Keysight U7250A MIPI C-PHY Compliance Test Application

Methods of Implementation

KEYSIGHT TECHNOLOGIES

Notices

Software Version

Version 01.00.0000 or greater

Edition

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MIPI C-PHY Compliance Test Application — At A Glance

The Keysight U7250A MIPI C-PHY Compliance Test Application allows the testing of all MIPI devices with the Keysight Infiniium oscilloscope based on the MIPI Alliance Standard for C-PHY v1.0 specification. MIPI stands for Mobile Industry Processor Interface. The MIPI alliance is a collaboration of mobile industry leader with the objective to define and promote open standards for interfaces to mobile application processors.

The MIPI C-PHY Compliance 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 MIPI C-PHY Compliance 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 MIPI C-PHY Compliance Test Application, you need the following equipment and software:

- U7250A MIPI C-PHY Compliance Test Application software.
- The minimum version of Infiniium oscilloscope software (see the U7250A Compliance Test Application release notes).
- Differential probe amplifier, with the minimum bandwidth of 5 GHz.
- E2677A differential solder-in probe head, E2675A differential browser probe head, E2678A differential socket probe head, and E2669A differential kit which includes E2675A, E2677A, and E2678A are recommended.
- 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 automated test application.

Below are the required licenses:

- U7250A MIPI C-PHY Compliance Test Application (MCC).
- Serial Data Analysis (SDA).
- InfiniiScan (SWT).

In This Book

This manual describes the tests that are performed by the MIPI C-PHY Compliance Test Application in more detail.

- Chapter 1, “Installing the MIPI C-PHY Compliance Test Application” describes how to install and license the automated test application software (if it was purchased separately).
- Chapter 2, “Preparing to Take Measurements” describes how to start the MIPI C-PHY Compliance Test Application and gives a brief overview of how it is used.
- Chapter 3, “TX Electrical Signaling and Timing Tests” contains an overview on the signaling and timing electrical tests for high-speed transmitters and low-power transmitters.
- Chapter 4, “1.2.1 High-Speed Transmitter (HS-TX) Electrical Tests” contains an overview on the electrical tests for high-speed transmitters (HS-TX).
- Chapter 5, “1.2.2 Low Power Transmitter (LP-TX) Electrical Tests” describes the electrical tests for low-power transmitters (LP-TX).
- Chapter 6, “1.2.3 High-Speed Transmitter (HS-TX) Timing Tests” describes the timing tests for high-speed transmitters (HS-TX).
- Chapter 7, “Calibrating the Infiniium Oscilloscope” describes how to calibrate the oscilloscope in preparation for running the MIPI C-PHY automated tests.
- Chapter 8, “InfiniiMax Probing” describes the probe amplifier and probe head recommendations for MIPI C-PHY conformance testing.

See Also

- The MIPI C-PHY Compliance Test Application’s Online Help, which describes:
  - Starting the MIPI C-PHY Compliance Test Application.
  - Creating or opening a test project.
  - Setting up the MIPI C-PHY test environment.
  - Selecting tests.
  - Configuring selected tests.
  - Defining compliance limits.
  - Connecting the oscilloscope to the DUT.
  - Running tests.
  - Automating the application.
  - Viewing test results.
  - Viewing/exporting/printing the HTML test report.
  - Saving test projects.
  - Installing/removing add-ins.
  - Controlling the application via a remote PC.
  - Using a second monitor.
- The MIPI C-PHY standard specifications are available in C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Contents

MIPI C-PHY Compliance Test Application – At A Glance 3

In This Book 4

1 Installing the MIPI C-PHY Compliance Test Application

Installing the Software 12

Installing the License Key 13

2 Preparing to Take Measurements

Calibrating the Oscilloscope 16

Starting the MIPI C-PHY Compliance Test Application 17

Online Help Topics 20

3 TX Electrical Signaling and Timing Tests

Overview 22

Test Availability in the C-PHY Compliance Test Application 24

4 1.2.1 High-Speed Transmitter (HS-TX) Electrical Tests

Probing for High-Speed Transmitter Electrical Tests 26

Test Procedure 26

Test 1.2.7 HS-TX Differential Voltages (VOD-AB, VOD-BC, VOD-CA) 28

Test Overview 28
Test Availability 29
References 29
Test Procedure 29
Expected/Observable Results 30

Test 1.2.8 HS-TX Differential Voltage Mismatch (ΔVOD) 31

Test Overview 31
Test Availability 31
References 31
Test Procedure 31
Expected/Observable Results 31

Test 1.2.9 HS-TX Single-Ended Output High Voltages (VOHHS(VA), VOHHS(VB), VOHHS(VC)) 32
Test Overview 32
Test Availability 32
References 32
Test Procedure 32
Expected/Observable Results 32
Test 1.2.10 HS-TX Static Common-Point Voltages (VCPTX) 33
Test Overview 33
Test Availability 33
References 33
Test Procedure 34
Expected/Observable Results 34
Test 1.2.11 HS-TX Static Common-Point Voltage Mismatch (ΔVCPTX(HS)) 35
Test Overview 35
Test Availability 35
References 35
Test Procedure 35
Expected/Observable Results 35
Test 1.2.12 HS-TX Dynamic Common-Point Variations Between 50-450MHz (ΔVCPTX(LF)) 36
Test Overview 36
Test Availability 36
References 36
Test Procedure 36
Expected/Observable Results 37
Test 1.2.13 HS-TX Dynamic Common-Point Variations Above 450MHz (ΔVCPTX(HF)) 38
Test Overview 38
Test Availability 38
References 38
Test Procedure 38
Expected/Observable Results 39
Test 1.2.14 HS-TX Rise Time (tR) 40
Test Overview 40
Test Availability 40
References 40
Test Procedure 40
Expected/Observable Results 41

Test 1.2.15 HS-TX Fall Time (tF) 42
Test Overview 42
Test Availability 42
References 42
Test Procedure 42
Expected/Observable Results 43

Test 1.2.17 30%-85% Post-EoT Rise Time (TREOT) 44
Test Overview 44
Test Availability 44
References 44
Test Procedure 44
Expected/Observable Results 45

Test 1.2.19 HS Clock Instantaneous UI (UIINST) 46
Test Overview 46
Test Availability 46
References 46
Test Procedure 46
Expected/Observable Results 47

Test 1.2.20 HS Clock Delta UI (ΔUI) 48
Test Overview 48
Test Availability 48
References 48
Test Procedure 48
Expected/Observable Results 48

5 1.2.2 Low Power Transmitter (LP-TX) Electrical Tests

Test 1.1.1 LP-TX Thevenin Output High Level Voltage (VOH) 50
Test Overview 50
Test Availability 50
References 50
Test Procedure 50
Expected/Observable Results 51

Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (VOL) 52
Test Overview 52
Test Availability 52
References 52
Test Procedure 52
Expected/Observable Results 53

Test 1.1.3 LP-TX 15% - 85% Rise Time (TRLP) 54
Test Overview 54
Test Availability 54
References 54
Test Procedure 54
Expected/Observable Results 55

Test 1.1.4 LP-TX 15% - 85% Fall Time (TFLP) 56
Test Overview 56
Test Availability 56
References 56
Test Procedure 56
Expected/Observable Results 57

Test 1.1.5 LP-TX Slew Rate vs. CLOAD 58
Test Overview 58
Test Availability 58
References 58
Test Procedure 58
Expected/Observable Results 59

Test 1.1.6 LP-TX Pulse Width of Exclusive-OR Clock (TLP-PULSE-TX) 60
Test Overview 60
Test Availability 60
References 60
Test Procedure 61
Expected/Observable Results 61

Test 1.1.7 LP-TX Period of Exclusive-OR Clock (TLP-PER-TX) 62
Test Overview 62
Test Availability 62
References 62
Test Procedure 63
Expected/Observable Results 63

6 1.2.3 High-Speed Transmitter (HS-TX) Timing Tests

Test 1.2.1 TLPX Duration 66
Test Overview 66
Test Availability 66
References 66
Test Procedure 66
Expected/Observable Results 67

Test 1.2.2 T3-PREPARE Duration 68

Test Overview 68
Test Availability 68
References 68
Test Procedure 68
Expected/Observable Results 69

Test 1.2.18 THS-EXIT Value 70

Test Overview 70
Test Availability 70
References 70
Test Procedure 70
Expected/Observable Results 71

7 Calibrating the Infiniium Oscilloscope

Required Equipment for Oscilloscope Calibration 74

To Run the Self Calibration 75

Internal or Self Calibration 75

Probe Calibration and De-skew 80

Required Equipment for Probe Calibration 80
SMA Probe Head Attenuation/Offset Calibration 80
SMA Probe Head Skew Calibration 87
Differential SMA Probe Head Atten/Offset Calibration 87
Differential SMA Probe Head Skew Calibration 91

8 InfiniiMax Probing

Index

1 Installing the MIPI C-PHY Compliance Test Application

Installing the Software / 12
Installing the License Key / 13

If you purchased the U7250A MIPI C-PHY Compliance Test Application separately, you must install the software and license key.

Installing the Software

1. Make sure you have the minimum version of Infiniium Oscilloscope software (see the U7250A test application release notes) by choosing **Help>About Infiniium**... from the main menu.
2. To obtain the MIPI C-PHY Compliance Test Application, go to Keysight Web site: http://www.keysight.com/find/scope-apps-sw/.
3. The link for MIPI C-PHY Compliance Test Application will appear. Double-click the link and follow the instructions to download and install the application software.

Installing the License Key

1. Request a license code from Keysight by following the instructions on the Entitlement Certificate.

   You will need the Oscilloscope's "Option ID Number", which you can find in the **Help>About Infiniium**... dialog box.
2. After you receive your license code from Keysight, choose **Utilities>Install Legacy Licenses...**.
3. In the Install Option License dialog, enter your license code and click **Install License**.
4. Click **OK i**n the dialog that tells you to restart the Infiniium oscilloscope application software to complete the license installation.
5. Click **Close** to close the Install Option License dialog.
6. Choose **File>Exit**.
7. Restart the Infiniium oscilloscope application software to complete the license installation.

2 Preparing to Take Measurements

Calibrating the Oscilloscope / 16
Starting the MIPI C-PHY Compliance Test Application / 17

Before running the MIPI C-PHY automated tests, you must calibrate the oscilloscope and probe. No test fixture is required for this MIPI C-PHY application. After the oscilloscope and probe have been calibrated, you are ready to start the MIPI C-PHY Compliance Test Application and perform the measurements.

Calibrating the Oscilloscope

- If you have not already calibrated the oscilloscope and probe, see Chapter 7, “Calibrating the Infiniium Oscilloscope.

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 MIPI C-PHY Compliance Test Application

1 From the Infiniium Oscilloscope's main menu, choose **Analyze>Automated Test Apps>U7250A MIPI C-PHY Test App.**

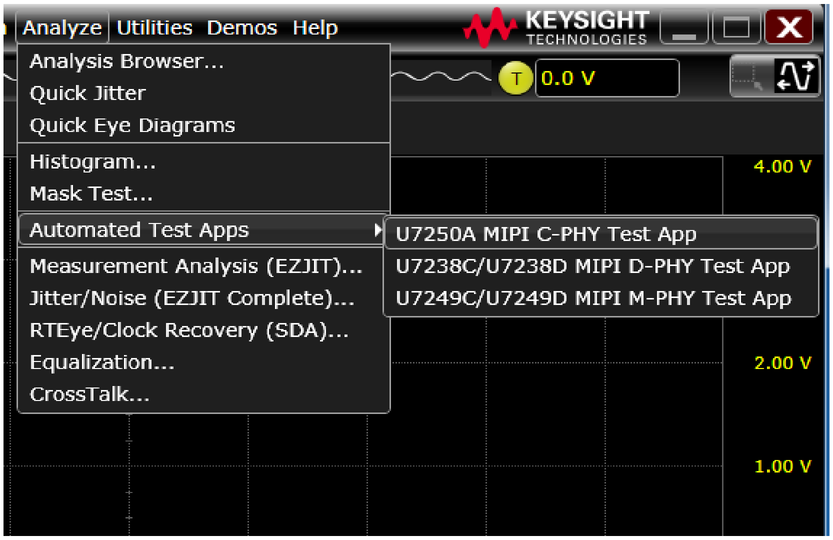

Figure 1 Starting the MIPI C-PHY Compliance Test Application

NOTE If the U7250A MIPI C-PHY Test App does not appear in the **Automated Test Apps** menu, the MIPI C-PHY Compliance Test Application has not been installed (see Chapter 1, "Installing the MIPI C-PHY Compliance Test Application").

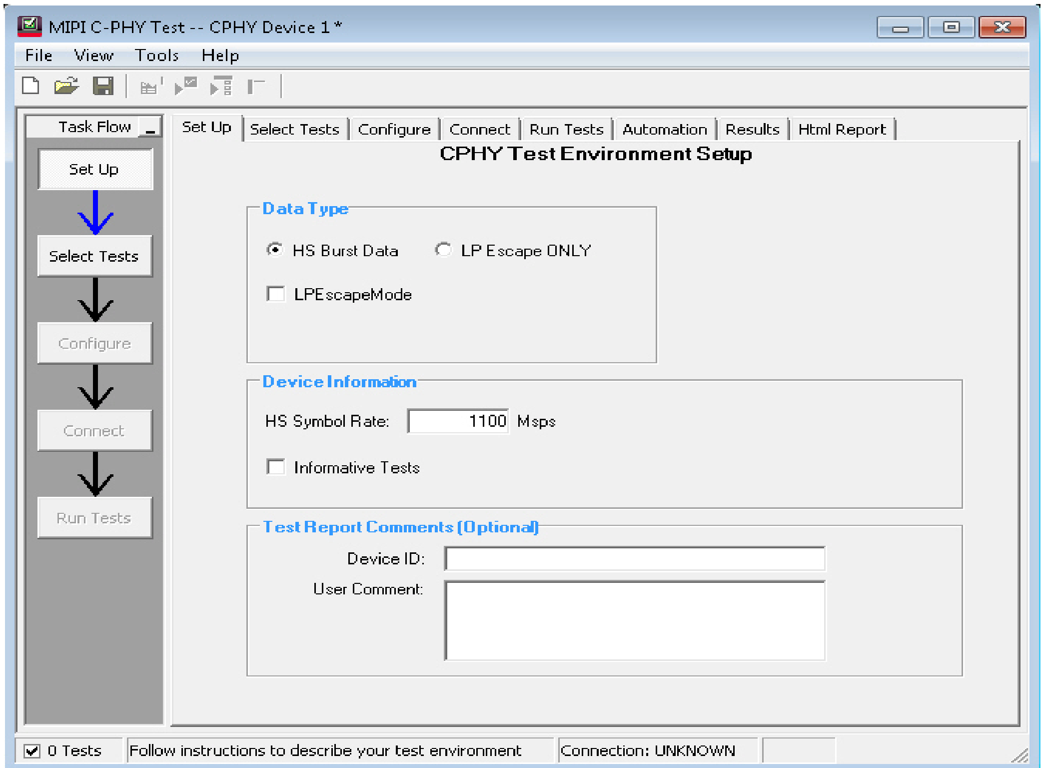

Figure 2 The MIPI C-PHY Compliance Test Application's default window

Figure 1 shows the procedure to launch the MIPI C-PHY Compliance Test Application and Figure 2 shows the MIPI C-PHY Compliance Test Application default window. The task flow pane, and the tabs in the main pane, show the steps you take in running the automated tests:

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

NOTE

The configuration options shown under the **Set Up** tab of the MIPI C-PHY Compliance Test Application main window dictate the availability of various tests. You may have to select more than one configuration option to make some tests available, else they appear unavailable/disabled. To know more about the configurable options under the **Set Up** tab that must be selected for each test, refer to the section, “Test Availability” under the method of implementation for each test in this document.

Online Help Topics

For information on using the MIPI C-PHY Compliance Test Application, see its Online Help (which you can access by choosing **Help>Contents**... from the application's main menu).

The MIPI C-PHY Compliance Test Application's Online Help describes:

- Starting the MIPI C-PHY Compliance Test Application.
- Creating or opening a test project.
- Setting up the MIPI C-PHY test environment.
- Selecting tests.
- Configuring selected tests.
- Defining compliance limits.
- Connecting the oscilloscope to the device under test (DUT).
- Running tests.
- Automating the application.
- Viewing test results.
- Viewing/exporting/printing the HTML test report.
- Saving test projects.
- Installing/removing add-ins.
- Controlling the application via a remote PC.
- Using a second monitor.

3 TX Electrical Signaling and Timing Tests

Overview / 22

The Keysight U7250A MIPI C-PHY Compliance Test Application enables compliance testing of the High-Speed Transmitter (HS-TX) and Low-Power Transmitter (LP-TX), in adherence to the MIPI C-PHY specifications.

Overview

The group of tests specified in this Methods of Implementation document pertains to the MIPI C-PHY specifications. The tests within these test groups are developed to cater for High-Speed Transmitter and Low-Power Transmitter testing.

Figure 3 and Figure 4 show the circuit diagram of a C-PHY Transceiver and the associated C-PHY signaling levels, respectively.

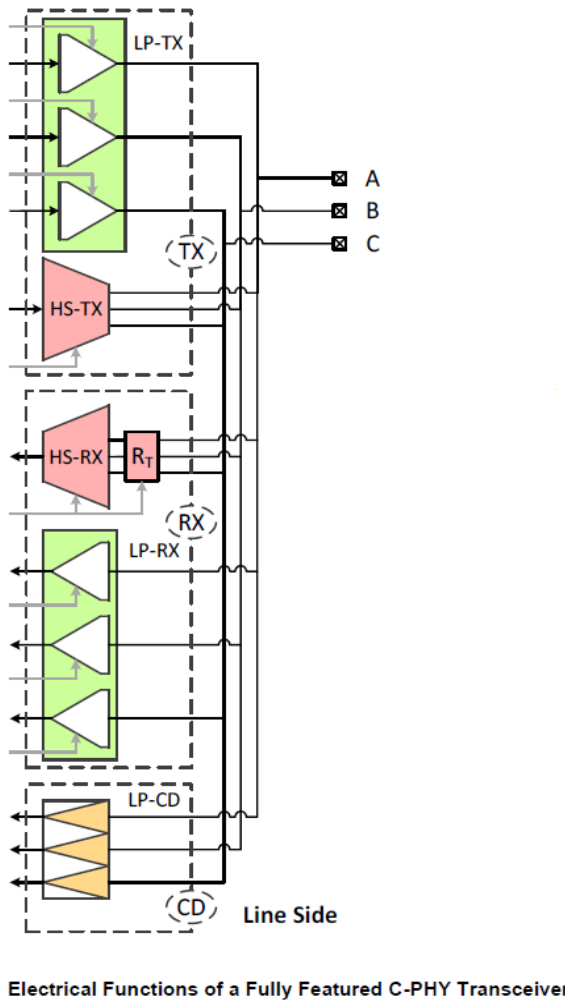

Figure 3 Circuit Diagram of a C-PHY Transceiver

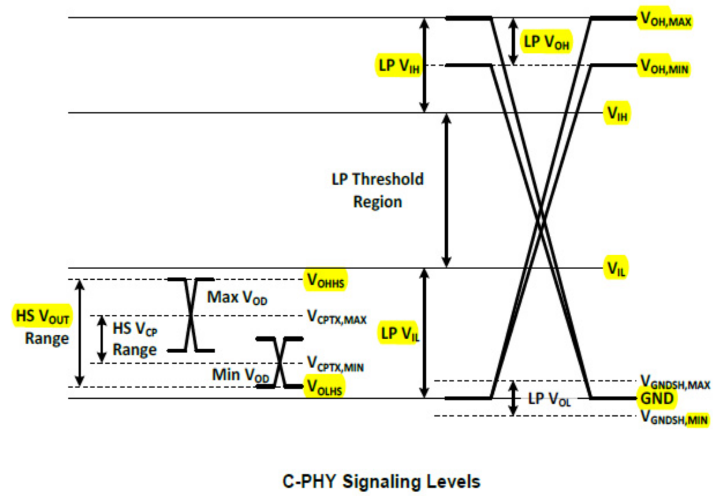

Figure 4 C-PHY Signaling Levels

Notice that the signal levels for the Differential High-Speed mode differ from that for the single-ended Low-Power mode. The High-Speed signaling levels are below the low level input threshold for the Low-Power mode such that the Low Power receiver always detects low on HS signals.

The actual maximum bit rate for the High-Speed mode is not specified in the MIPI C-PHY specifications. However, the specification document is primarily intended to define a solution for a bit range from 80 Mbps to 2.5 Gbps (or above) per Lane. A typical implementation is expected to have a bit rate of approximately 500Mbps per Lane.

For the Low-Power mode, the maximum data rate specified in the MIPI C-PHY specifications is 10Mbps.

Test Availability in the C-PHY Compliance Test Application

The C-PHY Compliance Test Application consists of some options in the **Set Up** tab that dictate the availability of certain tests. The test settings could be affected by one or more configuration options. For such tests, if one of the option is disabled, the test is unavailable. The options in the **Set Up** tab, as shown in Figure 5, which primarily affect the availability of tests are:

1 HS Burst Data – LPEscapeMode
2 LP Escape ONLY
3 Informative Tests

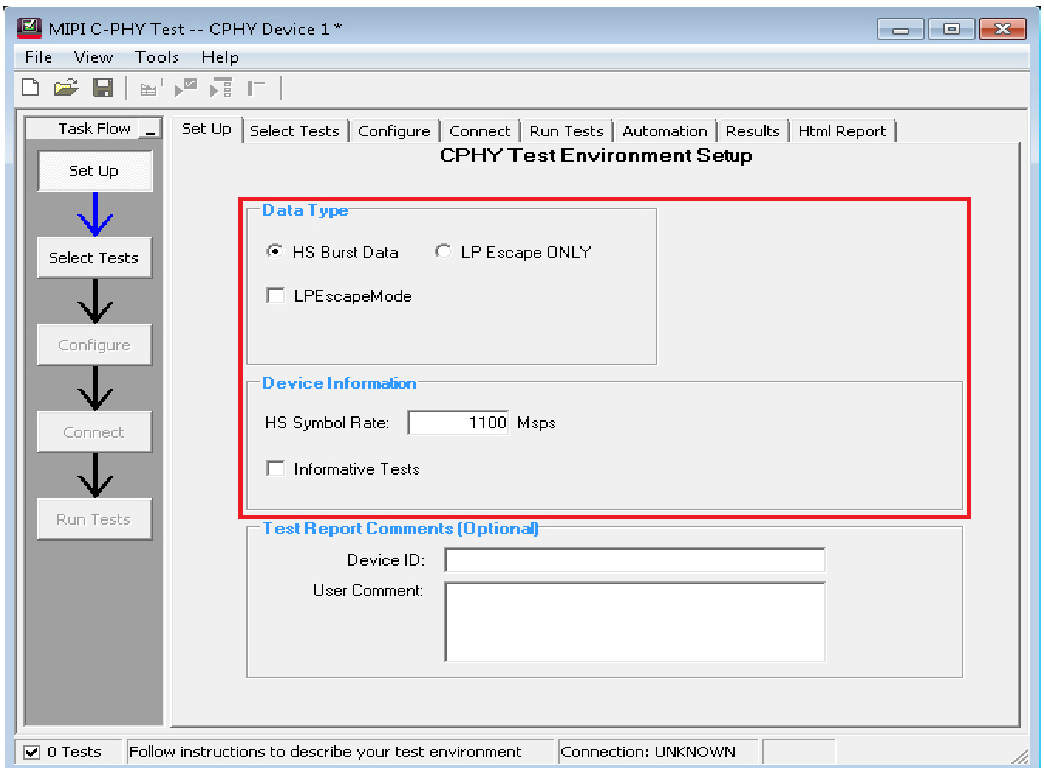

Figure 5 C-PHY Configuration Options in the **Set Up** tab

To check for the configuration options that impact the availability of each of the tests described in this document, refer to the “Test Availability” section for each test.

Broadly, the test groups are categorized as:

1 HS Electrical Tests
2 LP Tests
3 HS Timing Tests

4 1.2.1 High-Speed Transmitter (HS-TX) Electrical Tests

Probing for High-Speed Transmitter Electrical Tests / 26
Test 1.2.7 HS-TX Differential Voltages (VOD-AB, VOD-BC, VOD-CA) / 28
Test 1.2.8 HS-TX Differential Voltage Mismatch (ΔVOD) / 31
Test 1.2.9 HS-TX Single-Ended Output High Voltages (VOHHS(VA), VOHHS(VB), VOHHS(VC)) / 32
Test 1.2.10 HS-TX Static Common-Point Voltages (VCPTX) / 33
Test 1.2.11 HS-TX Static Common-Point Voltage Mismatch (ΔVCPTX(HS)) / 35
Test 1.2.12 HS-TX Dynamic Common-Point Variations Between 50-450MHz (ΔVCPTX(LF)) / 36
Test 1.2.13 HS-TX Dynamic Common-Point Variations Above 450MHz (ΔVCPTX(HF)) / 38
Test 1.2.14 HS-TX Rise Time (tR) / 40
Test 1.2.15 HS-TX Fall Time (tF) / 42
Test 1.2.17 30%-85% Post-EoT Rise Time (TREOT) / 44
Test 1.2.19 HS Clock Instantaneous UI (UIINST) / 46
Test 1.2.20 HS Clock Delta UI (ΔUI) / 48

This section provides the Methods of Implementation (MOIs) for the electrical tests for high-speed transmitters (HS-TX) using an Keysight Infiniium oscilloscope, InfiniiMax probes, and the MIPI C-PHY Compliance Test Application.

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Probing for High-Speed Transmitter Electrical Tests

When performing the HS Electrical tests, the MIPI C-PHY Compliance Test Application will prompt you to make the proper connections. The connections for the HS Electrical tests may look similar to the following diagram. Refer to the **Connect** tab in the MIPI C-PHY Compliance Test Application for the exact number of probe connections.

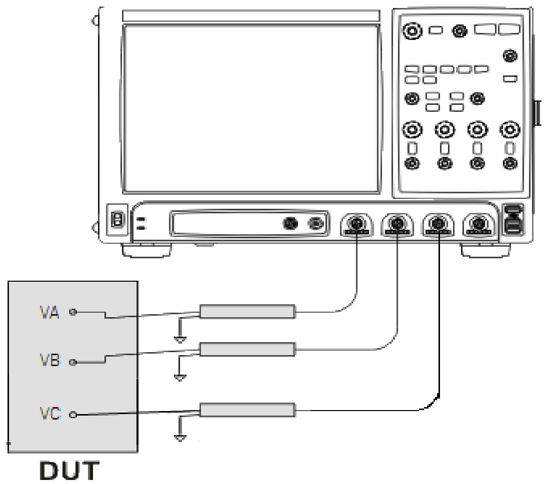


Figure 6 Probing for High-Speed Transmitter Electrical Tests

You can identify the channels used for each signal in the **Configure** tab of the MIPI C-PHY Compliance Test Application. (The channels shown in Figure 6 are just examples).

For more information on the probe amplifiers and probe heads, see Chapter 8, "InfiniiMax Probing," starting on page 93.

Test Procedure

1 Start the automated test application as described in "Starting the MIPI C-PHY Compliance Test Application" on page 17.
2 In the MIPI C-PHY Compliance Test Application, click the **Set Up** tab.
3 Select the **Data Type** and the **Device Information**.
4 Click the **Select Tests** tab and check the tests you want to run. Check the parent node or group to check all the available tests within the group.

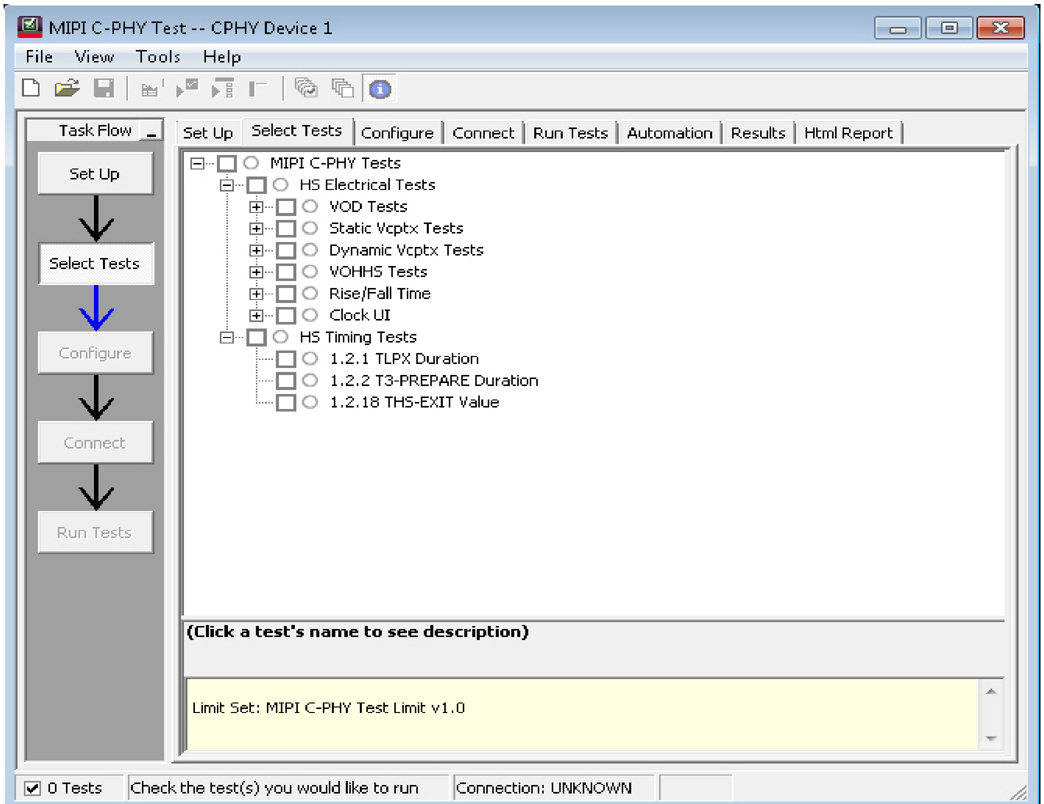


Figure 7 Selecting High-Speed Transmitter Electrical Tests

5 Follow the MIPI C-PHY Compliance Test Application's task flow to set up the configuration options, run the tests, and view the tests results.

Test 1.2.7 HS-TX Differential Voltages (V_{OD-AB}, V_{OD-BC}, V_{OD-CA})

Test Overview

The purpose of this test is to verify that the Differential Voltages (V_{OD-AB}, V_{OD-BC}, V_{OD-CA}) of the HS Transmitter DUT are within the conformance limits of the MIPI C-PHY standard specification.

The single-ended output voltages are defined V_A, V_B and V_C at the A, B and C pins, respectively. The differential output voltages V_{OD_AB}, V_{OD_BC} and V_{OD_CA} are defined at the difference of the voltages:

$$V_{OD\_AB} = V_A - V_B$$

$$V_{OD\_BC} = V_B - V_C$$

$$V_{OD\_CA} = V_C - V_A$$

Test Availability

Table 1 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Differential Voltages (V_{OD-AB}, V_{OD-BC}, V_{OD-CA}) test.

Table 1 Configuration Options for HS-TX Differential Voltages Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.7	1700	HS-TX Differential Voltages ($V_{OD-AB-Strong1}$) [Max]	×	✓	—	—	—
	1701	HS-TX Differential Voltages ($V_{OD-AB-Weak1}$) [Min]	×	✓	—	—	—
	1702	HS-TX Differential Voltages ($V_{OD-AB-Weak0}$) [Max]	×	✓	—	—	—
	1703	HS-TX Differential Voltages ($V_{OD-AB-Strong0}$) [Min]	×	✓	—	—	—
	1710	HS-TX Differential Voltages ($V_{OD-BC-Strong1}$) [Max]	×	✓	—	—	—
	1711	HS-TX Differential Voltages ($V_{OD-BC-Weak1}$) [Min]	×	✓	—	—	—
	1712	HS-TX Differential Voltages ($V_{OD-BC-Weak0}$) [Max]	×	✓	—	—	—
	1713	HS-TX Differential Voltages ($V_{OD-BC-Strong0}$) [Min]	×	✓	—	—	—
	1720	HS-TX Differential Voltages ($V_{OD-CA-Strong1}$) [Max]	×	✓	—	—	—
	1721	HS-TX Differential Voltages ($V_{OD-CA-Weak1}$) [Min]	×	✓	—	—	—
	1722	HS-TX Differential Voltages ($V_{OD-CA-Weak0}$) [Max]	×	✓	—	—	—
	1723	HS-TX Differential Voltages ($V_{OD-CA-Strong0}$) [Min]	×	✓	—	—	—

References

See Test 1.2.7 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

For Test ID 1700, 1710, 1720

1 Capture waveforms for V_A, V_B and V_C.

2 Construct the differential data waveform using the following equations:

$$DiffData(A-B) = V_A - V_B$$

$$DiffData(B-C) = V_B - V_C$$

$$DiffData(C-A) = V_C - V_A$$

3 Fold the required DiffData waveform to form a Data Eye.
4 Use the Histogram feature to measure the minimum and maximum values for the parameters Strong1, Weak1, Weak0 and Strong0 at a point, which is 20% of the UI width before the trigger point. Configure the Histogram window settings with the following options:
   a $V_{OD(Strong1,\ Weak1)}$ Histogram Window [Top](V)
   b $V_{OD(Strong1,\ Weak1)}$ Histogram Window [Bottom](V)
   c $V_{OD(Strong0,\ Weak0)}$ Histogram Window [Top](V)
   d $V_{OD(Strong0,\ Weak0)}$ Histogram Window [Bottom](V)
   e V_{OD} Histogram Window Width (UI)
5 Report the measured values of V_{OD} for all parameters mentioned in the previous step.
6 Compare the measured values of V_{OD} against the compliance test limits.

For Test ID 1701, 1702, 1703

1 Run the following test as a prerequisite:
   a Test 1.2.7 HS-TX Differential Voltages ($V_{OD\text{-}AB\text{-}Strong1}$)[Max] – (Test ID 1700).

   Store the test results after measuring all the required values of $V_{OD\text{-}AB}$ for the test signal.
2 Report the measured values of V_{OD} that you obtain from the prerequisite test.
3 Compare the measured values of V_{OD} against the compliance test limits.

For Test ID 1711, 1712, 1713

1 Run the following test as a prerequisite:
   a Test 1.2.7 HS-TX Differential Voltages ($V_{OD\text{-}BC\text{-}Strong1}$)[Max] – (Test ID 1710).

   Store the test results after measuring all the required values of $V_{OD\text{-}BC}$ for the test signal.
2 Report the measured values of V_{OD} that you obtain from the prerequisite test.
3 Compare the measured values of V_{OD} against the compliance test limits.

For Test ID 1721, 1722, 1723

1 Run the following test as a prerequisite:
   a Test 1.2.7 HS-TX Differential Voltages ($V_{OD\text{-}CA\text{-}Strong1}$)[Max] – (Test ID 1720).

   Store the test results after measuring all the required values of $V_{OD\text{-}CA}$ for the test signal.
2 Report the measured values of V_{OD} for that you obtain from the prerequisite test.
3 Compare the measured values of V_{OD} against the compliance test limits.

Expected/Observable Results

The measured value of V_{OD} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.2.8 HS-TX Differential Voltage Mismatch (ΔV_{OD})

Test Overview

The purpose of this test is to verify that the Differential Voltage Mismatch (ΔV_{OD}) of the HS Transmitter DUT is within the conformance limits of the MIPI C-PHY standard specification.

Test Availability

Table 2 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Differential Voltage Mismatch (ΔV_{OD}) test.

Table 2 Configuration Options for HS-TX Differential Voltage Mismatch Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.8	1800	HS-TX Differential Voltage Mismatch (ΔV_{OD})	×	✓	—	—	—

References

See Test 1.2.8 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following tests as a prerequisite:

a Test 1.2.7 HS-TX Differential Voltages ($V_{OD\text{-}AB\text{-}Strong1}$)[Max] – (Test ID 1700).

Store the test results after measuring all the required values of $V_{OD\text{-}AB}$ for the test signal.

b Test 1.2.7 HS-TX Differential Voltages ($V_{OD\text{-}BC\text{-}Strong1}$)[Max] – (Test ID 1710).

Store the test results after measuring all the required values of $V_{OD\text{-}BC}$ for the test signal.

c Test 1.2.7 HS-TX Differential Voltages ($V_{OD\text{-}CA\text{-}Strong1}$)[Max] – (Test ID 1720).

Store the test results after measuring all the required values of $V_{OD\text{-}CA}$ for the test signal.

2 Derive $V_{OD\text{-}MAX}$ from the maximum values of the parameter Strong1[Max] of V_{OD} measured for the AB, BC and CA pairs.

3 Derive $V_{OD\text{-}MIN}$ from the minimum values of the parameter Strong0[Min] of V_{OD} measured for the AB, BC and CA pairs.

4 Calculate the Differential Voltage Mismatch using the equation:

$$\Delta V_{OD} = |V_{OD\text{-}MAX}| - |V_{OD\text{-}MIN}|$$

5 Compare the measured values of ΔV_{OD} against the compliance test limits.

Expected/Observable Results

The measured value of ΔV_{OD} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.2.9 HS-TX Single-Ended Output High Voltages ($V_{OHHS(VA)}$, $V_{OHHS(VB)}$, $V_{OHHS(VC)}$)

Test Overview

The purpose of this test is to verify that the Single-Ended Output High Voltages ($V_{OHHS(VA)}$, $V_{OHHS(VB)}$ and $V_{OHHS(VC)}$) of the HS Transmitter DUT are less than the maximum conformance limit values of the MIPI C-PHY standard specification.

Test Availability

Table 3 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Single-Ended Output High Voltages ($V_{OHHS(VA)}$, $V_{OHHS(VB)}$ and $V_{OHHS(VC)}$) test.

Table 3 Configuration Options for HS-TX Single-Ended Output High Voltages Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.9	1900	HS-TX Single-Ended Output High Voltages ($V_{OHHS(VA)}$)	×	✓	—	—	—
	1901	HS-TX Single-Ended Output High Voltages ($V_{OHHS(VB)}$)	×	✓	—	—	—
	1902	HS-TX Single-Ended Output High Voltages ($V_{OHHS(VC)}$)	×	✓	—	—	—

References

See Test 1.2.9 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Capture waveforms for V_A, V_B and V_C.
2. Calculate the UI width from the input HS Symbol Rate.
3. Fold the required single-ended data signal (V_A, V_B or V_C) to form a Data Eye.
4. Enable the Histogram feature on the Oscilloscope.
5. Place the Histogram window on the upper level of the 3-level single-ended eye diagram such that the location of the window is at 20% of the UI width before the trigger point. Configure the Histogram window settings with the following options:
   - *a* V_{OHHS} Histogram Window [Top](V)
   - *b* V_{OHHS} Histogram Window [Bottom](V)
   - *c* V_{OHHS} Histogram Window Width (UI)
6. Measure the mean value of the Histogram and use this value as the final V_{OHHS} measurement result.
7. Compare the measured values of V_{OHHS} against the compliance test limits.

Expected/Observable Results

The measured value of V_{OHHS} for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.10 HS-TX Static Common-Point Voltages (V_{CPTX})

Test Overview

The purpose of this test is to verify that the Static Common-Point Voltages (V_{CPTX}) of the HS Transmitter DUT are within the conformance limits of the MIPI C-PHY standard specification. Figure 8 shows the static V_{CPTX} distortion on the single-ended high-speed signals.

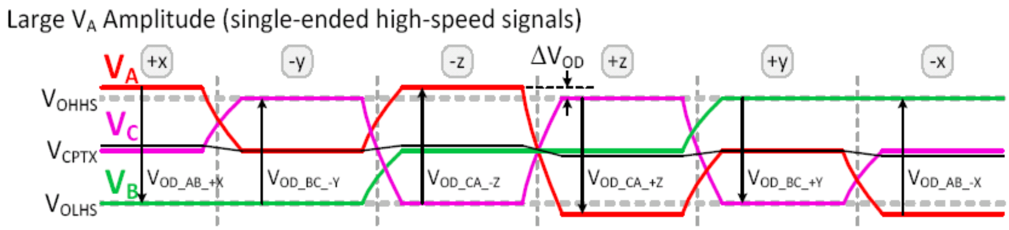


Figure 8 Static V_{CPTX} distortion on the single-ended high-speed signals

The common-point voltage V_{CPTX} is defined as the arithmetic mean value of the voltages at the A, B and C pins:

$$V_{CPTX} = (V_A + V_B + V_C) / 3$$

Test Availability

Table 4 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Static Common-Point Voltages (V_{CPTX}) test.

Table 4 Configuration Options for HS-TX Static Common-Point Voltages Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.10	2000	HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_+X}$)	×	✓	—	—	—
	2001	HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_-X}$)	×	✓	—	—	—
	2002	HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_+Y}$)	×	✓	—	—	—
	2003	HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_-Y}$)	×	✓	—	—	—
	2004	HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_+Z}$)	×	✓	—	—	—
	2005	HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_-Z}$)	×	✓	—	—	—

References

See Test 1.2.10 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

For Test ID 2000

1 Capture waveforms for V_A, V_B and V_C.
2 Construct the differential data waveform using the following equations:

$$DiffData(A-B) = V_A - V_B$$

$$DiffData(B-C) = V_B - V_C$$

$$DiffData(C-A) = V_C - V_A$$

3 Use the generated differential waveforms to decode the wire states of only the HS data by sampling at the center of the UI for each wire state.
4 Generate the common-point voltage V_{CPTX} signal using the equation:

$$V_{CPTX} = (V_A + V_B + V_C) / 3$$

5 Group the values of V_{CPTX} for similar HS wire states. For example, all values of V_{CPTX} that are sampled at the center of each of the UI measurements for the HS wire state +X are grouped together. Apply the same procedure for HS wire states -X, +Y, -Y, +Z and -Z.
6 Derive the maximum, minimum and mean values of V_{CPTX} for each of the HS wire state groups.
7 Record the mean value of V_{CPTX} as the final test result.
8 Compare the measured mean values of V_{CPTX} against the compliance test limits.

For Test ID 2001, 2002, 2003, 2004, 2005

1 Run the following test as a prerequisite:
   a Test 1.2.10 HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_+X}$) — (Test ID 2000).

   Store the test results after measuring the actual values of V_{CPTX} for the test signal.
2 Report the measured values of V_{CPTX} for that you obtain from the prerequisite test.
3 Compare the measured values of V_{CPTX} against the compliance test limits.

Expected/Observable Results

The measured value of V_{CPTX} for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.11 HS-TX Static Common-Point Voltage Mismatch ($\Delta V_{CPTX(HS)}$)

Test Overview

The purpose of this test is to verify that the Static Common-Point Voltage Mismatch ($\Delta V_{CPTX(HS)}$) of the HS Transmitter DUT is less than the maximum conformance limit values of the MIPI C-PHY standard specification.

Test Availability

Table 5 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Static Common-Point Voltage Mismatch ($\Delta V_{CPTX(HS)}$) test.

Table 5 Configuration Options for HS-TX Static Common-Point Voltage Mismatch Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.11	2100	HS-TX Static Common-Point Voltage Mismatch ($\Delta V_{CPTX(HS)}$)	×	✓	—	—	—

References

See Test 1.2.11 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following tests as a prerequisite:

   a Test 1.2.10 HS-TX Static Common-Point Voltages ($V_{CPTX\_HS\_+X}$) — (Test ID 2000).

   Store the test results after measuring the actual values of V_{CPTX} for the test signal.

2 Calculate the V_{MAXCP}, V_{MINCP} and $\Delta V_{CPTX(HS)}$ using the equations:

$$V_{MAXCP} = \max (V_{CPTX\_HS\_+X}, V_{CPTX\_HS\_-X}, V_{CPTX\_HS\_+Y}, V_{CPTX\_HS\_-Y}, V_{CPTX\_HS\_+Z}, V_{CPTX\_HS\_-Z})$$

$$V_{MINCP} = \min (V_{CPTX\_HS\_+X}, V_{CPTX\_HS\_-X}, V_{CPTX\_HS\_+Y}, V_{CPTX\_HS\_-Y}, V_{CPTX\_HS\_+Z}, V_{CPTX\_HS\_-Z})$$

$$\Delta V_{CPTX(HS)} = (V_{MAXCP} - V_{MINCP}) / 2$$

3 Compare the measured values of $\Delta V_{CPTX(HS)}$ against the compliance test limits.

Expected/Observable Results

The measured value of $\Delta V_{CPTX(HS)}$ for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.12 HS-TX Dynamic Common-Point Variations Between 50-450MHz ($\Delta V_{CPTX(LF)}$)

Test Overview

The purpose of this test is to verify that the AC Common-Point Signal Level Variations Between 50 and 450MHz ($\Delta V_{CPTX(LF)}$) of the HS Transmitter DUT are less than the maximum allowable conformance limit values of the MIPI C-PHY standard specification. Figure 9 shows the dynamic V_{CPTX} distortion on the single-ended high-speed signals.

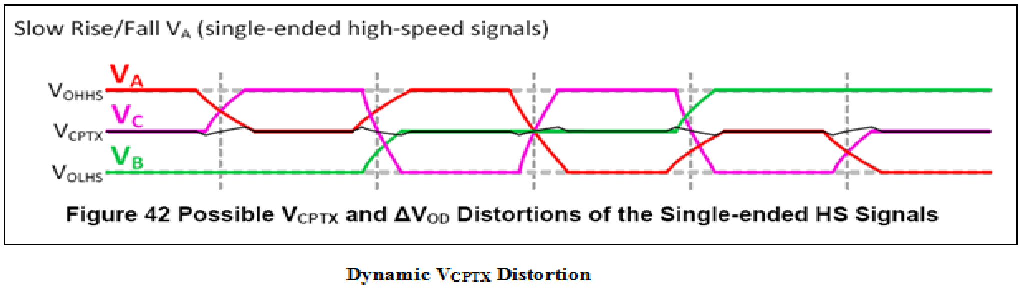


Figure 9 Dynamic V_{CPTX} distortion on the single-ended high-speed signals

Test Availability

Table 6 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Dynamic Common-Point Variations Between 50-450MHz ($\Delta V_{CPTX(LF)}$) test.

Table 6 Configuration Options for HS-TX Dynamic Common-Point Variations Between 50 and 450MHz Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.12	2200	HS-TX Dynamic Common-Point Variations Between 50-450MHz ($\Delta V_{CPTX(LF)}$)	×	✓	—	—	—

References

See Test 1.2.12 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Capture waveforms for V_A, V_B and V_C.
2 Generate the common-point voltage V_{CPTX} signal using the equation:

$$V_{CPTX} = (V_A + V_B + V_C) / 3$$

3 Apply a band-pass filter with 3dB bandwidth frequency of 50MHz and 450MHz to the common-point waveform.
4 Measure the minimum and maximum values of voltage for the filtered waveform.
5 Record the maximum value of voltage as $\Delta V_{CPTX(LF)}$.

6 Compare the measured value of $\Delta V_{CPTX(LF)}$ against the compliance test limits.

Expected/Observable Results

The measured value of $\Delta V_{CPTX(LF)}$ for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.13 HS-TX Dynamic Common-Point Variations Above 450MHz ($\Delta V_{CPTX(HF)}$)

Test Overview

The purpose of this test is to verify that the AC Common-Point Signal Level Variations Above 450MHz ($\Delta V_{CPTX(HF)}$) of the HS Transmitter DUT are less than the maximum allowable conformance limit values of the MIPI C-PHY standard specification. Figure 10 shows the dynamic V_{CPTX} distortion on the single-ended high-speed signals.

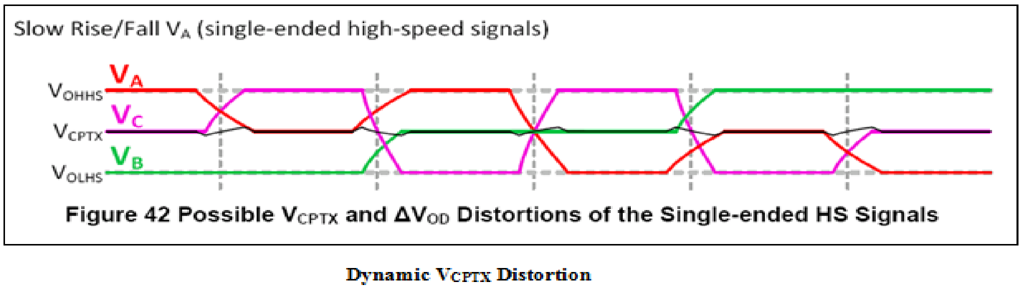


Figure 10 Dynamic V_{CPTX} distortion on the single-ended high-speed signals

Test Availability

Table 7 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Dynamic Common-Point Variations Above 450MHz ($\Delta V_{CPTX(HF)}$) test.

Table 7 Configuration Options for HS-TX Dynamic Common-Point Variations Above 450MHz Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.13	2300	HS-TX Dynamic Common-Point Variations Above 450MHz ($\Delta V_{CPTX(HF)}$)	×	✓	—	—	—

References

See Test 1.2.13 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Capture waveforms for V_A, V_B and V_C.
2. Generate the common-point voltage V_{CPTX} signal using the equation:

$$V_{CPTX} = (V_A + V_B + V_C) / 3$$

3. Apply a band-pass filter with 3dB bandwidth frequency of 450MHz to the common-point waveform.
4. Measure the RMS value of the voltage for the filtered waveform.
5. Compare the measured value of $\Delta V_{CPTX(HF)}$ against the compliance test limits.

Expected/Observable Results

The measured value of $\Delta V_{CPTX(HF)}$ for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.14 HS-TX Rise Time (t_R)

Test Overview

The purpose of this test is to verify that the Rise Time (t_R) of the HS Transmitter DUT is within the conformance limit value of the MIPI C-PHY standard specification.

Test Availability

Table 8 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Rise Time (t_R) test.

Table 8 Configuration Options for HS-TX Rise Time Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.14	2400	HS-TX Rise Time (t_R) [1.5 Gsps and below]	×	✓	✓	✓	×
	2401	HS-TX Rise Time (t_R) [Above 1.5 Gsps]	×	✓	×	×	✓

References

See Test 1.2.14 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following tests as a prerequisite:

a Test 1.2.19 HS Clock Instantaneous UI (UI_{INST_Max}) – (Test ID 2900).

Store the test results after measuring the minimum, maximum and average Unit Interval of the differential waveform.

2 Use the waveforms for V_A and V_B captured in the prerequisite test.

3 Construct the differential data waveform using the equation:

$$DiffData(A-B) = V_A - V_B$$

4 Identify and extract all Strong zero to weak one transitions within the differential data waveform. To configure the threshold levels, which in turn, is used to identify all the states; use the following options:

a Strong1 Threshold (V)

b Weak1 Threshold (V)

c Weak0 Threshold (V)

d Strong0 Threshold (V)

5 Measure values of Rise Time for all the identified transitions between the -58mV and +58mV levels.

6 Calculate the mean Rise Time value from the values obtained in the previous step. Use the value of the mean Rise Time t_R(Mean) for the final test result.

7 Compare the measured value of t_R(Mean) against the compliance test limits.

Expected/Observable Results

The measured value of t_R for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.15 HS-TX Fall Time (t_F)

Test Overview

The purpose of this test is to verify that the Fall Time (t_F) of the HS Transmitter DUT is within the conformance limit value of the MIPI C-PHY standard specification.

Test Availability

Table 9 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS-TX Rise Time (t_R) test.

Table 9 Configuration Options for HS-TX Fall Time Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.15	2500	HS-TX Fall Time (t_F) [1.5 Gsps and below]	×	✓	✓	✓	×
	2501	HS-TX Fall Time (t_F) [Above 1.5 Gsps]	×	✓	×	×	✓

References

See Test 1.2.15 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following tests as a prerequisite:

a Test 1.2.19 HS Clock Instantaneous UI (UI_{INST_Max}) — (Test ID 2900).

Store the test results after measuring the minimum, maximum and average Unit Interval of the differential waveform.

2 Use the waveforms for V_A and V_B captured in the prerequisite test.

3 Construct the differential data waveform using the equation:

$$DiffData(A-B) = V_A - V_B$$

4 Identify and extract all strong one to weak zero transitions within the differential data waveform. To configure the threshold levels, which in turn, is used to identify all the states; use the following options:

a Strong1 Threshold (V)

b Weak1 Threshold (V)

c Weak0 Threshold (V)

d Strong0 Threshold (V)

5 Measure values of Fall Time for all the identified transitions between the -58mV and +58mV levels.

6 Calculate the mean Fall Time value from the values obtained in the previous step. Use the value of the mean Fall Time t_F(Mean) for the final test result.

7 Compare the measured value of t_F(Mean) against the compliance test limits.

Expected/Observable Results

The measured value of t_F for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.17 30%-85% Post-EoT Rise Time (T_{REOT})

Test Overview

The purpose of this test is to verify that the 30%-85% Post EoT Rise Time (T_{REOT}) of the LP Transmitter DUT is within the conformance limits of the MIPI C-PHY standard specification.

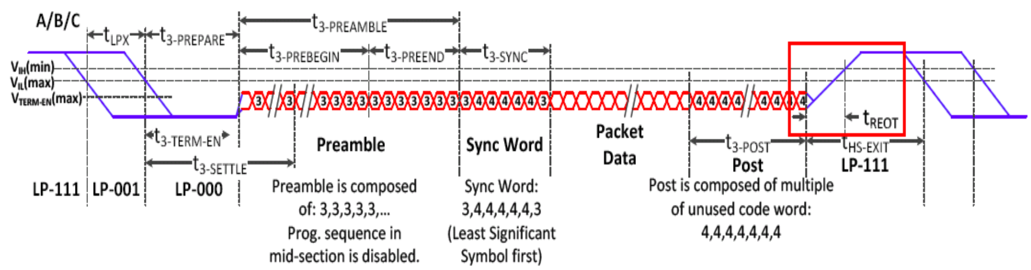


Figure 23 High-Speed Data Transmission in Burst

Figure 11 T_{REOT} Rise Time

Test Availability

Table 10 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the 30%-85% Post-EoT Rise Time (T_{REOT}) test.

Table 10 Configuration Options for 30%-85% Post-EoT Rise Time Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.17	2700	30%-85% Post EoT Rise Time (T_{REOT})	×	✓	—	—	—

References

See Test 1.2.17 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Position the trigger point at the center of the screen.
2. Trigger on the rising edge of V_A in the LP-111 state that occurs immediately after an HS Burst sequence.
3. Construct a differential data waveform using the equation:

$$DiffData(C\text{-}A) = V_C - V_A$$

4. Find the last transition edge of the differential waveform, DiffData(C-A) that crosses +/-48mV. Mark this time as T1.
5. Find the time after T1, when the rising edge of V_A crosses $V_{IH(min)}$ = 740mV. Mark this time as T2. Note that T2 must be greater than T1.

6 Calculate T_{REOT} using the equation:

$$T_{REOT} = T2 - T1$$

7 Compare the measured value of T_{REOT} against the compliance test limits.

Expected/Observable Results

The measured value of T_{REOT} for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.19 HS Clock Instantaneous UI (UI_{INST})

Test Overview

The purpose of this test is to verify that the value of the Instantaneous Unit Interval (UI_{INST}) of the HS Transmitter DUT is within the conformance limit value of the MIPI C-PHY standard specification. Figure 12 shows the Instantaneous Unit Intervals on the High-Speed signal.

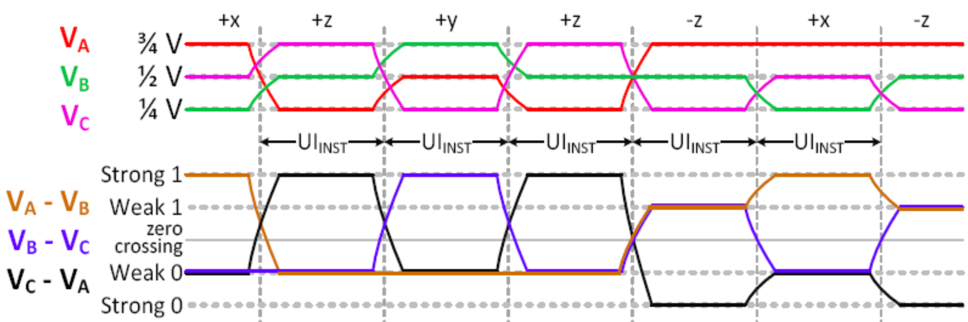


Figure 55 Example of Wire State Transitions at Symbol (UI) Boundaries

Figure 12 Instantaneous Unit Intervals on High-Speed signal

Test Availability

Table 11 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS Clock Instantaneous UI (UI_{INST}) test.

Table 11 Configuration Options for HS Clock Instantaneous UI Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.19	2900	HS Clock Instantaneous UI (UI_{INST_Max})	×	✓	—	—	—

References

See Test 1.2.19 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Capture waveforms for V_A, V_B and V_C.

2 Construct the differential data waveform using the equation:

$$DiffData(A-B) = V_A - V_B$$

$$DiffData(B-C) = V_B - V_C$$

$$DiffData(C-A) = V_C - V_A$$

3 Measure the minimum, maximum and average values of Unit Interval for the differential waveforms based on the zero crossings between each UI.

4 Store the minimum, maximum and average values of the Unit Interval as UI_Min, UI_Max and UI_Mean respectively.
5 Apply a Butterworth Low Pass test filter with a -3dB cut-off frequency of 2.0MHz to the measured UI data.
6 Measure and store the minimum, maximum and average values of the filtered Unit Interval data as $UI_{Inst\_Filt\_Min}$, $UI_{Inst\_Filt\_Max}$ and $UI_{Inst\_Filt\_Mean}$ respectively.
7 Use the value of UI_Max as the final measurement result and compare this value against the compliance test limits.

Expected/Observable Results

The measured value of UI_{INST} for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

Test 1.2.20 HS Clock Delta UI (ΔUI)

Test Overview

The purpose of this test is to verify that the frequency stability of the DUT's HS Clock during a single burst is within the conformance limit value of the MIPI C-PHY standard specification.

Test Availability

Table 12 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the HS Clock Delta UI (ΔUI) test.

Table 12 Configuration Options for HS Clock Delta Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY		HS Symbol Rate		
			Enabled	Disabled	<=1.0 Gsps	1.0 Gsps < x <=1.5 Gsps	>1.5 Gsps
1.2.20	3000	HS Clock Delta UI (ΔUI) [1 Gsps and below]	×	✓	✓	×	×
	3001	HS Clock Delta UI (ΔUI) [Above 1 Gsps]	×	✓	×	✓	✓

References

See Test 1.2.20 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following test as a prerequisite:

a Test 1.2.19 HS Clock Instantaneous UI (UI_{INST_Max}) – (Test ID 2900).

Store the test results after measuring the minimum, maximum and average values of the Low Pass filtered Unit Interval of the differential waveforms.

2 Calculate UI_Variant_Min and UI_Variant_Max using the equations:

$$UI\_Variant\_Min = [(UI_{Inst\_Filt\_Min} - UI_{Inst\_Filt\_Mean}) / UI_{Inst\_Filt\_Mean}] * 100\%$$

$$UI\_Variant\_Max = [(UI_{Inst\_Filt\_Max} - UI_{Inst\_Filt\_Mean}) / UI_{Inst\_Filt\_Mean}] * 100\%$$

3 Determine UI_Variant_Worst based on the values of UI_Variant_Min and UI_Variant_Max calculated in the previous step.

4 Use the value of UI_Variant_Worst as the final test result and compare the determined value of UI_Variant_Worst against the compliance test limits.

Expected/Observable Results

The measured UI variation for the test signal must be within the conformance limit values as specified in the CTS Specification mentioned under the References section.

5 1.2.2 Low Power Transmitter (LP-TX) Electrical Tests

Test 1.1.1 LP-TX Thevenin Output High Level Voltage (VOH) / 50
Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (VOL) / 52
Test 1.1.3 LP-TX 15% - 85% Rise Time (TRLP) / 54
Test 1.1.4 LP-TX 15% - 85% Fall Time (TFLP) / 56
Test 1.1.5 LP-TX Slew Rate vs. CLOAD / 58
Test 1.1.6 LP-TX Pulse Width of Exclusive-OR Clock (TLP-PULSE-TX) / 60
Test 1.1.7 LP-TX Period of Exclusive-OR Clock (TLP-PER-TX) / 62

This section provides the Methods of Implementation (MOIs) for electrical tests for low-power transmitters (LP-TX) using an Keysight Infiniium Oscilloscope, InfiniiMax probes, and the MIPI C-PHY Compliance Test Application.

Test 1.1.1 LP-TX Thevenin Output High Level Voltage (V_{OH})

Test Overview

The purpose of this test is to verify that the Thevenin Output High Level Voltage (V_{OH}) of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification.

Test Availability

Table 13 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX Thevenin Output High Level Voltage (V_{OH}) test.

Table 13 Configuration Options for LP-TX Thevenin Output High Level Voltage Test

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.1	100	LP-TX Thevenin Output High Level Voltage (V_{OH}) ESCAPEMODE	✓	×	—	—	—	—
	101	LP-TX Thevenin Output High Level Voltage (V_{OH})	×	✓	×	✓	✓	×

References

See Test 1.1.1 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

For Test ID 100 (Data LP EscapeMode [Enabled])

1. Trigger on LP Data EscapeMode entry pattern of the data signal. If the LP EscapeMode is unavailable, the trigger is unable to capture any valid signal required for data processing.
2. Locate and use the Mark-1 state pattern to determine the end of the EscapeMode sequence.
3. Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to the EscapeMode sequence waveform data of the acquired V_A.
4. Use the Histogram methodology to measure V_{OH} of the filtered test waveform data. The vertical Histogram window must start at the point that indicates 50% of the absolute peak-to-peak V_A signal amplitude.
5. Calculate the mode of the Histogram in the previous step and record this value as V_{OH} for V_A.
6. Repeat steps 3 - 5 for V_B and V_C.
7. Report the measurement results as:

   Value of V_{OH} for V_A

   Value of V_{OH} for V_B

   Value of V_{OH} for V_C
8. Compare the measured "worst" value of V_{OH} against the compliance test limits.

For Test ID 101 (Data LP EscapeMode [Disabled], Informative Test [Enabled])

1 Trigger on the LP rising edge signal for V_A. The Oscilloscope triggers according to the configuration of the “LP Observation” attribute. By default, ten rising edges are acquired.

2 Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to each acquired LP rising edge waveform data.

3 Use the Histogram methodology to measure V_{OH} of the accumulated filtered test waveform data. The vertical Histogram window must start at the point that indicates 50% of the absolute peak-to-peak V_A signal amplitude.

4 Calculate the mode of the Histogram in the previous step and record this value as V_{OH} for V_A.

5 Repeat steps 1 - 4 for V_B and V_C.

6 Report the measurement results as:

Value of V_{OH} for V_A

Value of V_{OH} for V_B

Value of V_{OH} for V_C

7 Compare the measured “worst” value of V_{OH} against the compliance test limits.

Expected/Observable Results

The measured “worst” value of V_{OH} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (V_{OL})

Test Overview

The purpose of this test is to verify that the Thevenin Output Low Level Voltage (V_{OL}) of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification.

Test Availability

Table 14 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX Thevenin Output Low Level Voltage (V_{OL}) test.

Table 14 Configuration Options for LP-TX Thevenin Output Low Level Voltage Test

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.2	200	LP-TX Thevenin Output Low Level Voltage (V_{OL}) ESCAPEMODE	✓	×	—	—	—	—
	201	LP-TX Thevenin Output Low Level Voltage (V_{OL})	×	✓	×	✓	✓	×

References

See Test 1.1.2 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

For Test ID 200 (Data LP EscapeMode [Enabled])

1 Run the following test as a prerequisite:

   a Test 1.1.1 LP-TX Thevenin Output High Level Voltage (V_{OH}) ESCAPEMODE – (Test ID 100).

   Store the test results after measuring the V_{OH} values for the Low Power signals.

2 Use the entire LP EscapeMode sequence captured in the prerequisite test.

3 Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to the EscapeMode sequence waveform data of the acquired V_A.

4 Use the Histogram methodology to measure V_{OL} of the filtered test waveform data. The vertical Histogram window must start at the point that indicates 50% of the absolute peak-to-peak V_A signal amplitude.

5 Calculate the mode of the Histogram in the previous step and record this value as V_{OL} for V_A.

6 Repeat steps 3 - 5 for V_B and V_C.

7 Report the measurement results as:

   Value of V_{OL} for V_A

   Value of V_{OL} for V_B

   Value of V_{OL} for V_C

8 Compare the measured "worst" value of V_{OL} against the compliance test limits.

For Test ID 201 (Data LP EscapeMode [Disabled], Informative Test [Enabled])

1 Trigger on the LP falling edge signal for V_A. The Oscilloscope triggers according to the configuration of the “LP Observation” attribute. By default, ten falling edges are acquired.

2 Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to each acquired LP falling edge waveform data.

3 Use the Histogram methodology to measure V_{OL} of the accumulated filtered test waveform data. The vertical Histogram window must start at the point that indicates 50% of the absolute peak-to-peak V_A signal amplitude.

4 Calculate the mode of the Histogram in the previous step and record this value as V_{OL} for V_A.

5 Repeat steps 1 - 4 for V_B and V_C.

6 Report the measurement results as:

Value of V_{OL} for V_A

Value of V_{OL} for V_B

Value of V_{OL} for V_C

7 Compare the measured “worst” value of V_{OL} against the compliance test limits.

Expected/Observable Results

The measured “worst” value of V_{OL} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.1.3 LP-TX 15% - 85% Rise Time (T_{RLP})

Test Overview

The purpose of this test is to verify that the 15% - 85% Rise Time (T_{RLP}) of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification.

Test Availability

Table 15 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX 15% - 85% Rise Time (T_{RLP}) test.

Table 15 Configuration Options for LP-TX 15% - 85% Rise Time Test

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.3	300	LP-TX 15% - 85% Rise Time (T_{RLP}) ESCAPEMODE	✓	×	—	—	—	—

References

See Test 1.1.3 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Run the following tests as a prerequisite:
   a Test 1.1.1 LP-TX Thevenin Output High Level Voltage (V_{OH}) ESCAPEMODE – (Test ID 100).
   b Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (V_{OL}) ESCAPEMODE – (Test ID 200).

   Store the test results after measuring all values of V_{OH} and V_{OL} for the Low Power signals.
2. Use the entire LP EscapeMode sequence captured in the prerequisite tests.
3. Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to the EscapeMode sequence waveform data of the mentioned V_A; prior to measuring the actual Rise Time.
4. All rising edges in the filtered EscapeMode Sequence waveform data of the filtered V_A are processed to measure the corresponding Rise Time.
5. Using the values of V_{OH} and V_{OL} as reference from the prerequisite tests, measure the 15% - 85% Rise Time for each rising edge of the V_A waveform.
6. Record the average Rise Time for V_A.
7. Repeat steps 3 - 6 for V_B and V_C.
8. Report the measurement results as:

   Average value of T_{RLP} for V_A

   Average value of T_{RLP} for V_B

   Average value of T_{RLP} for V_C
9. Compare the measured "worst" value of T_{RLP} against the compliance test limits.

Expected/Observable Results

The measured “worst” value of T_{RLP} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.1.4 LP-TX 15% - 85% Fall Time (T_{FLP})

Test Overview

The purpose of this test is to verify that the 15% - 85% Fall Time (T_{FLP}) of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification.

Test Availability

Table 16 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX 15% - 85% Fall Time (T_{FLP}) test.

Table 16 Configuration Options for LP-TX 15% - 85% Fall Time Test

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.4	400	LP-TX 15% - 85% Fall Time (T_{FLP}) ESCAPEMODE	✓	×	—	—	—	—
	401	LP-TX 15% - 85% Fall Time (T_{FLP})	×	✓	×	✓	✓	×

References

See Test 1.1.4 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

For Test ID 400 (Data LP EscapeMode [Enabled])

1 Run the following tests as a prerequisite:

  a Test 1.1.1 LP-TX Thevenin Output High Level Voltage (V_{OH}) ESCAPEMODE — (Test ID 100).

  b Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (V_{OL}) ESCAPEMODE — (Test ID 200).

  Store the test results after measuring all values of V_{OH} and V_{OL} for the Low Power signals.

2 Use the entire LP EscapeMode sequence captured in the prerequisite tests.

3 Apply a 400MHz, 4th-order Butterworth Low Pass test filter to the EscapeMode sequence waveform data of the mentioned V_A; prior to measuring the actual Fall Time.

4 All falling edges in the filtered EscapeMode Sequence waveform data of the filtered V_A are processed to measure the corresponding Fall Time.

5 Using the values of V_{OH} and V_{OL} as reference from the prerequisite tests, measure the 15% - 85% Fall Time for each falling edge of the V_A waveform.

6 Record the average Fall Time for V_A.

7 Repeat steps 3 - 6 for V_B and V_C.

8 Report the measurement results as:

Average value of T_{FLP} for V_A

Average value of T_{FLP} for V_B

Average value of T_{FLP} for V_C

9 Compare the measured "worst" value of T_{FLP} against the compliance test limits.

For Test ID 401 (Data LP EscapeMode [Disabled], Informative Test [Enabled])

1 Run the following tests as a prerequisite:
   a Test 1.1.1 LP-TX Thevenin Output High Level Voltage (V_{OH}) – (Test ID 101).
   b Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (V_{OL}) – (Test ID 201).

   Store the test results after measuring all values of V_{OH} and V_{OL} for the Low Power signals.
2 Use all of the LP falling edges captured in the prerequisite tests.
3 Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to each captured LP falling edge waveform data.
4 Using the values of V_{OH} and V_{OL} as reference from the prerequisite tests, measure the 15% - 85% Fall Time for each filtered falling edge of the V_A waveform.
5 Record the average Fall Time for V_A.
6 Repeat steps 3 - 5 for V_B and V_C.
7 Report the measurement results as:

   Average value of T_{FLP} for V_A

   Average value of T_{FLP} for V_B

   Average value of T_{FLP} for V_C
8 Compare the measured “worst” value of T_{FLP} against the compliance test limits.

Expected/Observable Results

The measured “worst” value of T_{FLP} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.1.5 LP-TX Slew Rate vs. C_{LOAD}

Test Overview

The purpose of this test is to verify that the Slew Rate of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification, for specific capacitive loading conditions.

Test Availability

Table 17 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX Slew Rate vs. C_{LOAD} test.

Table 17 Configuration Options for LP-TX Slew Rate vs. C_{LOAD} Test

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.5	500	LP-TX Slew Rate vs. C_{LOAD} (RiseEdgeMax)	✓	×	—	—	—	—
	501	LP-TX Slew Rate vs. C_{LOAD} (RiseEdgeMin)	✓	×	—	—	—	—
	502	LP-TX Slew Rate vs. C_{LOAD} (RiseEdgeMargin)	✓	×	—	—	—	—
	503	LP-TX Slew Rate vs. C_{LOAD} (FallEdgeMax)	✓	×	—	—	—	—
	504	LP-TX Slew Rate vs. C_{LOAD} (FallEdgeMin)	✓	×	—	—	—	—

References

See Test 1.1.5 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Run the following tests as a prerequisite:
   a Test 1.1.1 LP-TX Thevenin Output High Level Voltage (V_{OH}) ESCAPEMODE – (Test ID 100).
   b Test 1.1.2 LP-TX Thevenin Output Low Level Voltage (V_{OL}) ESCAPEMODE – (Test ID 200).

   Store the test results after measuring all values of V_{OH} and V_{OL} for the Low Power signals.
2. Use the entire LP EscapeMode sequence captured in the prerequisite tests.
3. Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to the EscapeMode sequence waveform data of the mentioned V_A; prior to measuring the actual Slew Rate.
4. Measure Slew Rate on the EscapeMode sequence waveform data of the filtered V_A for the V_A waveform.
5. Repeat steps 3 and 4 for V_B and V_C.
6. Store the maximum, minimum and margin values of Slew Rate.
7. Report the measurement results.
8. Compare the measured "worst" value of Slew Rate against the compliance test limits.

Expected/Observable Results

The measured “worst” value of Slew Rate for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.1.6 LP-TX Pulse Width of Exclusive-OR Clock ($T_{LP-PULSE-TX}$)

Test Overview

The purpose of this test is to verify that the Pulse Width of the XOR Clock ($T_{LP-PULSE-TX}$) of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification. Figure 13 shows the generation of LP XOR Clock from V_A and V_C.

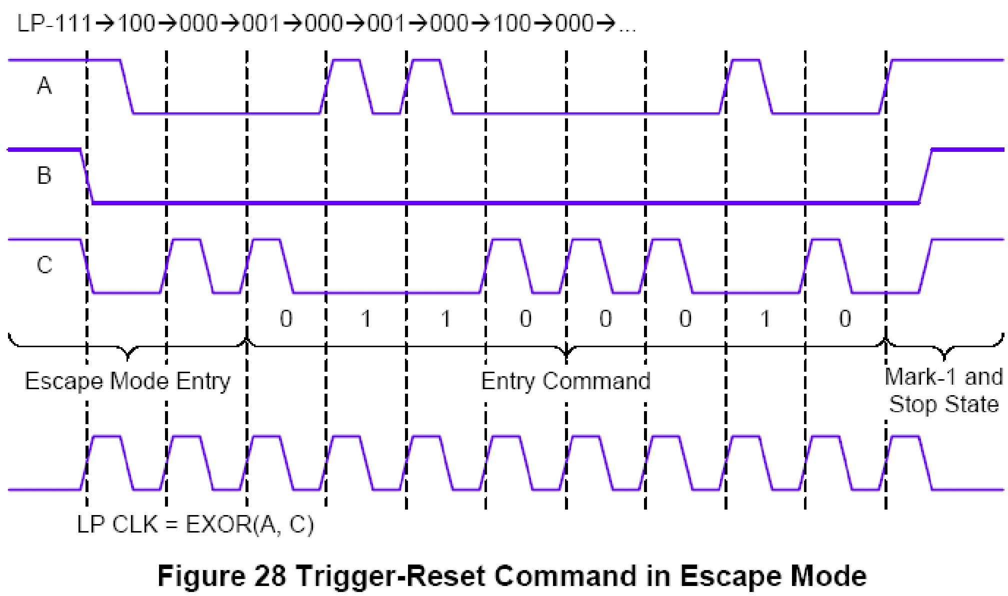


Figure 13 Generation of LP XOR Clock from V_A and V_C.

Test Availability

Table 18 shows the the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX Pulse Width of Exclusive-OR Clock ($T_{LP-PULSE-TX}$) test.

Table 18 Configuration Options for LP-TX Pulse Width of Exclusive-OR Clock Test

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.6	600	LP-TX Pulse Width of Exclusive-OR Clock ($T_{LP-PULSE-TX}$)	✓	×	—	—	—	—
	601	LP-TX Pulse Width of Exclusive-OR Clock ($T_{LP-PULSE-TX}$) [Initial]	✓	×	—	—	—	—

References

See Test 1.1.6 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Trigger on LP Data EscapeMode entry pattern of the data signal. If the LP EscapeMode is unavailable, the trigger is unable to capture any valid signal required for data processing.
2. Locate and use the Mark-1 state pattern to determine the end of the EscapeMode sequence.
3. Apply a 400MHz, 4^{th}-order Butterworth Low Pass test filter to the EscapeMode sequence waveform data.
4. Find all crossing points at the minimum trip level (500mV) and at the maximum trip level (790mV) for V_A and V_C respectively.
5. Find the initial pulse width and the minimum pulse width of all the other signal pulses at the specified minimum trip level and maximum trip level. (Here, a pulse is defined as a positive pulse, that is, rising-to-falling-edge pulse).
6. Find the rising-to-rising and falling-to-falling periods of the XOR Clock at the specified minimum trip level and maximum trip level.
7. Record the “worst” case value for the pulse width found between the minimum trip level and maximum trip level as the value of $T_{LP\text{-}PULSE\text{-}TX}$.
8. Compare the measured “minimum” value of $T_{LP\text{-}PULSE\text{-}TX}$ against the compliance test limits.

Expected/Observable Results

The measured “minimum” value of $T_{LP\text{-}PULSE\text{-}TX}$ for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.1.7 LP-TX Period of Exclusive-OR Clock ($T_{LP-PER-TX}$)

Test Overview

The purpose of this test is to verify that the Period ($T_{LP-PER-TX}$) of the XOR Clock of the DUT's LP Transmitter is within the conformance limits of the MIPI C-PHY standard specification. Figure 14 shows the generation of LP XOR Clock from V_A and V_C.

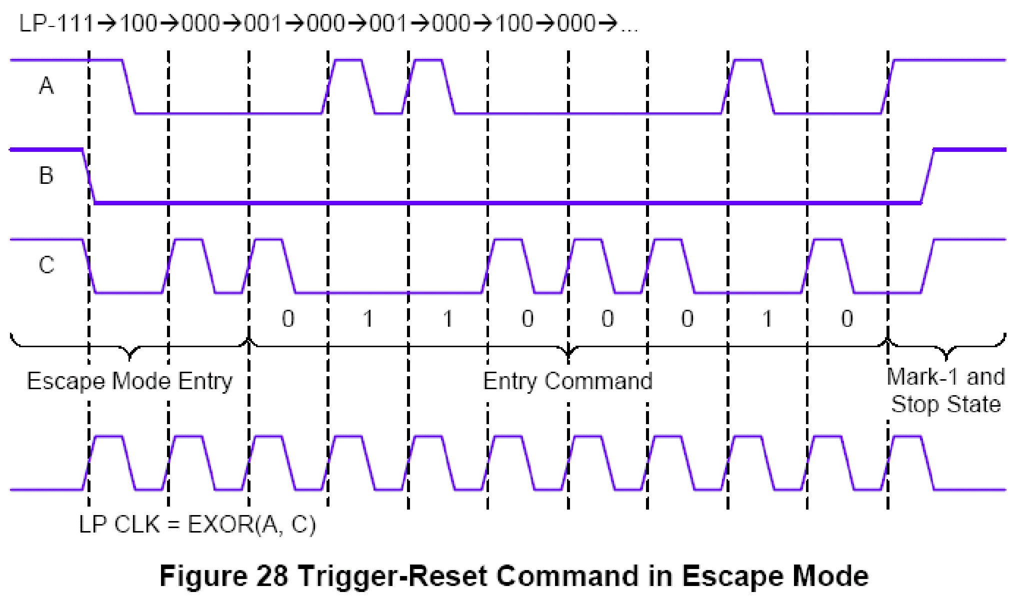


Figure 14 Generation of LP XOR Clock from V_A and V_C

Test Availability

Table 19 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the LP-TX Period of Exclusive-OR Clock ($T_{LP-PER-TX}$) test.

Table 19 LP-TX Period of Exclusive-OR Clock Test Requirements for LP Signaling

CTS Test ID	Test ID	Test Name	HS Burst Data - LPEscapeMode		LP Escape ONLY		Informative Tests	
			Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
1.1.7	700	LP-TX Period of Exclusive-OR Clock ($T_{LP-PER-TX}$) [Rising-to-Rising]	✓	×	—	—	—	—
	701	LP-TX Period of Exclusive-OR Clock ($T_{LP-PER-TX}$) [Falling-to-Falling]	✓	×	—	—	—	—

References

See Test 1.1.7 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following test as a prerequisite:

   a Test 1.1.6 LP-TX Pulse Width of Exclusive-OR Clock ($T_{LP\text{-}PULSE\text{-}TX}$) – (Test ID 600).

   The actual measurement algorithm for $T_{LP\text{-}PER\text{-}TX}$ is performed as part of this prerequisite test.

2 Measure the minimum value for all the rising-to-rising and falling-to-falling periods of the XOR clock at the minimum trip level (500mV) and the maximum trip level (790mV) as $T_{LP\text{-}PER\text{-}TX}$.

3 Record the value of $T_{LP\text{-}PER\text{-}TX}$ as the final test result.

4 Compare the measured “minimum” value of $T_{LP\text{-}PER\text{-}TX}$ against the compliance test limits.

Expected/Observable Results

The measured value of $T_{LP\text{-}PER\text{-}TX}$ for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

6 1.2.3 High-Speed Transmitter (HS-TX) Timing Tests

Test 1.2.1 TLPX Duration / 66
Test 1.2.2 T3-PREPARE Duration / 68
Test 1.2.18 THS-EXIT Value / 70

This section provides the Methods of Implementation (MOIs) for the timing tests for high-speed transmitters (HS-TX) using an Keysight Infiniium Oscilloscope, InfiniiMax probes, and the MIPI C-PHY Compliance Test Application.

Test 1.2.1 T_{LPX} Duration

Test Overview

The purpose of this test is to verify that the duration (T_{LPX}) of the final LP-001 state immediately prior to the High Speed Transmission is greater than the minimum conformance limits of the MIPI C-PHY standard specification. Figure 15 shows the Data Lane T_{LPX} Interval in a High-Speed Data Transmission.

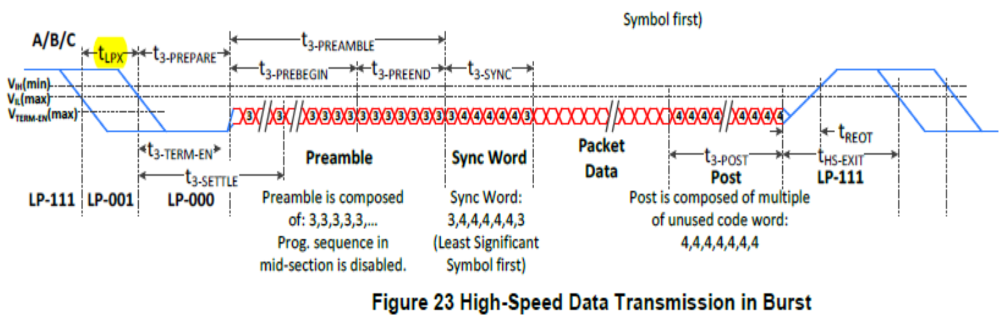


Figure 15 Data Lane T_{LPX} Interval in a High-Speed Data Transmission

Test Availability

Table 20 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the Duration (T_{LPX}) test.

Table 20 Configuration Options for T_{LPX} Duration Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY	
			Enabled	Disabled
1.2.1	1100	T_{LPX} Duration	×	✓

References

See Test 1.2.1 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1. Trigger on the falling edge of V_A in the LP-001 state, which occurs immediately before an HS Burst sequence.
2. Mark the time when the falling edge of V_A first crosses $V_{IL(Max)}$ = 550mV. Denote this time as T1.
3. Mark the time when the first falling edge of V_C after T1, crosses V_{IL_Max} = 550mV. Denote this time as T2. Note that T2 must be greater than T1.
4. Calculate T_{LPX} using the equation:

$$T_{LPX} = T2 - T1$$

5. Compare the calculated value of T_{LPX} against the compliance test limits.

Expected/Observable Results

The calculated value of T_{LPX} for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.2.2 $T_{3\text{-}PREPARE}$ Duration

Test Overview

The purpose of this test is to verify that the duration ($T_{3\text{-}PREPARE}$) of the final LP-000 state immediately prior to the High Speed Transmission is within the conformance limits of the MIPI C-PHY standard specification. Figure 16 shows the $T_{3\text{-}PREPARE}$ Interval in a High-Speed Data Transmission.

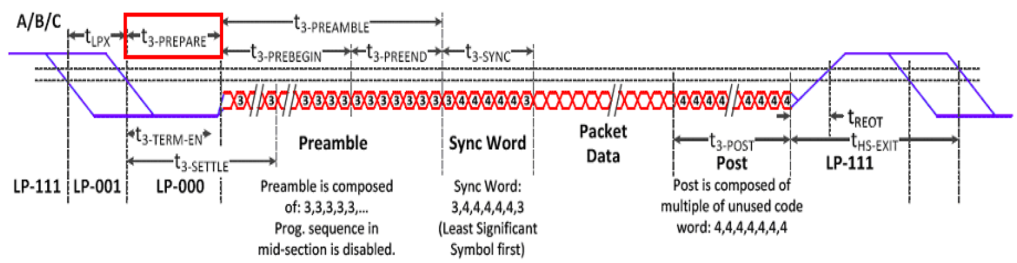


Figure 23 High-Speed Data Transmission in Burst

Figure 16 $T_{3\text{-}PREPARE}$ Interval in a High-Speed Data Transmission

Test Availability

Table 21 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the Duration ($T_{3\text{-}PREPARE}$) test.

Table 21 Configuration Options for $T_{3\text{-}PREPARE}$ Duration Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY	
			Enabled	Disabled
1.2.2	1200	$T_{3\text{-}PREPARE}$ Duration	×	✓

References

See Test 1.2.2 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Run the following test as a prerequisite:

   a Test 1.2.1 T_{LPX} Duration – (Test ID 1100).

   Store the test results after measuring the T_{LPX} Duration of the test signal.

2 Use the waveforms V_A, V_B and V_c captured in the prerequisite test.

3 Construct the differential data waveform using the equation:

$$DiffData(A\text{-}B) = V_A - V_B$$

$$DiffData(B\text{-}C) = V_B - V_C$$

$$DiffData(C\text{-}A) = V_C - V_A$$

4 Use the measured value of T2 from the prerequisite test as the starting point for $T_{3\text{-}PREPARE}$.

5 Find and mark the first transition edge of the differential waveform, which crosses +/-48mV. Denote it as T3. Note that T3 must be greater than T2.

6 Calculate $T_{3\text{-PREPARE}}$ using the equation:

$$T_{3\text{-PREPARE}} = T3 - T2$$

7 Compare the calculated value of $T_{3\text{-PREPARE}}$ against the compliance test limits.

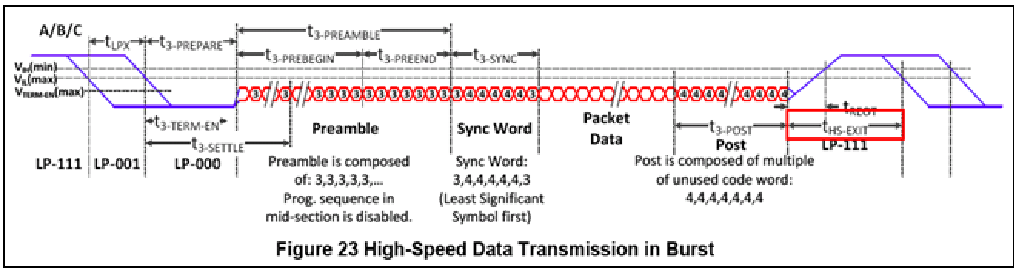
Expected/Observable Results

The calculated value of $T_{3\text{-PREPARE}}$ for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

Test 1.2.18 $T_{HS-EXIT}$ Value

Test Overview

The purpose of this test is to verify that the duration ($T_{HS-EXIT}$) the Data Lane Transmitter remains in the LP-111 (Stop) state after exiting HS mode is greater than minimum required value as per the conformance limits of the MIPI C-PHY standard specification. Figure 17 shows the $T_{HS-EXIT}$ Interval in a High-Speed Data Transmission.



$T_{HS-EXIT}$ Interval

Figure 17 $T_{HS-EXIT}$ Interval in a High-Speed Data Transmission

Test Availability

Table 22 shows the configuration options on the MIPI C-PHY Compliance Test Application that affect the availability of the $T_{HS-EXIT}$ Value test.

Table 22 Configuration Options for $T_{HS-EXIT}$ Value Test

CTS Test ID	Test ID	Test Name	LP Escape ONLY	
			Enabled	Disabled
1.2.18	2800	$T_{HS-EXIT}$ Value	×	✓

References

See Test 1.2.18 of the C-PHY Physical Layer Conformance Test Suite v1.0r10 (23Mar2015).

Test Procedure

1 Position the trigger point at the center of the screen. Trigger on the rising edge of V_A in the LP-111 state, which occurs immediately after an HS Burst sequence.

2 Construct the differential data waveform using the equation:

$$DiffData(C-A) = V_C - V_A$$

3 Find and mark the last transition edge of the differential waveform, DiffData(C-A), which crosses +/-70mV. Denote it as T4.

4 Find the time after T4 when the falling edge of V_A crosses $V_{IL(Max)}$ = 550mV. Mark this time as T5. Note that T5 must be greater than T4.

5 Calculate $T_{HS-EXIT}$ using the equation:

$$T_{HS-EXIT} = T5 - T4$$

6 Compare the calculated value of $T_{HS-EXIT}$ against the compliance test limits.

Expected/Observable Results

The calculated value of $T_{HS-EXIT}$ for the test signal must be within the conformance limit as specified in the CTS Specification mentioned under the References section.

7 Calibrating the Infiniium Oscilloscope

Required Equipment for Oscilloscope Calibration / 74
To Run the Self Calibration / 75
Probe Calibration and De-skew / 80

This section describes the Keysight Infiniium Oscilloscopes calibration procedures.

Required Equipment for Oscilloscope Calibration

To calibrate the Infiniium oscilloscope in preparation for running the MIPI C-PHY automated tests, you need the following equipment:

- Keyboard, qty = 1, (provided with the Keysight Infiniium oscilloscope).
- Mouse, qty = 1, (provided with the Keysight Infiniium oscilloscope).
- Precision 3.5 mm BNC to SMA male adapter, Keysight p/n 54855-67604, qty = 2 (provided with the Keysight Infiniium oscilloscope).
- Calibration cable (provided with the Keysight Infiniium oscilloscopes). Use a good quality 50 Ω BNC cable.

To Run the Self Calibration

NOTE **Let the Oscilloscope warm up before adjusting. Warm up the Oscilloscope for 30 minutes before starting calibration procedure. Failure to allow warm up may result in inaccurate calibration.**

The self calibration uses signals generated in the Oscilloscope to calibrate Channel sensitivity, offsets, and trigger parameters. You should run the self calibration

- yearly or according to your periodic needs,
- when you replace the acquisition assembly or acquisition hybrids,
- when you replace the hard drive or any other assembly,
- when the oscilloscope's operating temperature (after the 30 minute warm-up period) is more than ±5 °C different from that of the last calibration.

Internal or Self Calibration

NOTE **Calibration time: It takes approximately 1 hour to run the self calibration on the Oscilloscope, including the time required to change cables from Channel to Channel.**

This will perform an internal diagnostic and calibration cycle for the oscilloscope. For the Keysight oscilloscope, this is referred to as Calibration. This Calibration will take about 20 minutes. Perform the following steps:

1 Set up the oscilloscope with the following steps:
   a Connect the keyboard, mouse, and power cord to the rear of the oscilloscope.
   b Plug in the power cord.
   c Turn on the oscilloscope by pressing the power button located on the lower left of the front panel.
   d Allow the oscilloscope to warm up at least 30 minutes prior to starting the calibration procedure in step 3 below.
2 Locate and prepare the accessories that will be required for the internal calibration:
   a Locate the BNC shorting cap.
   b Locate the calibration cable.
   c Locate the two Keysight precision SMA/BNC adapters.
   d Attach one SMA adapter to the other end of the calibration cable — hand tighten snugly.
   e Attach another SMA adapter to the other end of the calibration cable — hand tighten snugly.

3 From the Infiniium Oscilloscope's main menu, click **Utilities>Calibration...**.

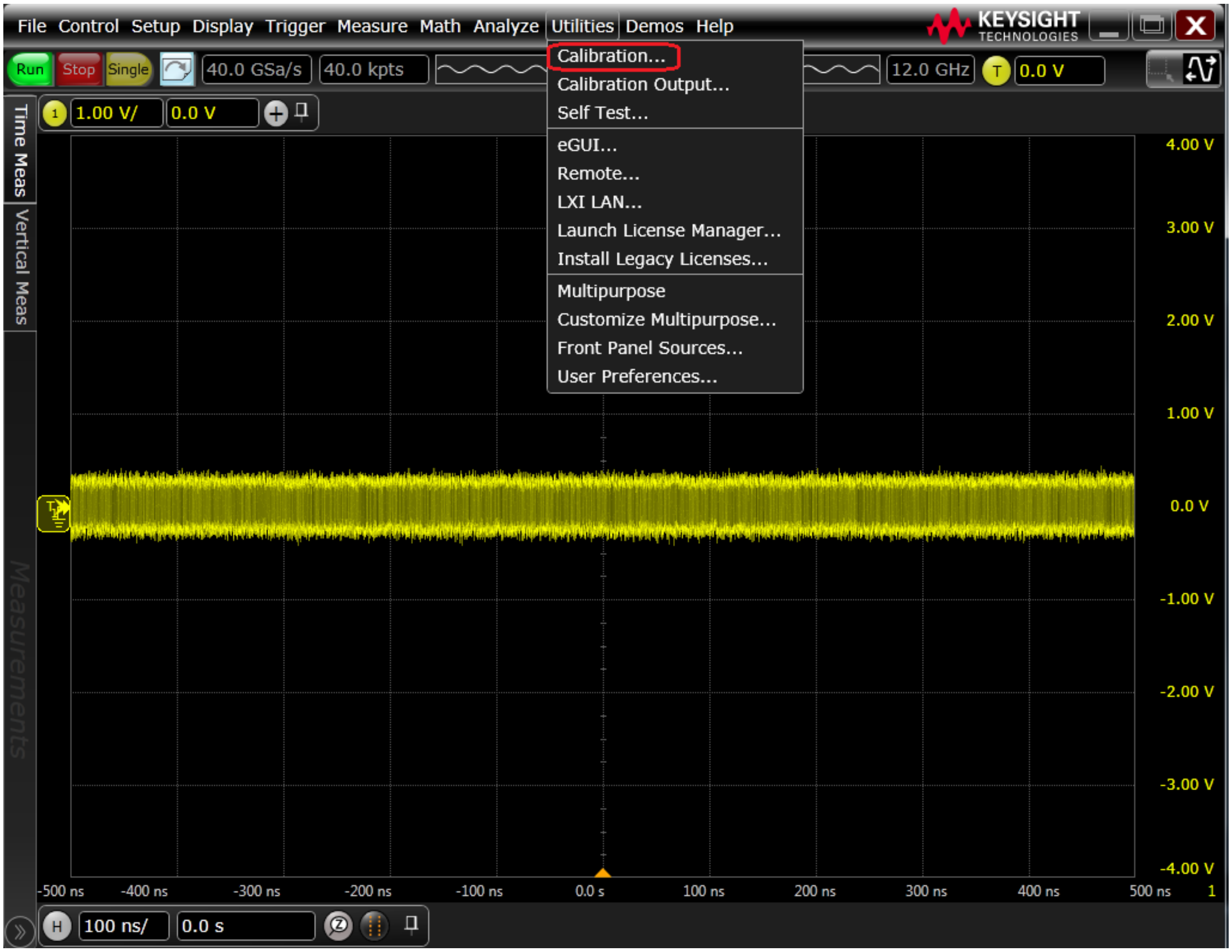


Figure 18 Accessing Calibration dialog on the Oscilloscope

The **Calibration** dialog appears.

4 To start the calibration process:

  a Clear the **Cal Memory Protect** checkbox.

  You cannot run self calibration if this box is checked. See Figure 19.

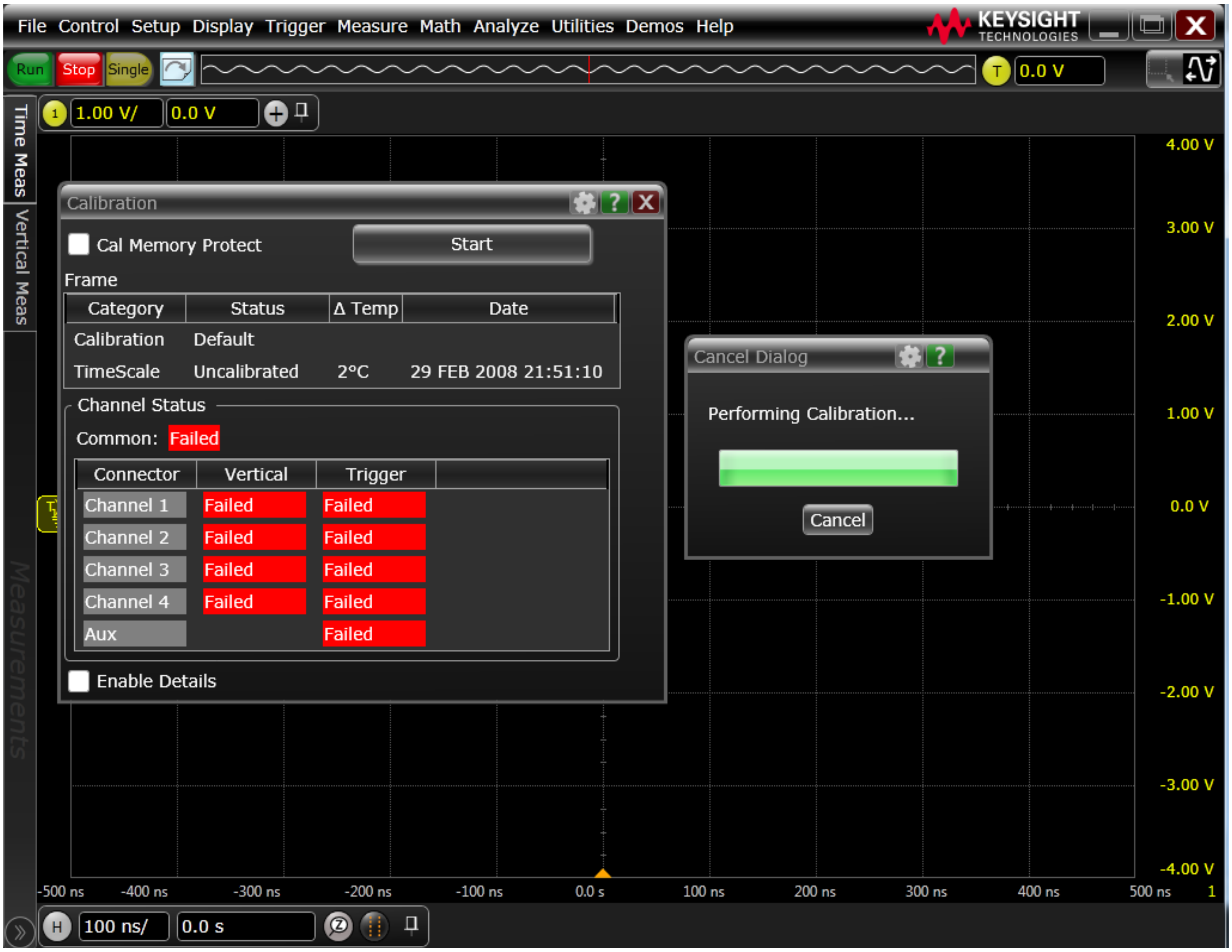


Figure 19 Clearing **Cal Memory Protect** and Starting Calibration

  b Click **Start** to begin calibration.

  c Follow the on-screen instructions.

d During the calibration of any Oscilloscope Channel, if the oscilloscope prompts you to perform a Time Scale Calibration, select **Standard Cal and Default Time Scale** in the **Calibration Options** dialog.

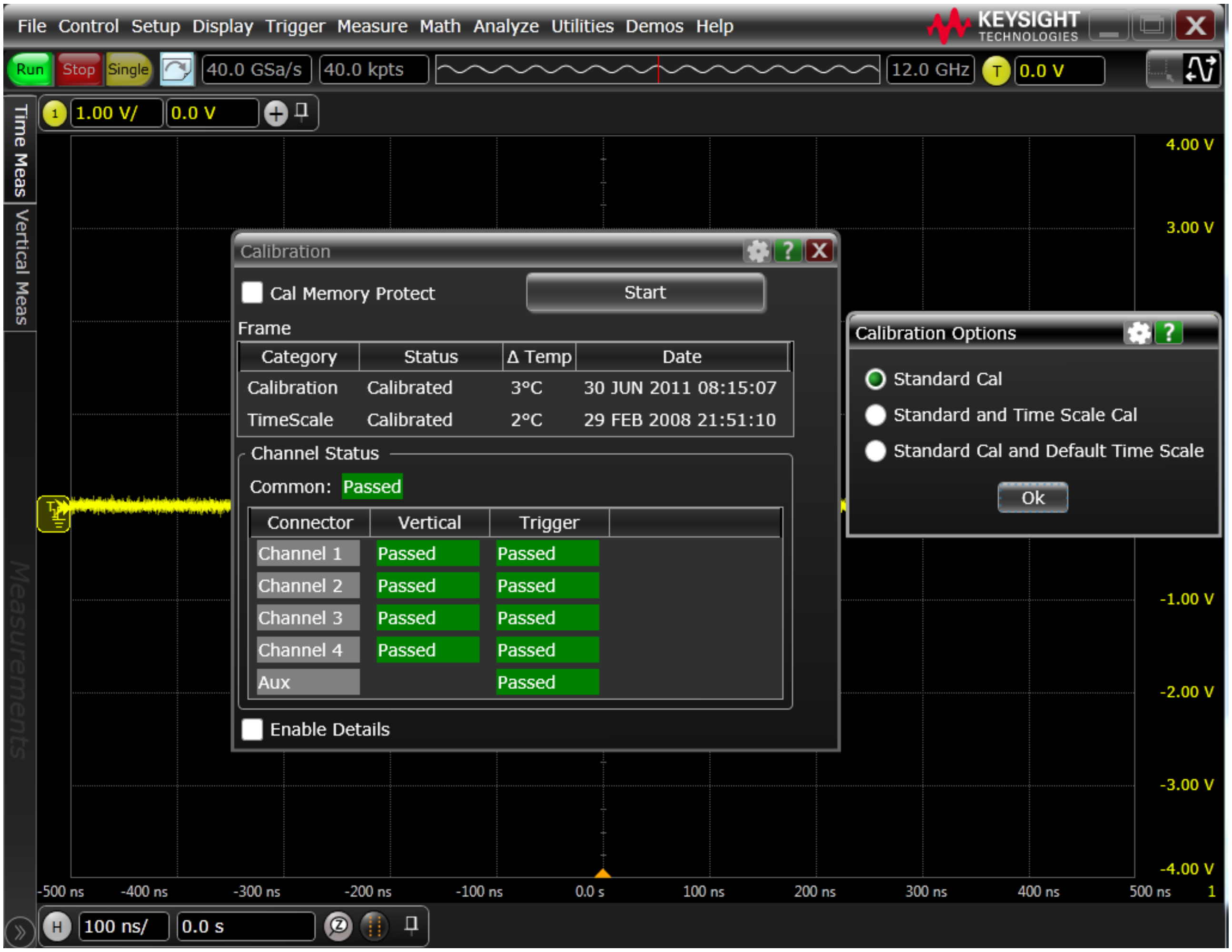


Figure 20 Selecting options from the **Calibration Options** dialog

The options under the **Calibration Options** dialog are:

- **Standard Calibration**—Oscilloscope does not perform time scale calibration and uses calibration factors from the previous time scale calibration and the reference signal is not required. The rest of the calibration procedure continues.
- **Standard and Time Scale Cal**—Oscilloscope performs time scale calibration. You must connect a reference signal to the Oscilloscope Channel, after ensuring that the reference signal meets the following specifications. Failure to meet these specifications result in an inaccurate calibration.

- **Standard Cal and Default Time Scale**—Oscilloscope uses the default time scale calibration factors and does not require the 10 MHz reference signal. The rest of the calibration procedure continues.

e Disconnect everything from all inputs and Aux Out.

f Connect the calibration cable from Aux Out to a specific Channel.

g Connect the calibration cable from Aux Out to each of the Channel inputs as requested.

h Connect the 50 Ω BNC cable from the Aux Out to the Aux Trig on the front panel of the Oscilloscope.

i A Passed/Failed indication is displayed for each calibration section. If any section fails, check the calibration cables and run the Oscilloscope **Self Test...** in the **Utilities...** menu.

j After the calibration procedure is completed, click **Close**.

NOTE

These steps do not need to be performed every time a test is run. However, if the ambient temperature changes more than 5 degrees Celsius from the calibration temperature, this calibration should be performed again. The delta between the calibration temperature and the present operating temperature is shown in the **Utilities>Calibration** menu.

Probe Calibration and De-skew

Along with calibrating the Infiniium Oscilloscope, it is a good practice to calibrate and de-skew the probes, before you start running the automated tests.

Required Equipment for Probe Calibration

Before performing the compliance tests, calibrate the probes. Calibration of the solder-in probe heads consists of a vertical calibration and a skew calibration. The vertical calibration should be performed before the skew calibration. Both calibrations should be performed for best probe measurement performance.

The calibration procedure requires the following parts.

- BNC (male) to SMA (male) adapter
- Deskew fixture
- 50 Ω SMA terminator

SMA Probe Head Attenuation/Offset Calibration

Perform the following steps

1. Connect BNC (male) to SMA (male) adapter to the deskew fixture on the connector closest to the yellow pincher.
2. Connect the 50 Ω SMA terminator to the connector farthest from the yellow pincher.
3. Connect the BNC side of the deskew fixture to the Aux Out BNC of the Infiniium oscilloscope.
4. Connect the probe to an oscilloscope channel.
5. To minimize the wear and tear on the probe head, it should be placed on a support to relieve the strain on the probe head cables.
6. Push down the back side of the yellow pincher. Insert the probe head resistor lead underneath the center of the yellow pincher and over the center conductor of the deskew fixture. The negative probe head resistor lead or ground lead must be underneath the yellow pincher and over one of the outside copper conductors (ground) of the deskew fixture. Make sure that the probe head is approximately perpendicular to the deskew fixture.
7. Release the yellow pincher.

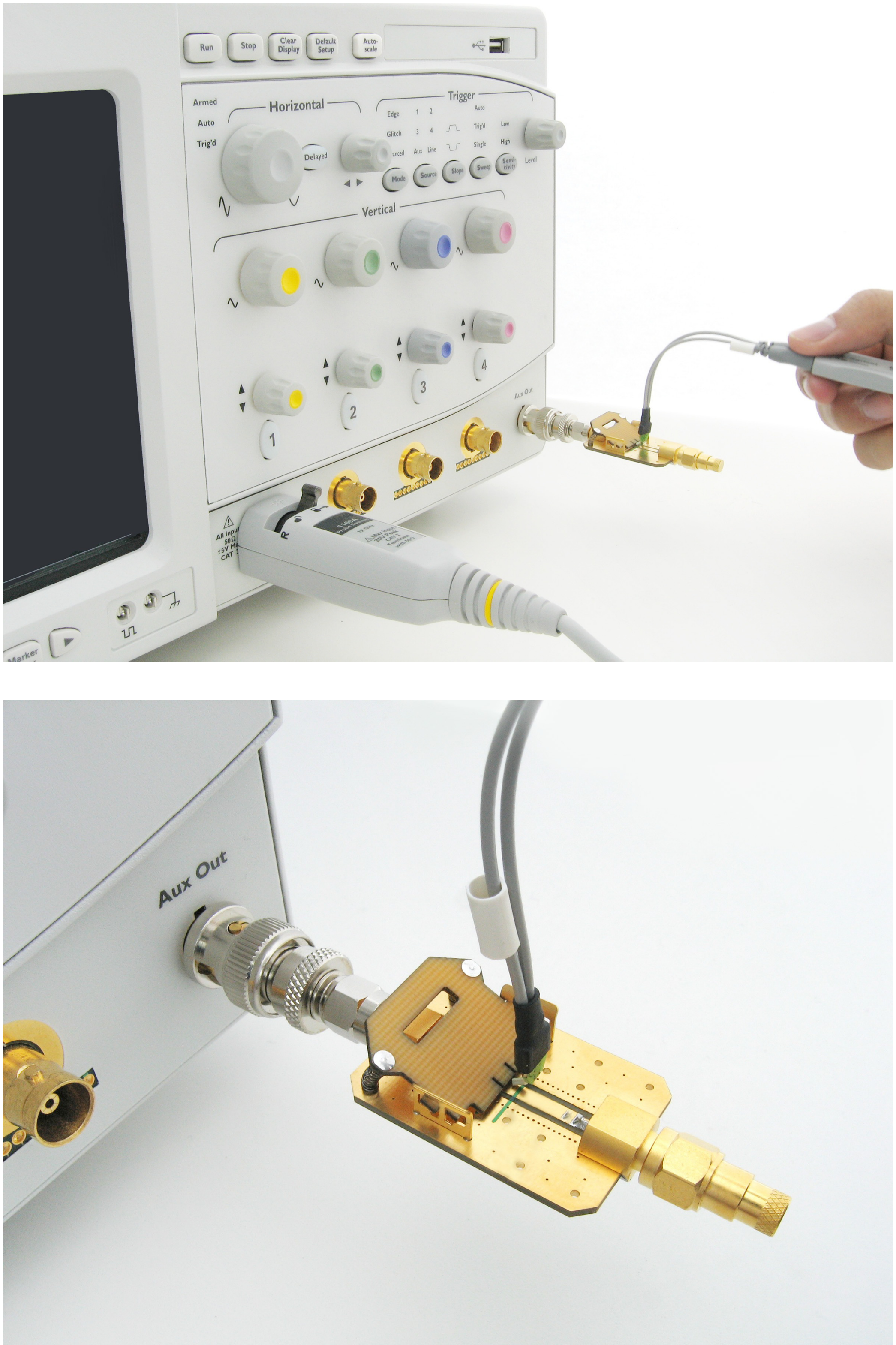


Figure 21 Example of Solder-in Probe Head Calibration Connection

8 To verify the connection, press the autoscale button on the front panel of the Infiniium Oscilloscope.

9 Set the volts per division to 100 mV/div.

10 Set the horizontal scale to 1.00 ns/div.

11 Set the horizontal position to approximately 3ns. A waveform similar to the one displayed in Figure 22 must appear.

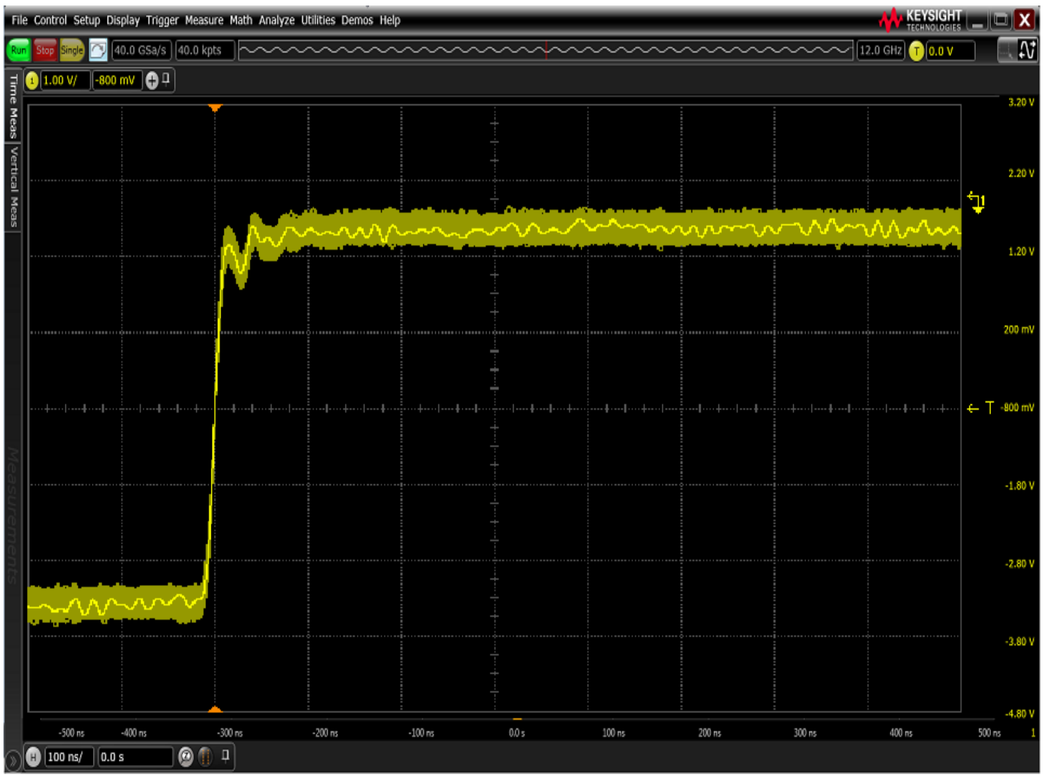


Figure 22 Example of a waveform when the probe connection is good

If a waveform similar to that shown in Figure 23 appears, it indicates that there is a bad connection and you must check all your probe connections.

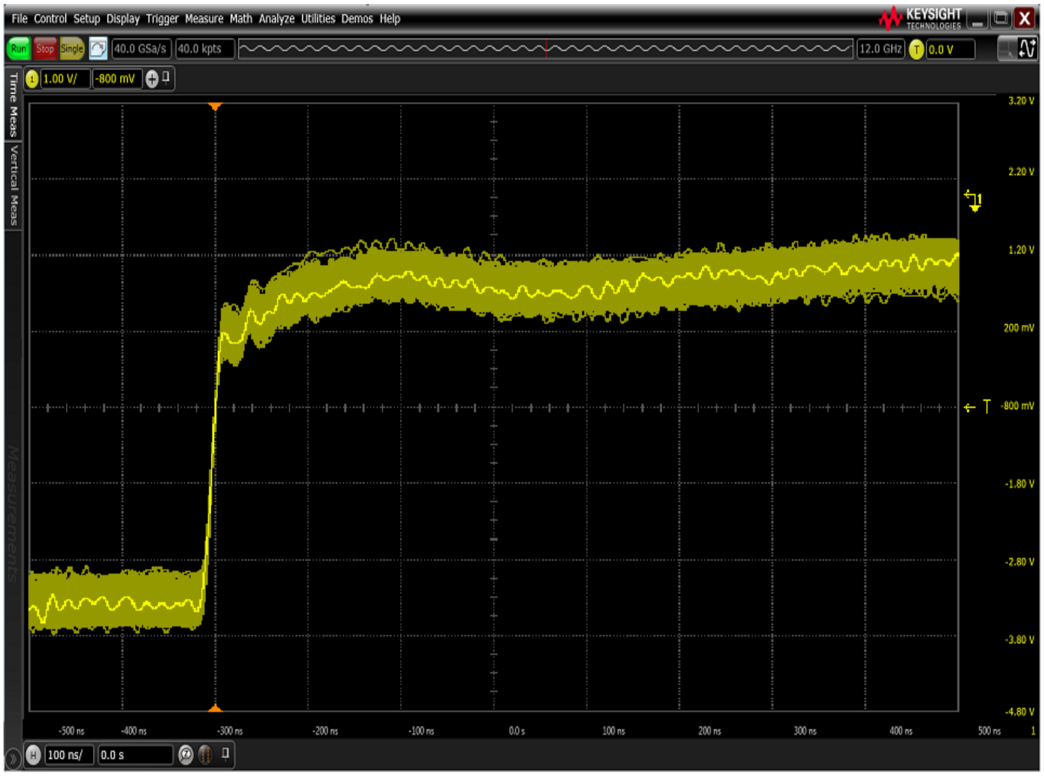
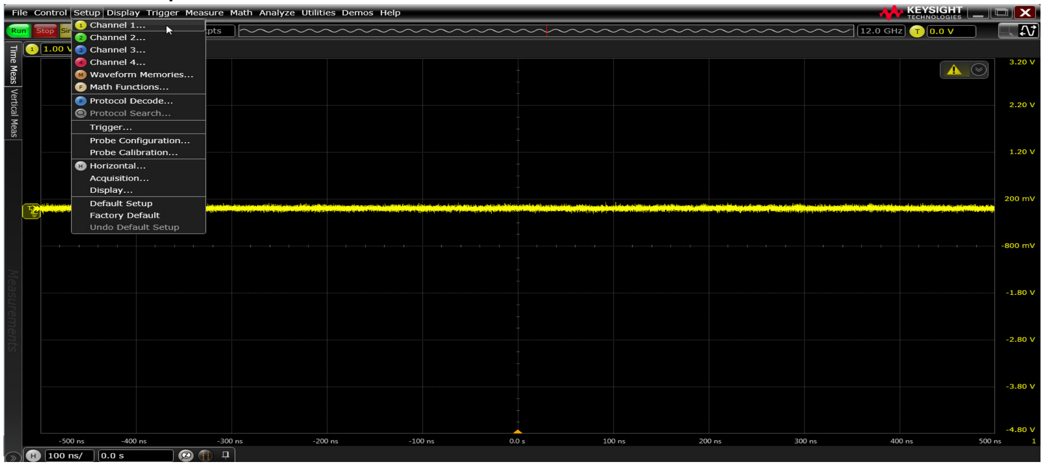


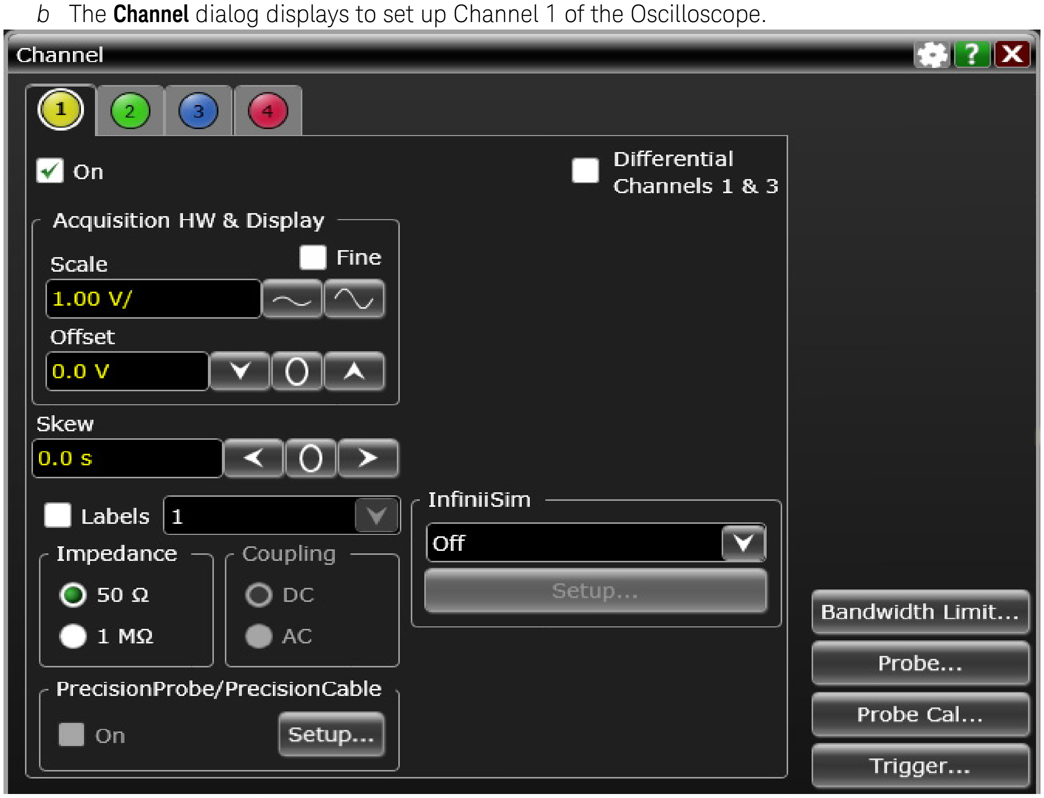
Figure 23 Example of a waveform when the probe connection is bad

12 On the Infiniium Oscilloscope,

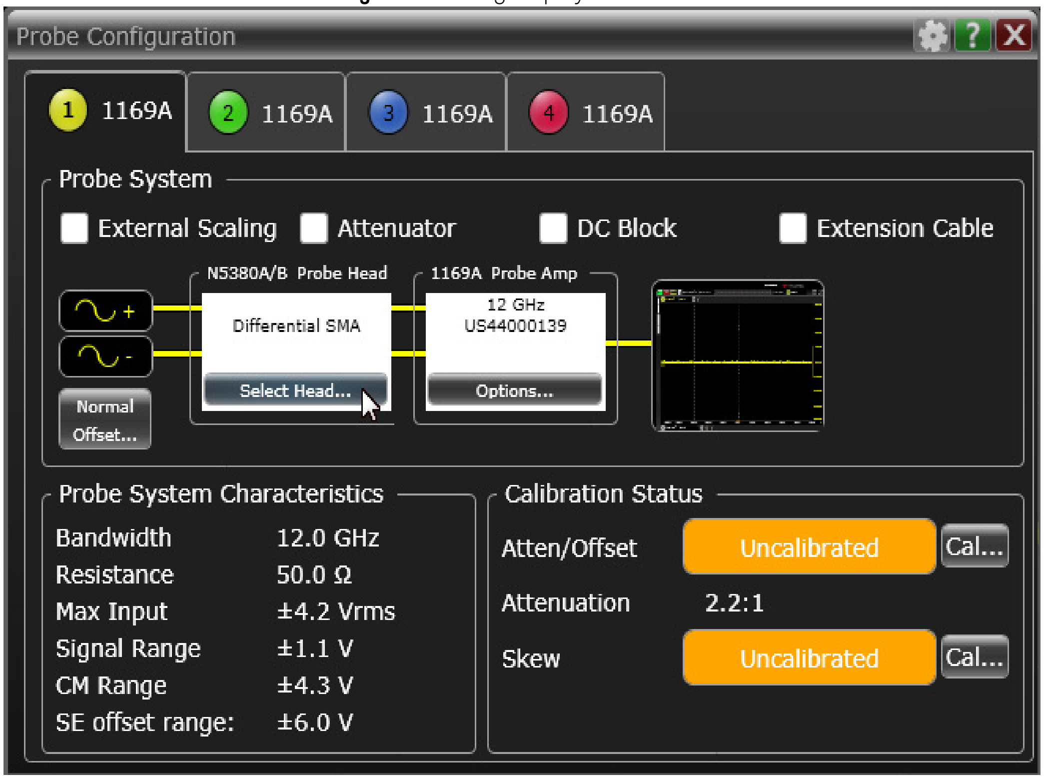
a Click **Setup>Channel 1...**.



b The **Channel** dialog displays to set up Channel 1 of the Oscilloscope.



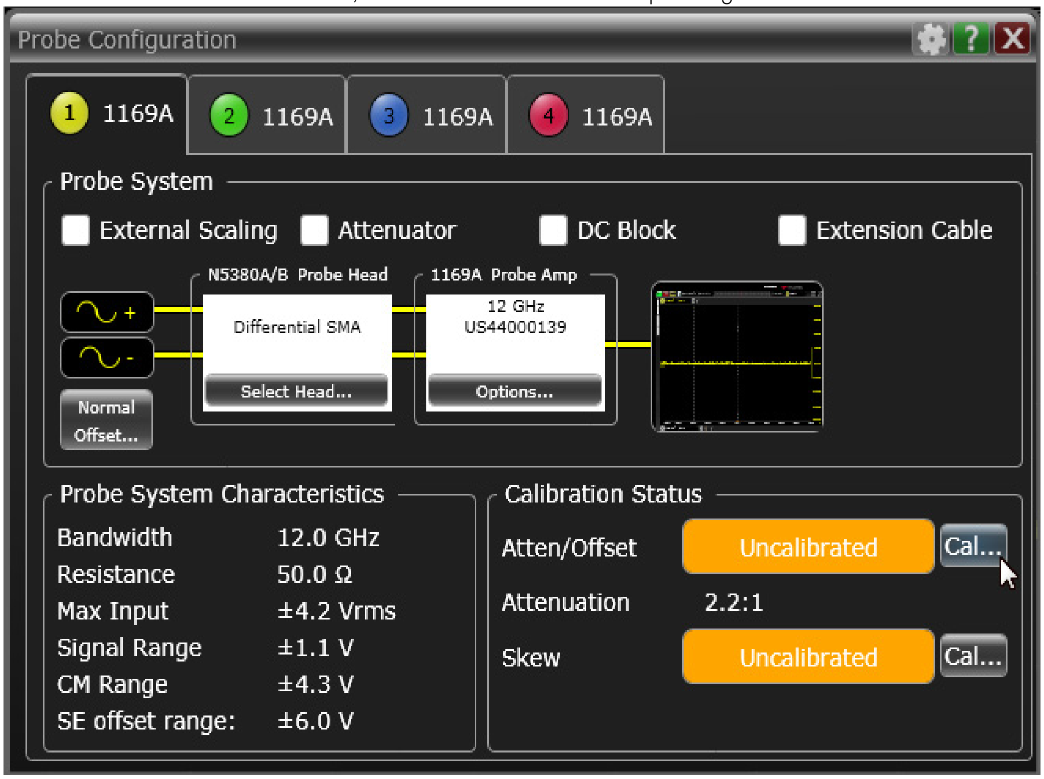
c Click **Probe...**. The **Probe Configuration** dialog displays.



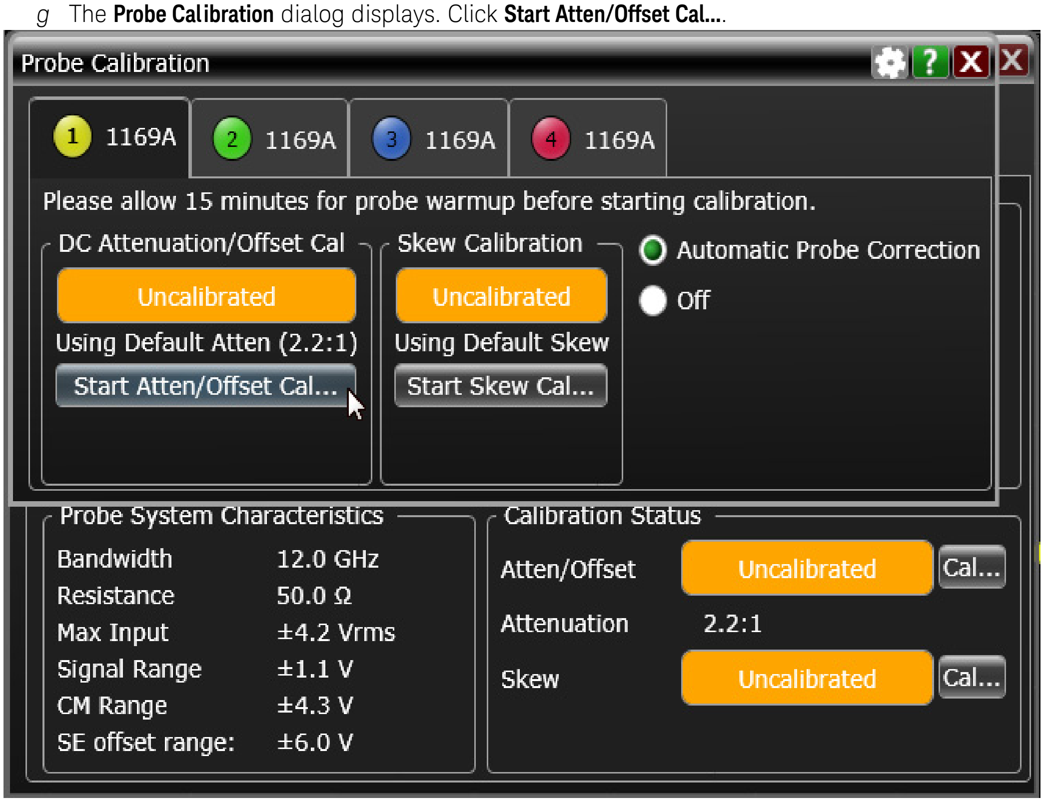
d In the **Differential SMA** block, click the **Select Head...** button.

e Select **N5380A/B** from the list.

f In the **Calibration Status** area, click the **Cal...** button corresponding to **Atten/Offset**.



g The **Probe Calibration** dialog displays. Click **Start Atten/Offset Cal...**.

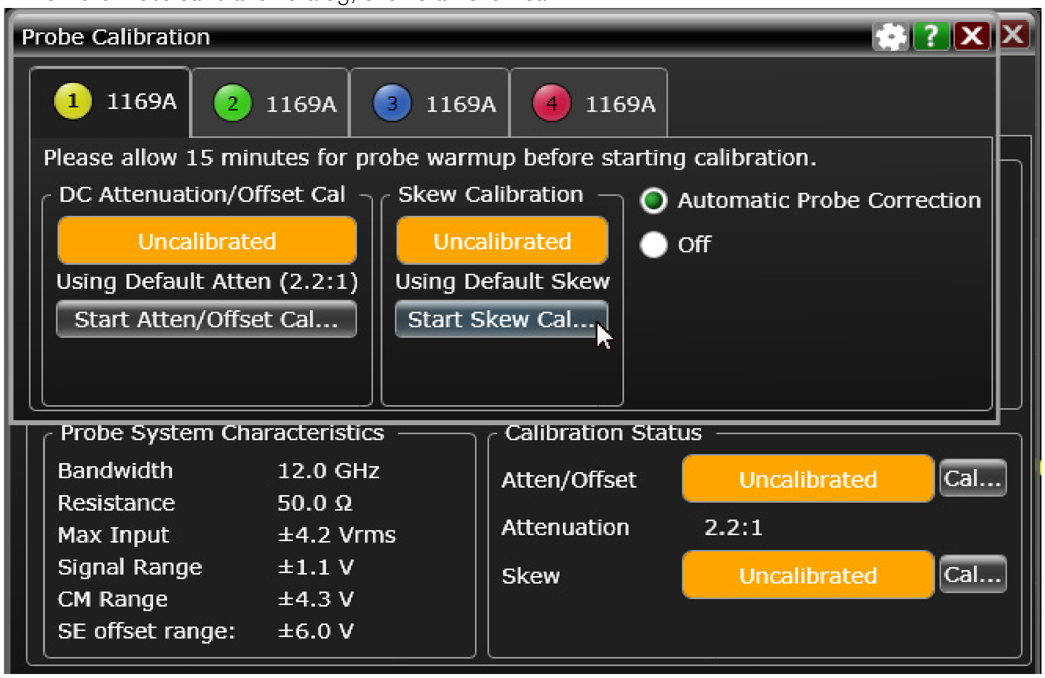


h The Calibration wizard displays. Follow the on-screen instructions. At the end of the Atten/Offset Calibration, perform the Skew calibration for the SMA Probe Head.

SMA Probe Head Skew Calibration

This procedure ensures that the timing skew errors between channels are minimized. After the Atten/Offset Calibration is done, perform the following steps for skew calibration:

1 On the **Probe Calibration** dialog, click **Start Skew Cal...**.



2 The Calibration wizard displays. Follow the on-screen instructions.

Differential SMA Probe Head Atten/Offset Calibration

Perform the following steps

1 Ensure that a probe, attached to an SMA Probe Head is connected to Channel 1 of the Oscilloscope.

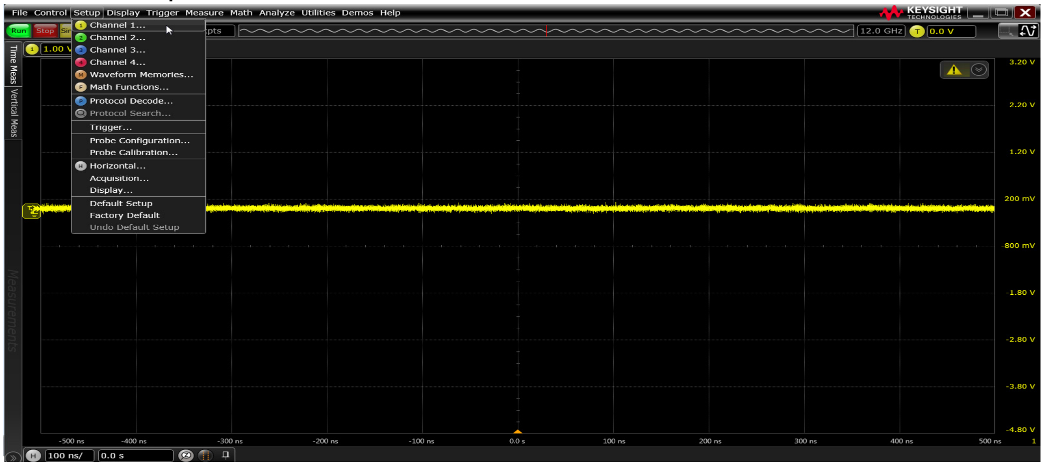
2 Install the 80 Ω resistors into the SMA Probe Head. These resistors are required only for probe calibration and de-skew.

3 Connect the De-skew fixture to AUX Out.

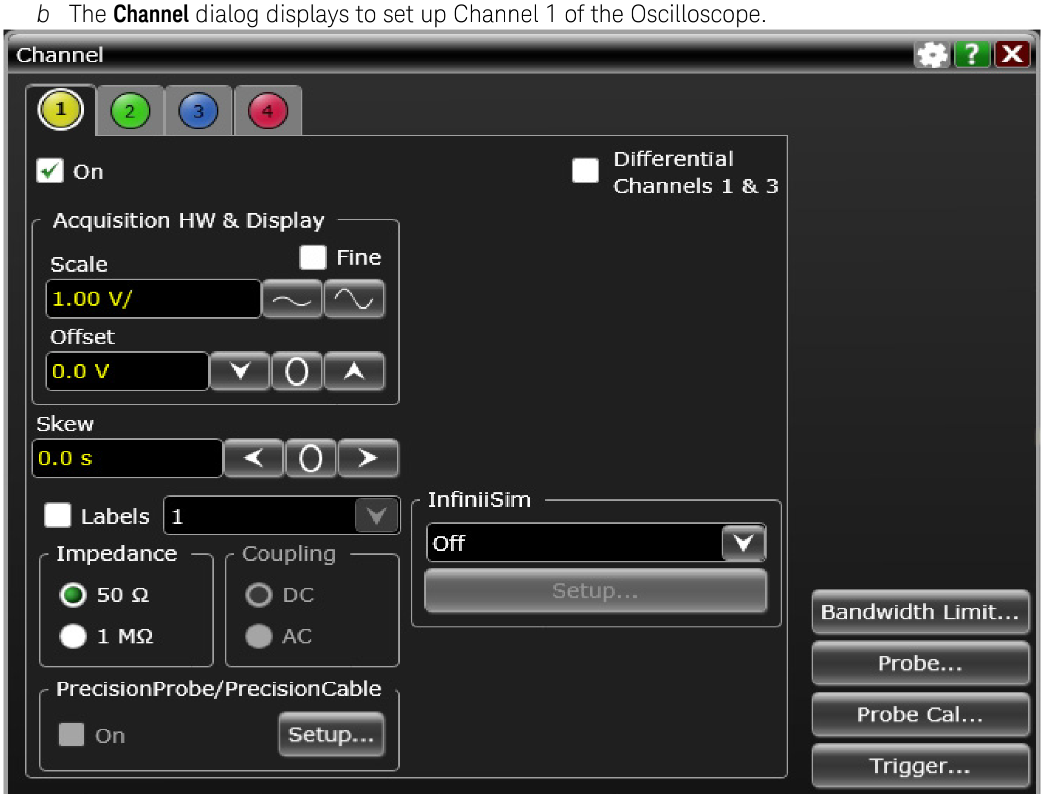
4 Clip the resistors on the De-Skew fixture.

5 On the Infiniium Oscilloscope,

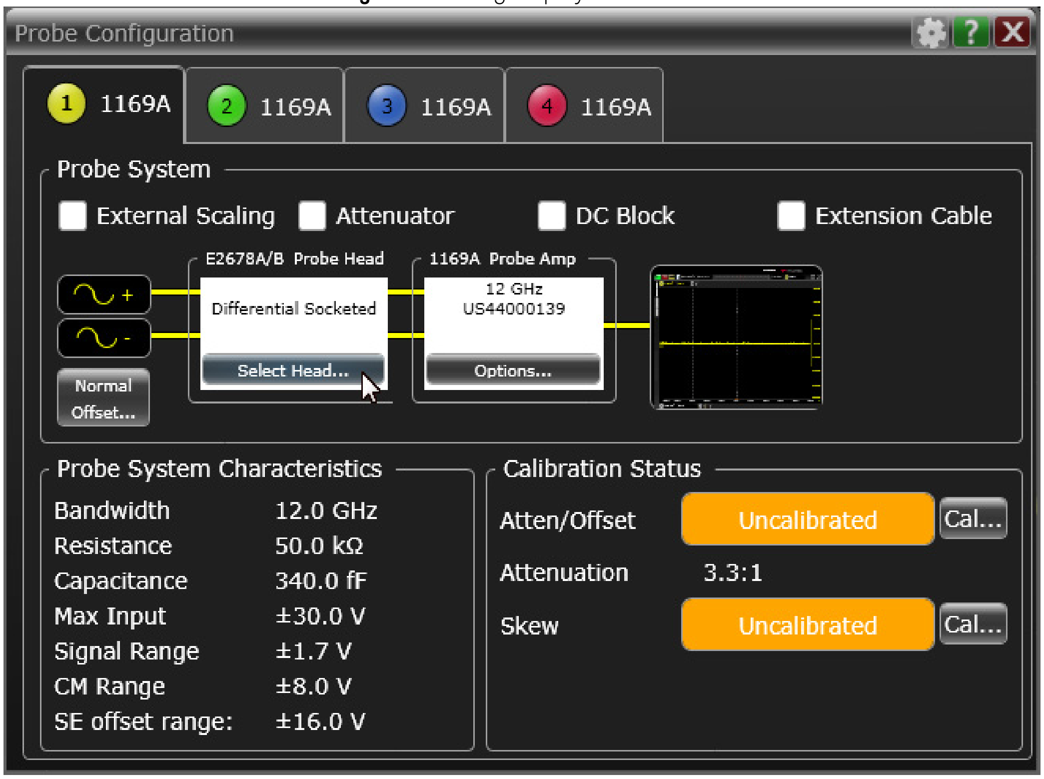
a Click **Setup>Channel 1...**.



b The **Channel** dialog displays to set up Channel 1 of the Oscilloscope.



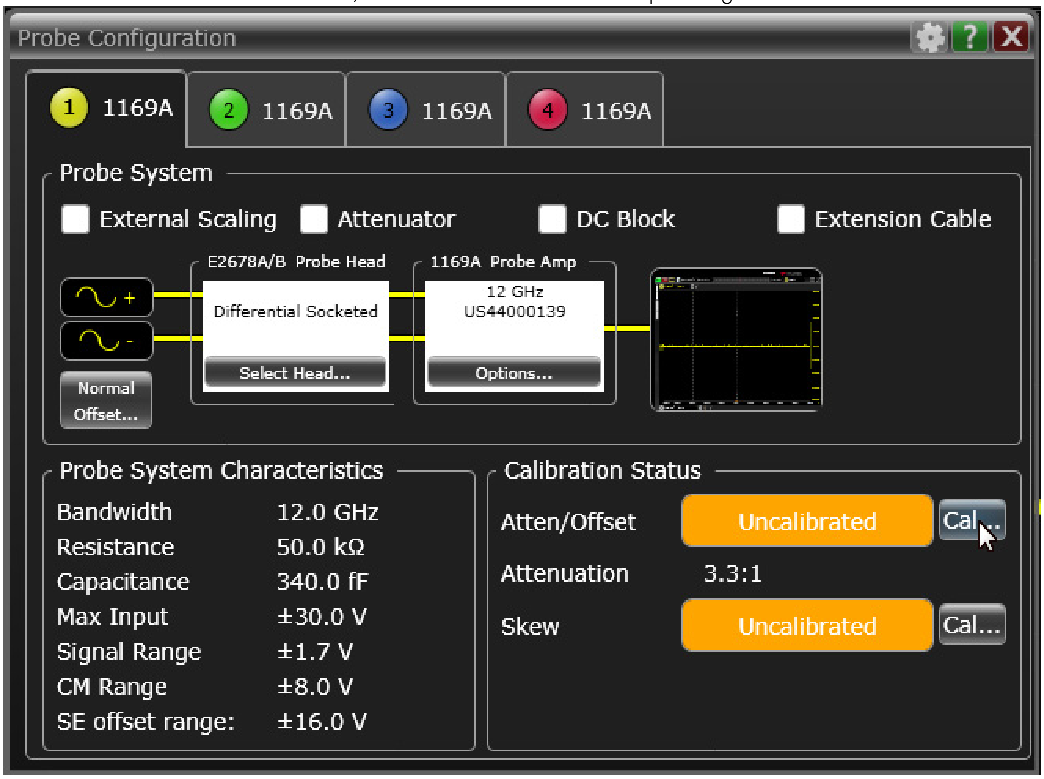
c Click **Probe...**. The **Probe Configuration** dialog displays.



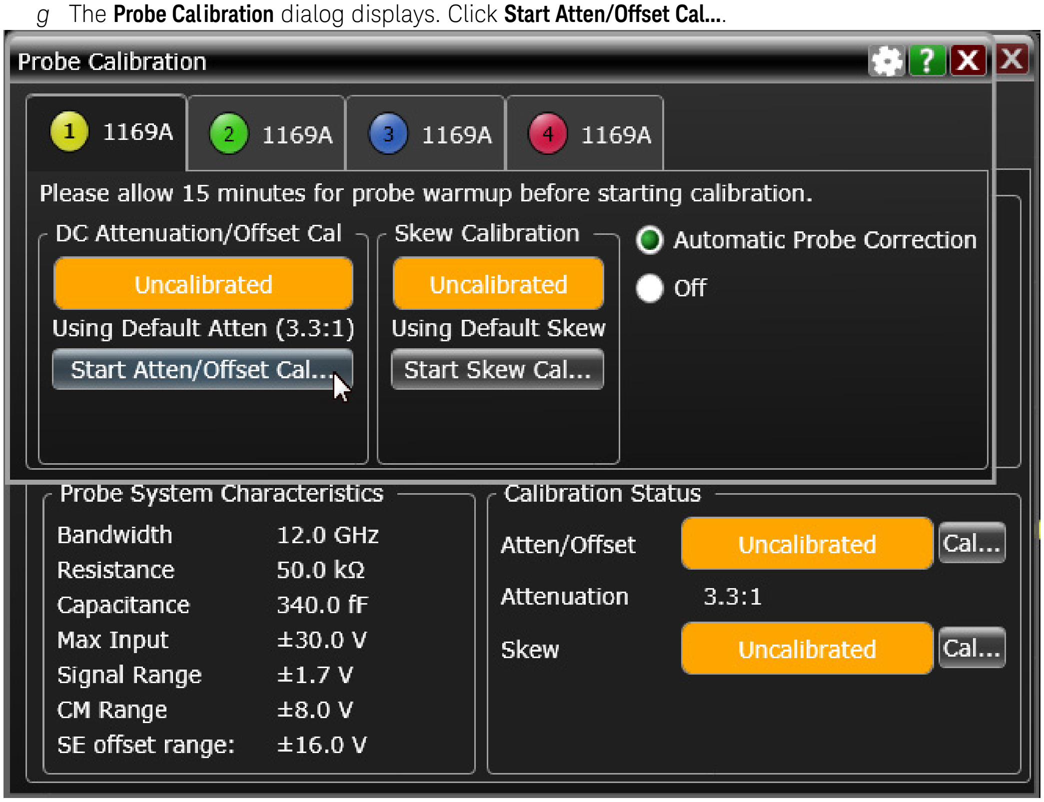
d In the **Differential Socketed** block, click the **Select Head...** button.

e Select **E2678A/B** from the list.

f In the **Calibration Status** area, click the **Cal...** button corresponding to **Atten/Offset**.



g The **Probe Calibration** dialog displays. Click **Start Atten/Offset Cal...**.

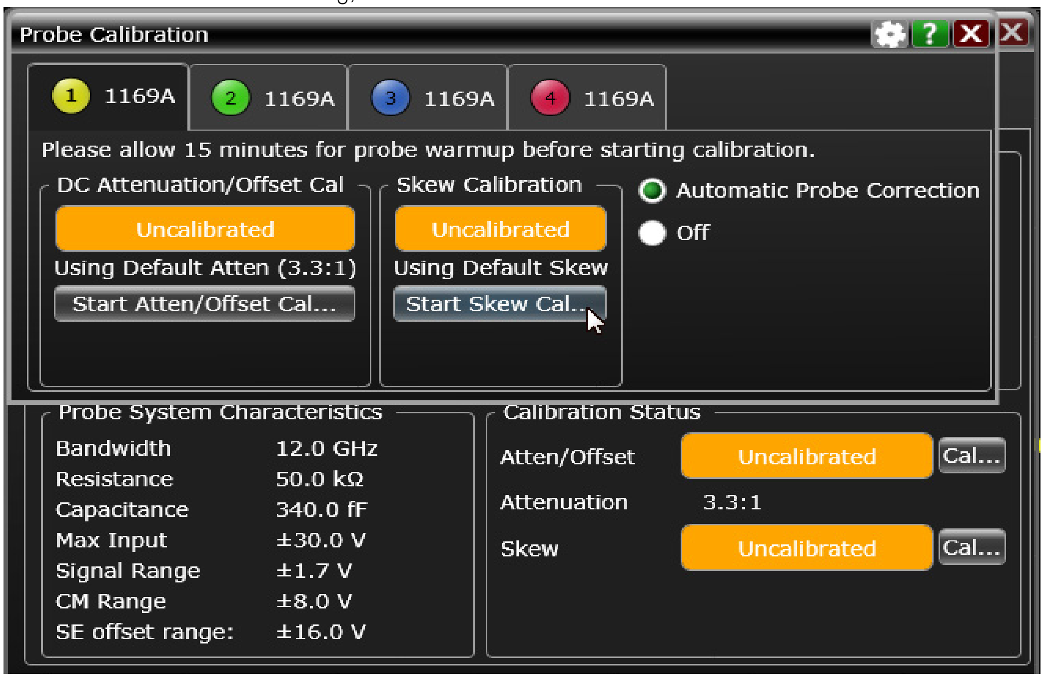


h The Calibration wizard displays. Follow the on-screen instructions. At the end of the Atten/Offset Calibration, perform the Skew calibration for the Differential SMA Probe Head.

Differential SMA Probe Head Skew Calibration

This procedure ensures that the timing skew errors between channels are minimized. After the Atten/Offset Calibration is done, perform the following steps for skew calibration:

1 On the **Probe Calibration** dialog, click **Start Skew Cal...**.



2 The Calibration wizard displays. Follow the on-screen instructions.

For more information on connecting probes to the Infiniium Oscilloscope, refer to the De-skew and Calibration manual. This manual comes together with the E2655A/B/C Probe De-skew and Performance Verification Kit.

NOTE Each probe is calibrated to the Oscilloscope Channel to which it is connected. Do not switch probes between Channels or other Oscilloscopes, else it becomes necessary to calibrate them again. One of the best practices is to label the probes with the Channel number on which they are calibrated.

8 InfiniiMax Probing

This section describes the recommended InfiniiMax Probes used with Keysight Infiniium Oscilloscopes.

Figure 24 1134A InfiniiMax Probe Amplifier

Keysight recommends 116xA or 113xA probe amplifiers, which range from 3.5 GHz to 12 GHz.

Keysight also recommends the E2677A differential solder-in probe head. Other probe head options include N5381A InfiniiMax II 12 GHz differential solder-in probe head, N5425A InfiniiMax ZIF probe head and N5426A ZIF Tips.

Figure 25 E2677A / N5381A Differential Solder-in Probe Head

Table 23 Probe Head Characteristics (with 1134A probe amplifier)

Probe Head	Model Number	Differential Measurement (BW, input C, input R)	Single-Ended Measurement (BW, input C, input R)
Differential Solder-in	E2677A	7 GHz, 0.27 pF, 50 kOhm	7 GHz, 0.44 pF, 25 kOhm

Used with 1168A or 1169A probe amplifier, the E2677A differential solder-in probe head provides 10 GHz and 12 GHz bandwidth respectively.

Index

A

ambient temperature, 16

B

BNC to SMA male adapter, 74

C

calibrating the oscilloscope, 73
calibration cable, 74
Calibration Options
  , 78
  Standard Cal and Default Time Scale, 79
  Standard Calibration, 78
circuit diagram, 22
common-point voltage, 33
configuration options, 24
Connect, 18

D

differential solder-in probe head, 93

E

Equation
  common-point voltage, 34
  common-point voltage mismatch, 35
  differential data waveform, 29
  Differential Voltage Mismatch, 31
  Post-EOT Rise Time, 45
  T3-PREPARE, 69
  THS-EXIT, 70
  TLPX Duration, 66

H

High-Speed mode, 23
Histogram, 30, 50

I

in this book, 4

K

keyboard, 3, 74
Keysight Web site, 12

L

label, 16
license code, 13
license key, installing, 13
Low-Power mode, 23
LP Observation, 51

M

MIPI, 3
mouse, 3, 74

O

Online Help, 4
Option ID Number, 13

P

precision 3.5 mm BNC to SMA male adapter, 74
Probing for Single-Ended Signals AC Input Parameters Tests, 28

R

report, 18
required equipment and software, 3
Results, 18

S

Select Tests, 18
self calibration, 75
Slew Rate, 58
State
  LP-000, 68
  LP-001, 66
  LP-111, 70

T

Test App
  Automation, 18
  Configure, 18
  connect, 18
  HTML report, 18
  results, 18
  run tests, 18
  select tests, 18
  Set Up, 18
test groups, 24
threshold levels, 40
timing skew errors, 87

V

Voltages
  differential, 28
  single-ended, 28

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