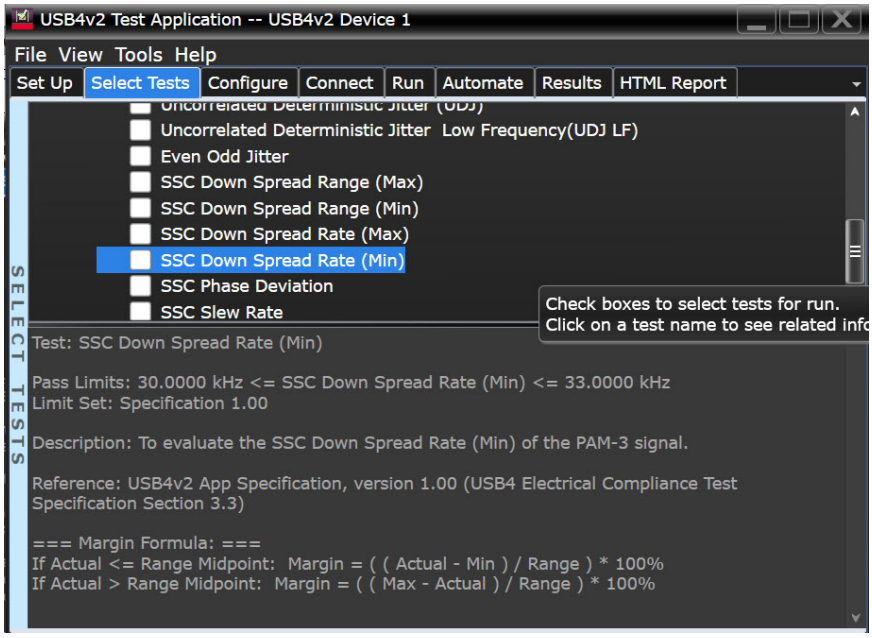



Figure 42 Selecting the transmitter SSC down spread rate (min) test

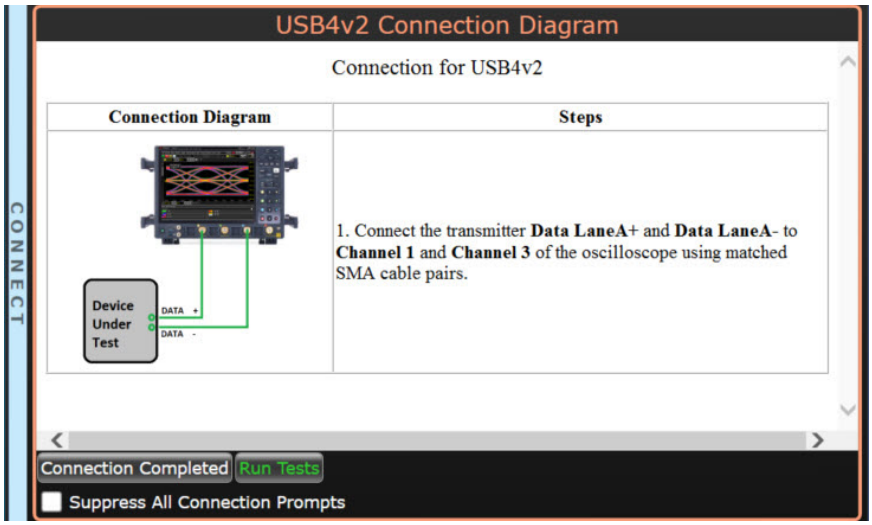



Figure 43 Connection diagram for the transmitter SSC down spread rate (min) test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# SSC Phase Deviation

## Test Overview

This test confirms if the SSC Phase Deviation of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| SSC Phase Deviation | 2.50 ns | 15.50 ns |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

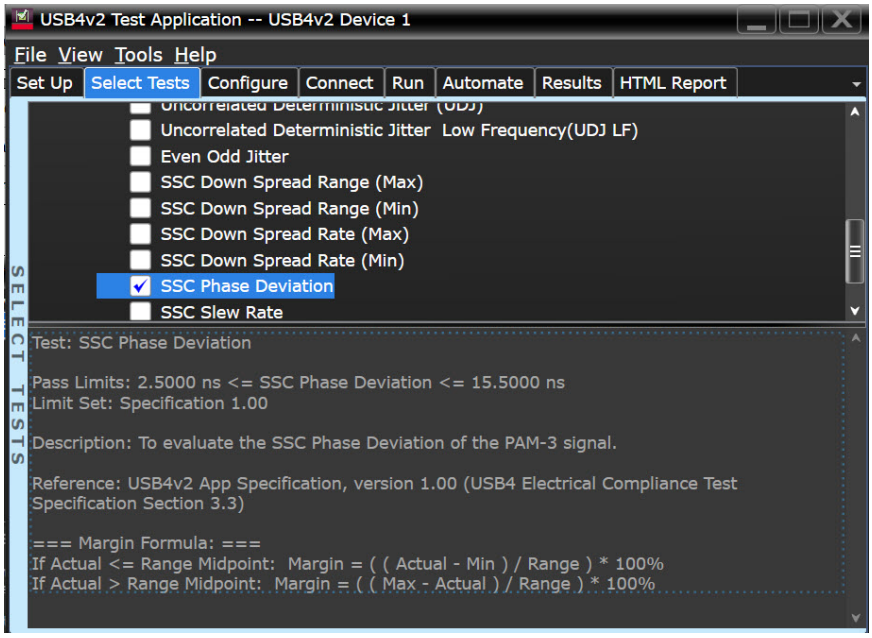



Figure 44 Selecting the transmitter SSC phase deviation test

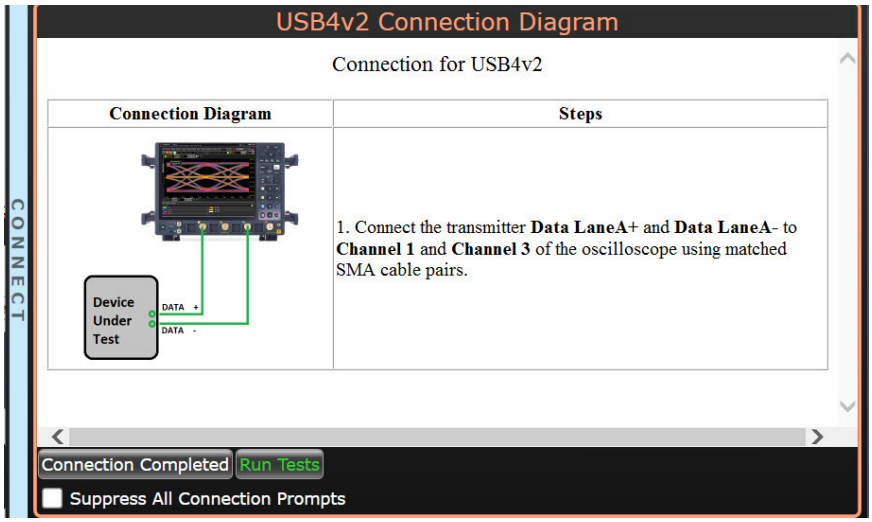



Figure 45 Connection diagram for the transmitter SSC phase deviation test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# SSC Slew Rate

## Test Overview

This test confirms if the SSC Slew Rate of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| SSC Slew Rate | 500.00 ppm/us |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

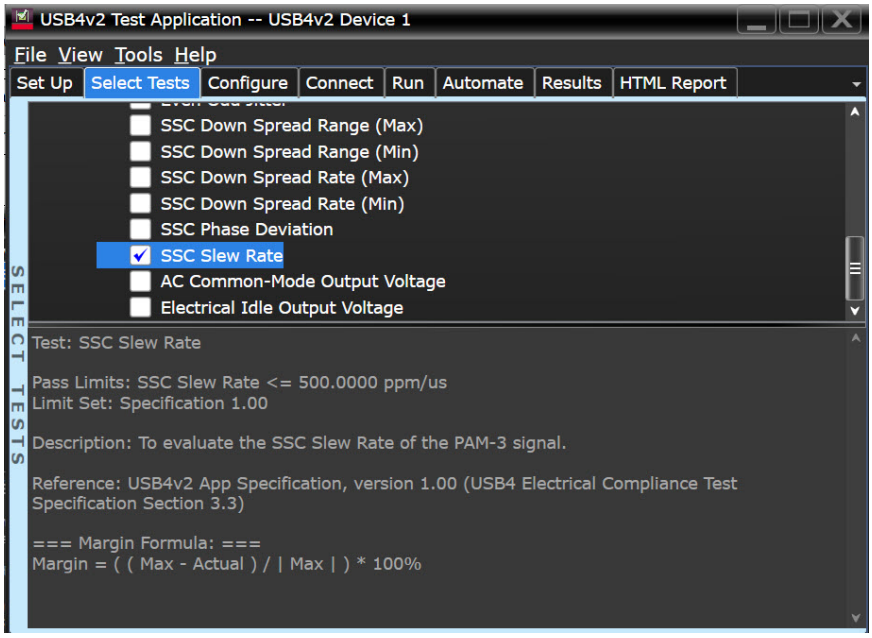



Figure 46 Selecting the SSC slew rate test

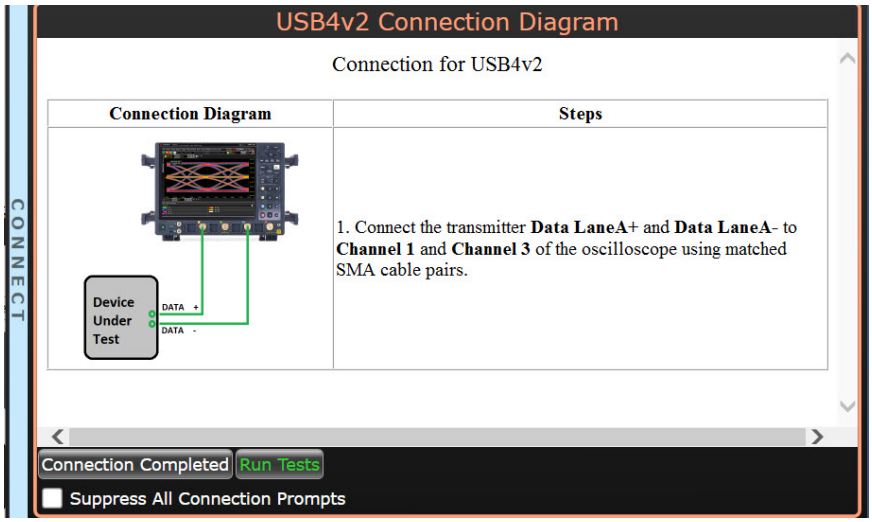



Figure 47 Connection diagram for the transmitter SSC slew rate test

Measurement Procedure

1 Use the **Best Preset** that obtains the lowest DDJ based on the **Transmitter Equalization** tests or user preference in the **Configure** tab.

**NOTE**

If **Transmitter Equalization** tests are not run, the application will not be able to obtain the **Best Preset** automatically, instead it will use the **User Defined Optimum Preset** to run the **Signal Integrity Tests**.

For more info, please see the Online Help > **Setting Up the Test Environment** page.

2 Run SigTest tool using corresponding preset waveform. No new signal acquisition is required in this test.

3 Check SigTest report for pass/fail status.

4 Repeat the test for all remaining USB4 Transmitter Lanes.

**NOTE**

Scope intrinsic noise file shall be provided to SigTest with the same scope settings used for capturing the file with the selected preset configuration as described in Appendix C (USB4 Electrical Compliance Test Specification).

Pass Condition

The results should be within the conformance limits as per the specification.

# AC Common-Mode Output Voltage

## Test Overview

This test confirms if the AC Common-Mode Output Voltage of the PAM-3 signal is within the USB4 v2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| AC Common-Mode Output Voltage | 100.00 $mV_{p-p}$ |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

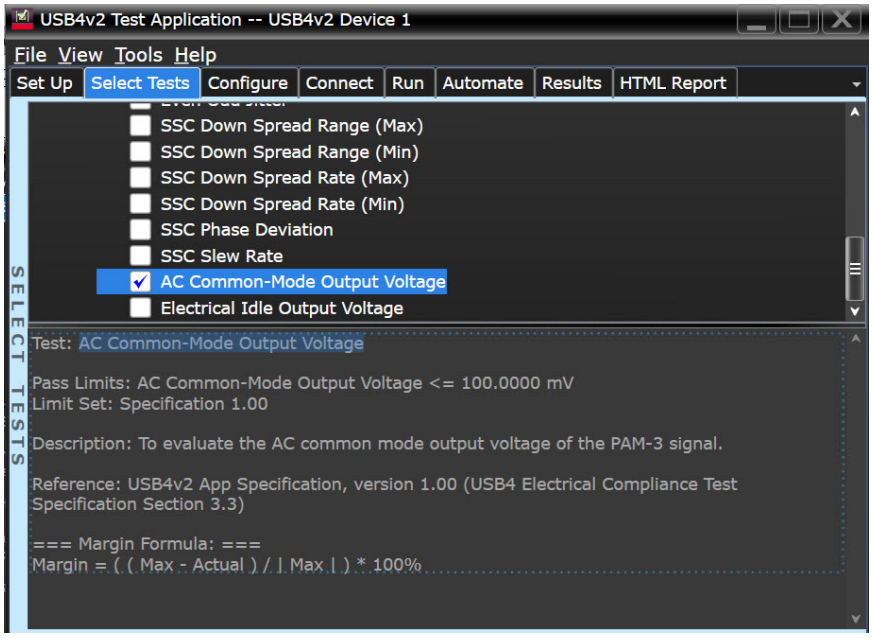



Figure 48 Selecting the AC common-mode output voltage test

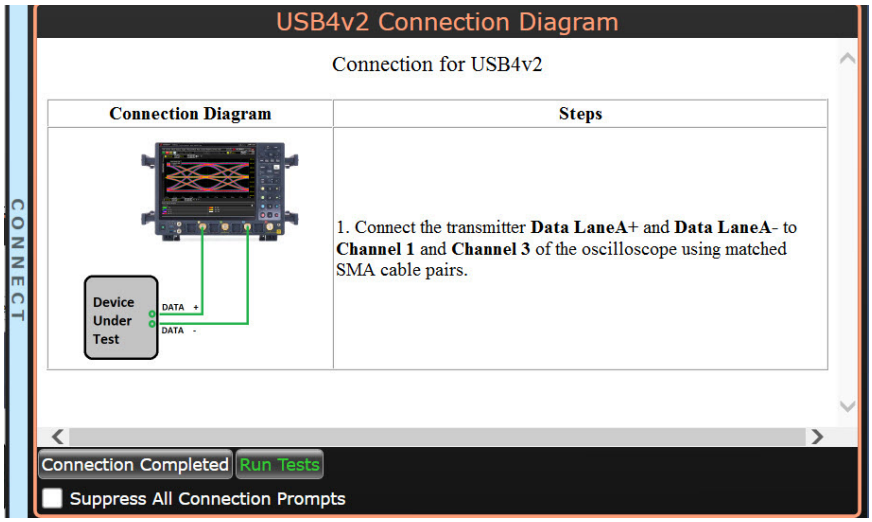



Figure 49 Connection diagram for the transmitter AC common-mode output voltage test

Measurement Procedure

1 Set oscilloscope as:
   - Bandwidth: 25 GHz
   - Sampling Rate ≥ 80 GSa/s (while keeping acquisition record length of 500 µs)
   - No CDR, no average, and no interpolation should be used.
   - The signal vertical scaling must be optimized per preset (obtaining at least 80% of the vertical range).
2 Lane under test should transmit PRTS7 pattern, remaining lanes should be activated as aggressors transmitting PRTS19. SSC should be enabled during the test.
3 Activate device under test with maximum number of aggressor lanes configured as transmitters. Configure lane under test and aggressors according to Appendix A of the USB4 Electrical Compliance Test Specification.

**NOTE** **Best Preset** is the one that produces the least DDJ.

4 Run SigTest tool.
5 Check SigTest report for pass/fail status.
6 Repeat the test for all remaining USB4 transmitter lanes.

Pass Condition

The results should be within the conformance limits as per the specification.

# Electrical Idle Output Voltage

## Test Overview

This test confirm if the Tx peak voltage while transmitting electrical idle is within USB4 v2.0 Specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Electrical Idle Output Voltage | 20 $mV_{p-p}$ |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification, section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

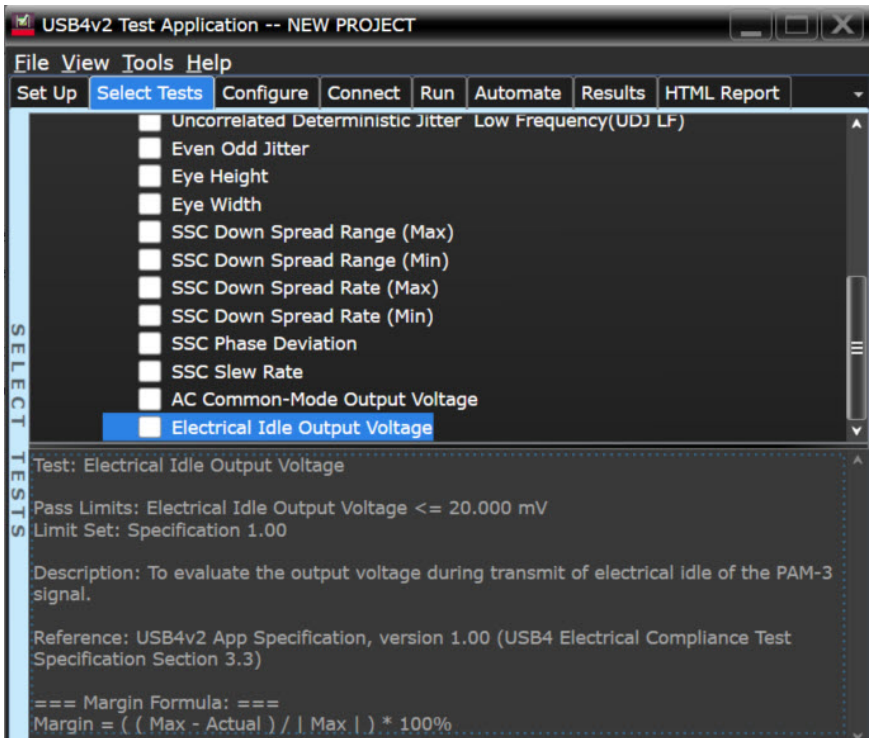



Figure 50 Selecting the electrical idle output voltage test

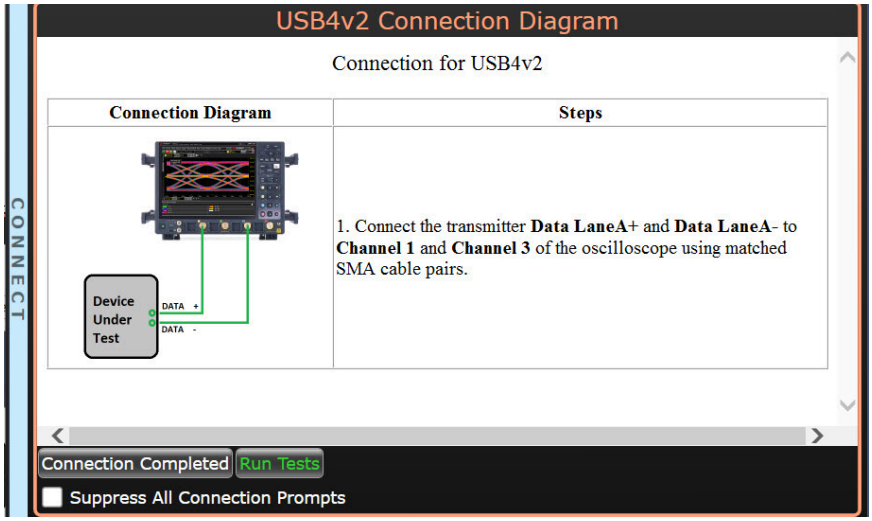



Figure 51 Connection diagram for the transmitter electrical idle output voltage test

### Measurement Procedure

1 Set oscilloscope as:
   - Bandwidth: 25 GHz
   - Sampling Rate ≥80 GSa/s (while keeping acquisition record length of 500 µs)
   - No CDR, no average, and no interpolation should be used.
   - The signal vertical scaling must be optimized per preset (obtaining at least 80% of the vertical range).
2 Configure DUT to electrical idle mode.
3 Activate device under test with maximum number of aggressor lanes configured as transmitters (Configure lane under test and aggressors according to Appendix A of the USB4 Electrical Compliance Test Specification.
4 Performs compliance testing using SigTest.
5 Reports the result values from SigTest and compares with compliance limits to report pass/fail.
6 Repeat the test for all remaining USB4 transmitter lanes.

### Pass Condition

The results should be within the conformance limits as per the specification.

# Init Frequency Variation Training

## Test Overview

This test confirms if the frequency variation during link training is within USB4 2.0 Specification limits

## Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| Init Frequency Variation Training | -300 ppm | 300 ppm |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | “SQ224 - PRTS7 PAM3” or “SQ128 - PRTS7 PAM3” |

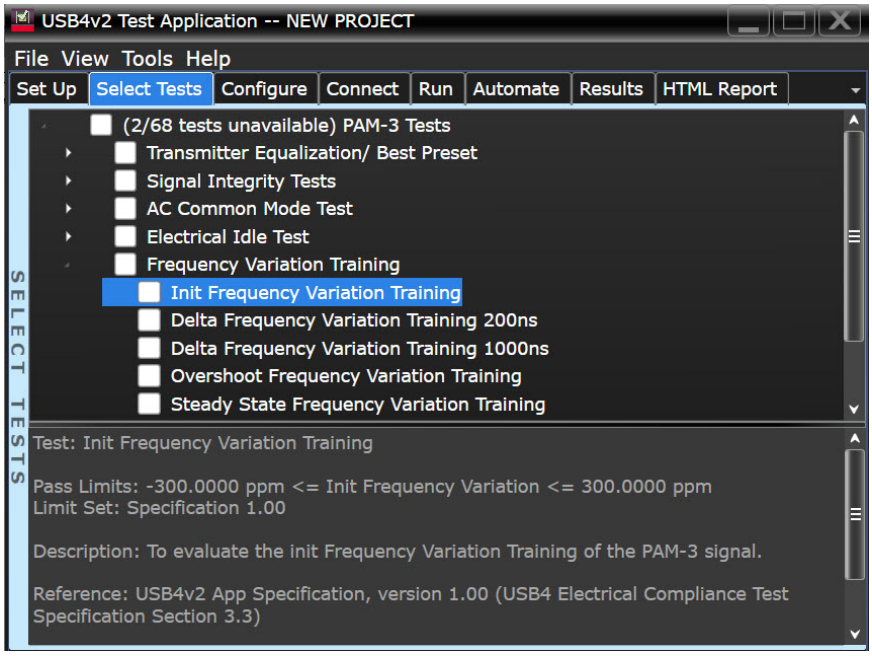



Figure 52 Selecting the init frequency variation training test

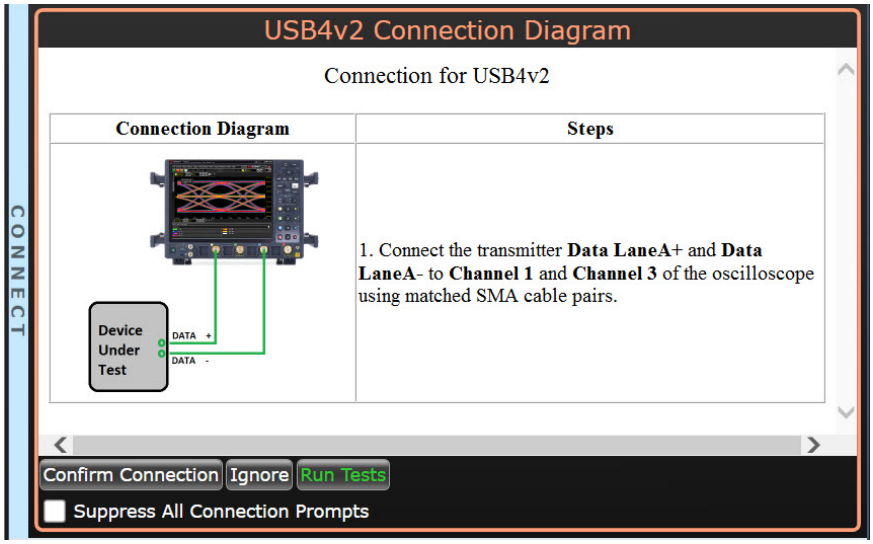



Figure 53 Connection diagram for the init frequency variation training test

Measurement Procedure

1 Configure transmitter under test with maximum number of aggressor lanes configured as transmitters connected to 50 Ω termination. (Configure Lane under test and aggressors according to Appendix A)

2 For emulating link training set router assembly components as following:
   - Configure router to transmit PRTS7 PAM3 pattern on all lanes. SSC modulation shall be disabled.
   - Configure re-timer facing USB type-c connector to transmit SQ224 (if supported) or SQ128 (if SQ224 is not supported) on all lanes. Re-timer shall prevent the transition to “Forwarding state”.

3 Set oscilloscope as:
   - Bandwidth: 25 GHz
   - Sampling rate: 80 GSa/s; while keeping acquisition record length of 500 µs.
   - No CDR, no average, and no interpolation to be used.
   - Optimize the signal vertical scaling (obtaining at least 80% of the vertical range).

4 Initiate transition to “Forwarding state” on the re-timer facing USB type-c connector.

5 Capture the clock switch event over three stages: pre-clock switch, clock switch, and post-clock switch in a single waveform as depicted in Figure 54.

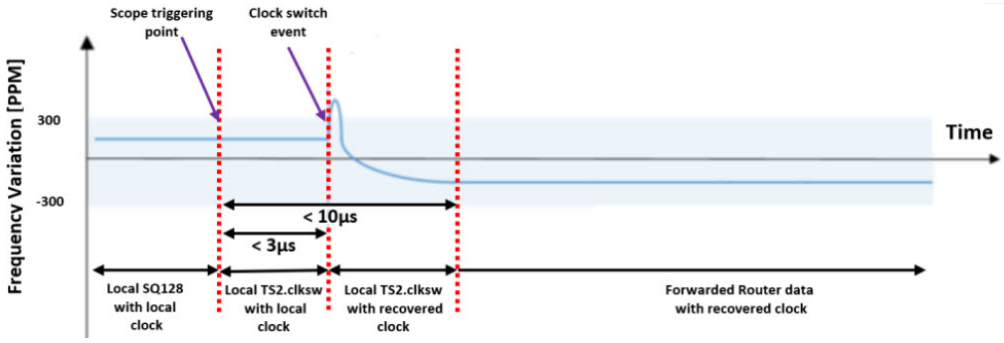



Figure 54 Frequency variation dynamics example

6 Perform measurement using SigTest tool.

7 Check SigTest report for pass/fail status.

8 Repeat above procedure 10 times. Use the worst case result as final.

9 Repeat the test for all the remaining lanes.

**NOTE** **The de-embedding of the cable assembly connecting TP2 compliance test point to the Oscilloscope is done by the SigTest tool. Measured cable assembly s-parameters s4p file will be used for de-embedding in SigTest tool. No additional de-embedding is needed; see Appendix B of the CTS for correct network analyzer setup.**

Pass Condition

The results should be within the conformance limits as per the specification.

## Delta Frequency Variation Training 200 ns

### Test Overview

This test confirms if the “delta frequency variation training 200 ns” is within USB4 2.0 specification limits.

### Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Delta Frequency Variation Training 200 ns | 600 ppm |

### Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

### Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | “SQ224 - PRTS7 PAM3” or “SQ128 - PRTS7 PAM3” |

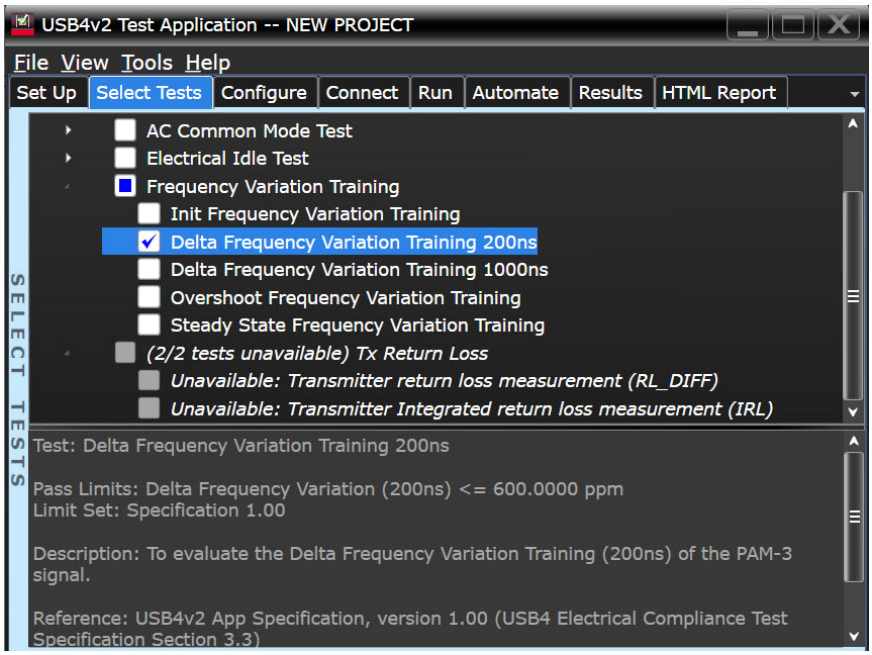



Figure 55 Selecting the delta frequency variation training 200 ns test

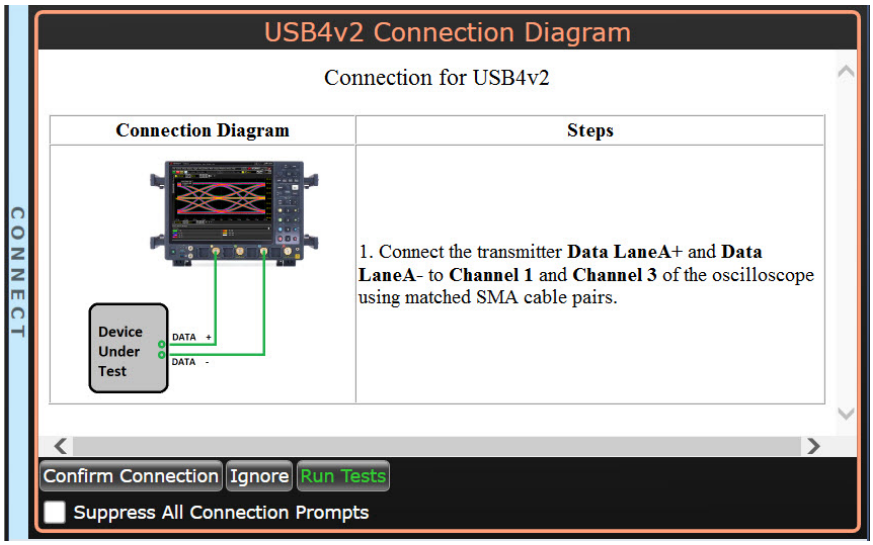



Figure 56 Connection diagram for the delta frequency variation training 200 ns test

### Measurement Procedure

1 Configure transmitter under test with maximum number of aggressor lanes configured as transmitters connected to 50 Ω termination. (Configure Lane under test and aggressors according to Appendix A)

2 For emulating link training set router assembly components as following:

- Configure router to transmit PRTS7 PAM3 pattern on all lanes. SSC modulation shall be disabled.
- Configure re-timer facing USB type-c connector to transmit SQ224 (if supported) or SQ128 (if SQ224 is not supported) on all lanes. Re-timer shall prevent the transition to “Forwarding state”.

3 Set oscilloscope as:

- Bandwidth: 25 GHz
- Sampling rate: 80 GSa/s; while keeping acquisition record length of 500 µs.
- No CDR, no average, and no interpolation to be used.
- Optimize the signal vertical scaling (obtaining at least 80% of the vertical range).

4 Initiate transition to “Forwarding state” on the re-timer facing USB type-c connector.

5 Capture the clock switch event over three stages: pre-clock switch, clock switch, and post-clock switch in a single waveform as depicted in Figure 54.

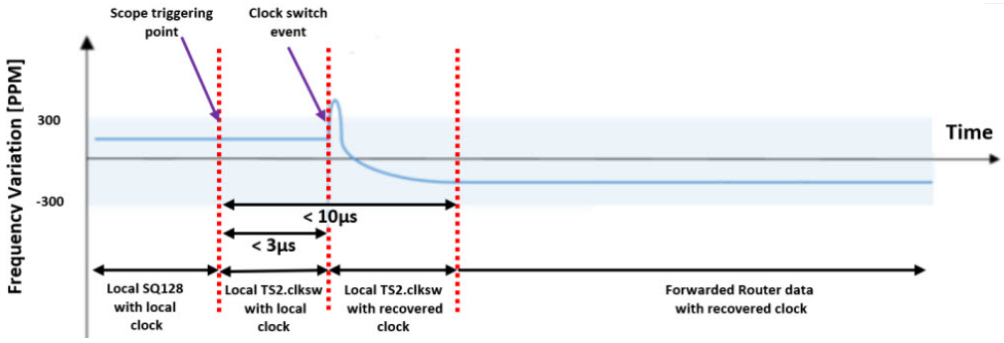



Figure 57 Frequency variation dynamics example

6 Perform measurement using SigTest tool.

7 Check SigTest report for pass/fail status.

8 Repeat above procedure 10 times. Use the worst case result as final.

9 Repeat the test for all the remaining lanes.

**NOTE** The de-embedding of the cable assembly connecting TP2 compliance test point to the Oscilloscope is done by the SigTest tool. Measured cable assembly s-parameters s4p file will be used for de-embedding in SigTest tool. No additional de-embedding is needed; see Appendix B of the CTS for correct network analyzer setup.

### Pass Condition

The results should be within the conformance limits as per the specification.

# Delta Frequency Variation Training 1000 ns

## Test Overview

This test confirms if the “delta frequency variation training 1000 ns” is within USB4 2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Delta Frequency Variation Training 1000 ns | 900 ppm |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | “SQ224 - PRTS7 PAM3” or “SQ128 - PRTS7 PAM3” |

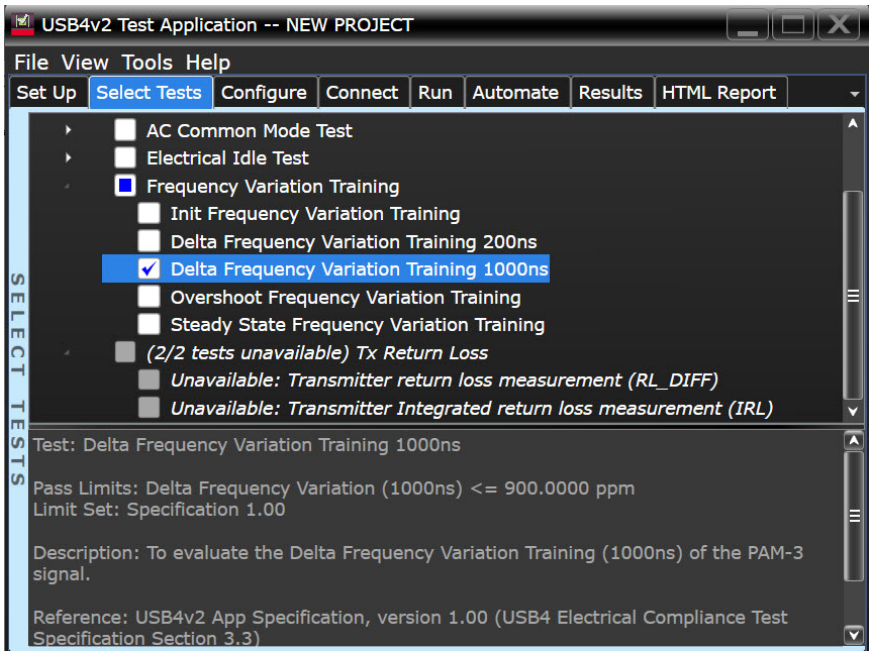



Figure 58 Selecting the delta frequency variation training 1000 ns test

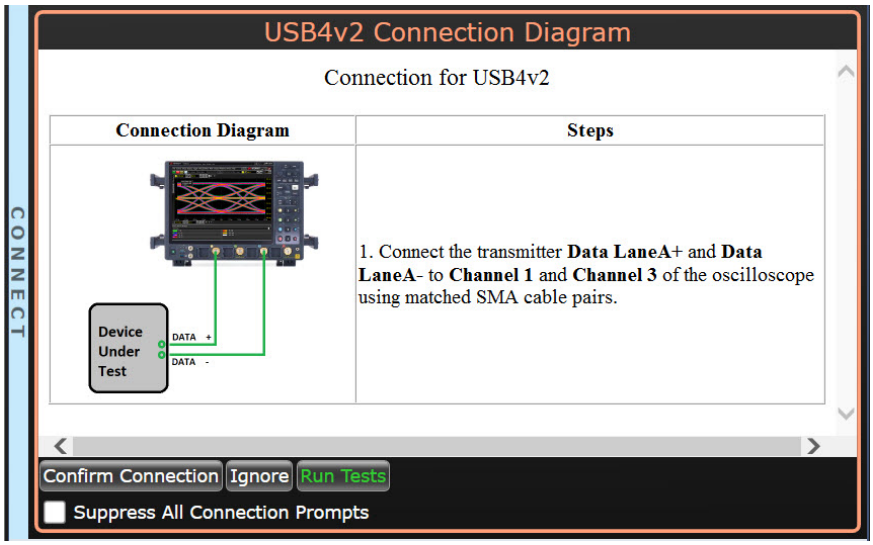



Figure 59 Connection diagram for the delta frequency variation training 1000 ns test

Measurement Procedure

1 Configure transmitter under test with maximum number of aggressor lanes configured as transmitters connected to 50 Ω termination. (Configure Lane under test and aggressors according to Appendix A)

2 For emulating link training set router assembly components as following:
   - Configure router to transmit PRTS7 PAM3 pattern on all lanes. SSC modulation shall be disabled.
   - Configure re-timer facing USB type-c connector to transmit SQ224 (if supported) or SQ128 (if SQ224 is not supported) on all lanes. Re-timer shall prevent the transition to “Forwarding state”.

3 Set oscilloscope as:
   - Bandwidth: 25 GHz
   - Sampling rate: 80 GSa/s; while keeping acquisition record length of 500 µs.
   - No CDR, no average, and no interpolation to be used.
   - Optimize the signal vertical scaling (obtaining at least 80% of the vertical range).

4 Initiate transition to “Forwarding state” on the re-timer facing USB type-c connector.

5 Capture the clock switch event over three stages: pre-clock switch, clock switch, and post-clock switch in a single waveform as depicted in Figure 54.

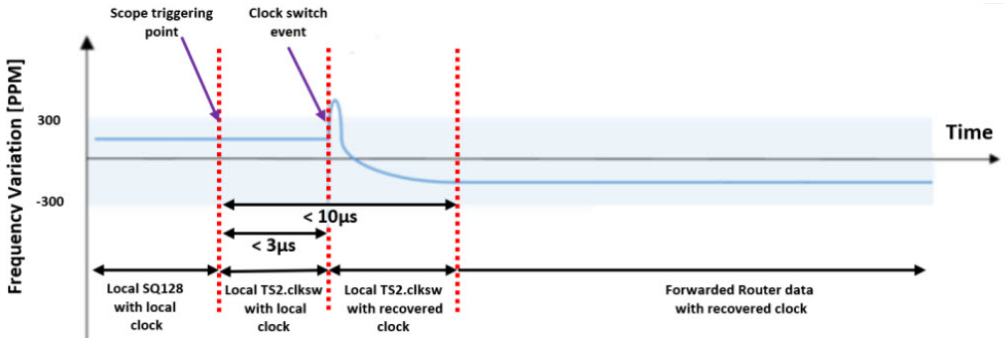



Figure 60 Frequency variation dynamics example

6 Perform measurement using SigTest tool.

7 Check SigTest report for pass/fail status.

8 Repeat above procedure 10 times. Use the worst case result as final.

9 Repeat the test for all the remaining lanes.

**NOTE** **The de-embedding of the cable assembly connecting TP2 compliance test point to the Oscilloscope is done by the SigTest tool. Measured cable assembly s-parameters s4p file will be used for de-embedding in SigTest tool. No additional de-embedding is needed; see Appendix B of the CTS for correct network analyzer setup.**

Pass Condition

The results should be within the conformance limits as per the specification.

# Overshoot Frequency Variation Training

## Test Overview

This test confirms if the “overshoot frequency variation training” is within USB4 2.0 specification limits.

## Pass Limits

| Test Parameter | Max Limit |
|---|---|
| Overshoot Frequency Variation Training | 600 ppm |

## Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

## Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | “SQ224 - PRTS7 PAM3” or “SQ128 - PRTS7 PAM3” |

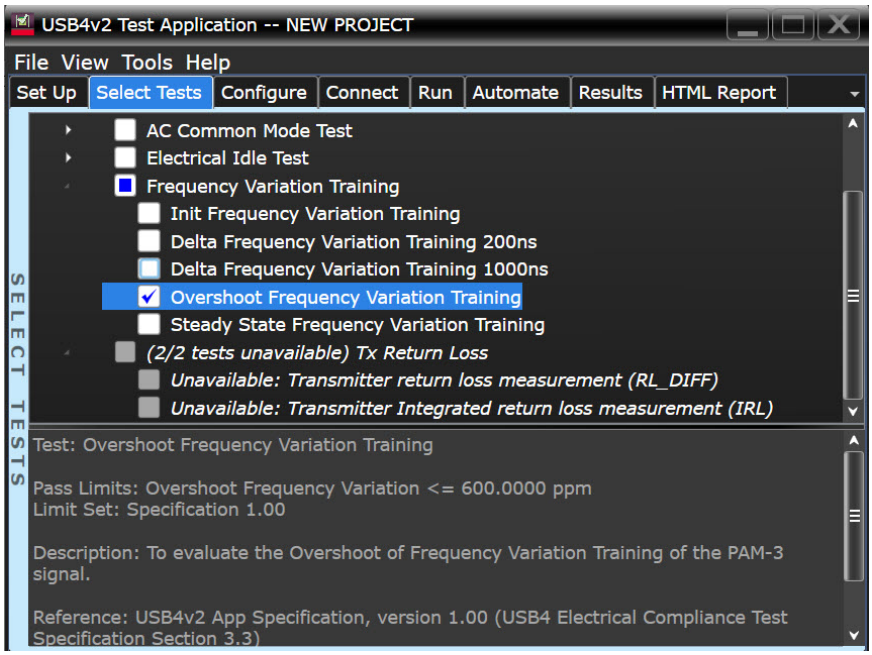



Figure 61 Selecting the overshoot frequency variation training test

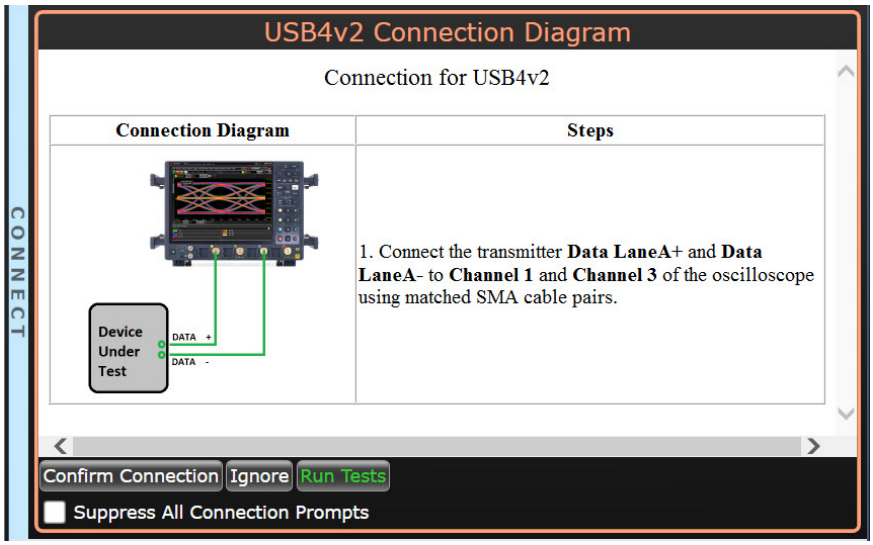



Figure 62 Connection diagram for the overshoot frequency variation training test

### Measurement Procedure

1 Configure transmitter under test with maximum number of aggressor lanes configured as transmitters connected to 50 Ω termination. (Configure Lane under test and aggressors according to Appendix A)

2 For emulating link training set router assembly components as following:

- Configure router to transmit PRTS7 PAM3 pattern on all lanes. SSC modulation shall be disabled.
- Configure re-timer facing USB type-c connector to transmit SQ224 (if supported) or SQ128 (if SQ224 is not supported) on all lanes. Re-timer shall prevent the transition to “Forwarding state”.

3 Set oscilloscope as:

- Bandwidth: 25 GHz
- Sampling rate: 80 GSa/s; while keeping acquisition record length of 500 µs.
- No CDR, no average, and no interpolation to be used.
- Optimize the signal vertical scaling (obtaining at least 80% of the vertical range).

4 Initiate transition to “Forwarding state” on the re-timer facing USB type-c connector.

5 Capture the clock switch event over three stages: pre-clock switch, clock switch, and post-clock switch in a single waveform as depicted in Figure 54.

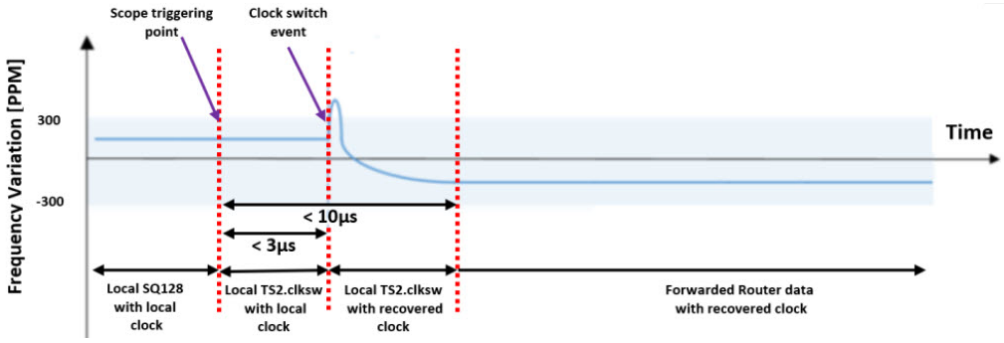



Figure 63 Frequency variation dynamics example

6 Perform measurement using SigTest tool.

7 Check SigTest report for pass/fail status.

8 Repeat above procedure 10 times. Use the worst case result as final.

9 Repeat the test for all the remaining lanes.

**NOTE** The de-embedding of the cable assembly connecting TP2 compliance test point to the Oscilloscope is done by the SigTest tool. Measured cable assembly s-parameters s4p file will be used for de-embedding in SigTest tool. No additional de-embedding is needed; see Appendix B of the CTS for correct network analyzer setup.

### Pass Condition

The results should be within the conformance limits as per the specification.

## Steady State Frequency Variation Training

### Test Overview

This test confirms if the “steady state frequency variation training” is within USB4 2.0 specification limits.

### Pass Limits

| Test Parameter | Min Limit | Max Limit |
|---|---|---|
| Steady State Frequency Variation Training | -300 ppm | 300 ppm |

### Test Reference

- USB4v2 App Specification, version 1.00 (USB4 Electrical Compliance Test Specification Section 3.3)

### Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | “SQ224 - PRTS7 PAM3” or “SQ128 - PRTS7 PAM3” |

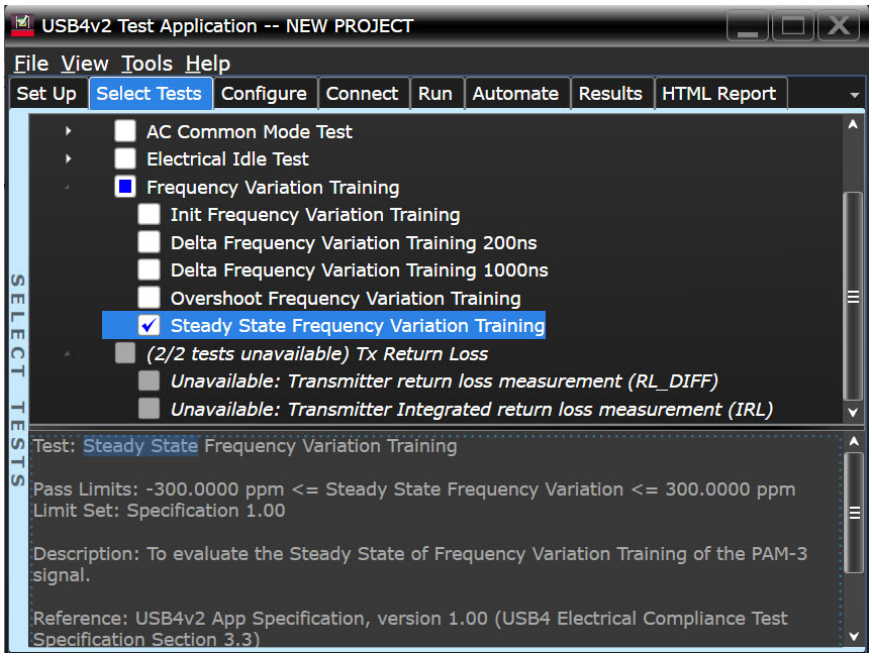



Figure 64 Selecting the steady state frequency variation training test

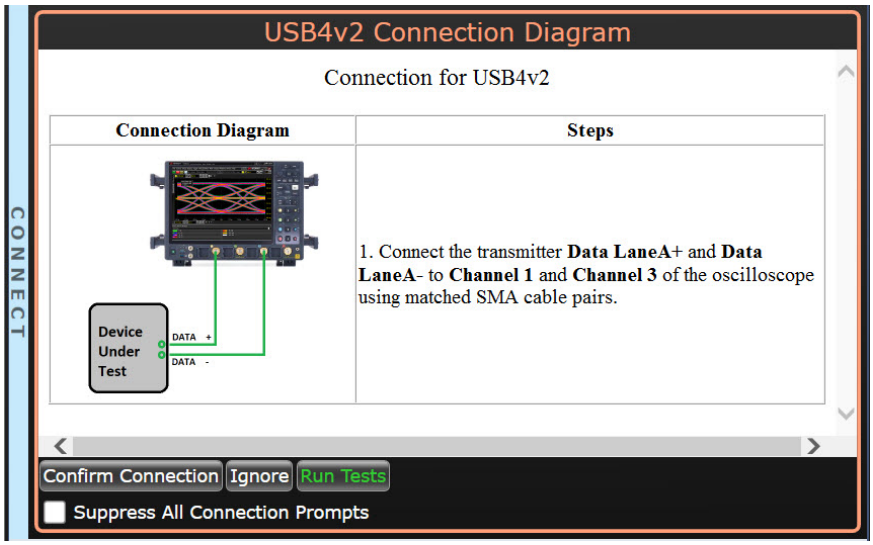



Figure 65 Connection diagram for the steady state frequency variation training test

Measurement Procedure

1 Configure transmitter under test with maximum number of aggressor lanes configured as transmitters connected to 50 Ω termination. (Configure Lane under test and aggressors according to Appendix A)

2 For emulating link training set router assembly components as following:
   - Configure router to transmit PRTS7 PAM3 pattern on all lanes. SSC modulation shall be disabled.
   - Configure re-timer facing USB type-c connector to transmit SQ224 (if supported) or SQ128 (if SQ224 is not supported) on all lanes. Re-timer shall prevent the transition to “Forwarding state”.

3 Set oscilloscope as:
   - Bandwidth: 25 GHz
   - Sampling rate: 80 GSa/s; while keeping acquisition record length of 500 µs.
   - No CDR, no average, and no interpolation to be used.
   - Optimize the signal vertical scaling (obtaining at least 80% of the vertical range).

4 Initiate transition to “Forwarding state” on the re-timer facing USB type-c connector.

5 Capture the clock switch event over three stages: pre-clock switch, clock switch, and post-clock switch in a single waveform as depicted in Figure 54.

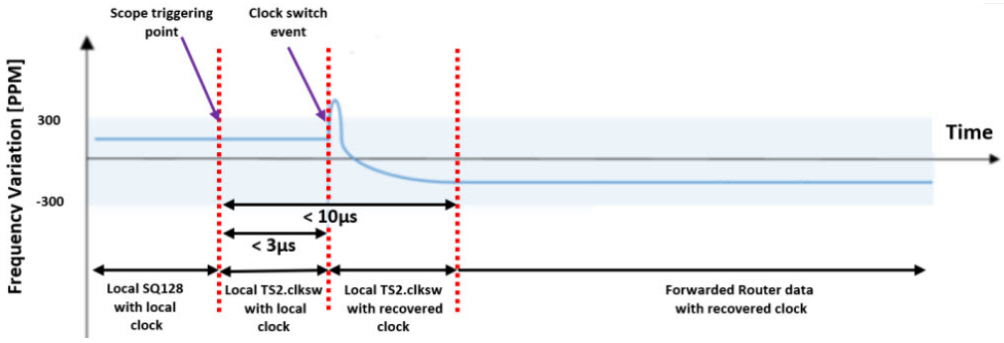



Figure 66 Frequency variation dynamics example

6 Perform measurement using SigTest tool.

7 Check SigTest report for pass/fail status.

8 Repeat above procedure 10 times. Use the worst case result as final.

9 Repeat the test for all the remaining lanes.

**NOTE** The de-embedding of the cable assembly connecting TP2 compliance test point to the Oscilloscope is done by the SigTest tool. Measured cable assembly s-parameters s4p file will be used for de-embedding in SigTest tool. No additional de-embedding is needed; see Appendix B of the CTS for correct network analyzer setup.

Pass Condition

The results should be within the conformance limits as per the specification.

## Transmitter Return Loss Measurement (RL_DIFF) Test

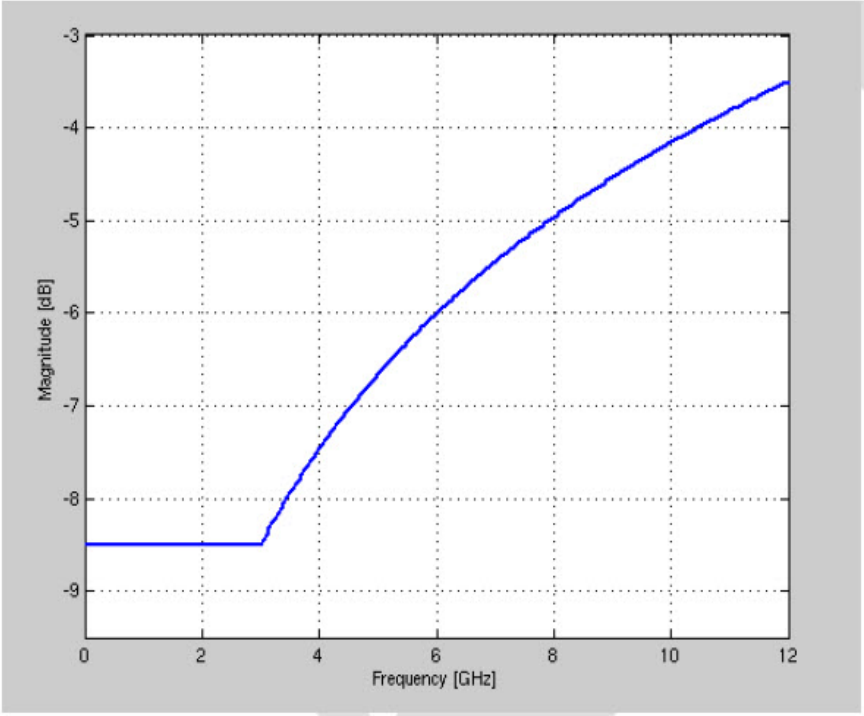
**NOTE** When running the Test App on a 2-Channel Oscilloscope, the **Select Tests** tab shall display tests pertaining to either **Lane 0 only** or to **Lane 1 only**.

### Test Overview

The objective of this test is to confirm that the Transmitter Return Loss Measurement (RL_DIFF) of a USB4v2 device is less than the maximum limit.

### Test Pass Requirement

$$\mathrm{SDD11(f)} = \begin{cases} -8.5 & 0.05 < f_{GHz} \leq 6 \\ -5.84 + 7.2 \cdot \log 10\left(\frac{f_{GHz}}{14}\right) & 6 < f_{GHz} \leq 14 \end{cases}$$



Test Setup

1 For the physical connections between the DUT & the Oscilloscope, see the connection diagrams in Figure 67 and Figure 68.

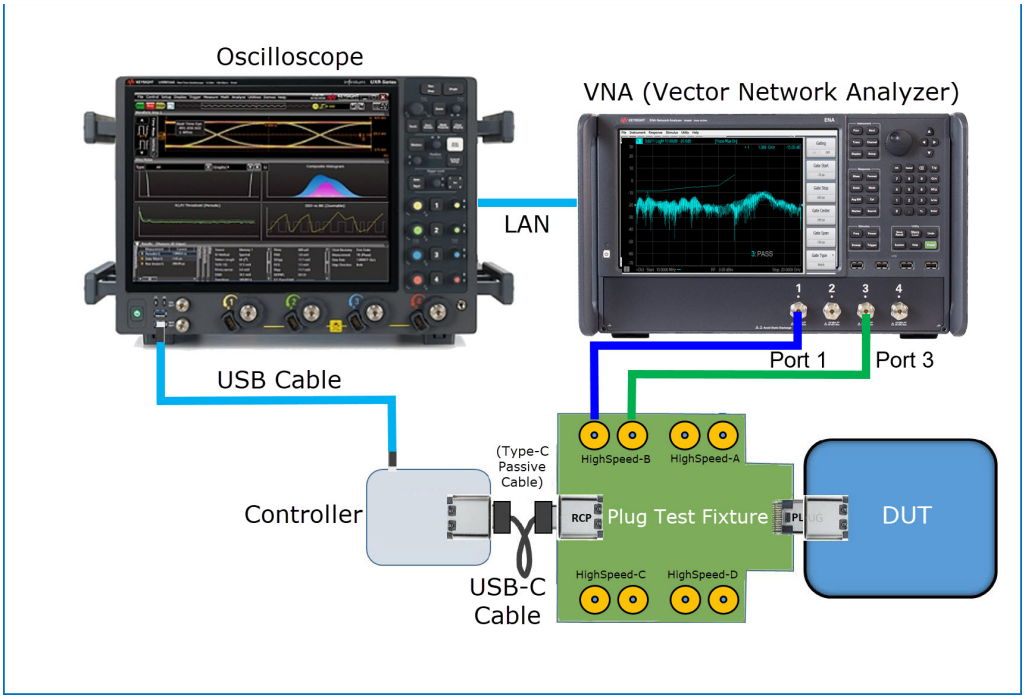



Figure 67 Tx Return loss test setup with Tx SMA test fixture connected to VNA

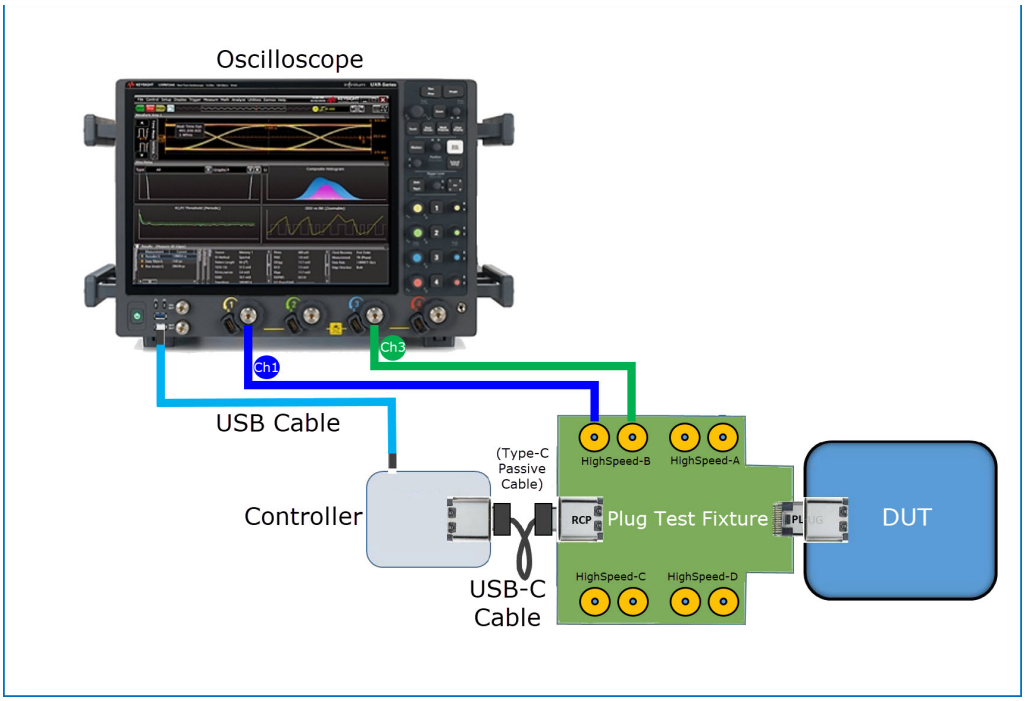
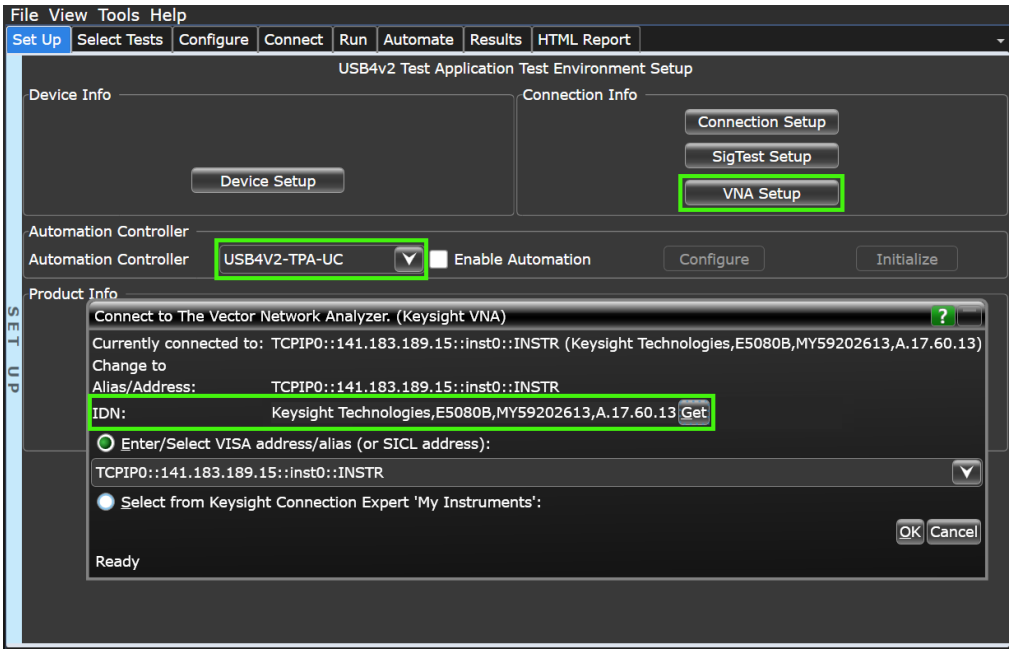



Figure 68 Tx Return loss test setup with Tx SMA test fixture connected to the scope

2 In the **Set Up** tab, please connect VNA in the Tx app.

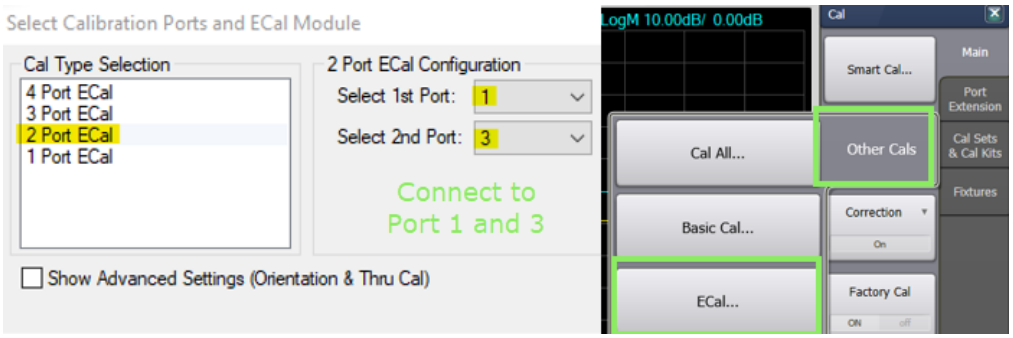



3 Prior calibration, setup Network Analyzer with following sweep settings:

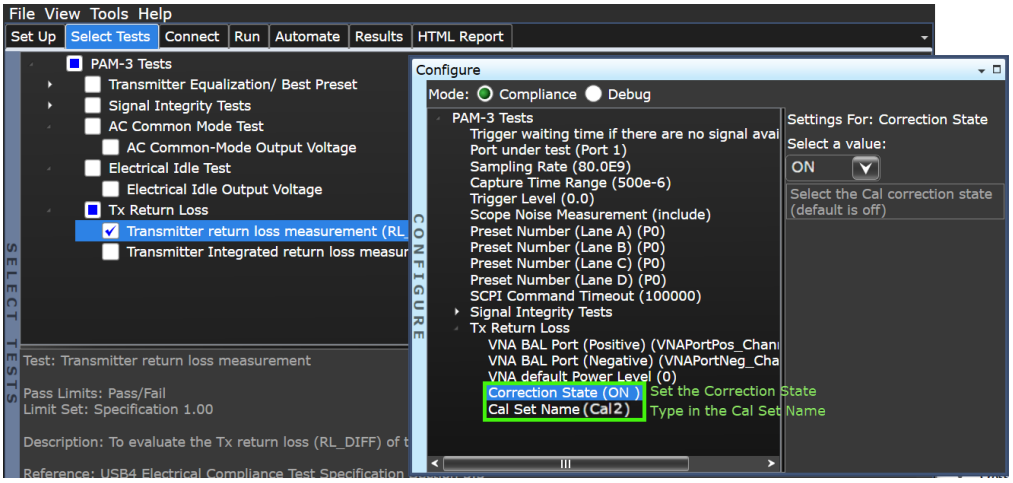
- Frequency range of 10 MHz to 20 GHz
- IF BW of 1 kHz
- At least 2000 points
- Impedance 85 ohm differential
- Define the Topology to Bal using VNA Port 1 and Port 3

**NOTE** Ensure that the VNA firmware revision is A.17.25.05 or higher to be compatible with the return loss test automation.

4 Run calibration on the network analyzer and test cables using a 2-port electronic kit (ECal). Save the Cal file.




5 In the **Select** test tab, select the Tx Return Loss Measurement and set the parameters in the **Configure** tab as shown in the figure below.




**NOTE** Please note that no gating setup is required for SMA fixture.

6 The test application:

- sets USB4ETT **Tool Usage Mode,**
- commands VNA to measure Tx Return Loss in S2P,
- commands the scope to save the PRTS7 waveform from the DUT,
- and compiles result using SigTest.

Test Procedure

1 Choose a supported USB4 speed to start with.
2 The test application sets USB4ETT tool to configure the DUT transmitter to output PRTS7 on all the required lanes.
3 Connect the channel 1 and 3 of the scope to the required lanes on the test fixture, configure the test pattern to PRTS7, and capture the waveform.
4 Connect the required lanes to the Network Analyzer and capture the S2P file.
5 Measure the Differential Return Loss using the S2P file and the PRTS7 waveform, and compile the result using SigTest.
6 If Differential Return Loss violates the above requirement, then the result is Fail.
7 Repeat the test for all remaining USB4 lanes.

Expected / Observable Results

If Differential Return Loss violated the specified requirement, then Fail.

Test References

See *USB4 Specification Version 2.00 Gen4, Section 3.3*

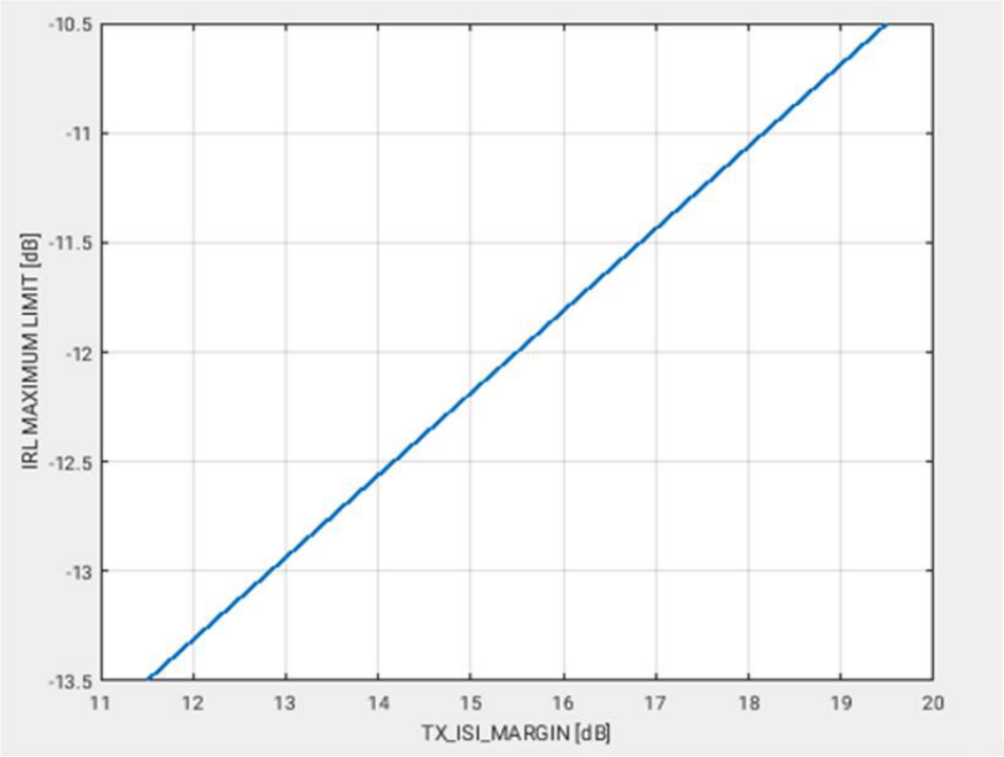
## Transmitter Integrated Return Loss Measurement

**NOTE** When running the Test App on a 2-Channel Oscilloscope, the **Select Tests** tab shall display tests pertaining to either **Lane 0 only** or to **Lane 1 only**.

### Test Overview

The objective of this test is to confirm that the Transmitter Integrated Return Loss Measurement (IRL) of a USB4v2 device is less than the maximum limit.

### Test Pass Requirement



### Test Setup

1 For the physical connections between the DUT & the Oscilloscope, see the connection diagrams in Figure 69 and Figure 70.

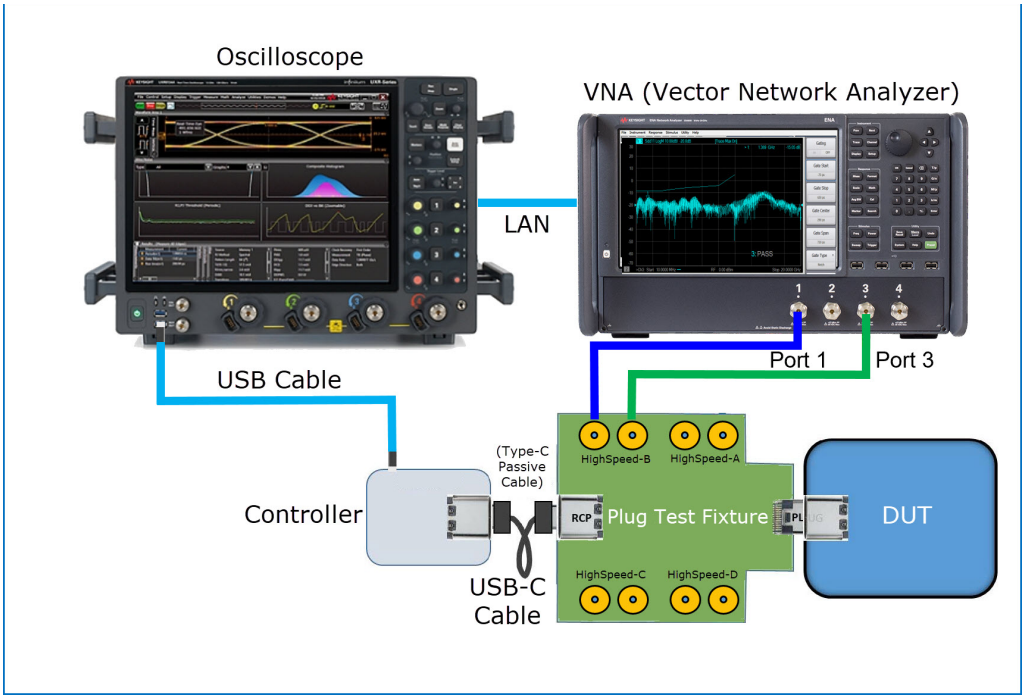



Figure 69 Tx Integrated return loss test setup with Tx SMA test fixture connected to VNA

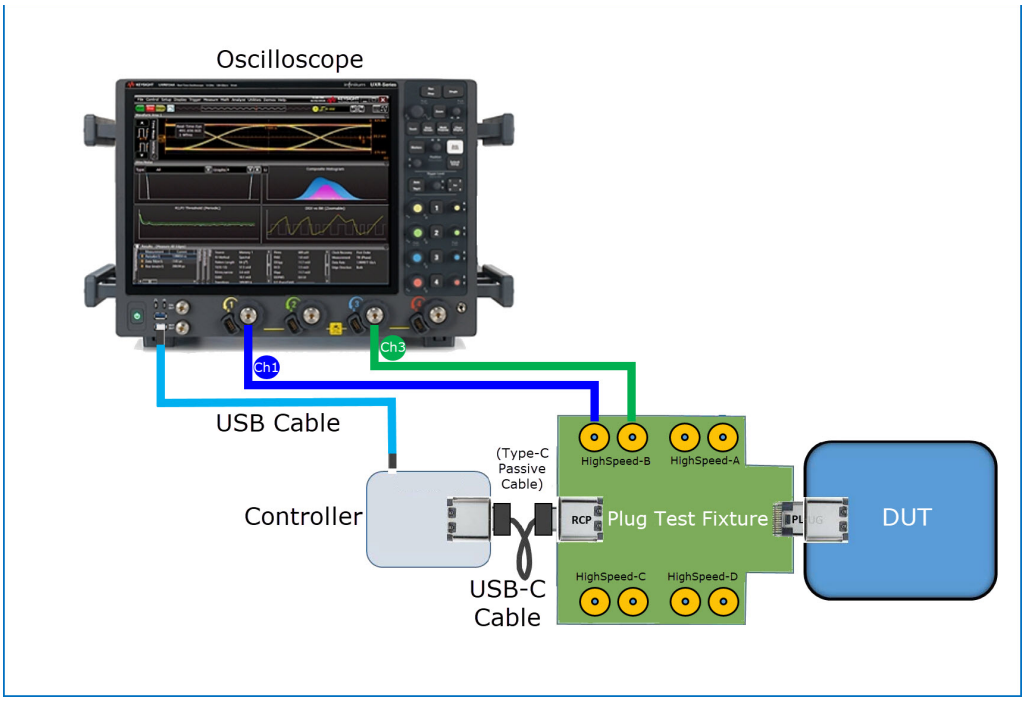
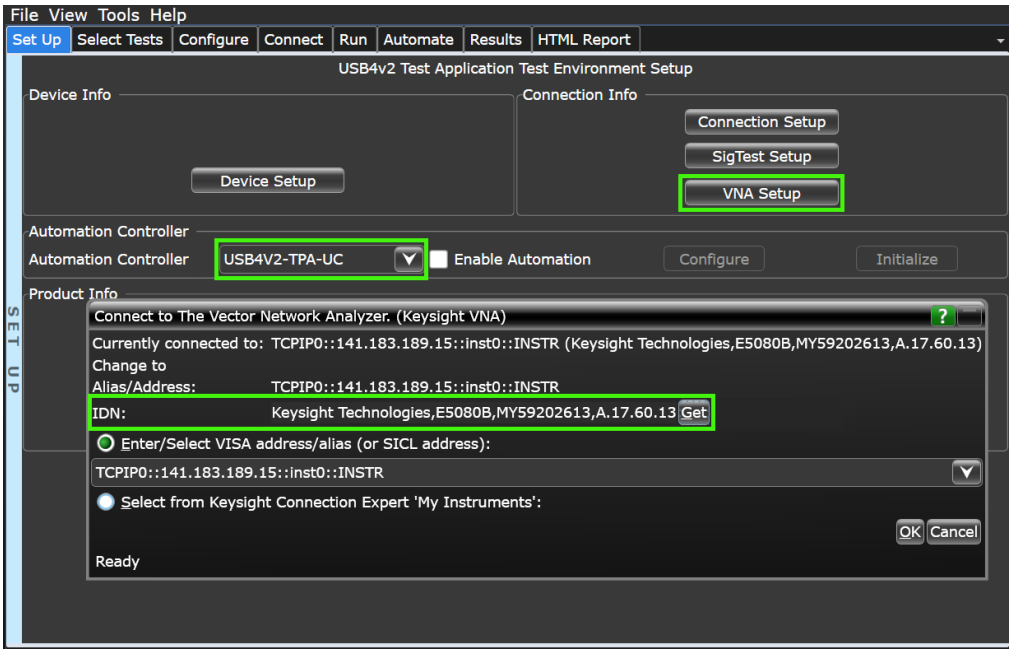



Figure 70 Tx Integrated return loss test setup with Tx SMA test fixture connected to the scope

2 In the **Set Up** tab, please connect VNA in the Tx app.

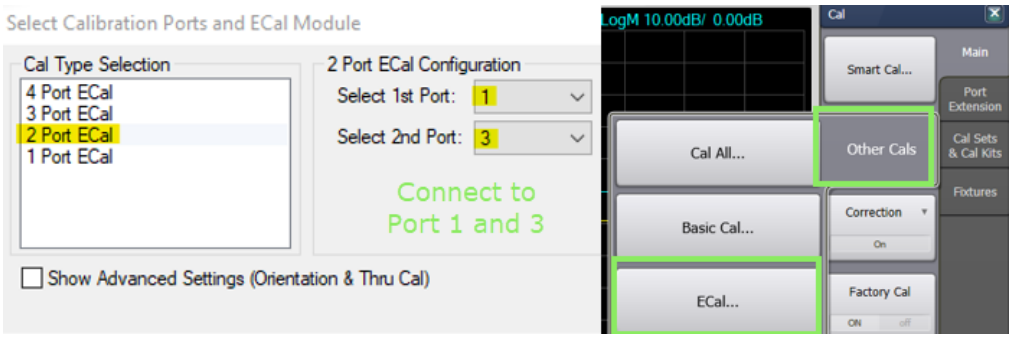



3 Prior calibration, setup Network Analyzer with following sweep settings:

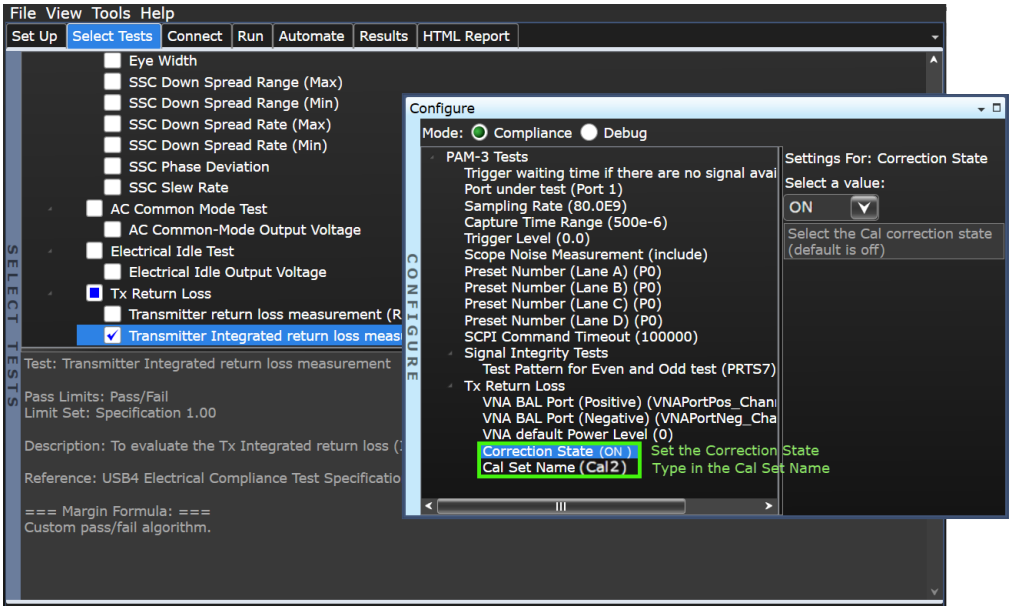
- Frequency range of 10 MHz to 20 GHz
- IF BW of 1 kHz
- At least 2000 points
- Impedance 85 ohm differential
- Define the Topology to Bal using VNA Port 1 and Port 3

**NOTE** Ensure that the VNA firmware revision is A.17.25.05 or higher to be compatible with the return loss test automation.

4 Run calibration on the network analyzer and test cables using a 2-port electronic kit (ECal). Save the Cal file.




5 In the **Select** test tab, select the Tx Integrated Return Loss Measurement and set the parameters in the **Configure** tab as shown in the figure below.




**NOTE** Please note that no gating setup is required for SMA fixture.

6 The test application:

- sets USB4ETT **Tool Usage Mode,**
- commands VNA to measure Tx Integrated Return Loss in S2P,
- commands the scope to save the PRTS7 waveform from the DUT,
- and compiles result using SigTest.

Test Procedure

1 Choose a supported USB4 speed to start with.
2 The test application sets USB4ETT tool to configure the DUT transmitter to output PRTS7 on all the required lanes.
3 Connect the channel 1 and 3 of the scope to the required lanes on the test fixture, configure the test pattern to PRTS7, and capture the waveform.
4 Connect the required lanes to the Network Analyzer and capture the S2P file.
5 Measure the Transmitter Integrated Return Loss (IRL) using the S2P file and the PRTS7 waveform, and compile the result using SigTest.
6 If Integrated Return Loss (IRL) violates the above requirement, then the result is Fail.
7 Repeat the test for all remaining USB4 lanes.

Expected / Observable Results

If Transmitter Integrated Return Loss (IRL) violated the specified requirement, then Fail.

Test References

See *USB4 Specification Version 2.00 Gen4, Section 3.3*

# Receiver Return Loss Measurement (RL_DIFF)

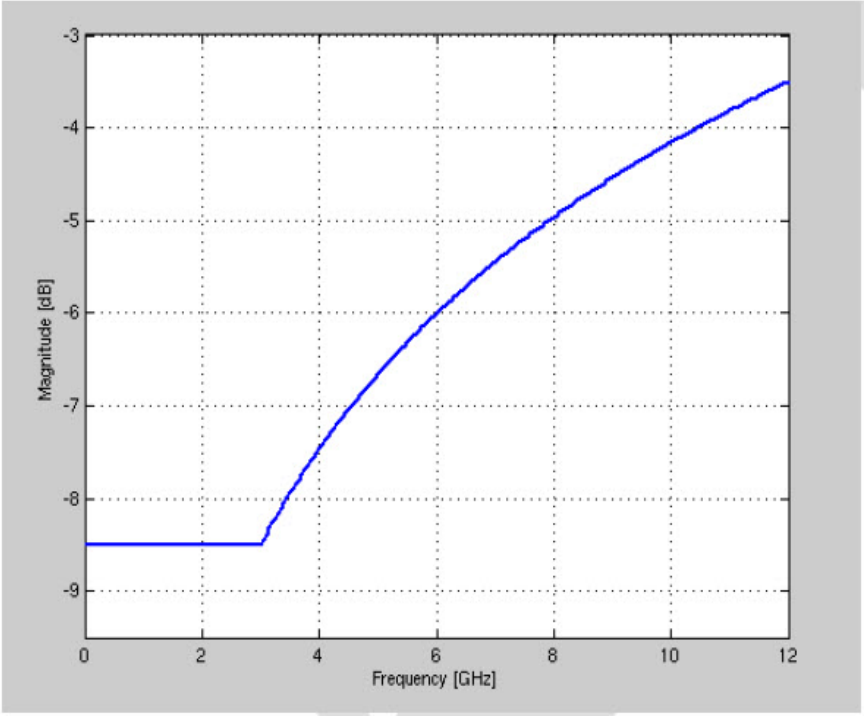
**NOTE** When running the Test App on a 2-Channel Oscilloscope, the **Select Tests** tab shall display tests pertaining to either **Lane 0 only** or to **Lane 1 only**.

## Test Overview

The objective of this test is to confirm that the Receiver Return Loss Measurement (RL_DIFF) of a USB4v2 device is less than the maximum limit.

## Test Pass Requirement

$$\mathrm{SDD11(f)} = \begin{cases} -8.5 & 0.05 < f_{GHz} \leq 6 \\ -5.84 + 7.2 \cdot \log 10\left(\frac{f_{GHz}}{14}\right) & 6 < f_{GHz} \leq 14 \end{cases}$$



Test Setup

1 For the physical connections, please see the connection diagram in Figure 71.

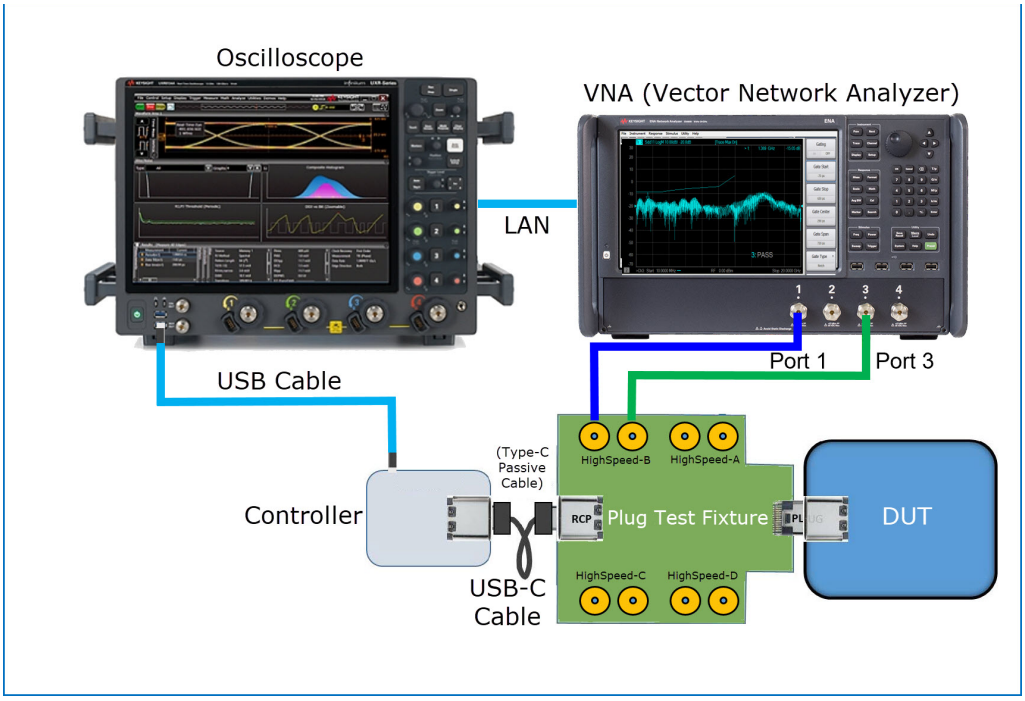
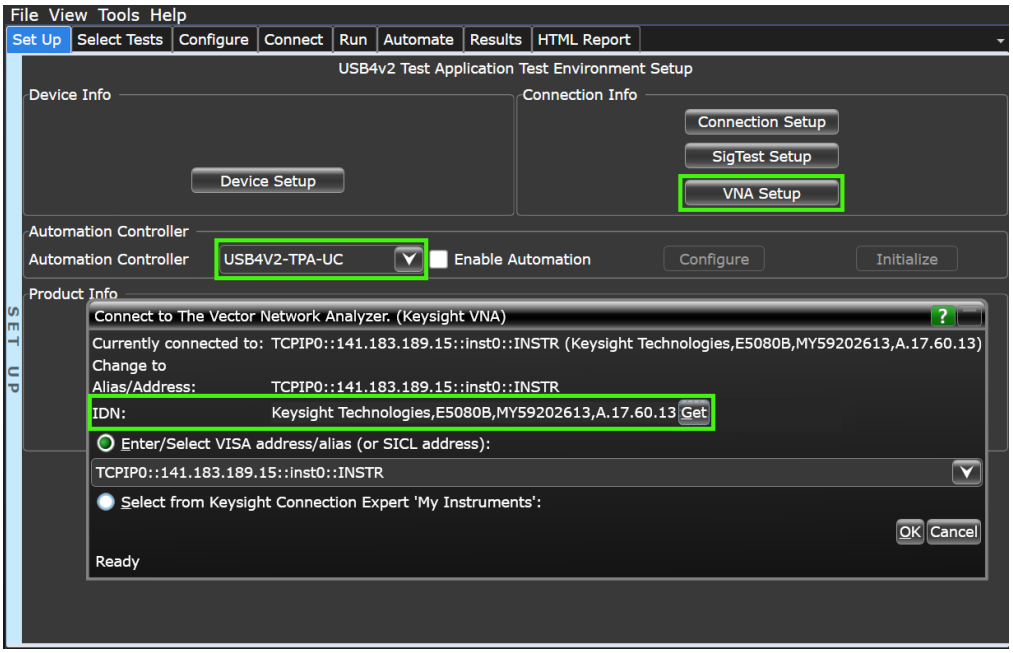



Figure 71 Rx Return loss test setup with SMA test fixture connected to VNA

2 In the **Set Up** tab, please connect VNA in the Tx app.

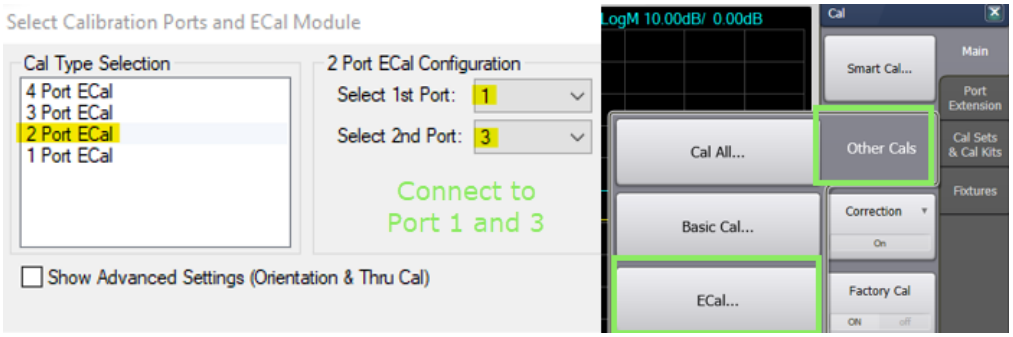



3 Prior calibration, setup Network Analyzer with following sweep settings:

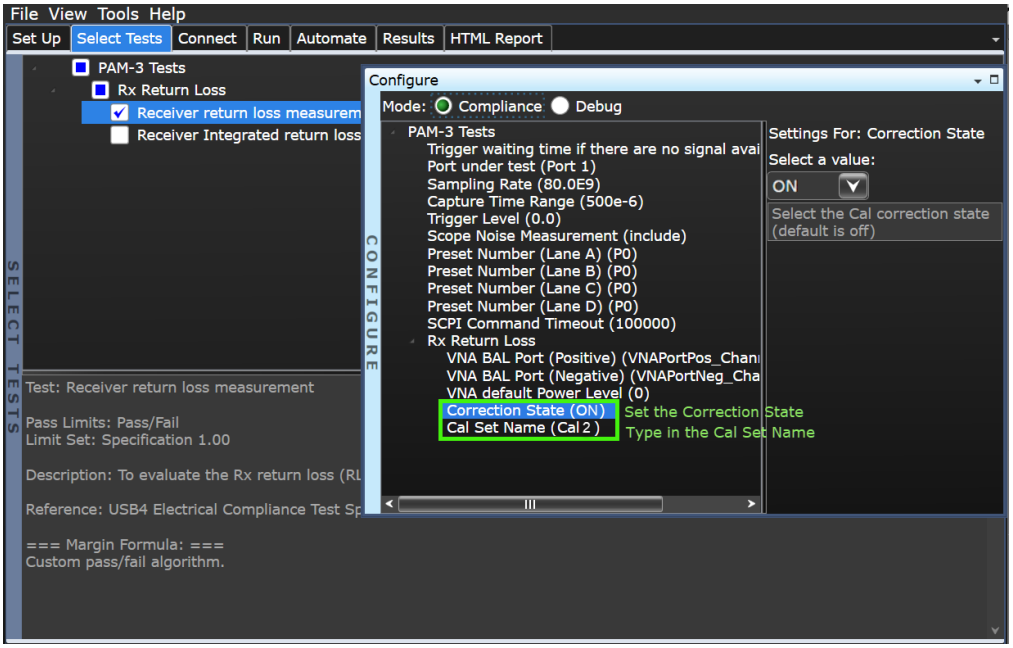
- Frequency range of 10 MHz to 20 GHz
- IF BW of 1 kHz
- At least 2000 points
- Impedance 85 ohm differential
- Define the Topology to Bal using VNA Port 1 and Port 3

**NOTE** Ensure that the VNA firmware revision is A.17.25.05 or higher to be compatible with the return loss test automation.

4 Run calibration on the network analyzer and test cables using a 2-port electronic kit (ECal). Save the Cal file.




5 In the **Select** test tab, select the Rx Return Loss Measurement and set the parameters in the **Configure** tab as shown in the figure below.




**NOTE** Please note that no gating setup is required for SMA fixture.

6 The test application:

- sets USB4ETT **Tool Usage Mode,**
- commands VNA to measure Rx Return Loss in S2P,
- and compiles result using SigTest.

Test Procedure

1 Choose a supported USB4 speed to start with.
2 The test application sets USB4ETT tool to configure the DUT transmitter to output PRTS7 on all the required lanes.
3 Connect the required lanes to the Network Analyzer and capture the S2P file.
4 Measure the Receiver Return Loss using the S2P file, and compile the result using SigTest.
5 If Receiver Return Loss violates the above requirement, then the result is Fail.
6 Repeat the test for all remaining USB4 lanes.

Expected / Observable Results

If Receiver Return Loss violated the specified requirement, then Fail.

Test References

See *USB4 Specification Version 2.00 Gen4, Section 3.3*

# Receiver Integrated Return Loss (IRL) Measurement

**NOTE** When running the Test App on a 2-Channel Oscilloscope, the **Select Tests** tab shall display tests pertaining to either **Lane 0 only** or to **Lane 1 only**.

## Test Overview

The objective of this test is to confirm that the Receiver Integrated Return Loss (IRL) Measurement of a USB4v2 device is less than the maximum limit.

## Test Pass Requirement

IRL ≤ -13.5 dB

## Test Setup

1 For the physical connections, please see the connection diagram in Figure 72.

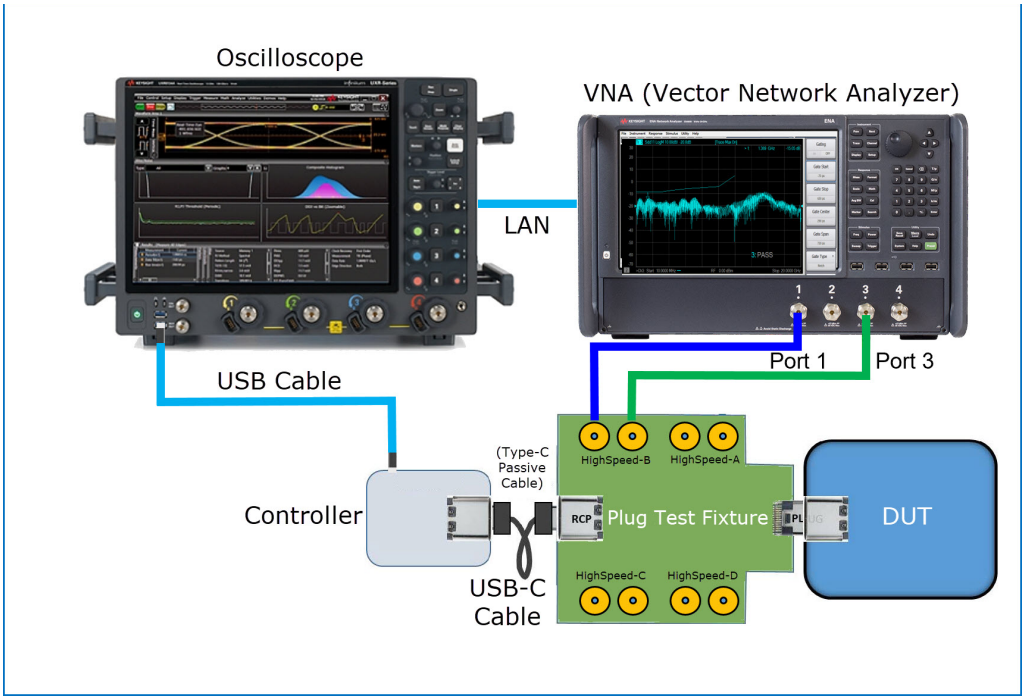
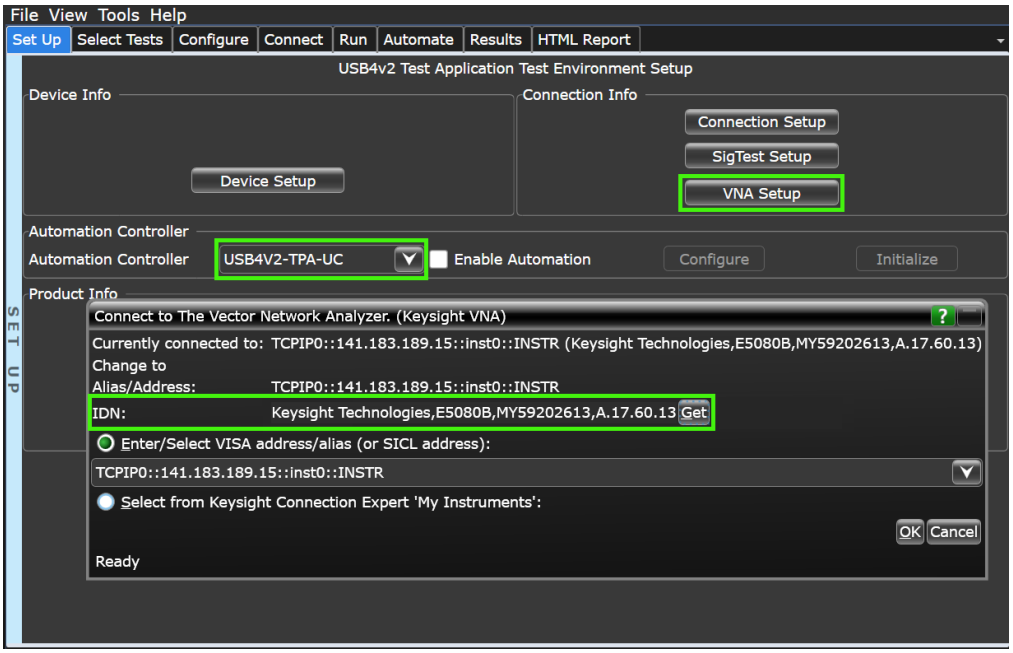



Figure 72 Rx Integrated Return Loss test setup with Tx SMA test fixture connected to VNA

2 In the **Set Up** tab, please connect VNA in the Tx app.

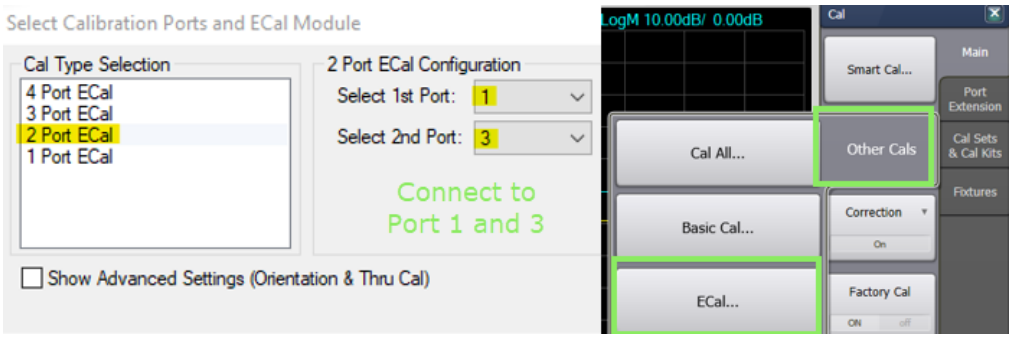



3 Prior calibration, setup Network Analyzer with following sweep settings:

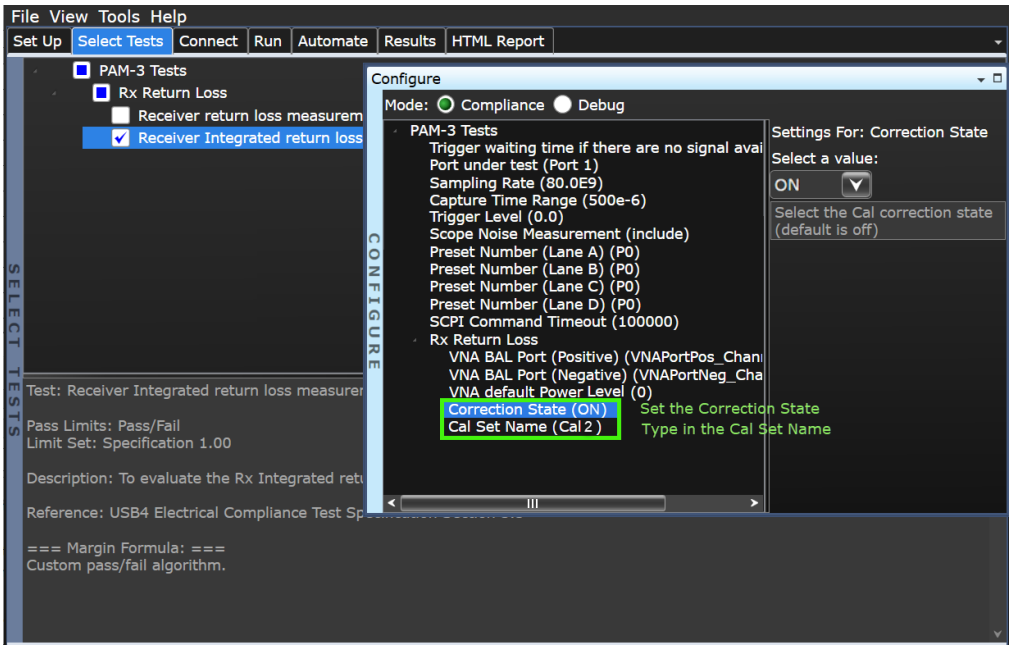
- Frequency range of 10 MHz to 20 GHz
- IF BW of 1 kHz
- At least 2000 points
- Impedance 85 ohm differential
- Define the Topology to Bal using VNA Port 1 and Port 3

**NOTE** Ensure that the VNA firmware revision is A.17.25.05 or higher to be compatible with the return loss test automation.

4 Run calibration on the network analyzer and test cables using a 2-port electronic kit (ECal). Save the Cal file.




5 In the **Select** test tab, select the Tx Return Loss Measurement and set the parameters in the **Configure** tab as shown in the figure below.




**NOTE** Please note that no gating setup is required for SMA fixture.

6 The test application:

- sets USB4ETT **Tool Usage Mode,**
- commands VNA to measure Rx Integrated Return Loss in S2P,
- and compiles result using SigTest.

Test Procedure

1 Choose a supported USB4 speed to start with.
2 The test application sets USB4ETT tool to configure the DUT transmitter to output PRTS7 on all the required lanes.
3 Connect the required lanes to the Network Analyzer and capture the S2P file.
4 Measure the Receiver Integrated Return Loss using the S2P file, and compile the result using SigTest.
5 If Receiver Integrated Return Loss violates the above requirement, then the result is Fail.
6 Repeat the test for all remaining USB4 lanes.

Expected / Observable Results

If Receiver Integrated Return Loss violated the specified requirement, then Fail.

Test References

See *USB4 Specification Version 2.00 Gen4, Section 3.3*

# 5 PAM-3 Equalization Tests



This chapter describes the PAM-3 Equalization Tests.

## Transmitter Equalization

### Test Overview

This test evaluates the Transmitter Equalization (P1, P2,... to P41) of the PAM-3 signal.

The transmitter equalization test list is as follows:

1 Transmitter Equalization (P1)
2 Transmitter Equalization (P2)
3 Transmitter Equalization (P3)
4 Transmitter Equalization (P4)
5 Transmitter Equalization (P5)
6 Transmitter Equalization (P6)
7 Transmitter Equalization (P7)
8 Transmitter Equalization (P8)
9 Transmitter Equalization (P9)
10 Transmitter Equalization (P10)
11 Transmitter Equalization (P11)
12 Transmitter Equalization (P12)
13 Transmitter Equalization (P13)
14 Transmitter Equalization (P14)
15 Transmitter Equalization (P15)
16 Transmitter Equalization (P16)
17 Transmitter Equalization (P17)
18 Transmitter Equalization (P18)
19 Transmitter Equalization (P19)
20 Transmitter Equalization (P20)
21 Transmitter Equalization (P21)
22 Transmitter Equalization (P22)
23 Transmitter Equalization (P23)
24 Transmitter Equalization (P24)
25 Transmitter Equalization (P25)
26 Transmitter Equalization (P26)
27 Transmitter Equalization (P27)
28 Transmitter Equalization (P28)
29 Transmitter Equalization (P29)
30 Transmitter Equalization (P30)
31 Transmitter Equalization (P31)
32 Transmitter Equalization (P32)
33 Transmitter Equalization (P33)
34 Transmitter Equalization (P34)
35 Transmitter Equalization (P35)
36 Transmitter Equalization (P36)
37 Transmitter Equalization (P37)
38 Transmitter Equalization (P38)

39 Transmitter Equalization (P39)
40 Transmitter Equalization (P40)
41 Transmitter Equalization (P41)

Pass Limits

**Table 2 Transmitter equalization preset table * **(USB4 Specification, Section 3.3.1)**

| Preset | C[-2] | C[-1] | C[0] | C[1] |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0.95 | -0.05 |
| 2 | 0 | 0 | 0.9 | -0.1 |
| 3 | 0 | | 0.85 | -0.15 |
| 4 | 0 | -0.05 | 0.95 | 0 |
| 5 | 0 | -0.05 | 0.9 | -0.05 |
| 6 | 0 | -0.05 | 0.85 | -0.1 |
| 7 | 0 | -0.05 | 0.8 | -0.15 |
| 8 | 0 | -0.1 | 0.9 | 0 |
| 9 | 0 | -0.1 | 0.85 | -0.05 |
| 10 | 0 | -0.1 | 0.8 | -0.1 |
| 11 | 0 | -0.1 | 0.75 | -0.15 |
| 12 | 0 | -0.15 | 0.85 | 0 |
| 13 | 0 | -0.15 | 0.8 | -0.05 |
| 14 | 0 | -0.15 | 0.75 | -0.1 |
| 15 | 0 | -0.15 | 0.7 | -0.15 |
| 16 | 0.025 | -0.15 | 0.825 | 0 |
| 17 | 0.025 | -0.15 | 0.775 | -0.05 |
| 18 | 0.025 | -0.15 | 0.725 | -0.1 |
| 19 | 0.025 | -0.15 | 0.675 | -0.15 |
| 20 | 0 | -0.2 | 0.8 | 0 |
| 21 | 0 | -0.2 | 0.75 | -0.05 |
| 22 | 0 | -0.2 | 0.7 | -0.1 |
| 23 | 0 | -0.2 | 0.65 | -0.15 |
| 24 | 0.025 | -0.2 | 0.775 | 0 |
| 25 | 0.025 | -0.2 | 0.725 | -0.05 |

| Preset | C[-2] | C[-1] | C[0] | C[1] |
|---|---|---|---|---|
| 26 | 0.025 | -0.2 | 0.675 | -0.1 |
| 27 | 0.025 | -0.2 | 0.625 | -0.15 |
| 28 | 0.05 | -0.2 | 0.75 | 0 |
| 29 | 0.05 | -0.2 | 0.7 | -0.05 |
| 30 | 0.05 | -0.2 | 0.65 | -0.1 |
| 31 | 0.05 | -0.2 | 0.6 | -0.15 |
| 32 | 0 | -0.25 | 0.75 | 0 |
| 33 | 0 | -0.25 | 0.7 | -0.05 |
| 34 | 0.025 | -0.25 | 0.725 | 0 |
| 35 | 0.025 | -0.25 | 0.675 | -0.05 |
| 36 | 0.05 | -0.25 | 0.7 | 0 |
| 37 | 0.05 | -0.25 | 0.65 | -0.05 |
| 38 | 0.075 | -0.25 | 0.675 | 0 |
| 39 | 0.075 | -0.25 | 0.625 | -0.05 |
| 40 | 0 | -0.1 | 0.4 | 0 |
| 41 | 0 | 0 | 0.5 | 0 |

- *For low swing mode (presets 40-41 only) the transmitter swing attenuation requirement is 6±1dB.
- **For both low and full swing modes the tolerance of the normalized coefficients shall be of ±0.015 for C[-2] and of ±0.025 for C[-1], C[0], and C[1] coefficients.

### Test Reference

- USB4 Electrical Compliance Test Specification, section 3.3

### Test Conditions

| Test Parameter | Condition |
|---|---|
| Signal Type | PAM3 |
| Symbol Rate | 25.6 GBd |
| Test Pattern | PRTS7 PAM3 |

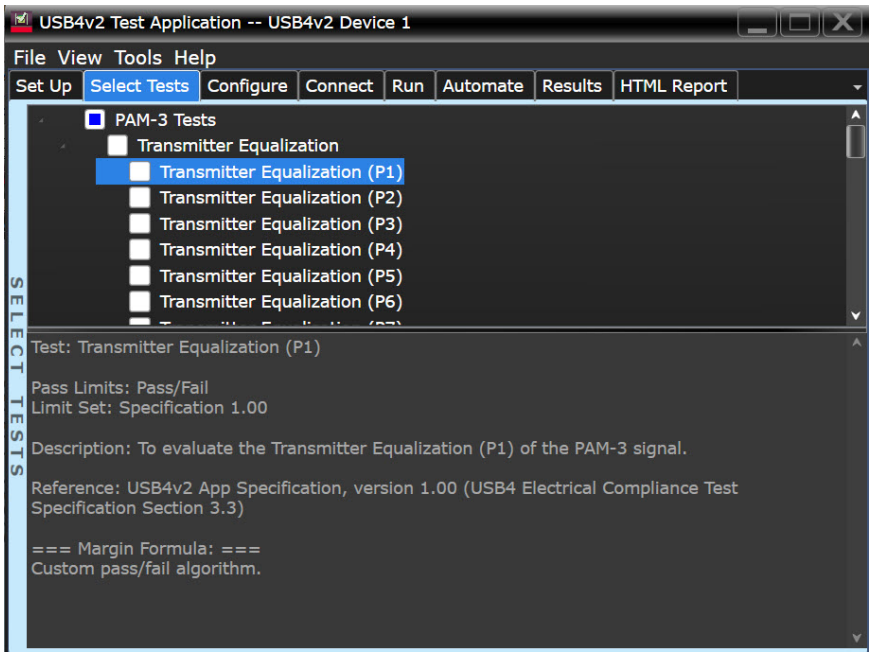



Figure 73 Selecting the transmitter equalization test

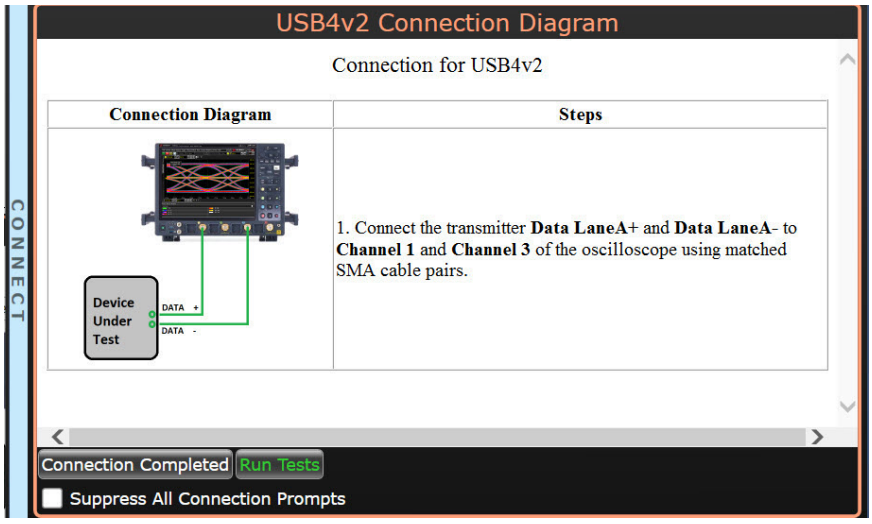



Figure 74 Connection diagram for transmitter equalization test

Measurement Procedure

1 Lane under test should transmit PRTS7 pattern, remaining lanes should be activated as aggressors transmitting PRTS19. SSC should be enabled during the test.
2 Activate device under test with maximum number of aggressor lanes configured as transmitters. Configure lane under test and aggressors according to Appendix A of the USB4 Electrical Compliance Test Specification.
3 Set Oscilloscope as:
   - Bandwidth: 25 GHz
   - Sampling rate ≥ 80 GSa/s (while keeping acquisition record length of 500 µs)
   - No CDR, no average, and no interpolation should be used.
   - The signal vertical scaling must be optimized per preset (obtaining at least 80% of the vertical range)
4 Capture the differential output signal with all presets one by one (total 42 waveforms). Record the oscilloscope vertical scaling setting (voltage/div) for each preset, it will be used for further scope intrinsic noise measurement as described in Appendix C of the USB4 Electrical Compliance Test Specification.
5 Run SigTest tool.
6 Check SigTest report for pass/fail status. All presets must be passing.
7 Repeat the test for all remaining USB4 transmitter lanes
8 In case more than one oscilloscope differential channel pair is used, please repeat the oscilloscope vertical scale tuning (voltage/div) and recording for each preset.

Pass Condition

NA (Not Applicable)