R&S®RTP-K28
C-PHY Compliance Test
User Manual

1179647202
Version 02

ROHDE&SCHWARZ
Make ideas real

This manual describes the C-PHY compliance test procedures with the following option:

- R&S®RTP-K28 (1802.9621.02) - C-PHY

The tests require the R&S ScopeSuite software.

The software contained in this product uses several valuable open source software packages. For information, see the "Open Source Acknowledgment" document, which is available for download from the R&S RTP product page at http://www.rohde-schwarz.com/product/rto.html > "Software".
Rohde & Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

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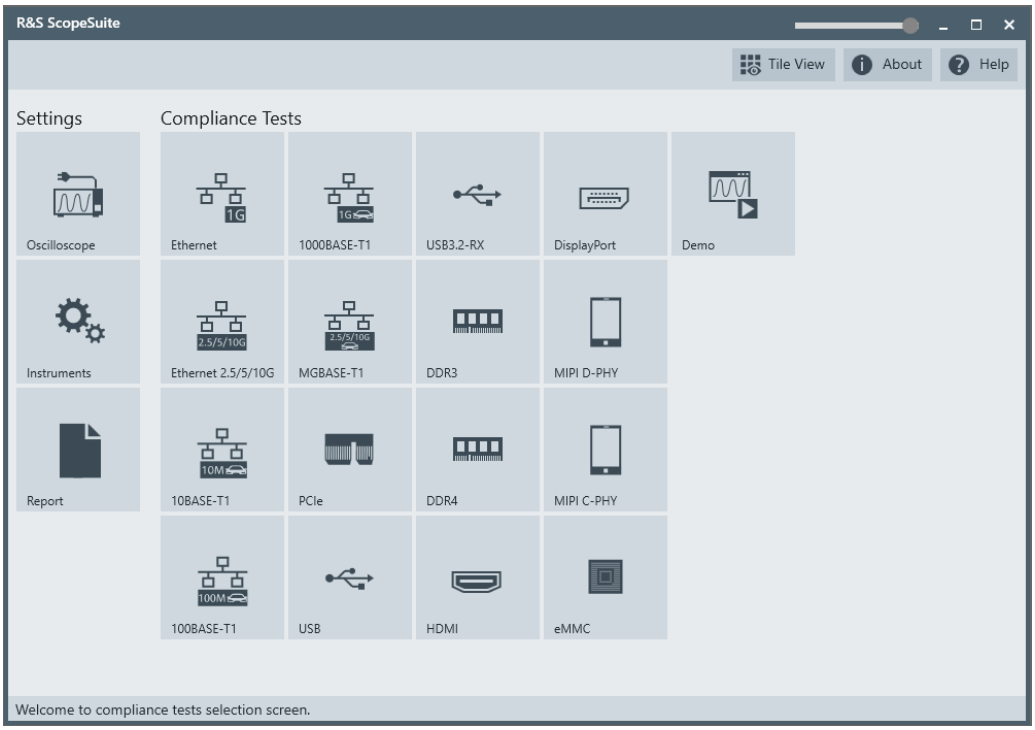
1179.6472.02 | Version 02 | R&S®RTP-K28

The following abbreviations are used throughout this manual: R&S®RTP is abbreviated as R&S RTP and R&S®ScopeSuite is abbreviated as R&S ScopeSuite.

Contents

1 R&S ScopeSuite overview

The R&S ScopeSuite software is used with R&S RTP oscilloscopes. It can be installed on a test computer or directly on the oscilloscope. For system requirements, refer to the Release Notes.



The R&S ScopeSuite main panel has several areas:

- "Settings": connection settings to oscilloscope and other instruments also default report settings
- "Compliance Tests": selection of the compliance test
- "Demo": accesses demo test cases that can be used for trying out the software without having a connection to an oscilloscope
- : shift sideways to change the transparency of the dialog box
- "Help": opens the help file, containing information about the R&S ScopeSuite configuration
- "About": gives information about the R&S ScopeSuite software
- "Tile View": allows a personalization of the compliance test selection
  You can configure which tests are visible in the compliance test section and which are hidden, so that only the ones you use are displayed.

► To hide a test from the "Compliance Tests" view, do one of the following:

a) Right-click on the compliance test that you want to hide.
The icon of the test changes, see Figure 1-1. Now with a left click you can hide the test.

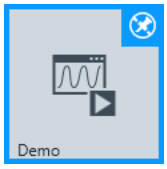


Figure 1-1: Unpin icon

b) Click on "Title View" to show a list of the available test cases. By clicking a test case in the show list, you can pin/unpin it from the main panel.

2 Preparing the measurements

2.1 Test equipment

For C-PHY compliance tests, the following test equipment is needed:

- R&S RTP oscilloscope with 4 channels and at least 13 GHz bandwidth
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the oscilloscope.
- Differential probes
- Three singled-ended active probes or SMA cables.
- R&S RTP-K28 C-PHY compliance test option (required option, installed on the oscilloscope)
- For Eye Tests: option R&S RTP-K136 or R&S RTP-K137 Advanced eye analysis
- Recommended test fixture for LP-TX tests: MIPI C-PHY Capacitive Load (C_{LOAD}) fixture
- Recommended termination board for HS-TX tests: MIPI C-PHY Reference Termination Board (RTB)

2.2 Installing software and license

The preparation steps are performed only once for each computer and instrument that are used for testing.

Uninstall older versions of the R&S ScopeSuite

If an older version of the R&S ScopeSuite is installed, make sure to uninstall the old version before you install the new one. You can find the version number of the current installation in "Help" menu > "About". To uninstall the R&S ScopeSuite, use the Windows " Control Panel" > "Programs".

For best operation results, we recommend that the installed firmware versions of the R&S ScopeSuite and the oscilloscope are the same.

To install the R&S ScopeSuite

1. Download the latest R&S ScopeSuite software from the "Software" section on the Rohde & Schwarz R&S RTP website:
   www.rohde-schwarz.com/product/rtp.html
   www.rohde-schwarz.com/product/rto.html
2. Install the R&S ScopeSuite software:
   - On the computer that is used for testing, or
   - On the R&S RTP.

For system requirements, refer to the Release Notes.

To install the license key on the R&S RTP

► When you got the license key of the compliance test option, enable it on the oscilloscope using [Setup] > "SW Options".
For a detailed description, refer to the R&S RTP user manual, chapter "Installing Options", or to the online help on the instrument.

2.3 Setting up the network

If the R&S ScopeSuite software runs on a test computer, the computer and the testing oscilloscope require a LAN connection.

There are two ways of connection:

- LAN (local area network): It is recommended that you connect to a LAN with DHCP server. This server uses the Dynamic Host Configuration Protocol (DHCP) to assign all address information automatically.
  If no DHCP server is available, assign fixed IP addresses to all devices.
- Direct connection of the instruments and the computer or connection to a switch using LAN cables: Assign fixed IP addresses to the computer and the instruments and reboot all devices.

To set up and test the LAN connection

1. Connect the computer and the instruments to the same LAN.
2. Start all devices.
3. If no DHCP server is available, assign fixed IP addresses to all devices.
4. Ping the instruments to make sure that the connection is established.
5. If VISA is installed, check if VISA can access the instruments.
   a) Start VISA on the test computer.
   b) Validate the VISA address string of each device.

See also:

- Chapter 2.5, "Connecting the R&S RTP", on page 9

2.4 Starting the R&S ScopeSuite

To start the R&S ScopeSuite on the test computer or on the oscilloscope:

► Double-click the R&S ScopeSuite program icon.

To start the R&S ScopeSuite on the instrument, in the R&S RTP firmware:

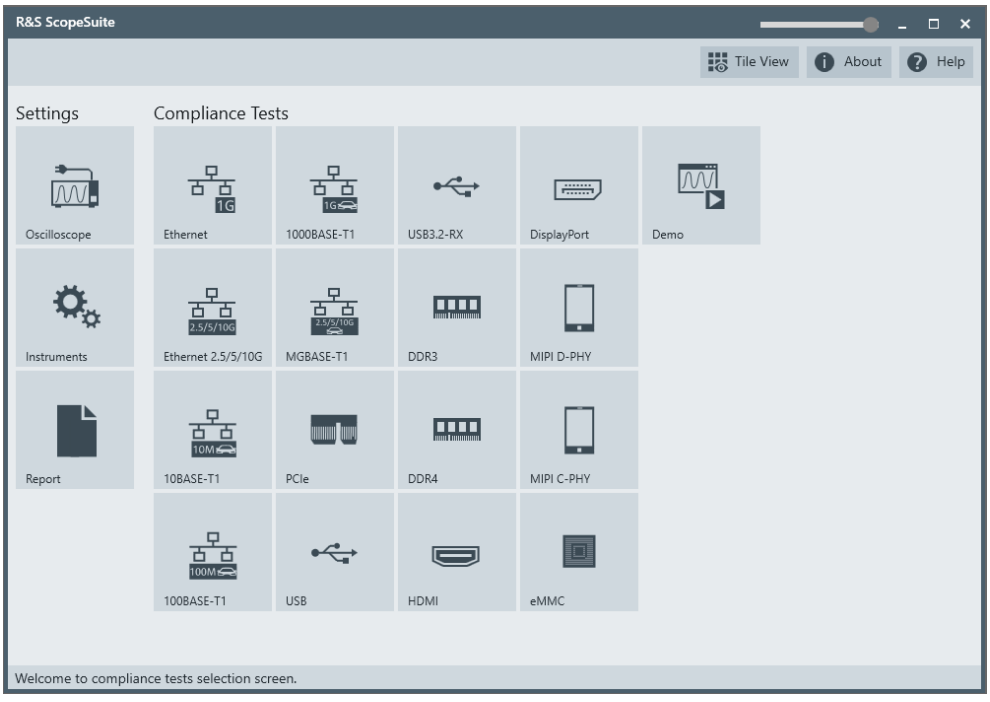
► In the "Apps" dialog, open the "Compliance" tab.

2.5 Connecting the R&S RTP

If the R&S ScopeSuite is installed directly on the instrument, the software detects the R&S RTP firmware automatically, and the "Oscilloscope" button is not available in the R&S ScopeSuite.

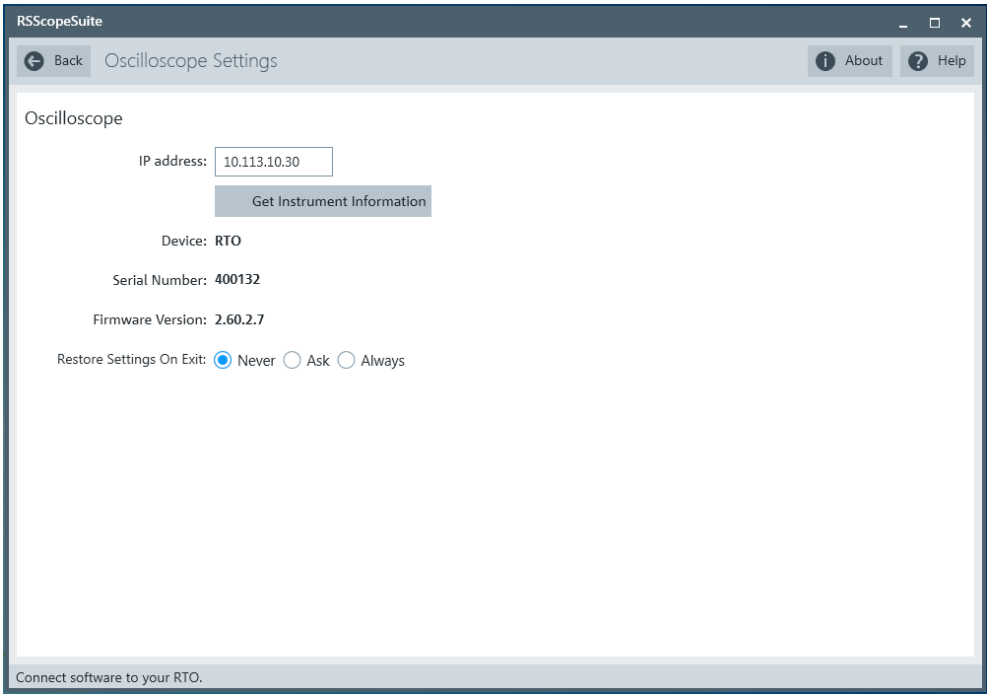
If the R&S ScopeSuite software runs on a test computer, the computer and the testing oscilloscope require a LAN connection, see Chapter 2.3, "Setting up the network", on page 8. The R&S ScopeSuite software needs the IP address of the oscilloscope to establish connection.

1. Start the R&S RTP.
2. Start the R&S ScopeSuite software.
3. Click "Settings" > "Oscilloscope".



4. Enter the IP address of the oscilloscope.
   To obtain the IP address: press the Rohde & Schwarz logo at the top-right corner of the oscilloscope's display.
5. Click "Get Instrument Information".

   The computer connects with the instrument and gets the instrument data.



If the connection fails, an error message is shown.

2.6 Connecting the arbitrary waveform generator

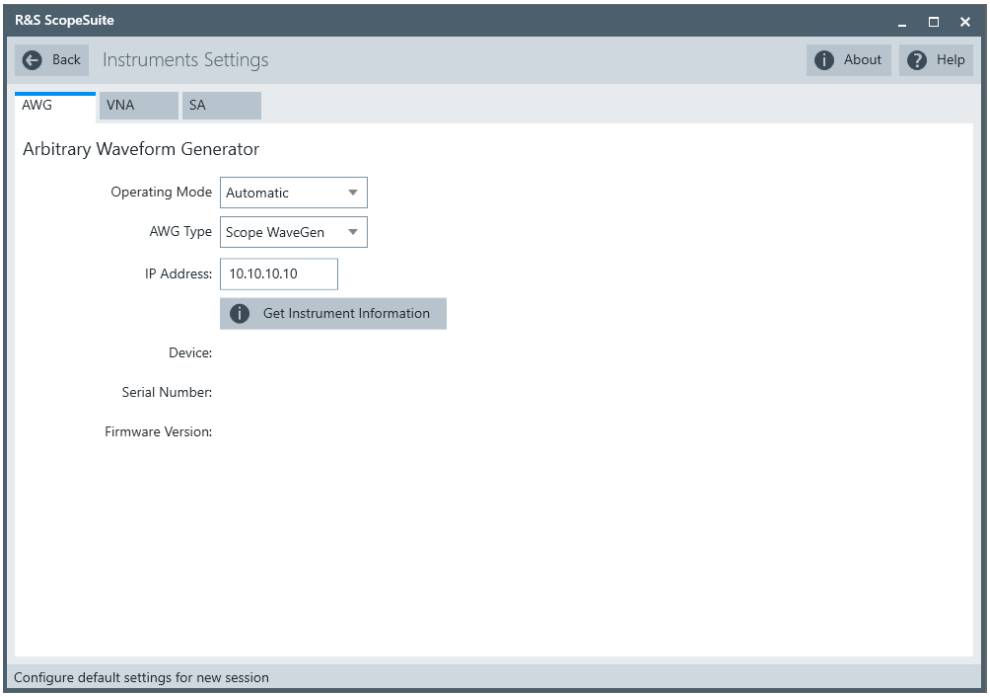
Automatic test execution is possible with all instruments that are listed in the R&S ScopeSuite, in the "Instrument Settings" dialog box. In automatic mode, the R&S ScopeSuite configures the instrument and ensures that the AWG sends the required waveforms. Automatic mode requires a LAN connection and the installation of a VISA implementation (R&S VISA, see www.rohde-schwarz.com/rsvisa) on the computer that is running the R&S ScopeSuite. If the R&S ScopeSuite is installed on the R&S RTP, no installation is needed because VISA is already installed on the instrument. If the Tabor WX2182B / WX2182C or Hameg HMF2550 is used for automatic testing, fixed IP addresses are required.

For manual test execution, it is recommended to use one of the listed AWGs, but you can also use another AWG. In manual mode, you connect the AWG to the test board and configure the instrument manually. VISA is not required. The R&S ScopeSuite uses VISA if it is installed, otherwise it uses the VXI-11 protocol.

To configure the arbitrary waveform generator for automatic testing

1. Connect the computer and the AWG.
2. Set up the LAN connection. See Chapter 2.3, "Setting up the network", on page 8.
3. In the R&S ScopeSuite, click "Instruments".
   Alternatively, you can select the "Instrument" tab in the test case configuration dialog.

4. Click the "AWG" tab.
5. Select "Operating mode" = "Automatic".
6. Select a supported "AWG Type" and enter its IP address.
   For a list of the supported AWGs, see chapter "Test Equipment".



7. Click "Get Instrument Information".

   The computer or R&S RTP connects with the instrument and retrieves the instrument data.
8. If the connection to the arbitrary waveform generator failed, check if the IP address is assigned correctly.

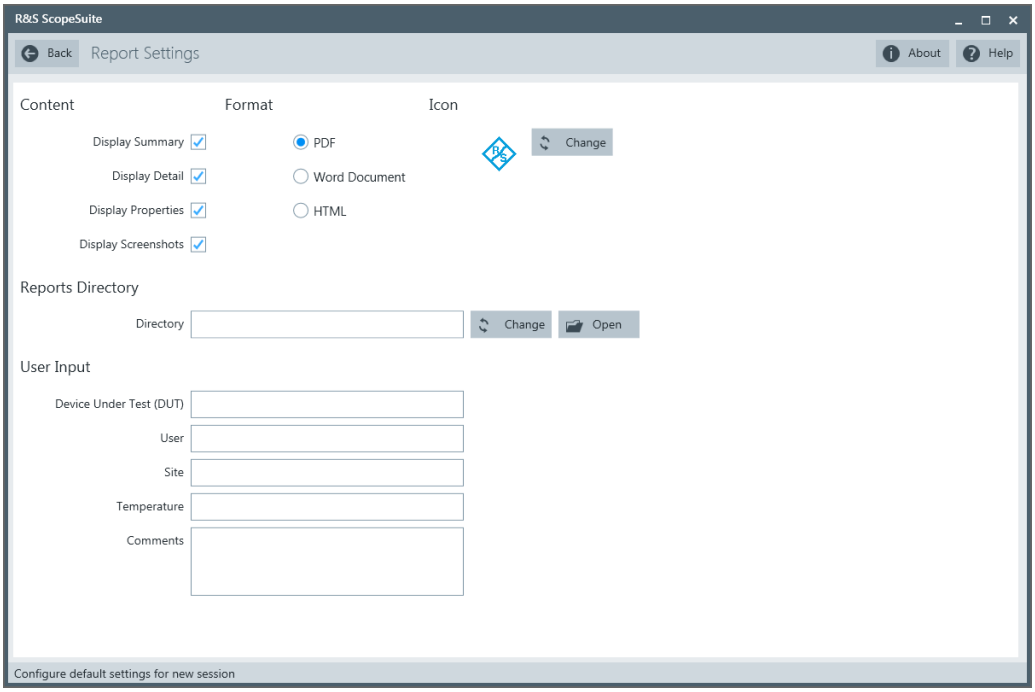
To configure the AWG for manual testing

► In the "AWG" tab, enable the "Manual" operating mode.

2.7 Report configuration

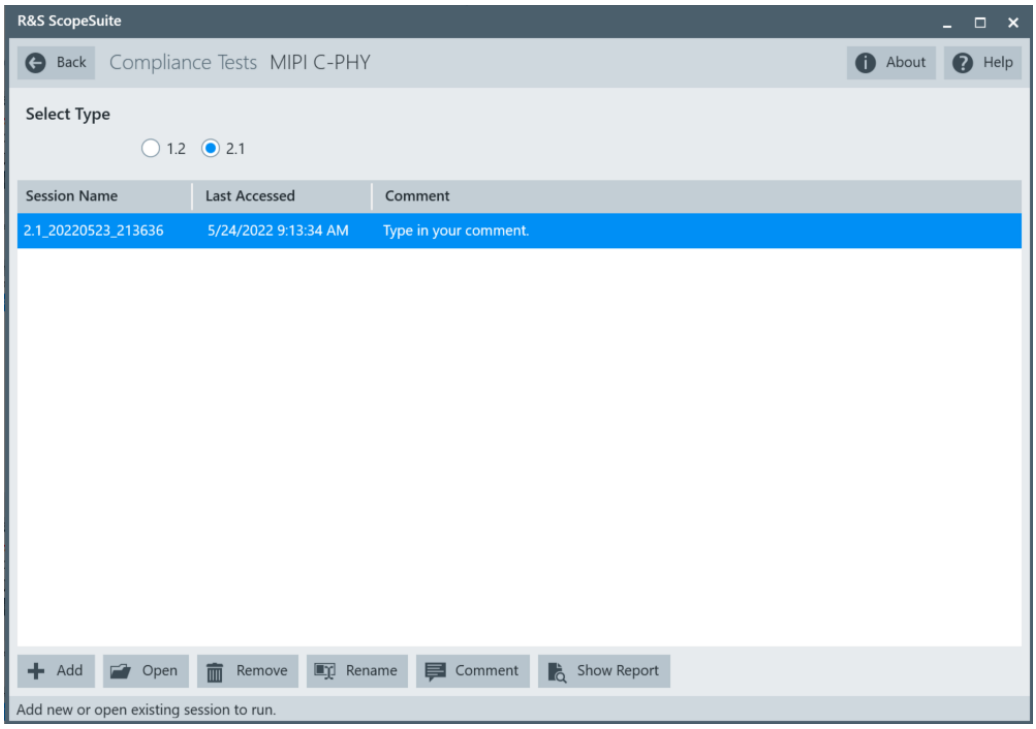
In the "Report Configuration" menu, you can select the format of the report and the details to be included in the report. You can also select an icon that is displayed in the upper left corner of the report.

Also, you can enter common information on the test that is written in the "General Information" section of the test report.


R&S ScopeSuite
Back
Report Settings
About
Help
Content
Format
Icon
Display Summary
Display Detail
Display Properties
Display Screenshots
PDF
Word Document
HTML
Change
Reports Directory
Directory
Change
Open
User Input
Device Under Test (DUT)
User
Site
Temperature
Comments
Configure default settings for new session

3 Performing tests

3.1 Starting a test session



After you open a compliance test, the "Session Selection" dialog appears. In this dialog, you can create new sessions, open or view existing report.

The following functions are available for handling test sessions:

Function	Description
"Add"	Adds a new session
"Open"	Opens the selected session
"Remove"	Removes the selected session
"Rename"	Changes the "Session Name"
"Comment"	Adds a comment
"Show report"	Generates a report for the selected session

To add a test session

1. In the R&S ScopeSuite window, select the compliance test.
2. In the "Session Selection" dialog press "Add".
3. If necessary change the "Session Name"

To open a test session

1. In the R&S ScopeSuite window, select the compliance test.
2. In the "Session Selection" dialog, select the session you want to open and double click on it.
   Alternatively, select the session and press "Open".

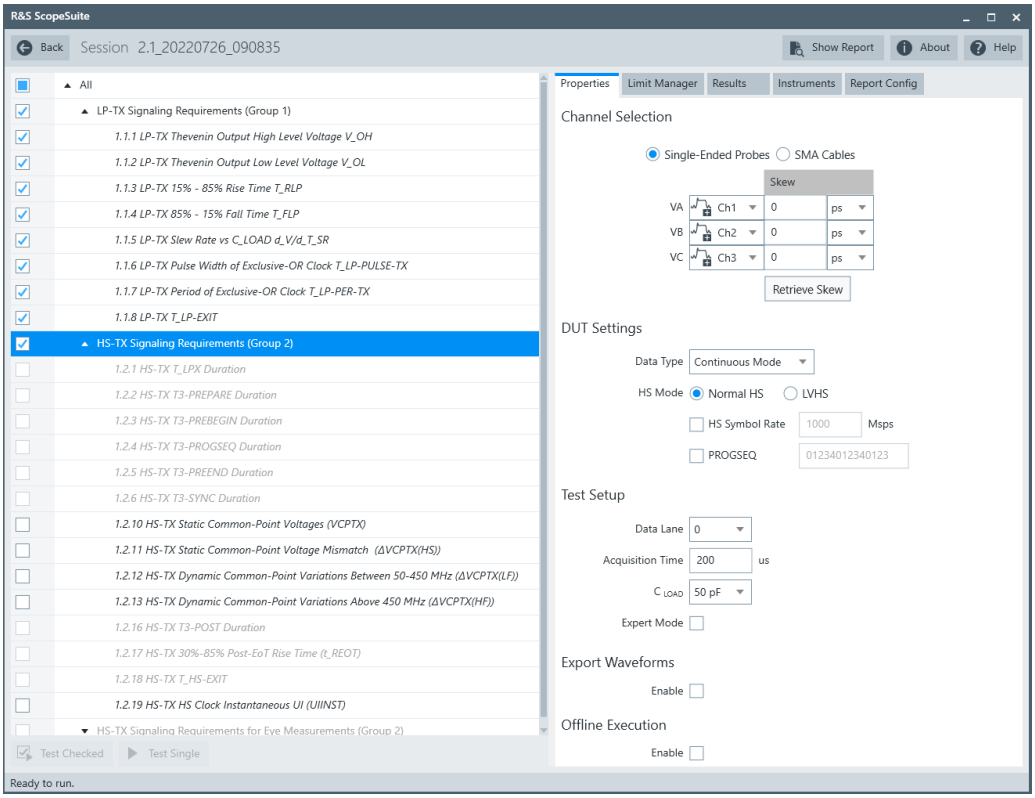
To show a report for a test session

1. In the R&S ScopeSuite window, select the compliance test.
2. In the "Session Selection" dialog, select the session you want the report for and press "Show report".

3.2 Configuring the test

1. In the R&S ScopeSuite window, select the compliance test to be performed:
   - "C-PHY"
2. Open a test session, see Chapter 3.1, "Starting a test session", on page 13.
3. Adjust the "Properties" settings for the test cases you want to perform.
4. Click "Limit Manager" and edit the limit criteria, see Chapter 3.2.1.1, "Limit manager", on page 16.
5. If you want to use special report settings the "Report Config" tab to define the format and contents of the report. Otherwise the settings defined in "RSScopeSuite" > "Settings" > "Report" are used. See Chapter 2.7, "Report configuration", on page 11.
6. Click "Test Checked"/"Test Single" and proceed as described in the relevant test case chapter.

3.2.1 General test settings



Each session dialog is divided into several sections:

- "Properties": shows the settings that can be made for the test case selected on the left side of the dialog. You can differentiate between the "All" and the sub test properties
  In the "All" > "Properties" tab you can configure the settings for all test cases in the current session. Once you change and save a setting in this tab, the changes will be done for all test in the sessions. At the same time, there will be a special marking for the functions that have different settings for different sub tests.
- "Limit Manager": sets the measurement limits that are used for compliance testing, see Chapter 3.2.1.1, "Limit manager", on page 16.
- "Results": shows an overview of the available test results for this session.
- "Instruments": defines instruments settings for connecting to external devices, that are specific for this test session.
  When a session is first created the global settings ("RSScopeSuite" > "Settings" > "Instruments") are copied to the session. This "Instruments" tab can be used to change those copied defaults.
- "Report Config": defines the format and contents of the report for this session.
  When a session is first created the global settings ("RSScopeSuite" > "Settings" > "Report") are copied to the session. This "Report Config" tab can be used to change those copied defaults.
- "Test Checked"/ "Test Single": starts the selected test group.

3.2.1.1 Limit manager

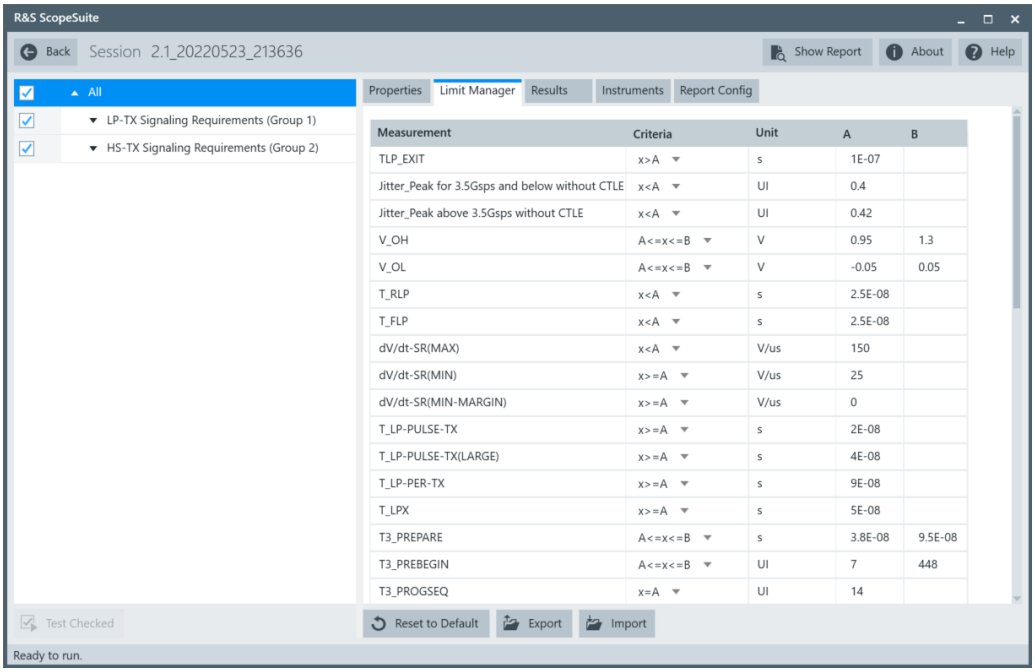
The "Limit Manager" shows the measurement limits that are used for compliance testing.

Each limit comprises the comparison criterion, the unit, the limit value A, and a second limit value B if the criterion requires two limits.

You can set the values to defaults, change the values in the table, export the table in xml format, or import xml files with limit settings.

You can also return the values to the original limits with "Reset to default".

► Check and adjust the measurement limits.



3.3 Getting test results

If you resume an existing session, new measurements are appended to the report, new diagrams and waveform files are added to the session folder. Existing files are not deleted or replaced. Sessions data remain until you delete them in the "Results" tab of the session.

The report format can be defined in "RSScopeSuite" > "Settings" > "Report" for all compliance tests (see also Chapter 2.7, "Report configuration", on page 11). If you want to use special report settings for a session, you can define the format and contents of the report in the "Report Config" tab of the session.

All test results are listed in the "Results" tab. Reports can be provided in PDF, MSWord, or HTML format. To view and print PDF reports, you need a PDF viewer, for example, the Acrobat Reader.

The test report file can be created at the end of the test, or later in the "Session Selection" dialog.

To show a test report

1. In the R&S ScopeSuite window, select the compliance test to be performed.
2. Select the session name in the "Session Selection" dialog and click "Show report".

   The report opens in a separate application window, depending on the file format. You can check the test results and print the report.

To delete the results, diagrams and waveform files of a session

1. In the "Session Selection" dialog select the session and open it.
2. In the "Results" tab, select the result to be deleted.
3. Click "Remove".

4 C-PHY compliance tests

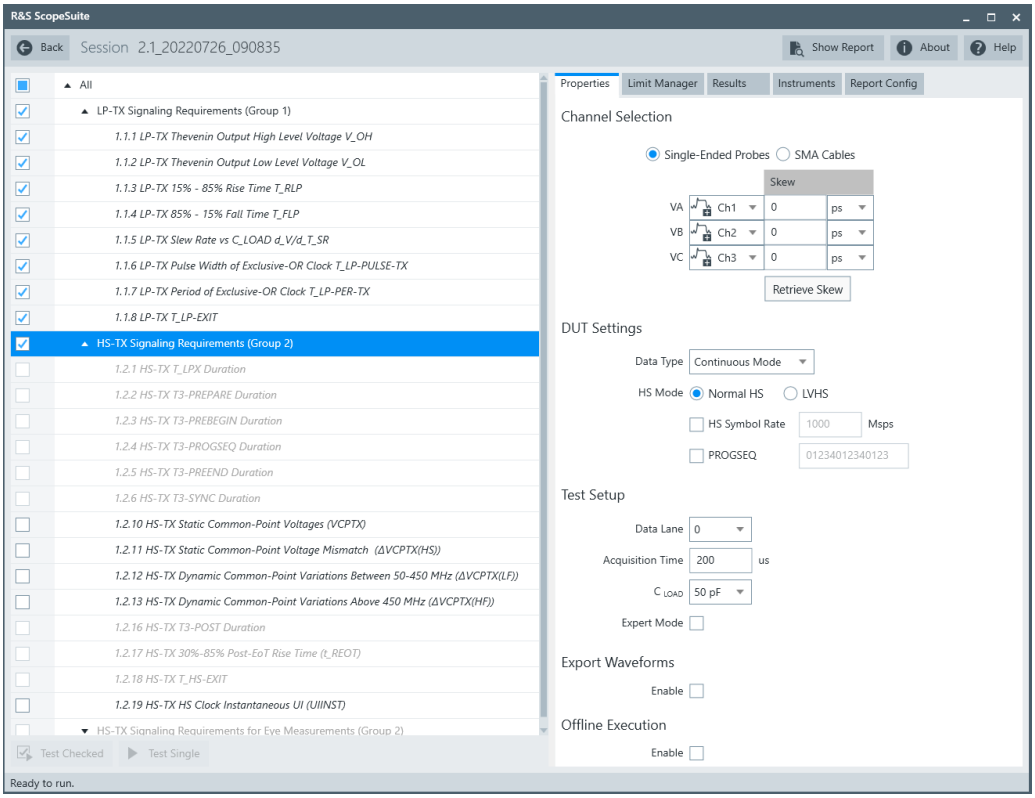
The software closely follows the MIPI Alliance's **Conformance Test Suite for C-PHY℠ Specification version 2.1**, dated July 31th, 2020.

4.1 Starting C-PHY compliance tests

1. Select "C-PHY" in the R&S ScopeSuite start window.
2. In the "Session Selection" dialog, choose the C-PHY standard version.
   You can select one of the following : "1.2", "2.1".
3. Add a new test session and name it. See Chapter 3.1, "Starting a test session", on page 13.
4. Open the test session.
5. Adjust the test configuration settings if necessary. See:
   - Chapter 3.2.1.1, "Limit manager", on page 16
   - Chapter 3.2, "Configuring the test", on page 14
6. Select/check the test cases that you want to run and click "Test Single"/"Test checked".
7. A step-by step guide explains the following individual setup steps. When you have finished all steps of the step-by-step guide, the compliance test runs automatically.

4.2 Test configuration for C-PHY

The test configuration consists of the general configuration settings as described in Chapter 3.2, "Configuring the test", on page 14, and some additional test-specific configuration settings, described below:



Channel selection
Selects the channels for the V_A, V_B and V_C waveforms.

Select, if you are using a "Single-Ended Probes" or "SMA Cables".

You can also define a skew value for each channel.

When opening a new session, the skew values are read from the oscilloscope and the skew fields are updated. To update the skew values at a later time, press "Retrieve Skew".

DUT Settings
In this part you can define the settings of your DUT.

Data type ← DUT Settings
Selects the data type of the DUT. You can select between the continuous and burst mode.

LP Mode ← DUT Settings
Selects the low-power mode. You can choose between a Normal low power (LP) mode or low voltage low power (LVLP) mode.

HS Mode ← DUT Settings
You can choose between a normal high speed (HS) mode or low voltage high speed (LVHS) mode.

HS Symbol Rate ← DUT Settings
Set the high-speed symbol rate of the DUT.

PROGSEQ ← DUT Settings
Enable for DUTs that support the programmable sequence. You can also enter the value of the sequence.

Data Lane
Select the data lane number to be tested. Default selection is data lane "0".

C_{LOAD}
- If a C_{LOAD} test fixture with 50 pF termination capacitance is used, select "50 pF".
- If the 50 pF C_{LOAD} fixture is removed, select "Open".

The test results may not be valid, if no C_{LOAD} test fixture with 50 pF termination capacitance is used. The optional "Open" configuration setting is used to provide a qualitative estimate of the amount of C_{LOAD} contributed by the DUT's PCB.

Export Waveform
Enables you to export a waveform. You can later load the waveforms to run the tests in the offline mode, see "Offline Execution".

You can define an export directory, or use the default one:

```
MyDocuments\Rohde-Schwarz\RSScopeSuite\<Version>\Waveforms\
<ComplianceTest>\<SessionType>\<SessionName>
```

For example:

```
%ProgramData%\Rohde-Schwarz\RSScopeSuite\5.20.0\Sessions\C-PHY
```

Offline Execution
If enabled, allows you to use exported waveforms as a source for the execution of the compliance test.

You can select one waveform for each needed signal.

4.3 LP-TX signaling requirements (group 1)

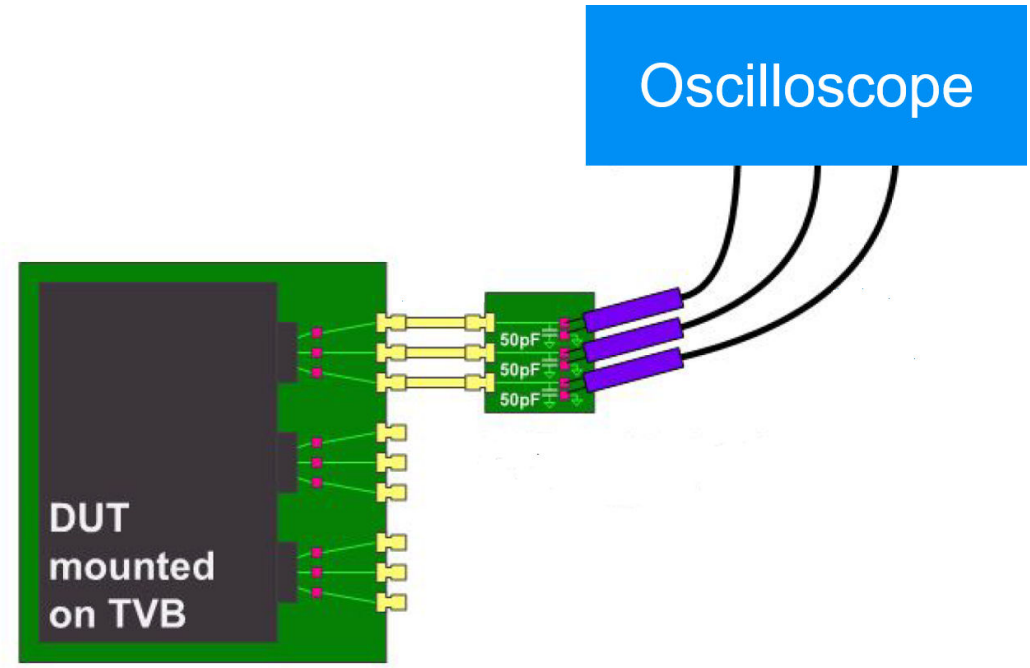
The purpose of group 1 test cases is to verify various requirements specific to data lane low power (LP) signaling. The tests of this group perform a set of related LP-TX measurements on a single Lane LP-TX waveform sequence (e.g., ULPS entry).

4.3.1 Test setup

Table 4-1: Equipment for group 1 LP-TX signaling requirements test

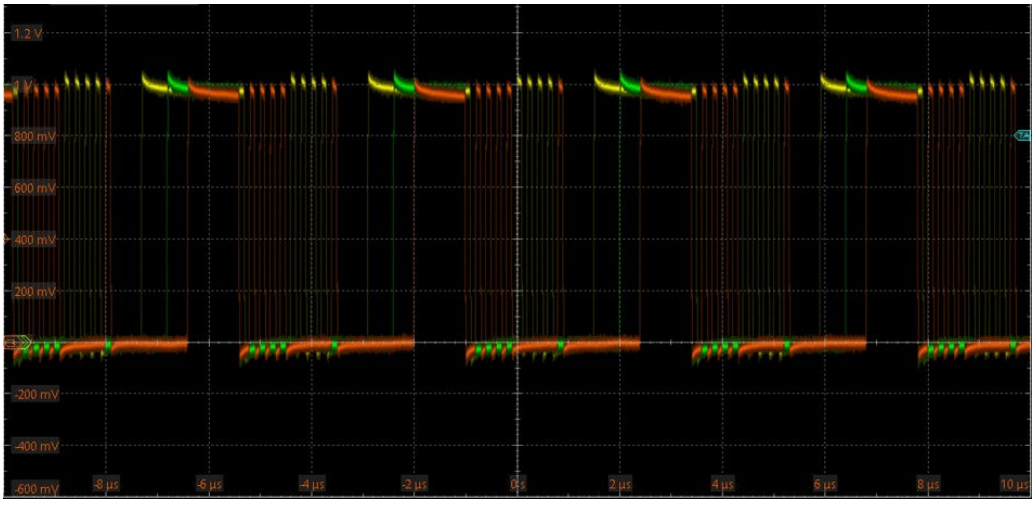
Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and at least 13 GHz bandwidth	1
Probes	Any single-ended active probes or SMA cables	3

Item	Description, model	Quantity
Test fixture	UNH-IOL MIPI C-PHY Capacitive Load (CLOAD) fixture	1
DUT	Any MIPI C-PHY device	1



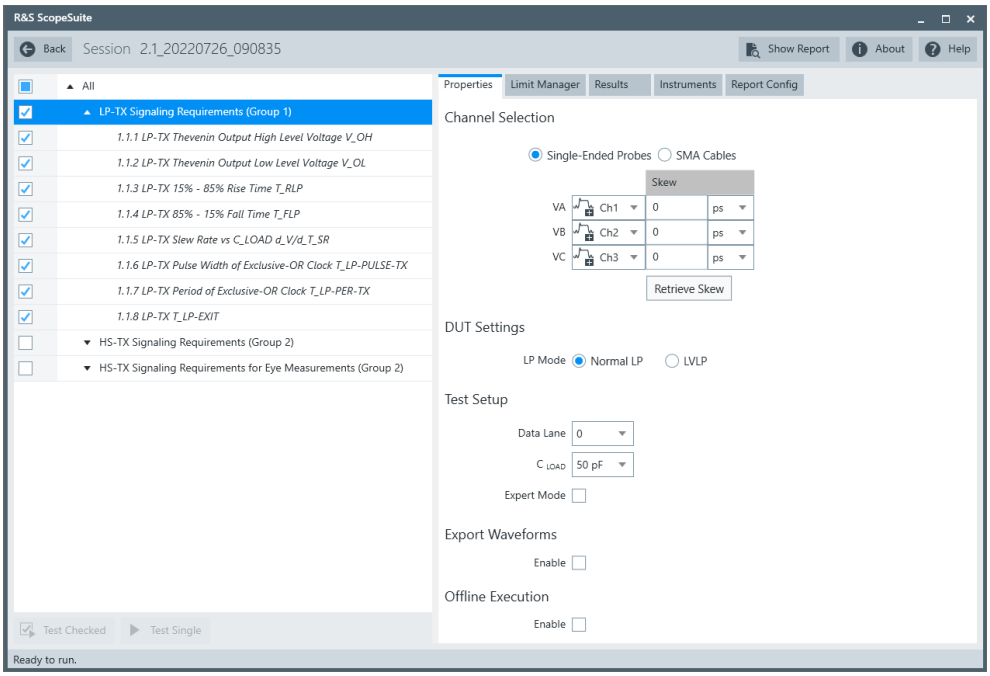
Waveform Requirements

A typical LP signal waveform for this test case is as shown in the figure below:



4.3.2 Performing group 1 test cases

1. Start the test as described in Chapter 4.1, "Starting C-PHY compliance tests", on page 18.
2. Select the test case group: "LP-TX Signaling Requirements (Group 1)".



3. Set the "Properties" for the measurement:
   a) Select, if you are using a "Single-Ended Probes" or "SMA Cables".
   b) Set the channel skew for VA, VB and VC.
   c) Select the devices "LP mode": "Normal LP" or "LVP".
   d) Select the "Data Lane" you want to measure.
   e) Configure the C_{Load}.
4. Click "Test Single" to run only the selected test case.
   Click "Test Checked" to run all test cases that are checked on the tree.
5. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.

Further steps:

- Chapter 3.3, "Getting test results", on page 16

4.3.3 Measurements

4.3.3.1 1.1.1 LP-TX Thevenin output high-level voltage (V_{OH})

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run on both "Normal LP" or "LVLP" mode.

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.

Measurements

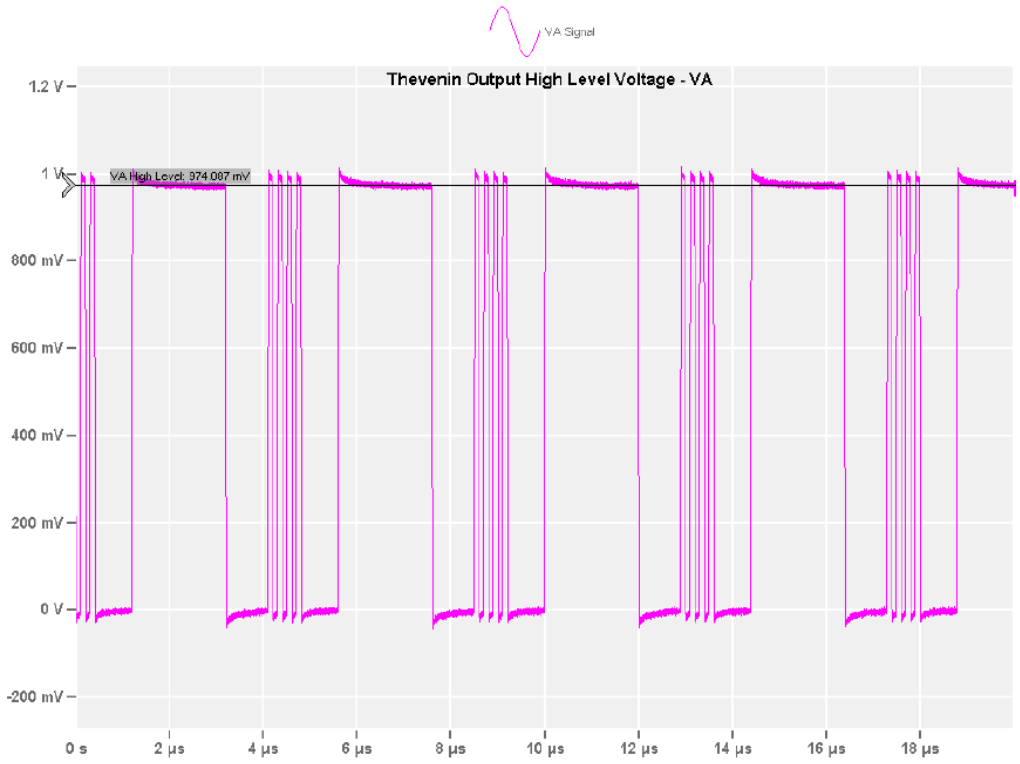
V_{OH} is measured as the mode of all waveform samples that are greater than 50% of the absolute peak-to-peak VA, VB, and VC signal amplitudes. It should be measured across all LP-1 states in a single LP Escape Mode sequence. (Note that a ULPS Entry sequence is specified for this test, and all other measurements in this group).

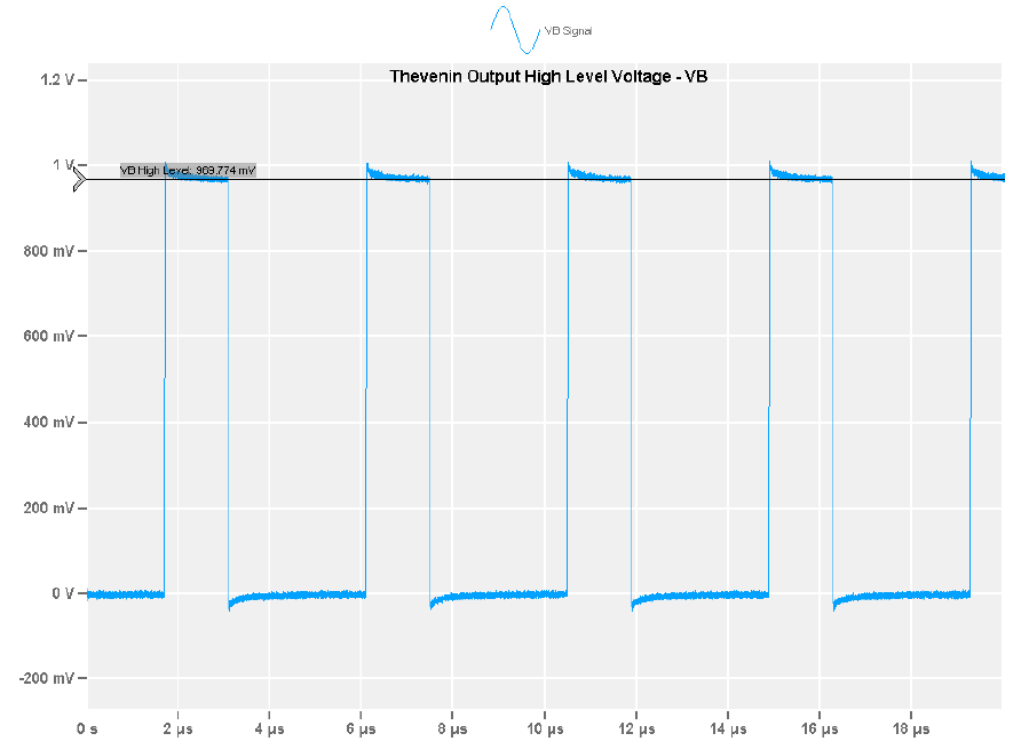
V_{OH} is the Thevenin output, high-level voltage in the high-level state, when the pad pin is not loaded.

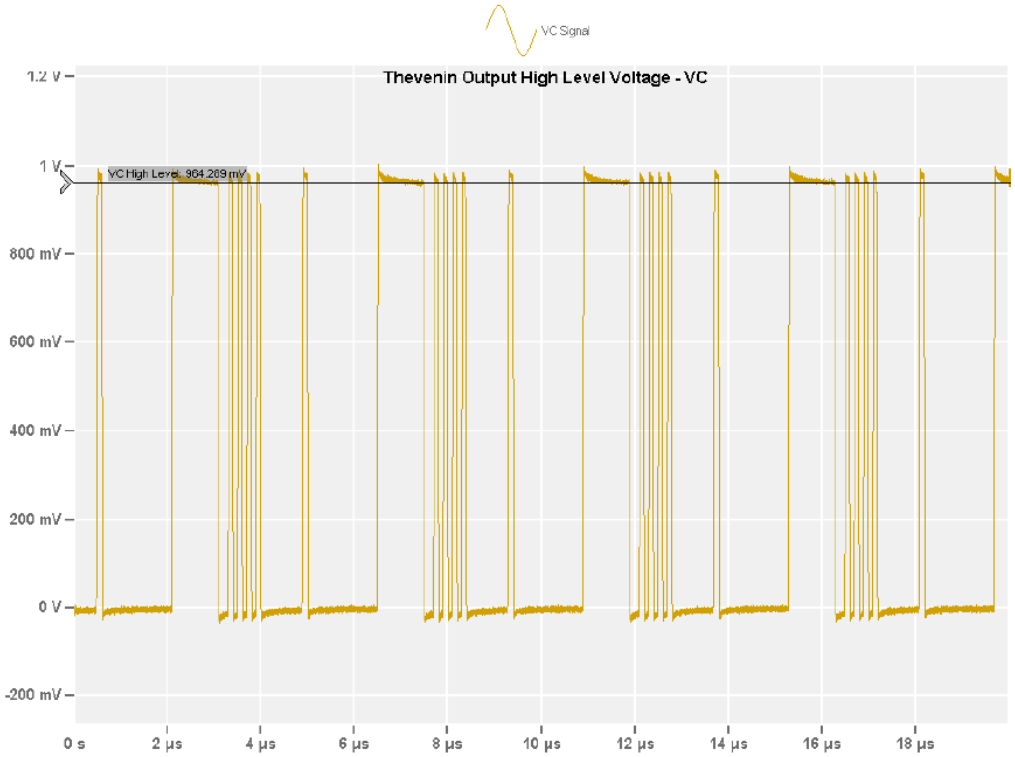
A 400 MHz, 4th-order Butterworth lowpass test filter is applied to the source waveform for this measurement.

For all data lanes, in "Normal LP" operation, verify that the VOH of the VA, VB and VC waveforms is between 0.95 V and 1.3 V.

For all data lanes, in "LVLP" operation, verify that the VOH of the VA, VB and VC waveforms is between 0.95 V and 1.1 V for all data lanes.


VA Signal
Thevenin Output High Level Voltage - VA
VA High Level: 974.087 mV
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
0 s
2 µs
4 µs
6 µs
8 µs
10 µs
12 µs
14 µs
16 µs
18 µs


VB Signal
Thevenin Output High Level Voltage - VB
VB High Level: 963.774 mV
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
0 s
2 µs
4 µs
6 µs
8 µs
10 µs
12 µs
14 µs
16 µs
18 µs



4.3.3.2 1.1.2 - LP-TX Thevenin output low-level voltage (V_{OL})

This test case applies to both CPHY versions 1.2 and 2.1. The test case is relevant for "Normal LP" mode.

The purpose of this test is to verify that transmitter Output Low-Level Voltage (V_{OL}) of the DUT's LP transmitter is within the conformance limits.

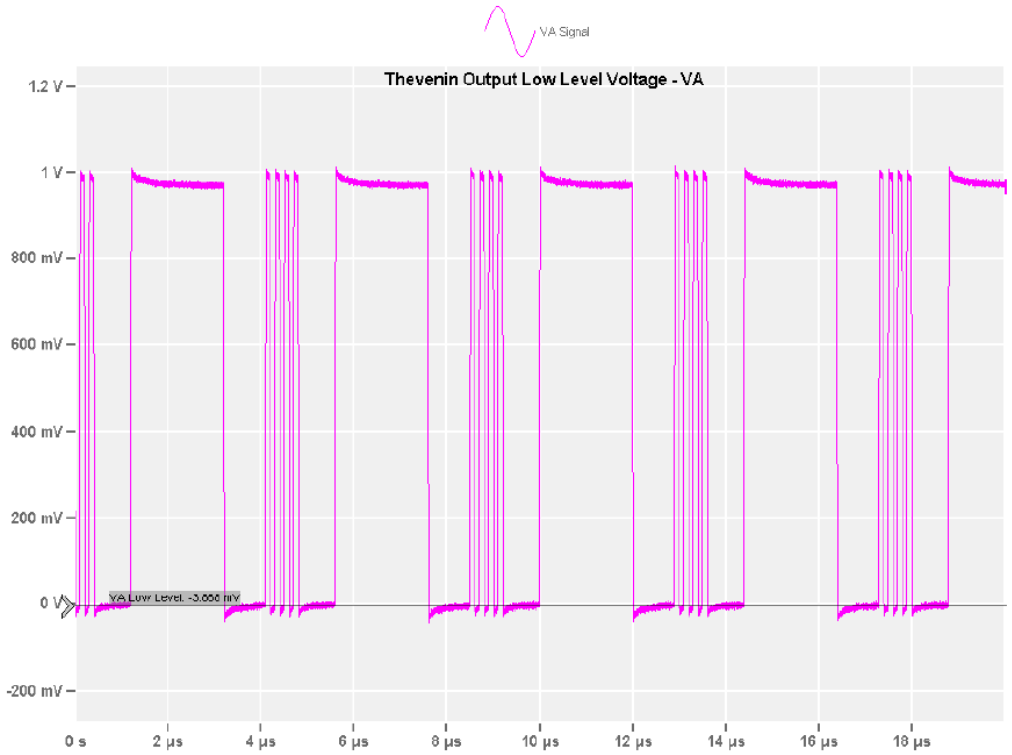
Measurements

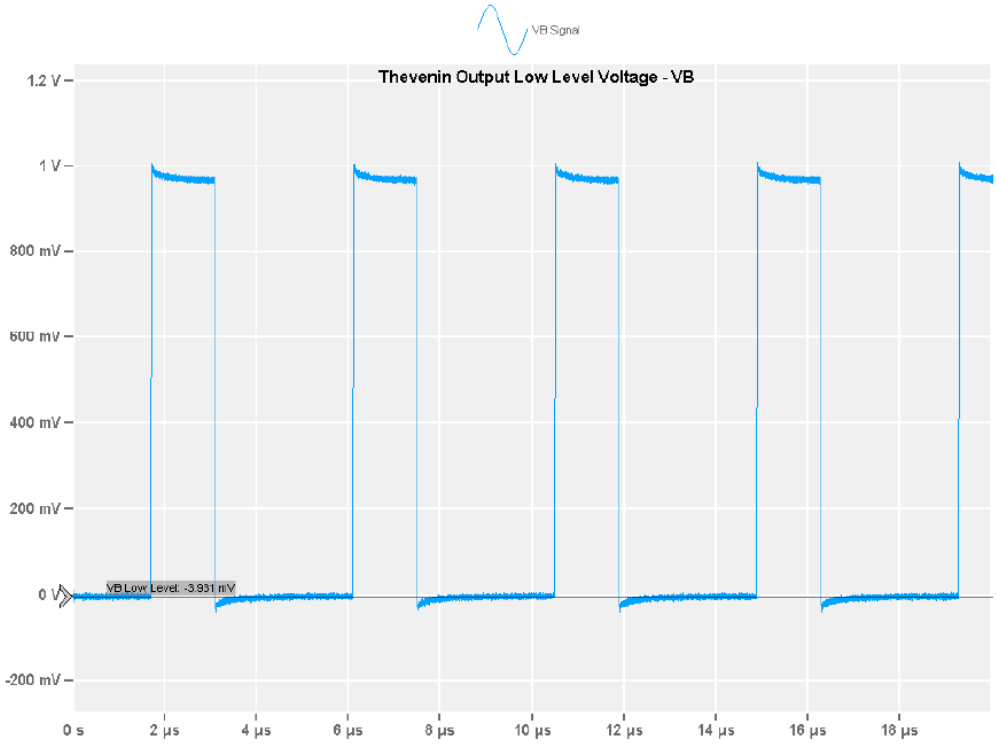
V_{OL} is measured as the mode of all waveform samples that are less than 50% of the absolute peak-to-peak VA, VB, and VC signal amplitudes. It should be measured across all LP-0 states in a single LP Escape Mode sequence.

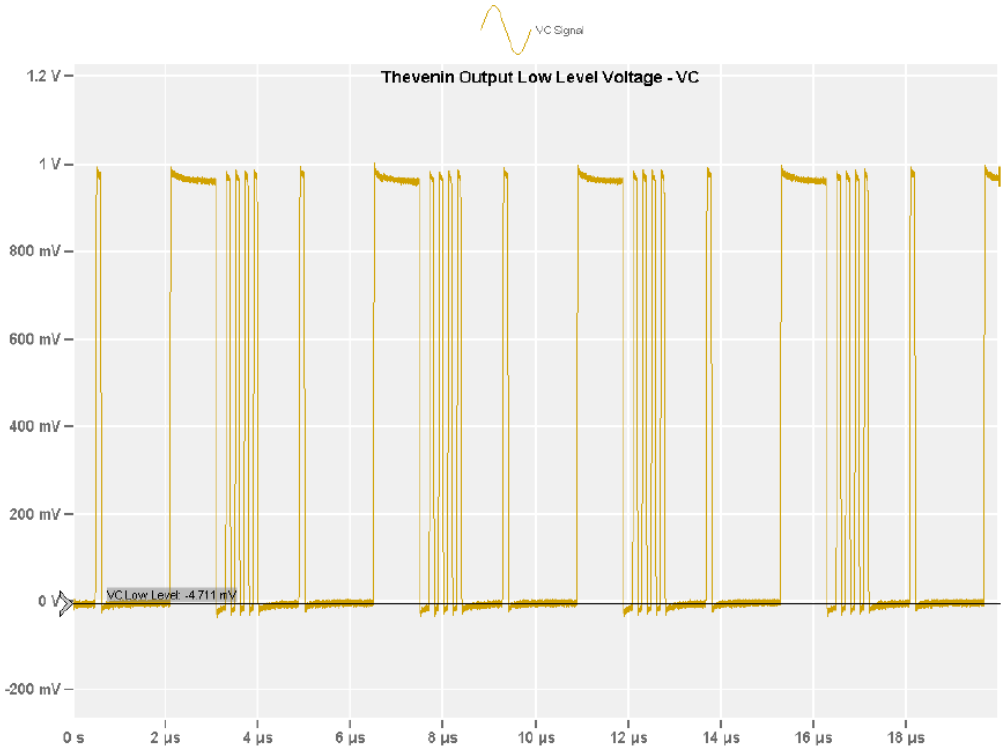
V_{OL} is the thevenin output, low-level voltage in the LP transmit mode. This is the voltage at an unloaded pad pin in the low-level state.

A 400 MHz, 4th-order Butterworth lowpass test filter is applied to the source waveform prior to performing the measurement.

For all data lanes, verify that the VOL of the VA, VB and VC waveforms is between -50 mV and +50 mV.


VA Signal
Thevenin Output Low Level Voltage - VA
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
VA Low Level: -3.656 mV
0 s
2 µs
4 µs
6 µs
8 µs
10 µs
12 µs
14 µs
16 µs
18 µs


VB Signal
Thevenin Output Low Level Voltage - VB
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
VB Low Level: -3.931 mV
0 s
2 µs
4 µs
6 µs
8 µs
10 µs
12 µs
14 µs
16 µs
18 µs



4.3.3.3 Measurements X 15%-85% rise time (t_{RLP})

This test case applies to both CPHY versions 1.2 and 2.1. The test case is relevant for "Normal LP" mode.

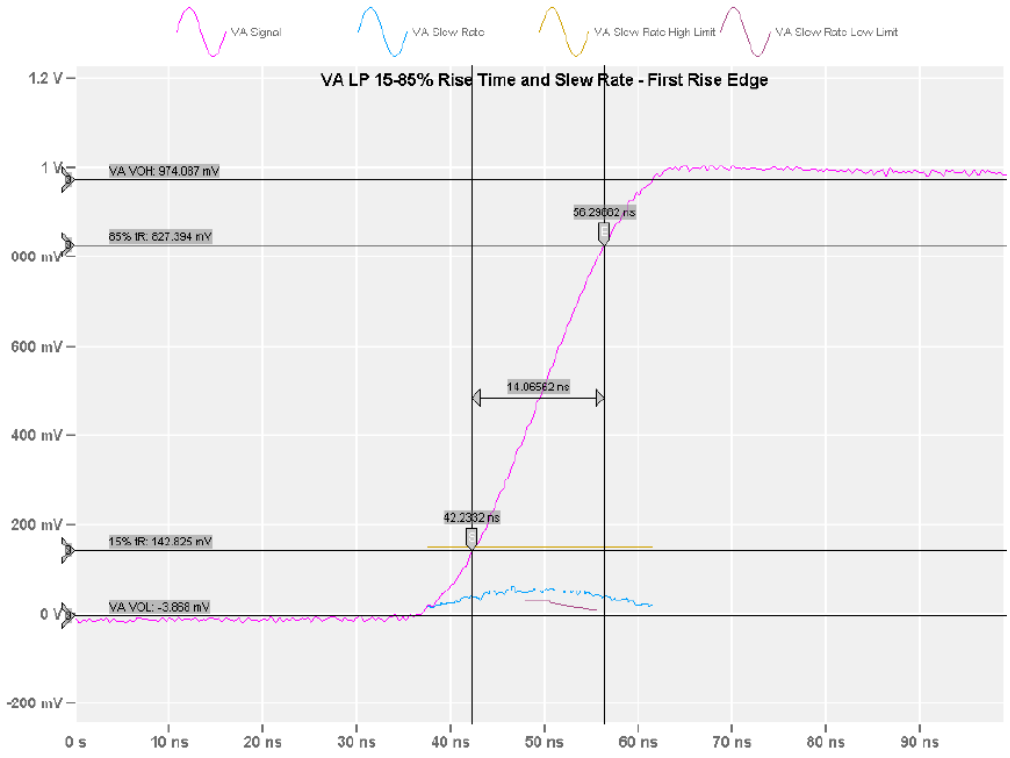
The purpose of this test is to verify that Transmitter Rise Time (t_{RLP}) of the DUT's LP transmitter is within the conformance limits.

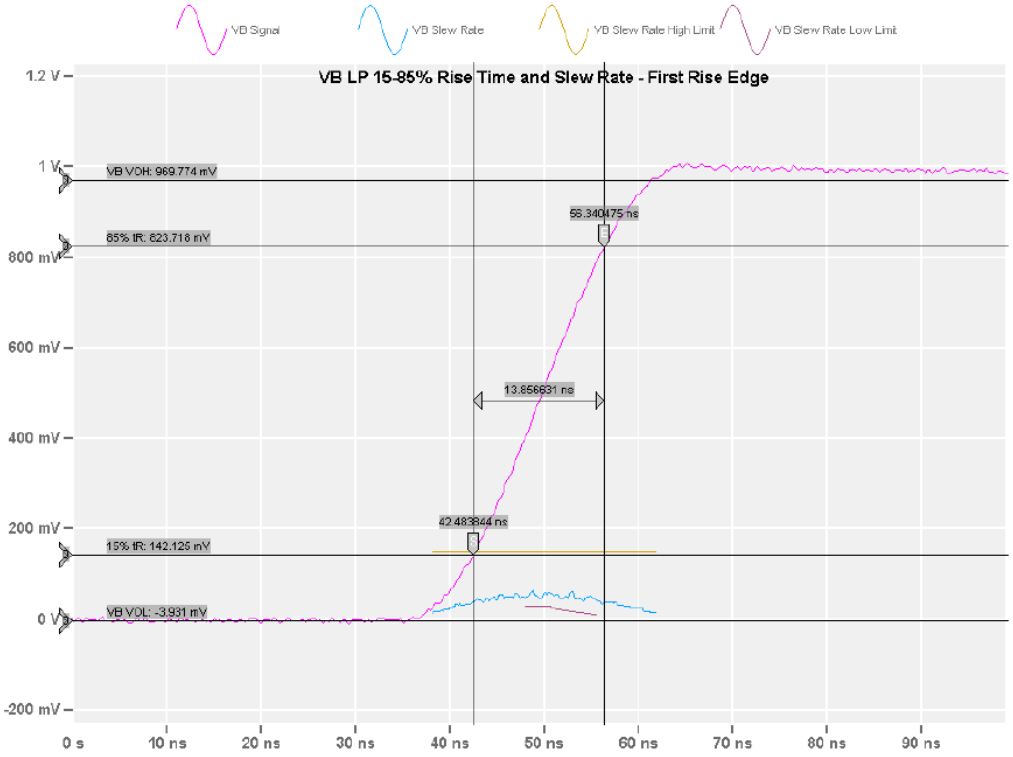
Measurements

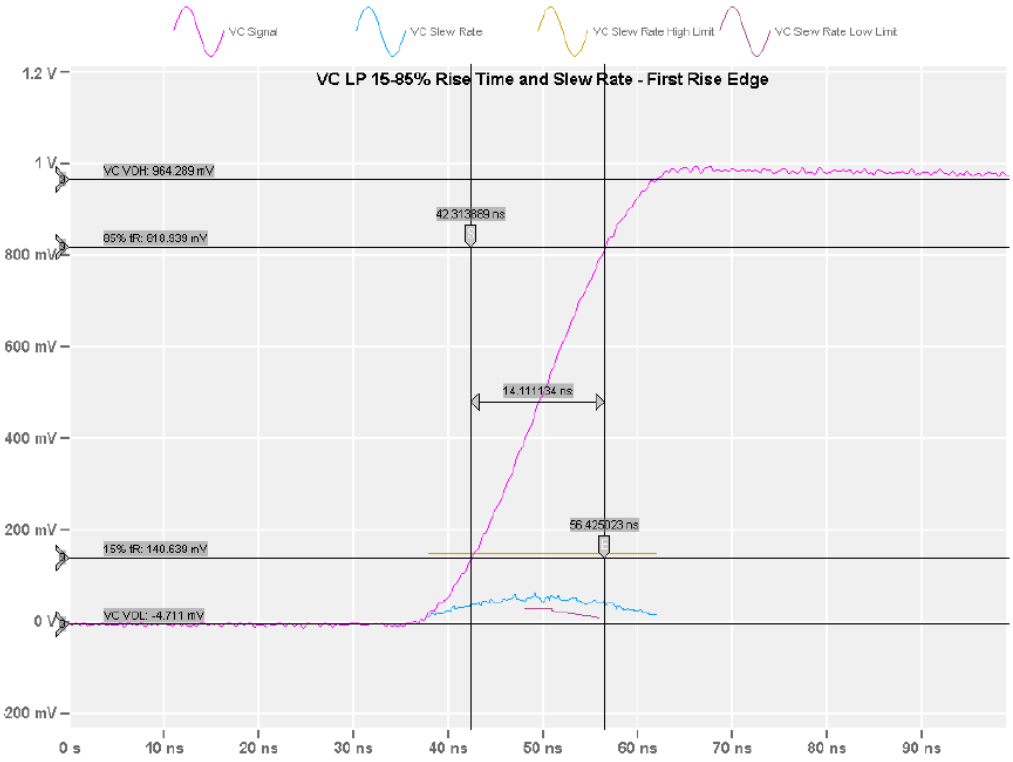
The times t_{RLP} is the 15%-85% rise times of the output signal voltage, when the LP transmitter is driving a capacitive load C_{LOAD}. The 15 % -85 % levels are relative to the fully settled V_{OH} and V_{OL} voltages.

A 400 MHz, 4th-order Butterworth lowpass test filter is applied to the source waveform prior to performing the measurement.

For all data lanes, verify that t_{RLP} for the VA, VB and VC waveforms is less than 25 ns.


VA Signal
VA Slew Rate
VA Slew Rate High Limit
VA Slew Rate Low Limit
VA LP 15-85% Rise Time and Slew Rate - First Rise Edge
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
VA VOH: 974.087 mV
85% tR: 827.394 mV
50.29002 ns
14.06582 ns
42.2332 ns
15% tR: 142.825 mV
VA VOL: -3.868 mV
0 s
10 ns
20 ns
30 ns
40 ns
50 ns
60 ns
70 ns
80 ns
90 ns


VB Signal
VB Slew Rate
VB Slew Rate High Limit
VB Slew Rate Low Limit
VB LP 15-85% Rise Time and Slew Rate - First Rise Edge
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
VB VOH: 969.774 mV
85% tR: 823.718 mV
55.340475 ns
13.856631 ns
42.483844 ns
15% tR: 142.126 mV
VB VOL: -3.931 mV
0 s
10 ns
20 ns
30 ns
40 ns
50 ns
60 ns
70 ns
80 ns
90 ns



4.3.3.4 1.1.4 - LP-TX 15%-85% fall time (t_{FLP})

This test case applies to both CPHY versions 1.2 and 2.1. The test case is relevant for "Normal LP" mode.

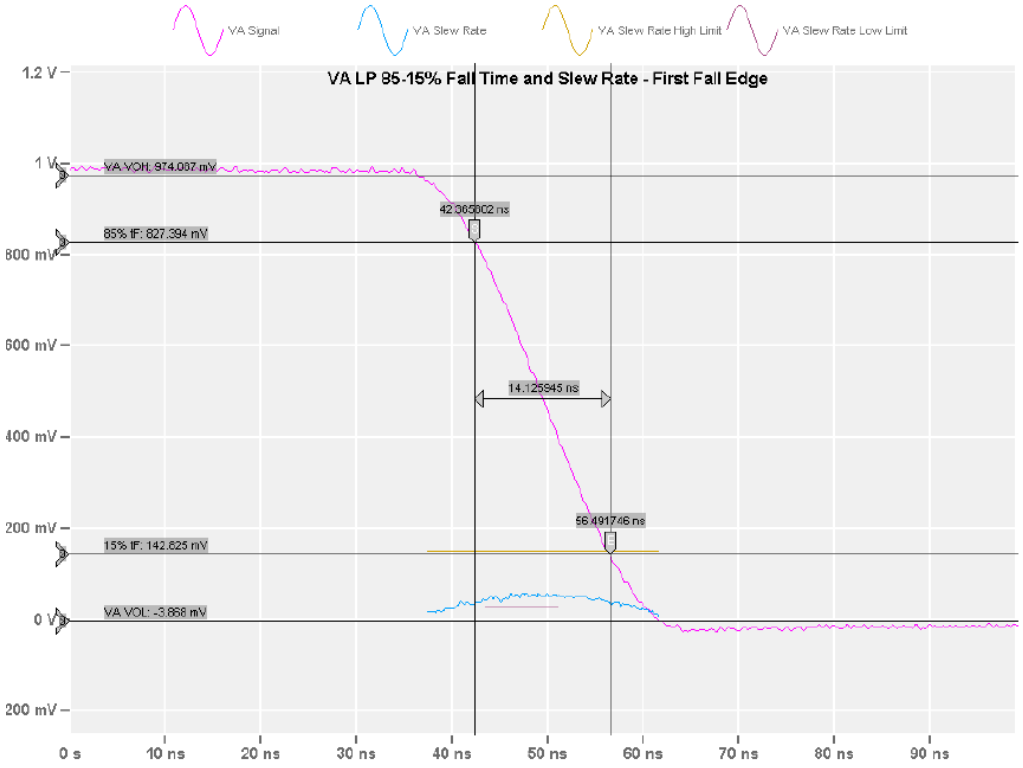
The purpose of this test is to verify that the 15%-85% Fall Time (t_{FLP}) of the DUT's LP transmitter is within the conformance limits.

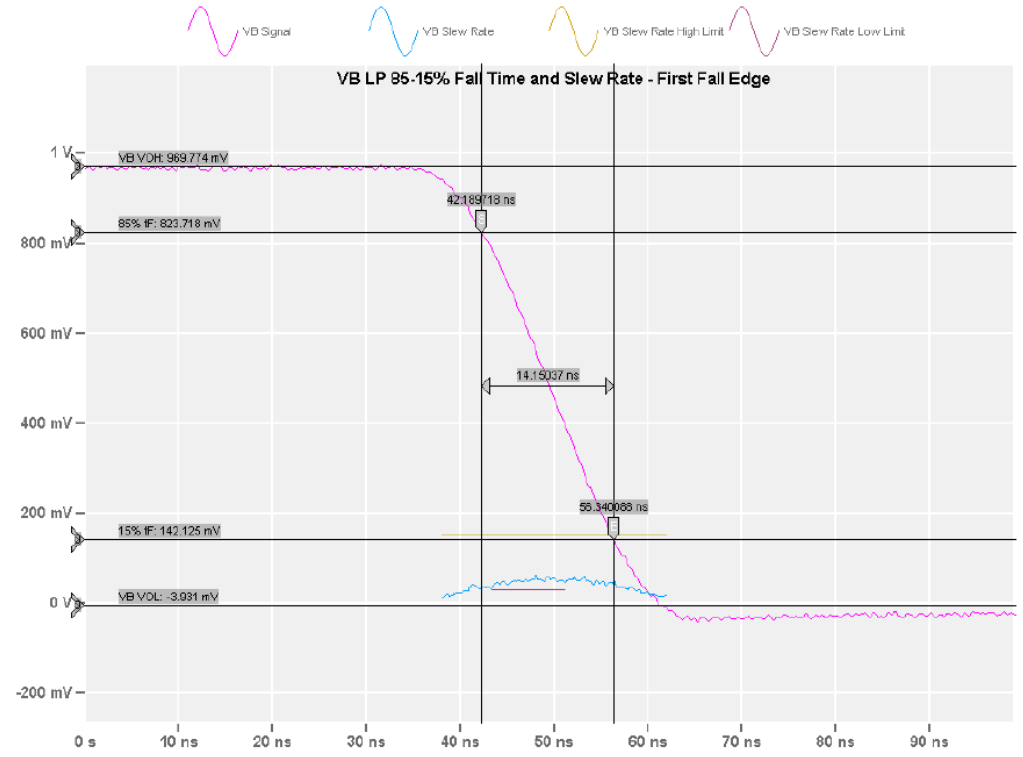
Measurements

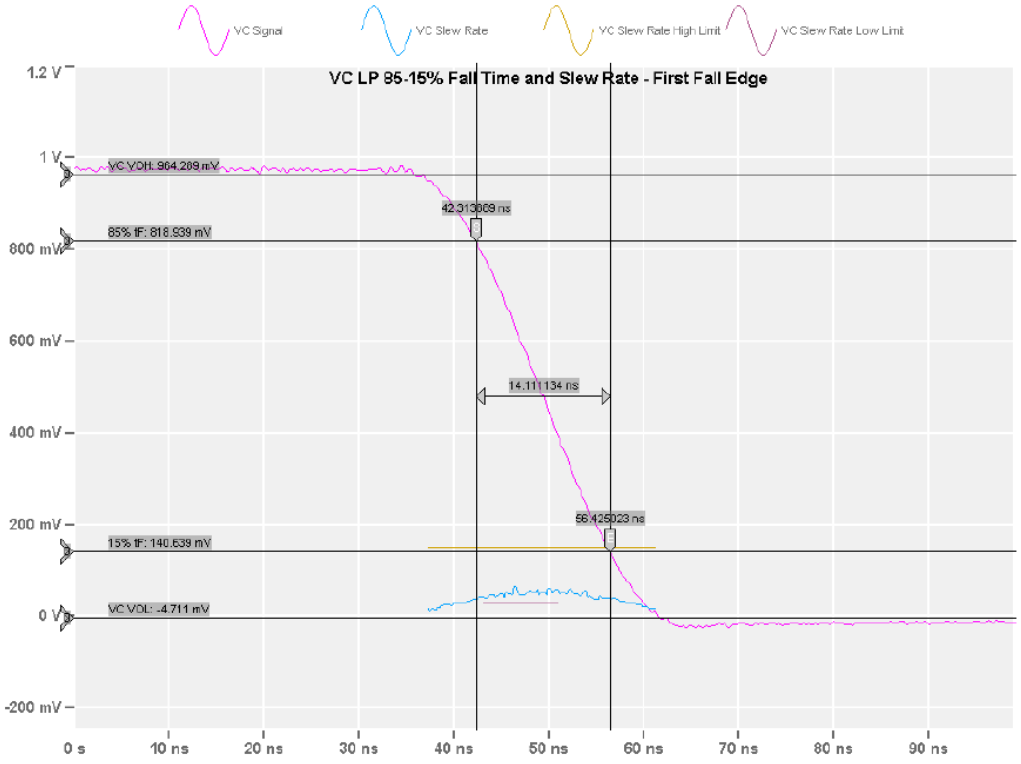
The times t_{FLP} is the 15%-85% fall times of the output signal voltage, when the LP transmitter is driving a capacitive load C_{LOAD}. The 15 % -85 % levels are relative to the fully settled V_{OH} and V_{OL} voltages.

A 400 MHz, 4th-order Butterworth lowpass test filter is applied to the source waveform prior to performing the measurement.

For all data lanes, verify that t_{FLP} for the VA, VB and VC waveforms is less than 25 ns.


VA Signal
VA Slew Rate
VA Slew Rate High Limit
VA Slew Rate Low Limit
VA LP 85-15% Fall Time and Slew Rate - First Fall Edge
1.2 V
1 V
800 mV
600 mV
400 mV
200 mV
0 V
200 mV
VA VOH: 974.087 mV
85% tF: 827.394 mV
42.065002 ns
14.125845 ns
56.491746 ns
15% tF: 142.625 mV
VA VOL: -3.858 mV
0 s
10 ns
20 ns
30 ns
40 ns
50 ns
60 ns
70 ns
80 ns
90 ns


VB Signal
VB Slew Rate
VB Slew Rate High Limit
VB Slew Rate Low Limit
VB LP 85-15% Fall Time and Slew Rate - First Fall Edge
1 V
800 mV
600 mV
400 mV
200 mV
0 V
-200 mV
VB VOH: 969.774 mV
85% tF: 823.718 mV
42.189718 ns
14.15037 ns
56.340088 ns
15% tF: 142.125 mV
VB VOL: -3.931 mV
0 s
10 ns
20 ns
30 ns
40 ns
50 ns
60 ns
70 ns
80 ns
90 ns



4.3.3.5 1.1.5 – LP-TX slew rate vs. C_{LOAD}: $\delta V/\delta t_{SR}$

This test case applies to both CPHY versions 1.2 and 2.1. The test case is relevant for "Normal LP" mode.

The purpose of this test is to verify that the Slew Rate ($\delta V/\delta t_{SR}$) of the DUT's LP transmitter is within the conformance limits, for specific capacitive loading conditions.

Measurements

The measurement is performed using the 50 pF C_{LOAD} test fixture.

For the Maximum Slew Rate test, the results are evaluated against the 70 pF limit of 150 mV / ns across the entire signal edge.

For the Minimum Slew Rate test for falling edges, the results are evaluated against the 25 mV/ns limit across the voltage range of 400 mV. to 790 mV.

For the Minimum Slew Rate test for rising edges, the results are evaluated against the 25 mV/ns limit across the voltage range of 400 mV to 550 mV, and against the equation-based limit for the 550 to 790 mV voltage range.

A 400 MHz 4th - order Butterworth lowpass filter is applied to the source waveform before performing the measurement.

Falling edges

For the 50 pF C_{LOAD}, for VA, VB, and VC, and for all data lanes, verify that:

- The Maximum δV/δtSR is less than 150 mV/ns across the entire edge

- The Minimum δV/δtSR is greater than 25 mV/ns across the 400 to 790 mV region

Rising edges

For the 50 pF C_{LOAD}, for VA, VB, and VC, and for all data Lanes verify that:

- The Maximum δV/δtSR is less than 150 mV/ns across the entire edge
- The Minimum δV/δtSR is greater than 25 mV/ns across the 400-550 mV region
- The Minimum δV/δtSR Margin is greater than 0 mV/ns across the 550-790 mV region

4.3.3.6 1.1.6 - LP-TX pulse width of exclusive-OR clock ($t_{LP\text{-}PULSE\text{-}TX}$)

This test case applies to both CPHY versions 1.2 and 2.1. The test case is relevant for "Normal LP" mode.

The purpose of this test is to verify that the pulse width ($t_{LP\text{-}PULSE\text{-}TX}$) of the DUT's LP transmitter XOR Clock is within the conformance limits.

Measurements

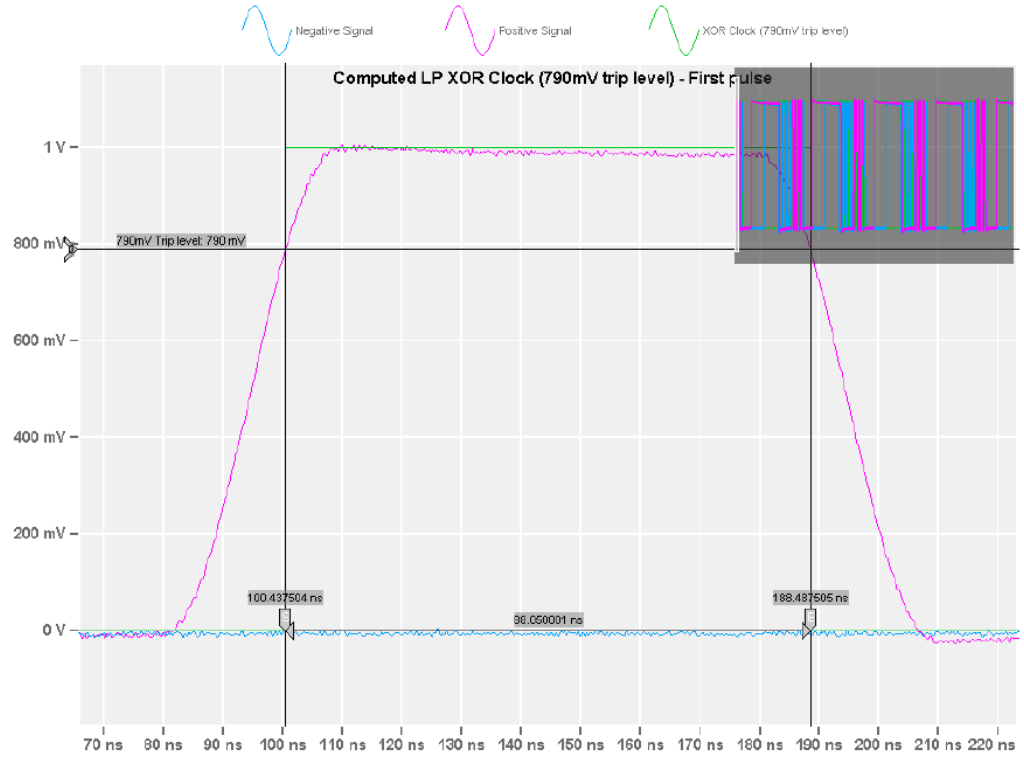
For the purposes of this test, two trip - level cases are evaluated, representing the maximum and minimum allowed trip levels.

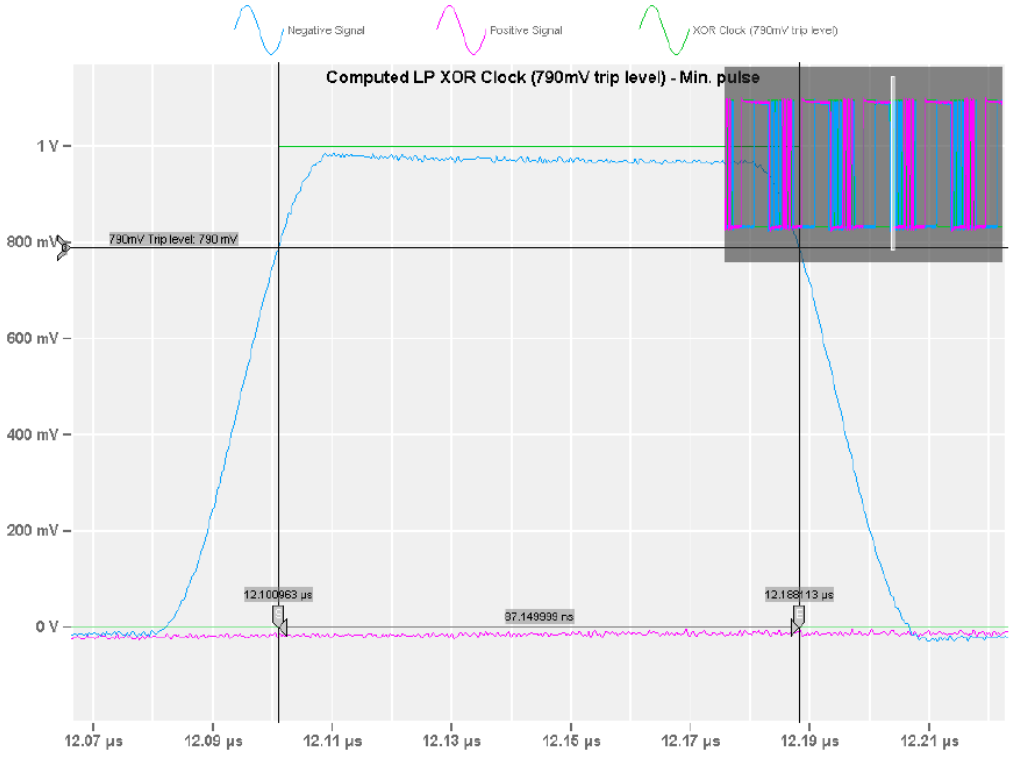
Note that $V_{IL,MAX}$ = 550 mV, $V_{OL,MIN}$ = -50 mV, $V_{IH,MIN}$ = 740 mV, and $V_{OL,\ MAX}$ = 50 mV. Thus, the minimum trip level becomes 550 – 50 = 500 mV, and the maximum trip level is 740 + 50 = 790 mV.

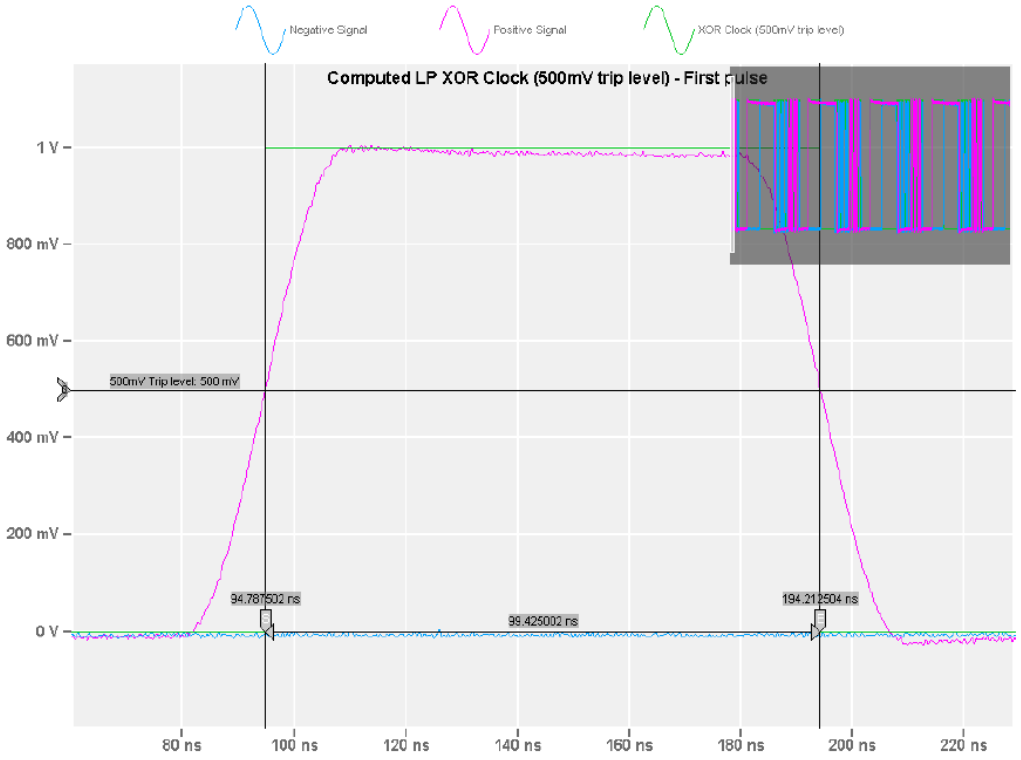
A 400 MHz, 4th-order Butterworth lowpass test filter is applied to the source waveform prior to performing the measurement.

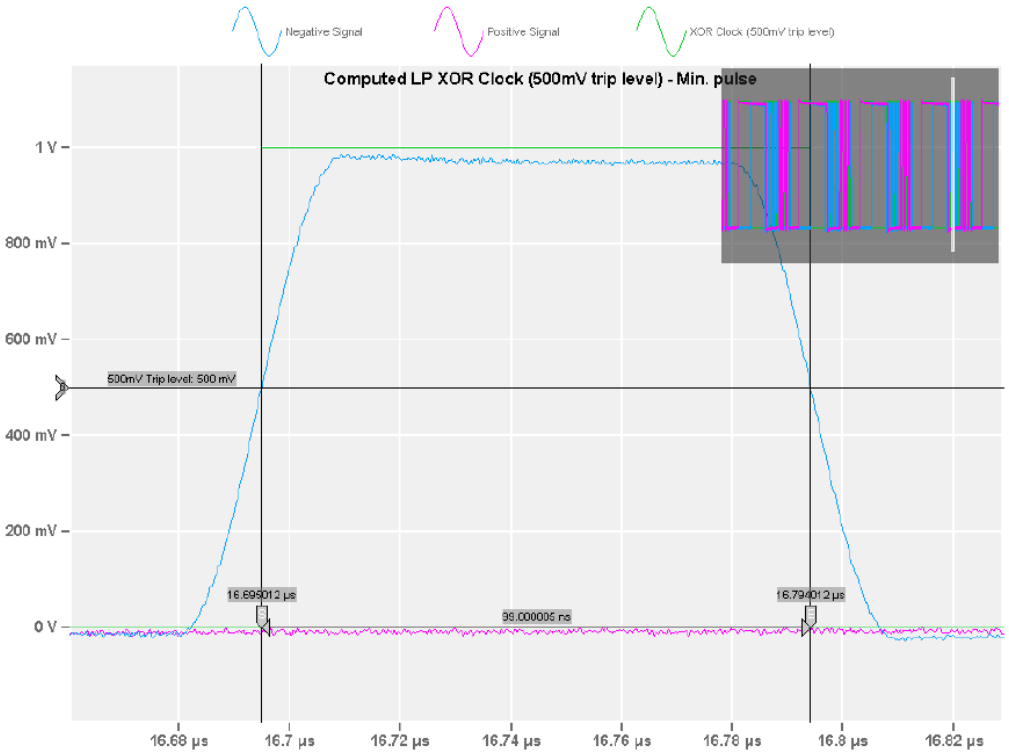
For both trip-level voltages, and for all lanes verify that:

- The first LP XOR Clock pulse after the initial Stop state is greater than 40 ns
- The minimum of all other clock pulses is greater than 20 ns


Negative Signal
Positive Signal
XOR Clock (790mV trip level)
Computed LP XOR Clock (790mV trip level) - First pulse
1 V
800 mV
600 mV
400 mV
200 mV
0 V
790mV Trip level: 790 mV
100.437504 ns
188.487505 ns
70 ns
80 ns
90 ns
100 ns
110 ns
120 ns
130 ns
140 ns
150 ns
160 ns
170 ns
180 ns
190 ns
200 ns
210 ns
220 ns


Negative Signal
Positive Signal
XOR Clock (790mV trip level)
Computed LP XOR Clock (790mV trip level) - Min. pulse
1 V
800 mV
600 mV
400 mV
200 mV
0 V
790mV Trip level: 790 mV
12.100963 µs
97.149999 ns
12.07 µs
12.09 µs
12.11 µs
12.13 µs
12.15 µs
12.17 µs
12.19 µs
12.21 µs


Negative Signal
Positive Signal
XOR Clock (500mV trip level)
Computed LP XOR Clock (500mV trip level) - First pulse
1 V
800 mV
600 mV
500mV Trip level: 500 mV
400 mV
200 mV
0 V
94.787502 ns
99.425002 ns
194.212504 ns
80 ns
100 ns
120 ns
140 ns
160 ns
180 ns
200 ns
220 ns


Negative Signal
Positive Signal
XOR Clock (500mV trip level)
Computed LP XOR Clock (500mV trip level) - Min. pulse
1 V
800 mV
600 mV
500mV Trip level: 500 mV
400 mV
200 mV
0 V
16.695012 µs
99.000005 ns
16.794012 µs
16.68 µs
16.7 µs
16.72 µs
16.74 µs
16.76 µs
16.78 µs
16.8 µs
16.82 µs

4.3.3.7 1.1.7 - LP-TX period of exclusive-OR clock ($t_{LP-PER-TX}$)

This test case applies to both CPHY versions 1.2 and 2.1. The test case is relevant for "Normal LP" mode.

The purpose of this test is to verify that the period ($t_{LP-PER-TX}$) of the DUT's LP transmitter XOR Clock is within the conformance limits.

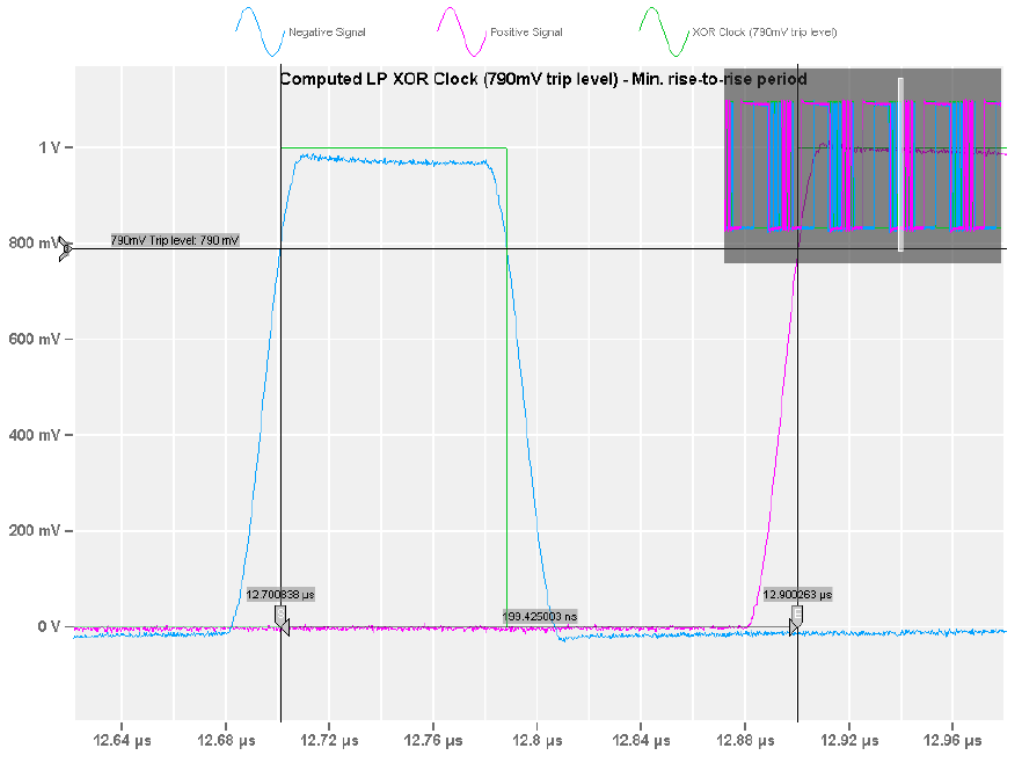
Measurements

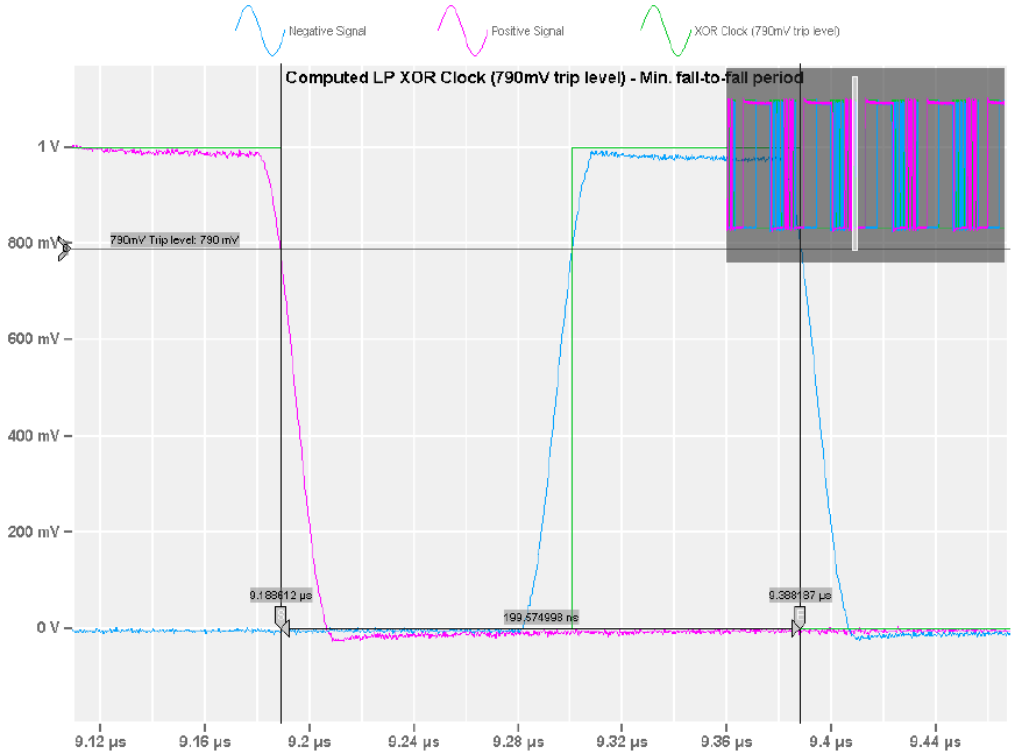
For the sake of consistency with the test (Test 1.1.6. LP - TX Pulse Width of Exclusive - OR Clock $t_{LP - PLUSE - TX}$), the 500 mV and 790 mV trip-levels are used, and the measurement is performed with the 50 pF C_{LOAD} test fixture.

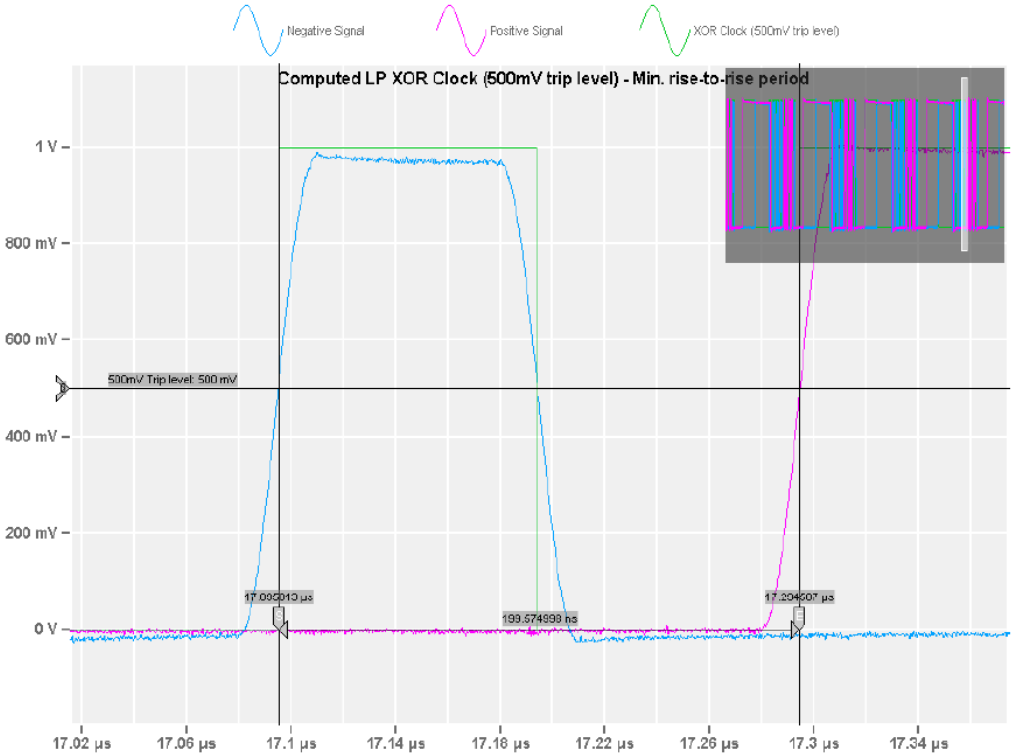
A 400 MHz, 4th-order Butterworth lowpass test filter is applied to the source waveform prior to performing the measurement.

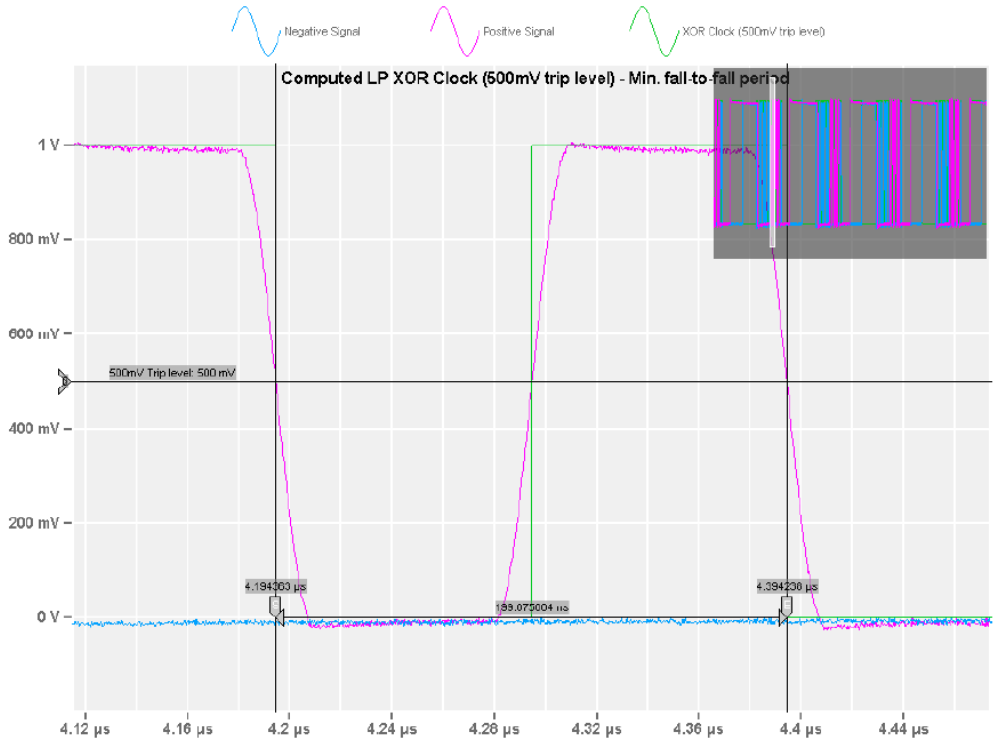
For both trip-level voltages, and for all Lanes verify that:

- the minimum $t_{LP-PER-TX}$ rising-edge-to-rising-edge period is greater than 90 ns
- the minimum $t_{LP-PER-TX}$ falling-edge-to-falling-edge period is greater than 90 ns




Negative Signal
Positive Signal
XOR Clock (790mV trip level)
Computed LP XOR Clock (790mV trip level) - Min. fall-to-fall period
1 V
800 mV
790mV Trip level: 790 mV
600 mV
400 mV
200 mV
0 V
9.188612 µs
199.574998 ns
9.388187 µs
9.12 µs
9.16 µs
9.2 µs
9.24 µs
9.28 µs
9.32 µs
9.36 µs
9.4 µs
9.44 µs


Negative Signal
Positive Signal
XOR Clock (500mV trip level)
Computed LP XOR Clock (500mV trip level) - Min. rise-to-rise period
1 V
800 mV
600 mV
500mV Trip level: 500 mV
400 mV
200 mV
0 V
17.09013 µs
199.574998 ns
17.29007 µs
17.02 µs
17.06 µs
17.1 µs
17.14 µs
17.18 µs
17.22 µs
17.26 µs
17.3 µs
17.34 µs



4.3.3.8 1.1.8 – $t_{LP-EXIT}$ value

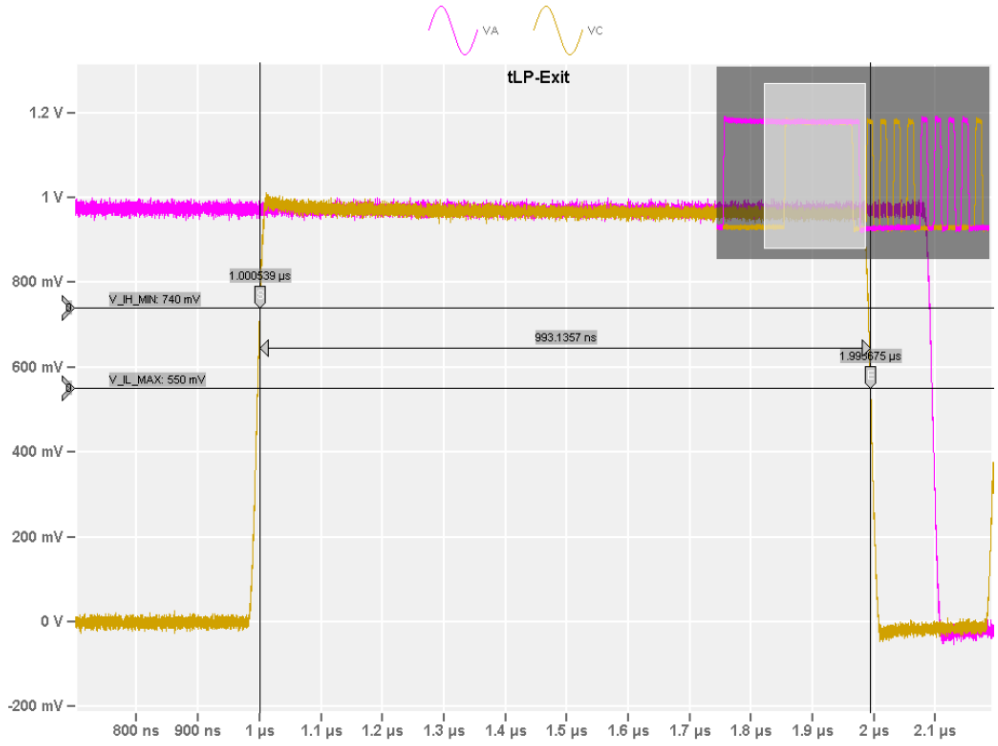
This test case applies to CPHY 2.1. The test case is relevant for "Normal LP" mode.

The purpose of this test is to verify that the duration that the Lane transmitter remains in the LP-111 (Stop) state after completing an Escape Command or Turnaround Procedure and before starting an Escape Command or Turnaround Procedure or High-Speed Transmission Burst ($t_{LP-EXIT}$), is greater than or equal to the minimum required value

Measurements

In this test, the $t_{LP-EXIT}$ interval for a given Lane is measured at the end of an LP sequence when the V_C rising edge crosses $V_{IH, MIN}$ (740 mV) until either V_A(LP - 001) or V_C(LP-100) falling edge crosses $V_{IL, MAX}$ (550 mV) at the beginning of the next sequence, which can be an LP sequence or an HS burst.

For all Lanes verify that $t_{LP-EXIT}$ is no less than 100 ns for all observed bursts.



4.4 HS-TX signaling requirements (group 2) - burst measurements

The HS-TX signaling tests verify various trasnsmitter requirements pertaining to HS signaling.

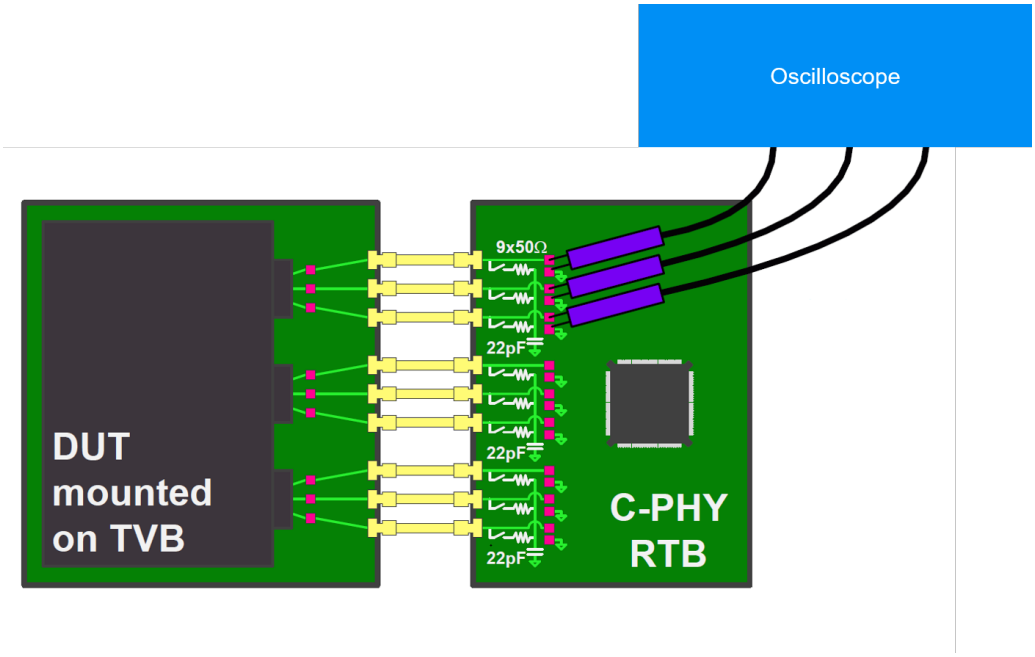
The structure of this group is intended to facilitate the execution of a set of several HS-TX measurements. Some tests are related to the LP exit/entry sequences that occur before and after the burst sequence.

This test group is relevant only for transmitter devices.

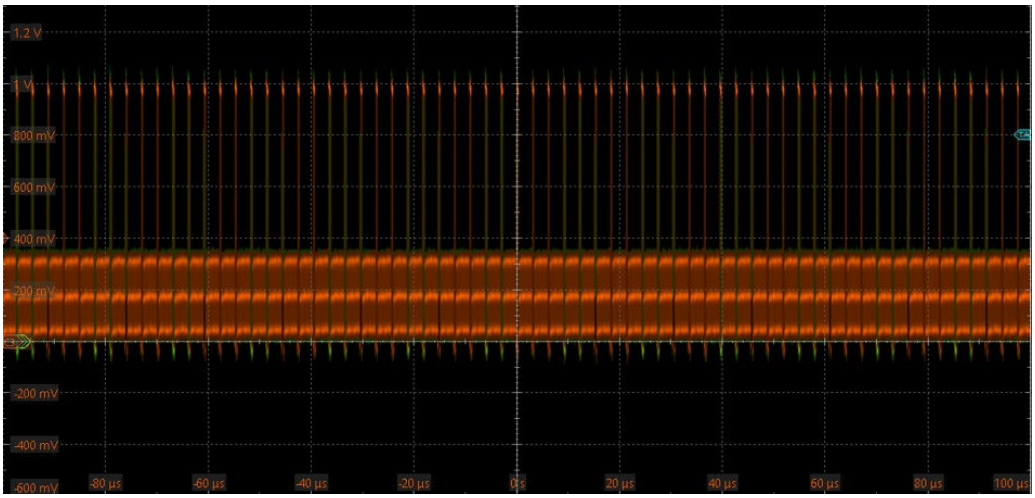
4.4.1 Test setup

Table 4-2: Equipment for Group 2 HS-TX signaling requirements test

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and at least 13 GHz bandwidth	1
Probes	Any single-ended active probes or SMA cables	3
Test fixture	MIPI C-PHY Reference Termination Board (RTB)	1
DUT	Any MIPI C-PHY device	1

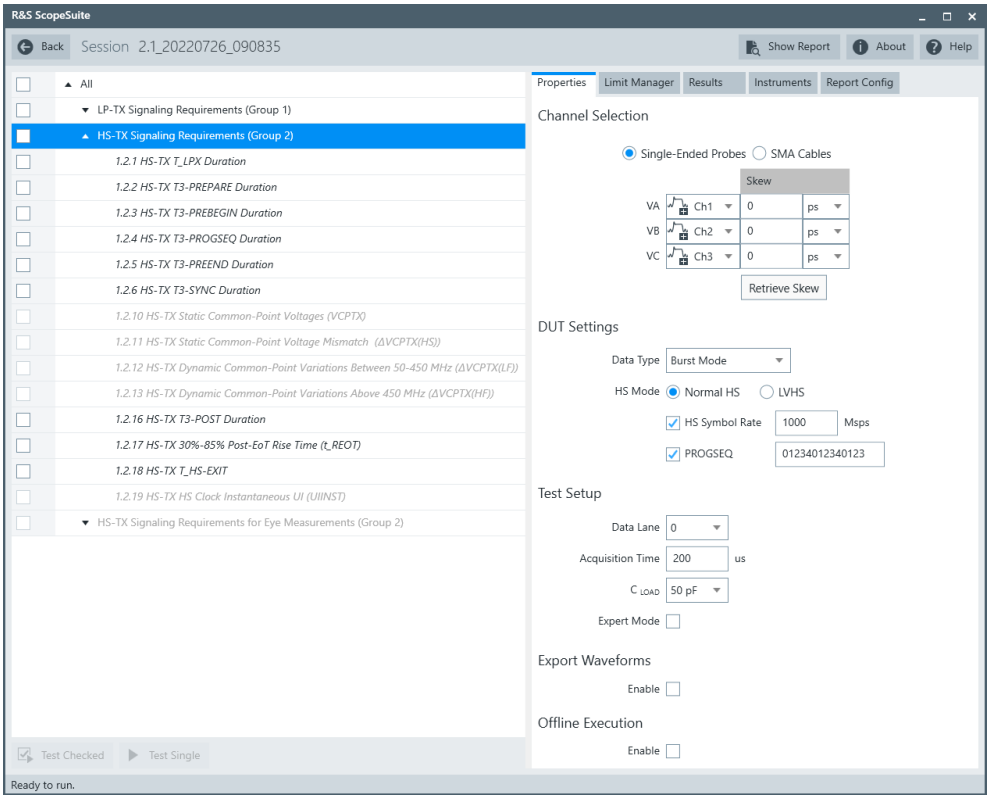


Waveform Requirements



4.4.2 Performing group 2 test cases

1. Start the test as described in Chapter 4.1, "Starting C-PHY compliance tests", on page 18.
2. Select the test case group: "HS-TX Signaling Requirements (Group 2)".
3. Set "DUT" > "Data type" = "Burst".



4. Set the "Properties" for the measurement:
   a) Select, if you are using a "Single-Ended Probes" or "SMA Cables".
   b) Set the channel skew for VA, VB and VC.
   c) Select the devices "HS mode": "Normal HS" or "LVHS".
   d) Enable and set a value for "HS Symbol Rate" if you know the value. Otherwise, R&S RTP will estimates a symbol rate.
   e) Enable ""“PROGSEQ" and set its value, if the DUT supports progress sequence option.
   f) Select the "Data Lane" you want to measure.
   g) Set an "Acquisition Time" value between 1us and 200us.
   h) Configure the C_{Load}.
5. Click "Test Single" to run only the selected test case.
   Click "Test Checked" to run all test cases that are checked on the tree.
6. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.

Further steps:

- Chapter 3.3, "Getting test results", on page 16

4.4.3 Measurements

4.4.3.1 1.2.1 HS-TX t_{LPX} duration

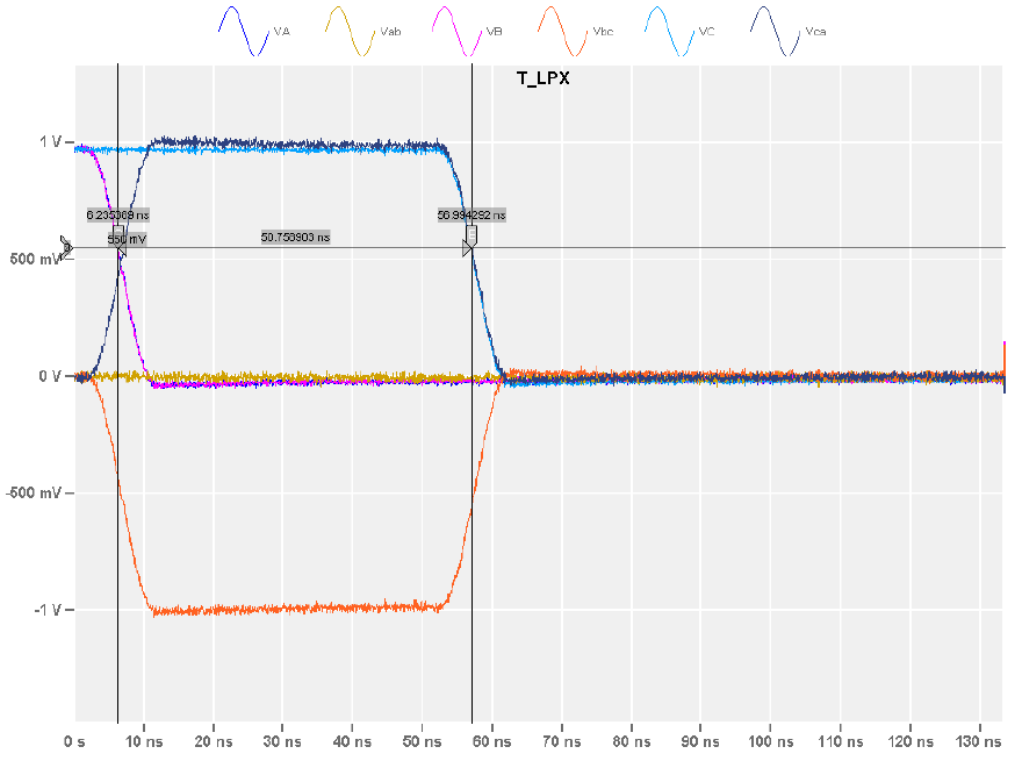
This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the duration (t_{LPX}) of the final LP-001 state immediately before HS transmission is greater than the minimum conformant value.

Measurements

The state is measured starting at the time where the V_A falling edge crosses below the maximum low - level LP threshold, $V_{IL, MAX}$ (550 mV), and ending at the time where the V_C falling edge crosses below the same $V_{IL, MAX}$ threshold.

Verify that t_{LPX} is greater than or equal to 50 ns for all lanes.



4.4.3.2 1.2.2 HS-TX $t_{3\text{-PREPARE}}$ duration

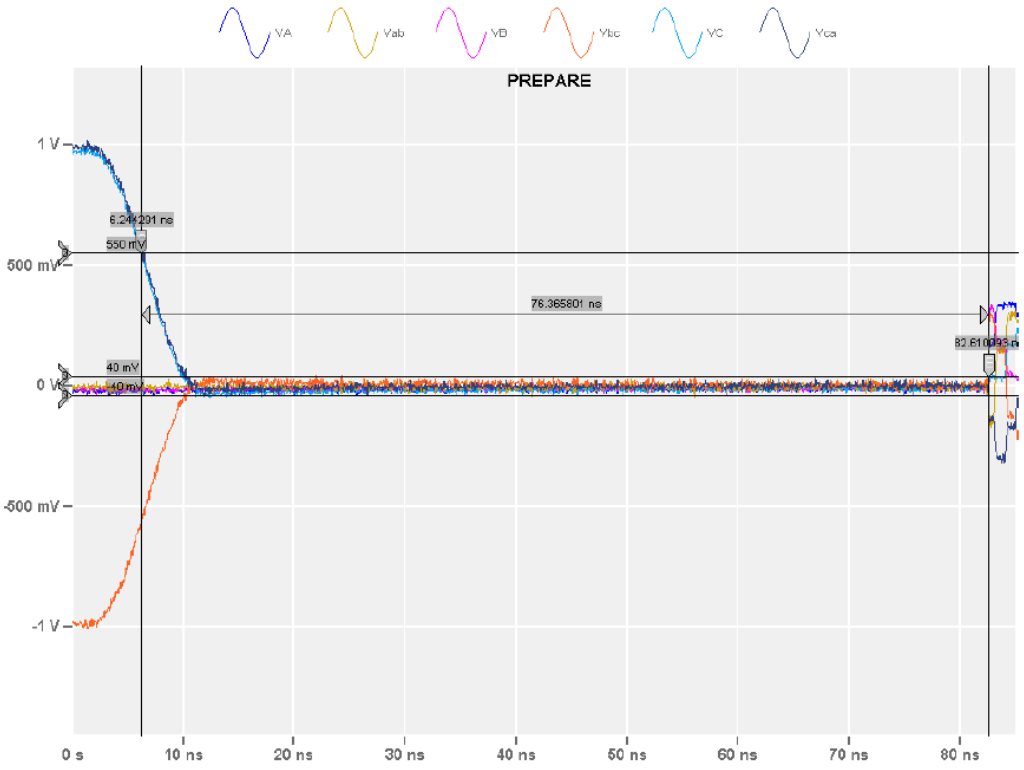
This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the duration of the final LP-000 state immediately before HS transmission ($t_{3\text{-PREPARE}}$) is within the conformance limits.

Measurements

The $t_{3\text{-PREPARE}}$ interval begins at the time where the Lane V_C signal crosses below $V_{IL,MAX}$ (550 mV), and ends at the beginning of the first HS state, at the point where the V_{AB}, V_{BC}, and V_{CA} differential waveforms all cross above the minimum differential threshold level(+/ -40 mV).

Verify that $t_{3\text{-PREPARE}}$ is between 38 and 95 ns.



4.4.3.3 1.2.3 HS-TX $t_{3\text{-PREBEGIN}}$ duration

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the time of $t_{3\text{-PREBEGIN}}$ is within the conformance limits.

Measurements

The $t_{3\text{-PREBEGIN}}$ interval begins at the first differential state where the V_{AB}, V_{BC}, and V_{CA} differential waveforms all cross above the minimum differential threshold level(±40 mV), and ends at the first bit of the $t_{3\text{-PROGSEQ}}$ sequence or the first bit of the $t_{3\text{-PREEND}}$ sequence.

Verify that $t_{3\text{-PREBEGIN}}$ is between 7 and 448 UI.

4.4.3.4 1.2.4 HS-TX $t_{3\text{-}PROGSEQ}$ duration

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

Available, if "PROGSEQ" is enabled in the "Properties" window.

The purpose of this test is to verify that the length of $t_{3\text{-}PROGSEQ}$ is within the conformance limits.

Measurements

The $t_{3\text{-}PROGSEQ}$ interval begins at the end of $t_{3\text{-}PREBEGIN}$, and ends at the first bit of the $t_{3\text{-}PREEND}$ sequence.

Verify that $t_{3\text{-}PROGSEQ}$ is 14 UI.

4.4.3.5 1.2.5 HS-TX $t_{3\text{-}PREEND}$ duration

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the duration of $t_{3\text{-}PREEND}$ is correct.

Measurements

The $t_{3\text{-}PREEND}$ interval begins at the end of $t_{3\text{-}PROGSEQ}$ or at the end of the $t_{3\text{-}PREBEGIN}$ sequence, and ends at the first bit of the $t_{3\text{-}SYNC}$ sequence.

Verify that $t_{3\text{-}PREEND}$ is 7 UI.

4.4.3.6 1.2.6 HS-TX $t_{3\text{-}SYNC}$ duration

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the duration of $t_{3\text{-}SYNC}$ is correct.

Measurements

The $t_{3\text{-}SYNC}$ interval begins at the end of $t_{3\text{-}PREEND}$, and ends at the first bit of the packet data.

Verify for the first Sync Word transmitted in a burst, the measured duration of $t_{3\text{-}SYNC}$ is 7 UI and it contains the symbol sequence, ‘3,4,4,4,4,4,3’.

4.4.3.7 1.2.16 HS-TX – $t_{3\text{-}POST}$ duration

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

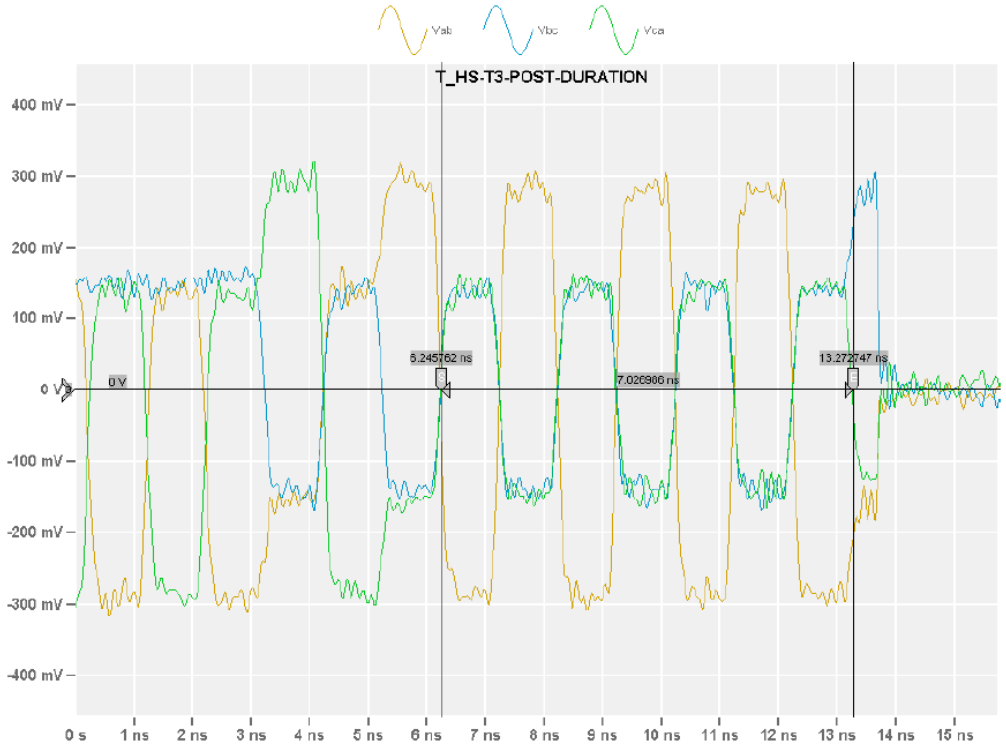
The purpose of this test is to verify that the duration the DUT TX drives the final differential states following the payload data of an HS-TX burst($t_{3\text{ - POST}}$), is greater than the minimum required value.

Measurements

The Post field may often consist of multiple groups of seven “4” symbols to provide a sufficient number of clocks to the upper layer protocol to clear out any pipeline stages that may contain received data.

For all lanes, verify that:

- The length of $t_{3\text{-POST}}$ is from 7 to 224 UI
- The $t_{3\text{-POST}}$ value consists of all ‘4’ symbols.



4.4.3.8 1.2.17 HS-TX 30%-85% post-eoT rise time (t_{REOT})

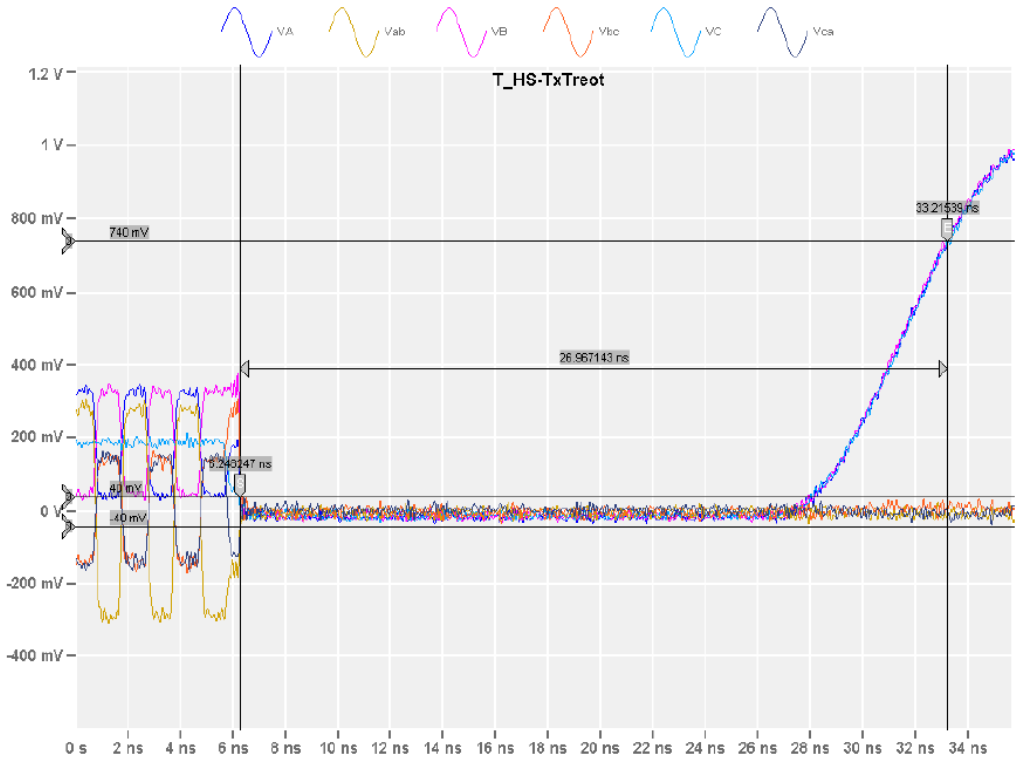
This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the 30%-85% Post-EoT Rise Time (t_{REOT}) of the DUT LP transmitter is within the conformance limits.

Measurements

The t_{REOT} Rise Time is measured starting at the time where the differential waveform last crosses below the minimum valid HS-RX differential threshold level of +/ -40 mV, and ends where V_A crosses $V_{IH,\ MIN}$ = 740 mV.

For all lanes verify that t_{REOT} is less than 35 ns.



4.4.3.9 1.2.18 HS-TX $t_{HS-EXIT}$ value

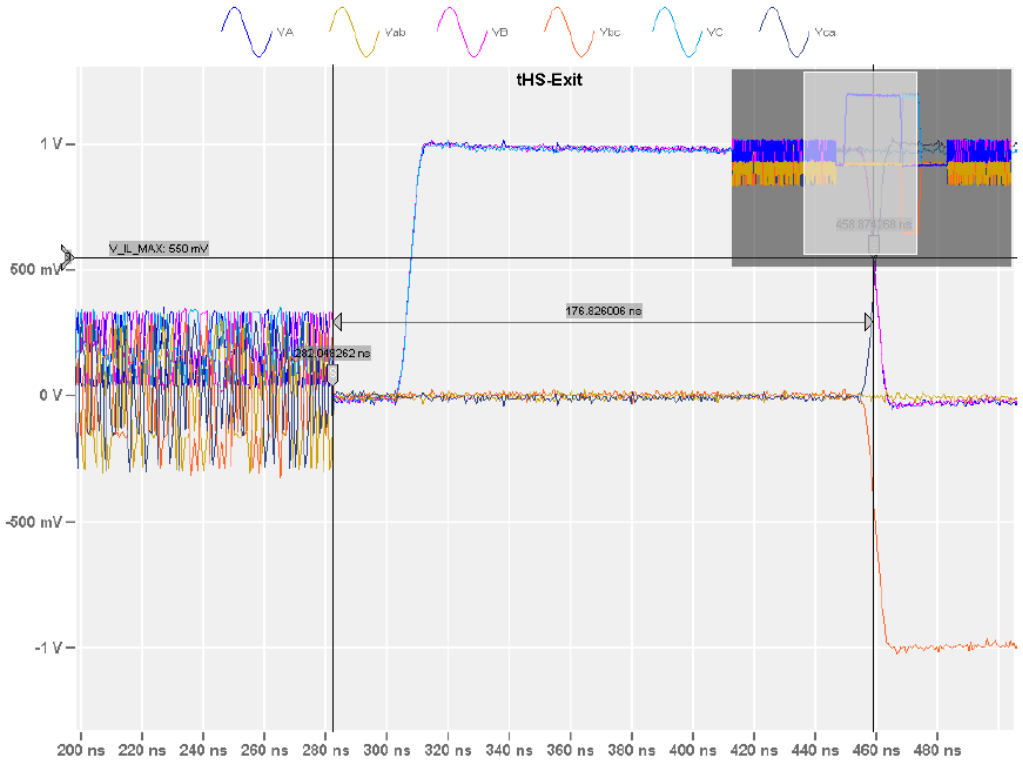
This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the duration that the Lane transmitter remains in the LP-111 (Stop) state after exiting HS mode (t_{HSEXIT}), is greater than the minimum required value.

Measurements

The values are observed over multiple HS bursts to determine the minimum value. t_{HSEXIT} interval starts at the end of the $t_{3\text{-}POST}$ interval and ends when the V_A LP-001 falling edge crosses $V_{IL,MAX}$ (550 mV) during the HS entry sequence of the next successive HS burst.

For all lanes verify that $t_{HS\text{-}EXIT}$ is no less than 100 ns for all observed bursts.



4.5 HS-TX signaling requirements (group 2) - continuous measurements

The HS-TX signaling tests verifies various trasnsmitter requirements pertaining to HS signaling.

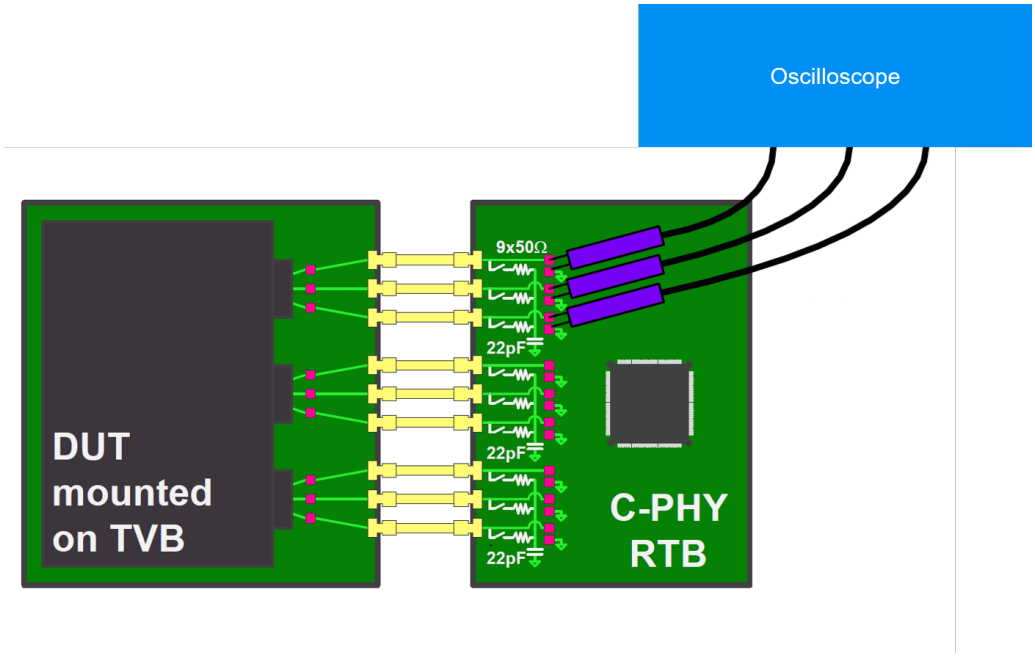
The structure of this group is intended to facilitate the execution of a set of several HS-TX measurements. Some tests are related to the LP exit/entry sequences that occur before and after the burst sequence.

This test group is relevant only for transmitter devices.

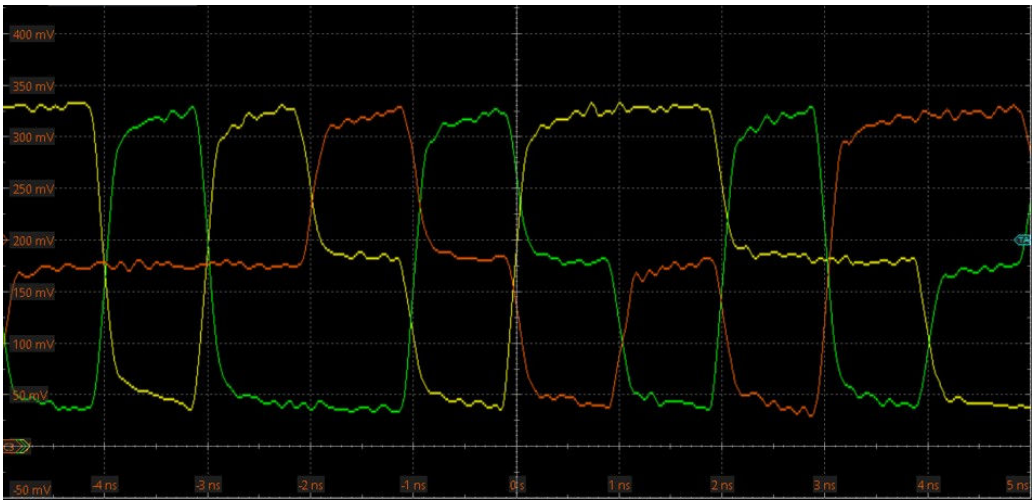
4.5.1 Test setup

Table 4-3: Equipment for Group 2 HS-TX signaling requirements test

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and at least 13 GHz bandwidth	1
Probes	Any single-ended active probes or SMA cables	3
Test fixture	MIPI C-PHY Reference Termination Board (RTB)	1
DUT	Any MIPI C-PHY device	1

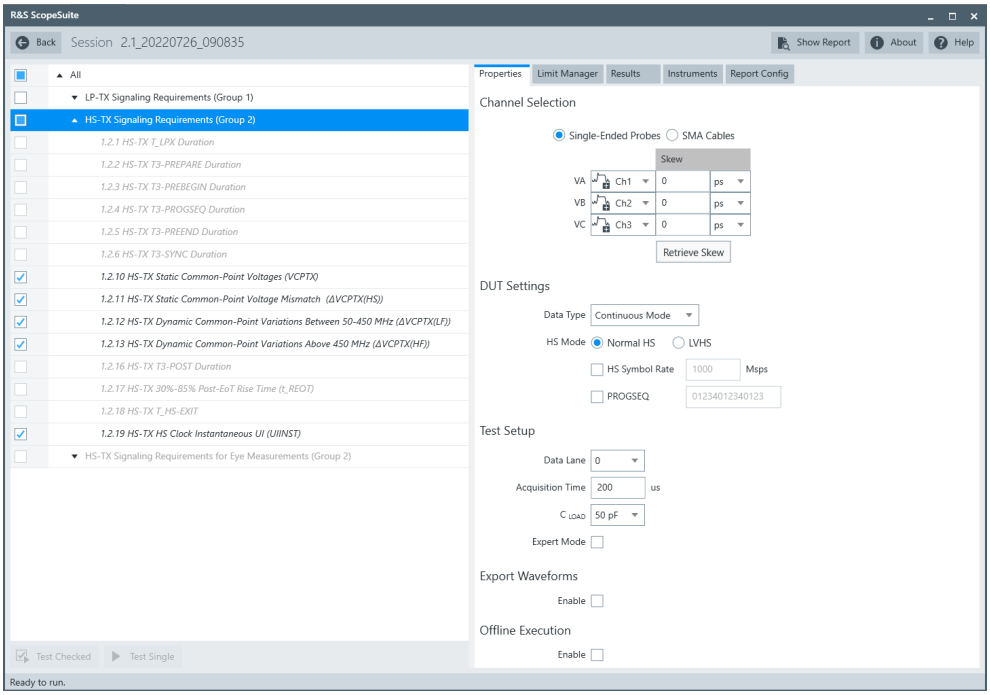


Waveform requirements



4.5.2 Performing group 2 test cases

1. Start the test as described in Chapter 4.1, "Starting C-PHY compliance tests", on page 18.
2. Select the test case group: "HS-TX Signaling Requirements (Group 2)".



3. Set "DUT" > "Data type" = "Continuous Mode"
4. Set the "Properties" for the measurement:
   a) Select, if you are using a "Single-Ended Probes" or "SMA Cables".
   b) Set the channel skew for VA, VB and VC.
   c) Select the devices "HS mode": "Normal HS" or "LVHS".
   d) Enable and set a value for "HS Symbol Rate" if you know the value. Otherwise, R&S RTP will estimates a symbol rate.
   e) Select the "Data Lane" you want to measure.
   f) Set an "Acquisition Time" value between 1us and 200us.
   g) Configure the C_{Load}.
5. Click "Test Single" to run only the selected test case.
   Click "Test Checked" to run all test cases that are checked on the tree.
6. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.

Further steps:

- Chapter 3.3, "Getting test results", on page 16

4.5.3 Measurements

4.5.3.1 1.2.10 HS-TX Static common-point voltages (V_{CPTX})

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run on both "Normal HS" or "LVHS" mode.

The purpose of this test is to verify that the static common-point voltages (V_{CPTX}) of the DUT HS transmitter are within the conformance limits. The average common-point voltage observed over a minimum of 1000 +x UIs is computed as $V_{CPTX(HS\_+X)}$. This applies to +y, +z, -x, -y, -z

Measurements

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

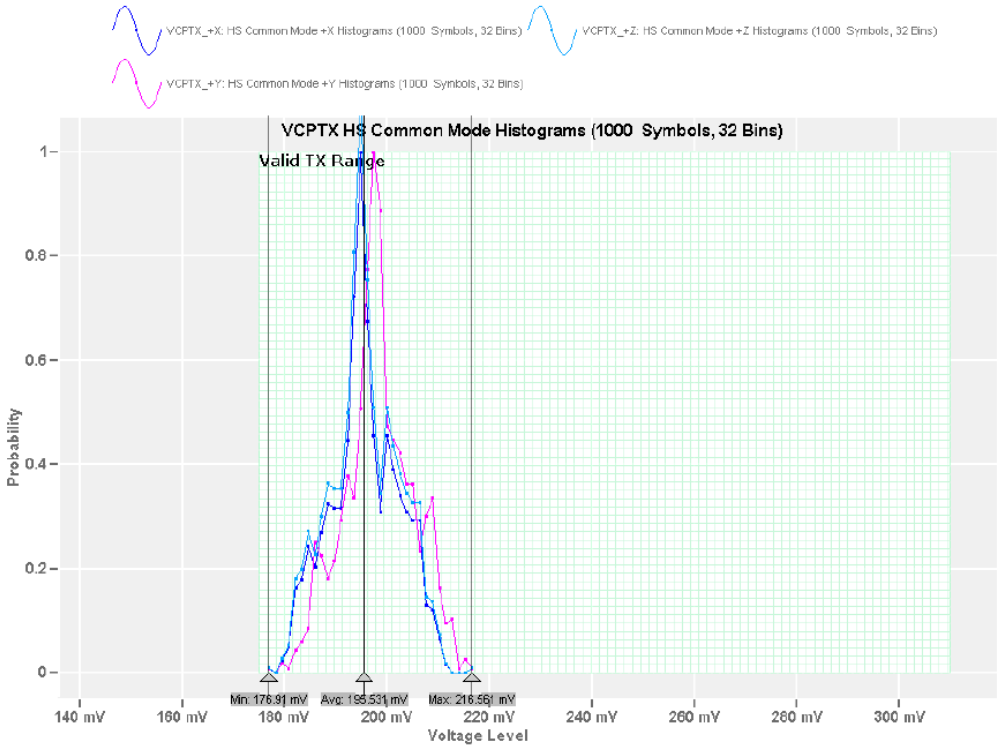
$$V_{CPTX} = \frac{V_A + V_B + V_C}{3}$$

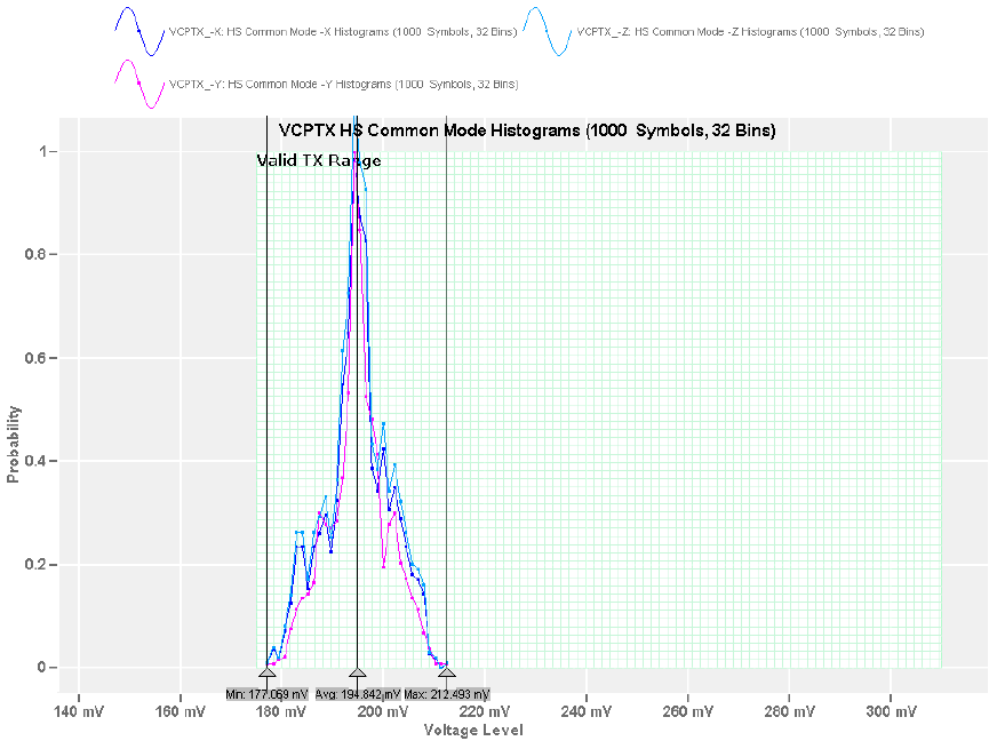
For all lanes in nominal voltage, verify that:

- $V_{CPTX(HS\_+X)}$ is between 175 mV and 310 mV
- $V_{CPTX(HS\_-X)}$ is between 175 mV and 310 mV
- $V_{CPTX(HS\_+Y)}$ is between 175 mV and 310 mV
- $V_{CPTX(HS\_-Y)}$ is between 175 mV and 310 mV
- $V_{CPTX(HS\_+Z)}$ is between 175 mV and 310 mV
- $V_{CPTX(HS\_-Z)}$ is between 175 mV and 310 mV

For all lanes in low voltage, verify that:

- $V_{CPTX(HS\_+X)}$ is between 150 mV and 255 mV
- $V_{CPTX(HS\_-X)}$ is between 150 mV and 255 mV
- $V_{CPTX(HS\_+Y)}$ is between 150 mV and 255 mV
- $V_{CPTX(HS\_-Y)}$ is between 150 mV and 255 mV
- $V_{CPTX(HS\_+Z)}$ is between 150 mV and 255 mV
- $V_{CPTX(HS\_-Z)}$ is between 150 mV and 255 mV


VCPTX_+X: HS Common Mode +X Histograms (1000 Symbols, 32 Bins)
VCPTX_+Z: HS Common Mode +Z Histograms (1000 Symbols, 32 Bins)
VCPTX_+Y: HS Common Mode +Y Histograms (1000 Symbols, 32 Bins)
VCPTX HS Common Mode Histograms (1000 Symbols, 32 Bins)
Valid TX Range
Probability
Voltage Level
140 mV
160 mV
180 mV
200 mV
220 mV
240 mV
260 mV
280 mV
300 mV


VCPTX_-X: HS Common Mode -X Histograms (1000 Symbols, 32 Bins)
VCPTX_-Z: HS Common Mode -Z Histograms (1000 Symbols, 32 Bins)
VCPTX_-Y: HS Common Mode -Y Histograms (1000 Symbols, 32 Bins)
VCPTX HS Common Mode Histograms (1000 Symbols, 32 Bins)
Valid TX Range
Probability
Voltage Level
140 mV
160 mV
180 mV
200 mV
220 mV
240 mV
260 mV
280 mV
300 mV

4.5.3.2 1.2.11 HS-TX static common-point voltage mismatch ($\Delta V_{CPTX(HS)}$)

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the static common-point voltage mismatch ($\Delta V_{CPTX(HS)}$) of the DUT HS transmitter is less than the maximum conformance limit.

Measurements

$V_{CPTX(HS\_+X)}$, $V_{CPTX\ (HS\_-X)}$, $V_{CPTX(HS\_+Y)}$, $V_{CPTX(HS\_-Y)}$, $V_{CPTX(HS\_+Z)}$, and $V_{CPTX(HS\_-Z)}$ are used to compute the HS-TX Static Common-Point Voltage Mismatch, $\Delta V_{CPTX(HS)}$.

The static common-point voltage mismatch between the six High-Speed states is defined as:

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

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

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

For all lanes verify that $\Delta V_{CPTX(HS)}$ is less than 9mV.

4.5.3.3 1.2.12 HS-TX dynamic common-point variations between 50-450 MHz ($\Delta V_{CPTX(LF)}$)

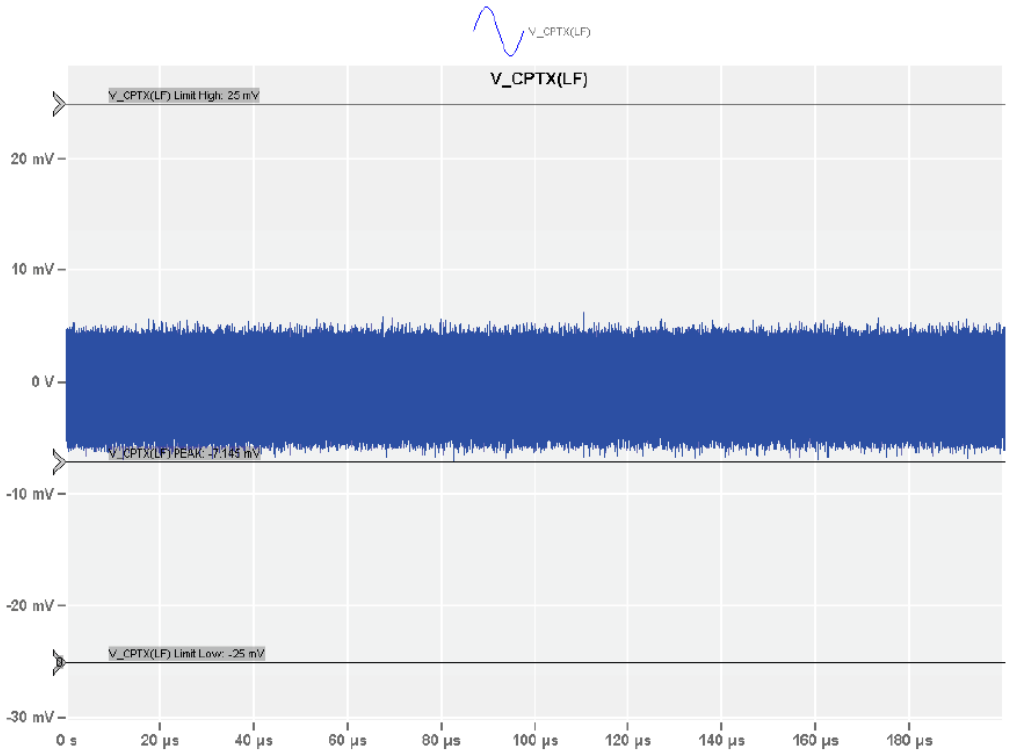
This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the AC Common-Point Signal Level Variations between 50 MHz and 450 MHz ($\Delta V_{CPTX(LF)}$) of the DUT HS transmitter are less than the maximum allowable limit.

Measurements

The selected implementation uses an 8th-order Butterworth IIR bandpass filter as the test filter, with –3 dB cutoff frequencies of 50 MHz and 450 MHz.

For all Lanes verify that $\Delta V_{CPTX(LF)}$ is less than 25 mVPEAK.



4.5.3.4 1.2.13 HS-TX dynamic common-point variations above 450 MHz ($\Delta V_{CPTX(HF)}$)

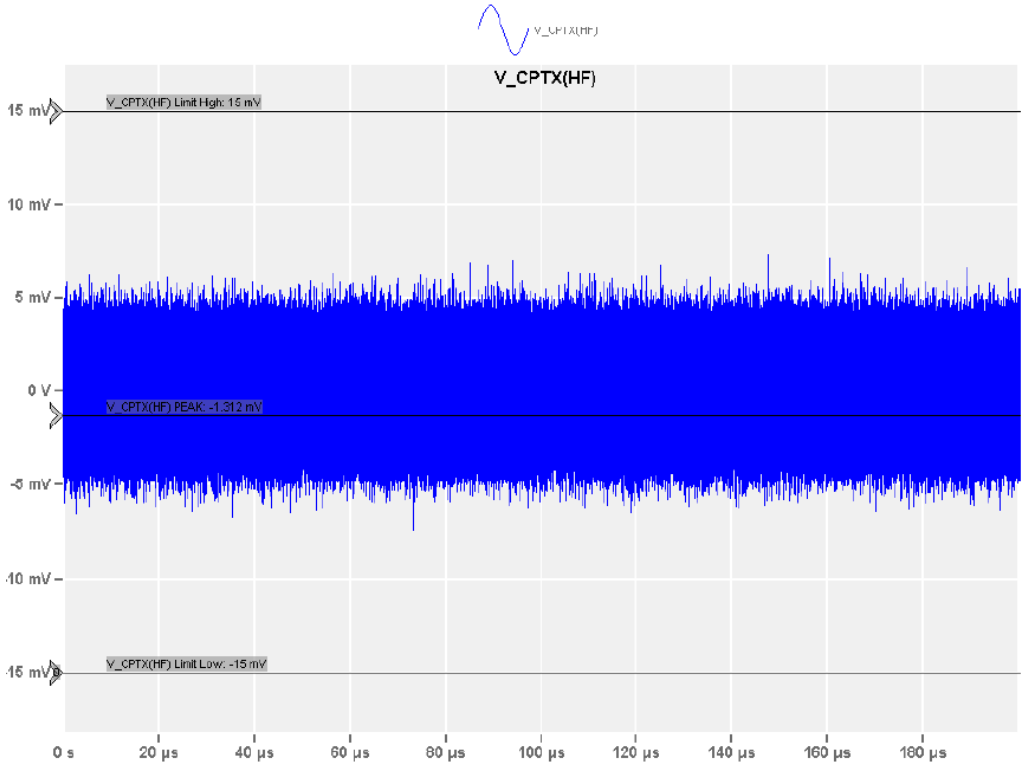
This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the AC Common-Mode Signal Level Variations above 450 MHz ($\Delta V_{CPTX(HF)}$) of the DUT HS transmitter are less than the maximum allowable limit.

Measurements

The test filter for this test is an 8th - order Butterworth highpass filter, with a cutoff frequency of 450 MHz.

For all lanes verify that $\Delta V_{CPTX(HF)}$ is less than 15 mVRMS.



4.5.3.5 1.2.14 HS-TX rise time (t_R)

This test case applies to CPHY version 1.2. The test case can be run for "Normal HS" mode.

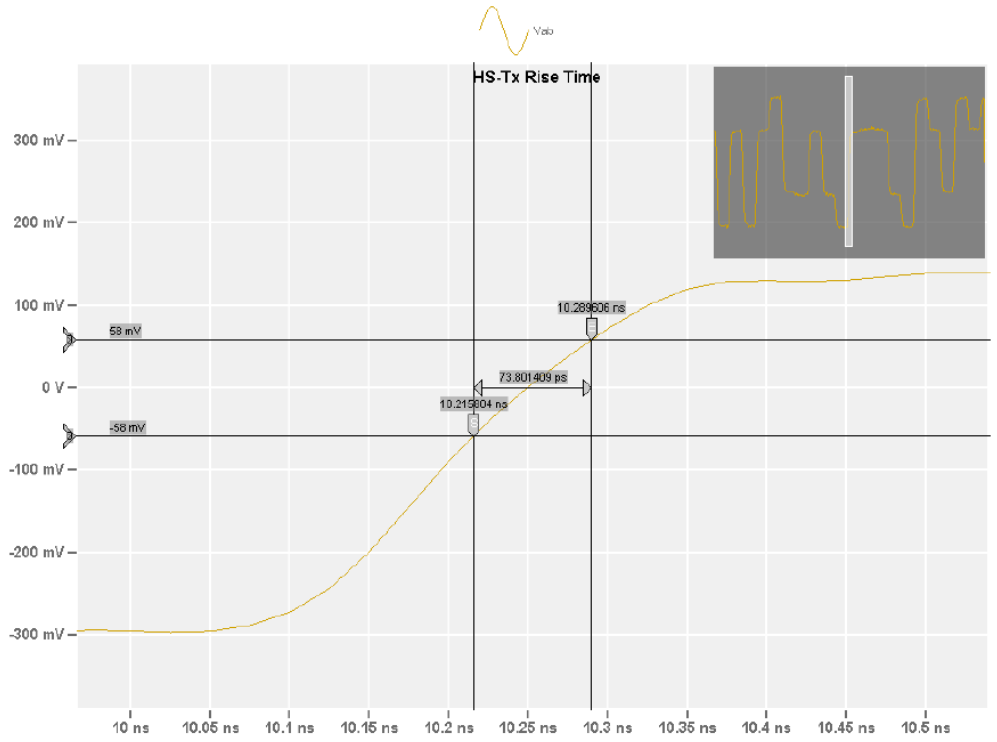
The purpose of this test is to verify that the Rise Time (t_R) of the DUT HS transmitter is within the conformance limits.

Measurements

The differential waveform is computed as difference of the V_A and V_B.The averaged rise time waveform will be computed for the strong zero to weak one transition, averaging at least 128 waveforms. The Rise Time (t_R) of the averaged reference waveform between the –58 and +58 mV levels is measured.

For all lanes, verify that:

- For DUTs operating ≤ 1.5 Gsps, t_R is less than max (0.4 UI, 360) ps.
- For DUTs operating > 1.5 Gsps: t_R is less than 0.285 UI.



4.5.3.6 1.2.15 HS-TX fall time (t_F)

This test case applies to CPHY version 1.2. The test case can be run for "Normal HS" mode.

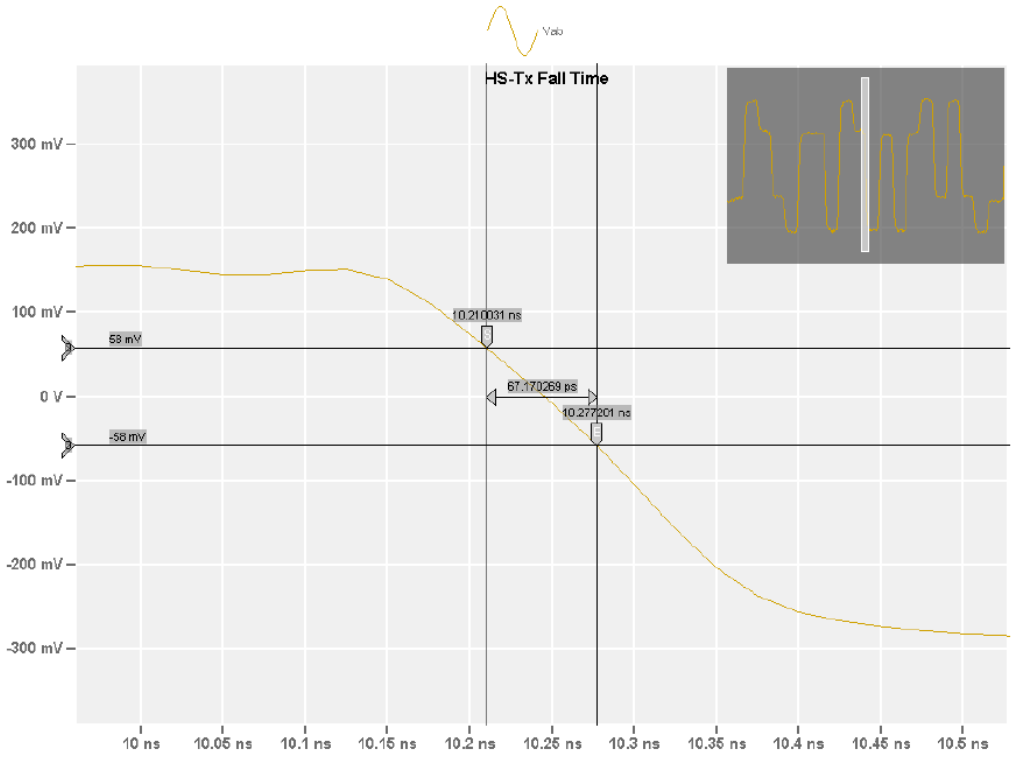
The purpose of this test is to verify that the Fall Time (t_F) of the DUT HS transmitter is within the conformance limits.

Measurements

The differential waveform is computed as difference of the V_A and V_B.The averaged fall time waveform will be computed for the weak one to strong zero transition, averaging at least 128 waveforms. The fall time (t_F) of the averaged reference waveform between the +58 and -58 mV levels is measured.

For all lanes, verify that:

- for DUTs operating ≤ 1.5 Gsps, t_F is less than max (0.4 UI, 360) ps.
- for DUTs operating > 1.5 Gsps: t_F is less than 0.285 UI.



4.5.3.7 1.2.19 HS-TX clock instantaneous UI (UI_{INST})

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the Instantaneous Unit Interval values (UI_{INST}) of the DUT HS transmitter are within the conformance limits.

Measurements

The sample contains at least several thousand UIs.The A-B, B - C, and C-A differential waveforms are computed to observe the zero crossings between each UI. The UI_{INST} values for each UI are measured as the difference between successive 0 V crossing times of the differential waveforms. For cases where multiple crossings occur between UIs, the first crossing is used, and the others ignored.

Verify that the maximum UI_{INST} value is less than 12.5 ns.

4.5.3.8 1.2.20 HS-TX clock delta UI (ΔUI)

This test case applies to CPHY version 1.2. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the frequency stability of the DUT HS Clock during a single burst is within the conformance limits.

Measurements

A double-pole (second-order) Butterworth lowpass filter with a - 3 dB cutoff frequency of 2.0 MHz is used to filter the UI data to remove the high frequency noise/ error components.

Measurements

Verify that:

- for DUTs operating ≤ 1 Gsps, ΔUI is between –10% and +10%.
- for DUTs operating > 1 Gsps, ΔUI is between –5% and +5%.

4.6 HS-TX signaling requirements for eye measurements (group 2)

The HS-TX signaling tests verifies various trasnsmitter requirements pertaining to HS signaling for eye measurements.

This test group is relevant only for transmitter devices.

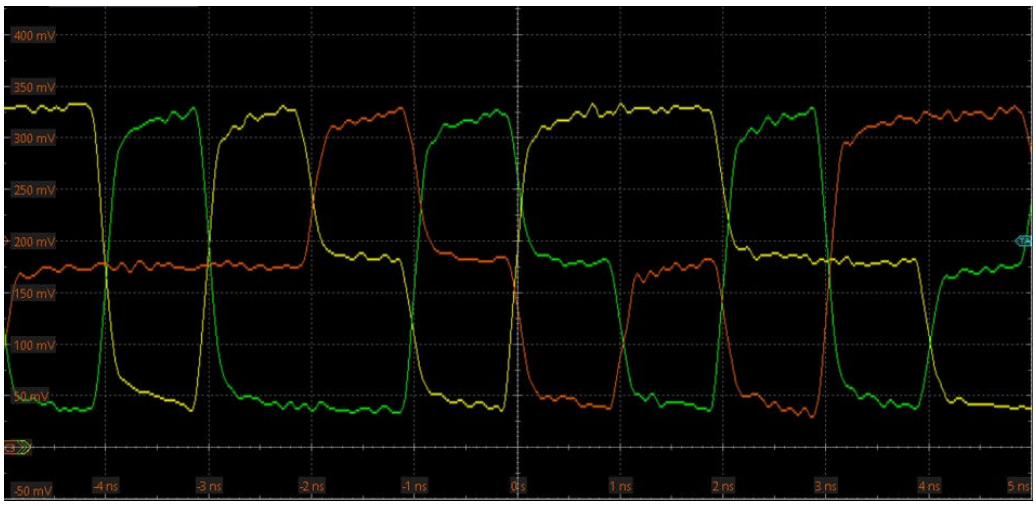
4.6.1 Test setup

Table 4-4: Equipment for Group 2 HS-TX signaling requirements for eye measurements test

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and at least 13 GHz bandwidth	1
Advanced eye analysis	Option R&S RTP-K136 or R&S RTP-K137	1
Probes	Any singled-ended active probes or SMA cables	3
Test fixture	MIPI C-PHY Reference Termination Board (RTB)	1
DUT	Any MIPI C-PHY device	1

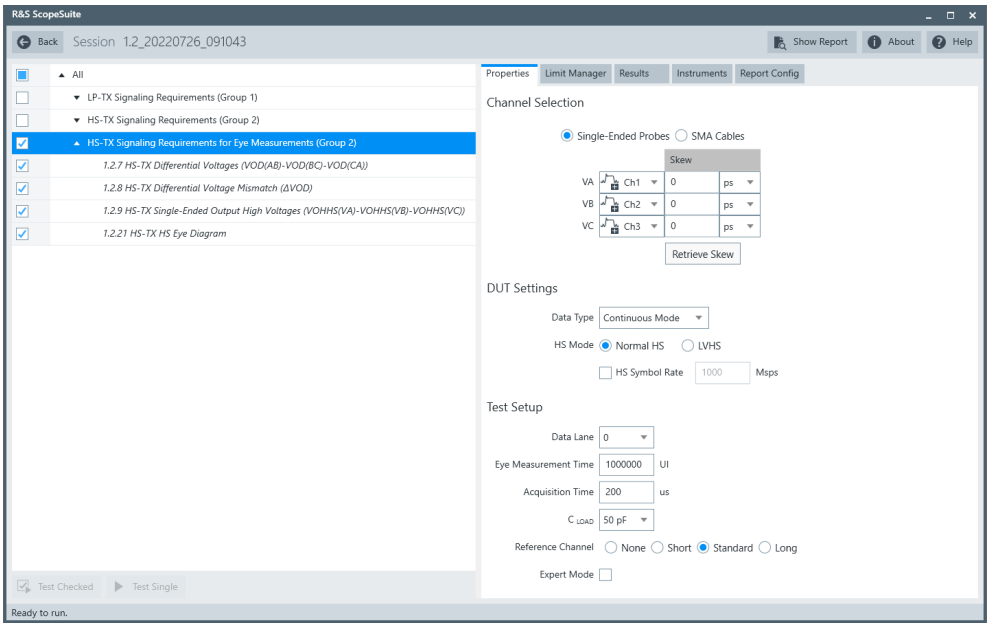
Waveform requirements

A typical signal waveform for this test case are as shown in the figure below:



4.6.2 Performing group 2 test cases

1. Start the test as described in Chapter 4.1, "Starting C-PHY compliance tests", on page 18.
2. Select the test case group: "HS-TX Signaling Requirements for Eye Measurements (Group 2)".



3. Set "DUT" > "Data type" = "Continuous Mode"
4. Set the "Properties" for the measurement:
   a) Select, if you are using a "Single-Ended Probes" or "SMA Cables".
   b) Set the channel skew for VA, VB and VC.
   c) Select the devices "HS mode": "Normal HS" or "LVHS".

d) Enable and set a value for "HS Symbol Rate" if you know the value. Otherwise, R&S RTP will estimates a symbol rate.
e) Select the "Data Lane" you want to measure.
f) Set the "Eye Measurement Time".
g) Set an "Acquisition Time" value between 1us and 200us.
h) Configure the C_{Load}.
i) Select the "Reference channel" type.

5. Click "Test Single" to run only the selected test case.
   Click "Test Checked" to run all test cases that are checked on the tree.
6. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.

Further steps:

- Chapter 3.3, "Getting test results", on page 16

4.6.3 Meausrements

4.6.3.1 1.2.7 HS-TX differential voltages (V_{OD_AB}, V_{OD_BC}, V_{OD_CA})

The purpose of this test is to verify that the Differential Voltages (V_{OD_AB}, V_{OD_BC}, V_{OD_CA}) of the DUT HS transmitter are within the conformance limits.

Measurements

Because the signal tends to settle more toward the right side of the UI, the amplitudes for the Strong 1, Weak 1, Weak 0, and Strong 0 are measured in a 5 % UI range around a point that is at a 20 % UI width before the trigger point, where the waveform eye is settled.

The measurement result is determined by computing the mean value of the Strong 1, Weak 1, Weak 0, and Strong 0 levels over a minimum of 1000 UI.This results in approximately 250 UI to compute the mean value of each of the four levels.

For all Lanes (Nominal voltage) verify that:

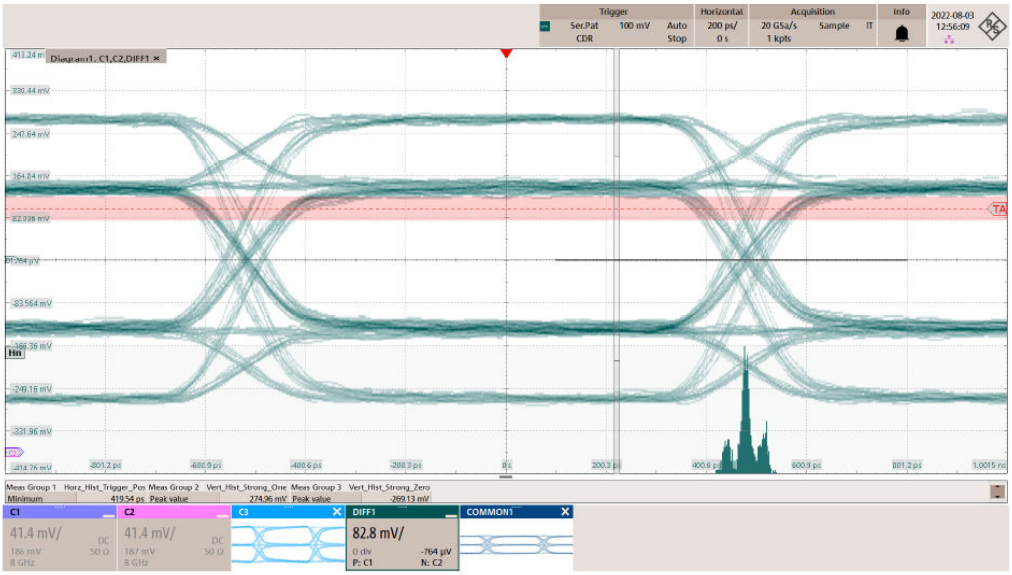
- $V_{OD\_AB(MEAN)}$ for the Strong 1 is less than 300 mV.
- $V_{OD\_AB(MEAN)}$ for the Weak 1 is greater than 90 mV.
- $V_{OD\_AB(MEAN)}$ for the Weak 0 is less than -90 mV.
- $V_{OD\_AB(MEAN)}$ for the Strong 0 is greater than -300 mV.
- $V_{OD\_BC(MEAN)}$ for the Strong 1 is less than 300 mV.
- $V_{OD\_BC(MEAN)}$ for the Weak 1 is greater than 90 mV.
- $V_{OD\_BC(MEAN)}$ for the Weak 0 is less than -90 mV.
- $V_{OD\_BC(MEAN)}$ for the Strong 0 is greater than -300 mV.
- $V_{OD\_CA(MEAN)}$ for the Strong 1 is less than 300 mV.

- $V_{OD\_CA(MEAN)}$ for the Weak 1 is greater than 90 mV.
- $V_{OD\_CA(MEAN)}$ for the Weak 0 is less than -90 mV.
- $V_{OD\_CA(MEAN)}$ for the Strong 0 is greater than -300 mV.

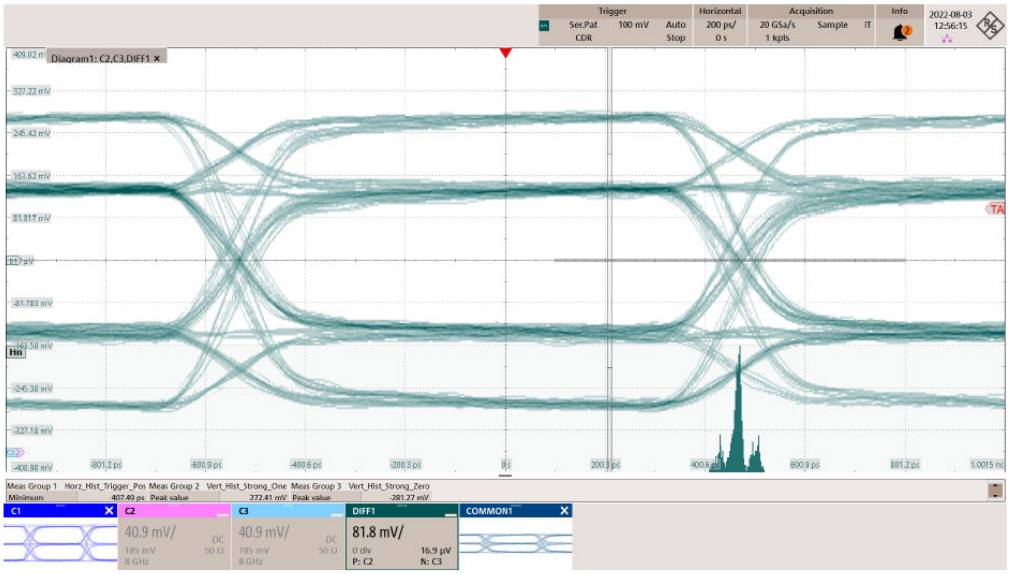
For all Lanes (Low voltage, LVHS) verify that:

- $V_{OD\_AB(MEAN)}$ for the Strong 1 is less than 300 mV.
- $V_{OD\_AB(MEAN)}$ for the Weak 1 is greater than 70 mV.
- $V_{OD\_AB(MEAN)}$ for the Weak 0 is less than -70 mV.
- $V_{OD\_AB(MEAN)}$ for the Strong 0 is greater than -300 mV.
- $V_{OD\_BC(MEAN)}$ for the Strong 1 is less than 300 mV.
- $V_{OD\_BC(MEAN)}$ for the Weak 1 is greater than 70 mV.
- $V_{OD\_BC(MEAN)}$ for the Weak 0 is less than -70 mV.
- $V_{OD\_BC(MEAN)}$ for the Strong 0 is greater than -300 mV.
- $V_{OD\_CA(MEAN)}$ for the Strong 1 is less than 300 mV.
- $V_{OD\_CA(MEAN)}$ for the Weak 1 is greater than 70 mV.
- $V_{OD\_CA(MEAN)}$ for the Weak 0 is less than -70 mV.
- $V_{OD\_CA(MEAN)}$ for the Strong 0 is greater than -300 mV.

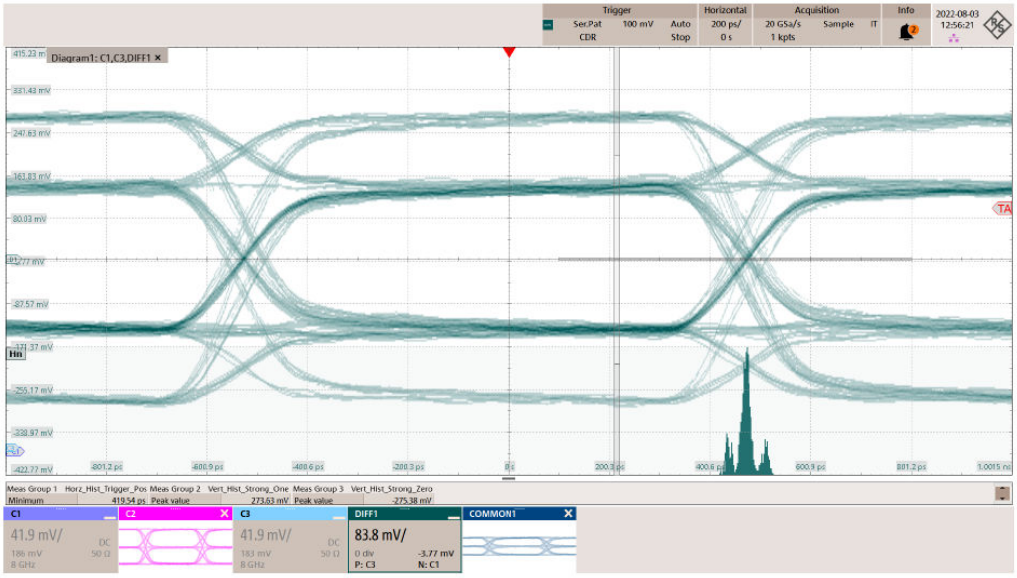
VOD_AB_Mean(Strong1)



VOD_BC_Mean(Strong1)



VOD_CA_Mean(Strong1)



4.6.3.2 1.2.8 HS-TX differential voltage mismatch (ΔV_{OD})

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" or "LVHS" mode.

The purpose of this test is to verify that the Differential Voltage Mismatch (ΔV_{OD}) of the DUT HS transmitter is within the conformance limits.

The output differential voltage mismatch, ΔV_{OD}, is defined as the difference of the maximum and minimum of: the absolute values of the differential strong one and strong zero output voltages of the three possible wire pairs.

Measurements

$$V_{OD\_MAX} = max(V_{OD\_AB\_+X}, |V_{OD\_AB\_-X}|, V_{OD\_BC\_+Y}, |V_{OD\_BC\_-Y}|, V_{OD\_CA\_+Z}, |V_{OD\_CA\_-Z}|)$$

$$V_{OD\_MIN} = min(V_{OD\_AB\_+X}, |V_{OD\_AB\_-X}|, V_{OD\_BC\_+Y}, |V_{OD\_BC\_-Y}|, V_{OD\_CA\_+Z}, |V_{OD\_CA\_-Z}|)$$

$$\Delta V_{OD} = V_{OD\_MAX} - V_{OD\_MIN}$$

For all lanes verify that the absolute value of ΔV_{OD} is less than 17 mV.

4.6.3.3 1.2.9 HS-TX single-ended output high voltages ($V_{OHHS}(V_A)$, $V_{OHHS}(V_B)$, $V_{OHHS}(V_C)$)

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

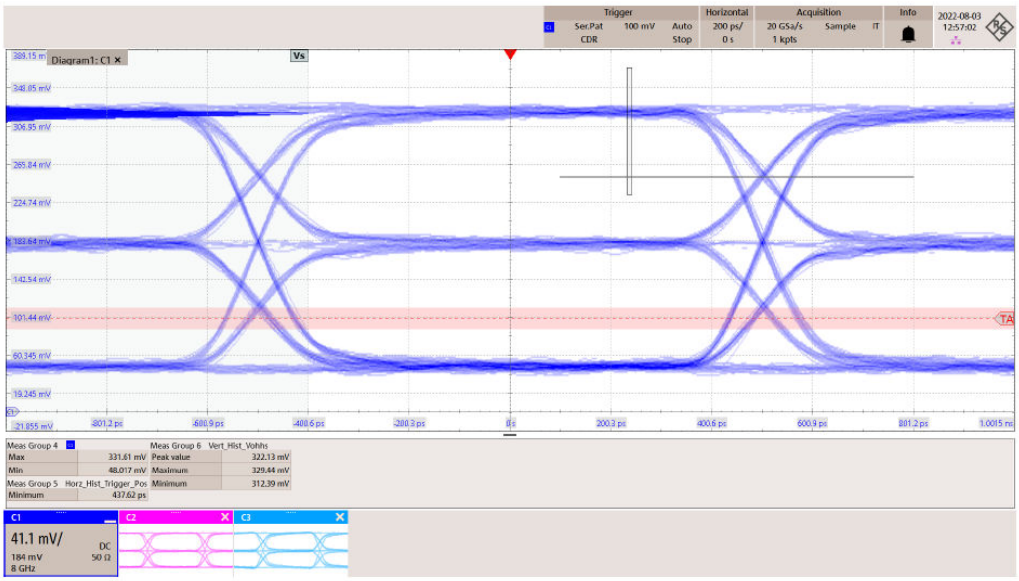
The purpose of this test is to verify that the Single-Ended Output High Voltages ($V_{OHHS}(V_A)$, $V_{OHHS}(V_B)$, $V_{OHHS}(V_C)$) of the DUT HS transmitter are less than the maximum conformance limit.

Measurements

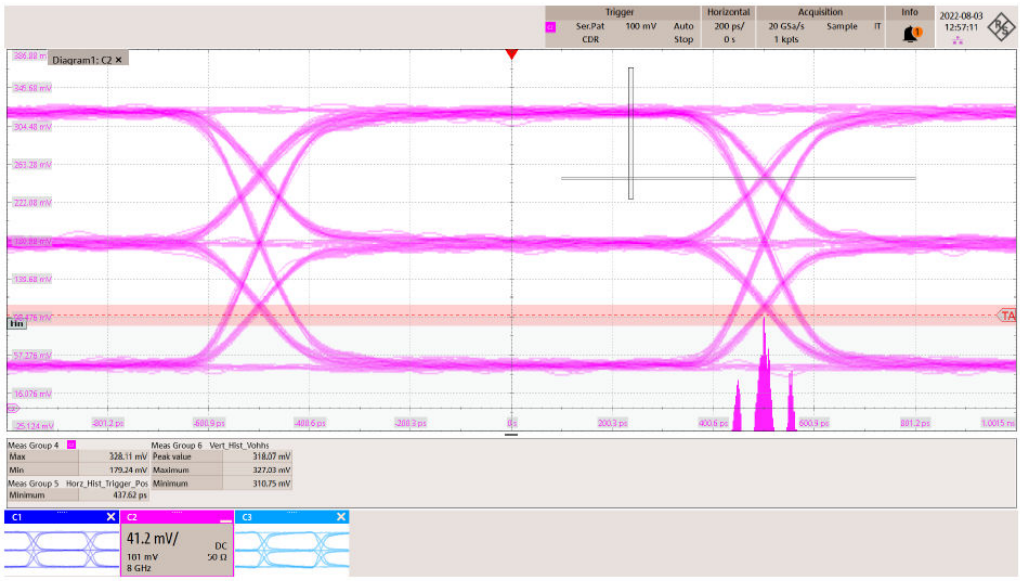
The V_{OHHS} values for V_A, V_B, and V_C (which are denoted as $V_{OHHS}(V_A)$, $V_{OHHS}(V_B)$, and $V_{OHHS}(V_C)$ for the purposes of this test) are computed using the same methodology as was used for V_{OD}.

For all lanes verify that $V_{OHHS}(V_A)$, $V_{OHHS}(V_B)$, and $V_{OHHS}(V_C)$) are less than 425 mV.

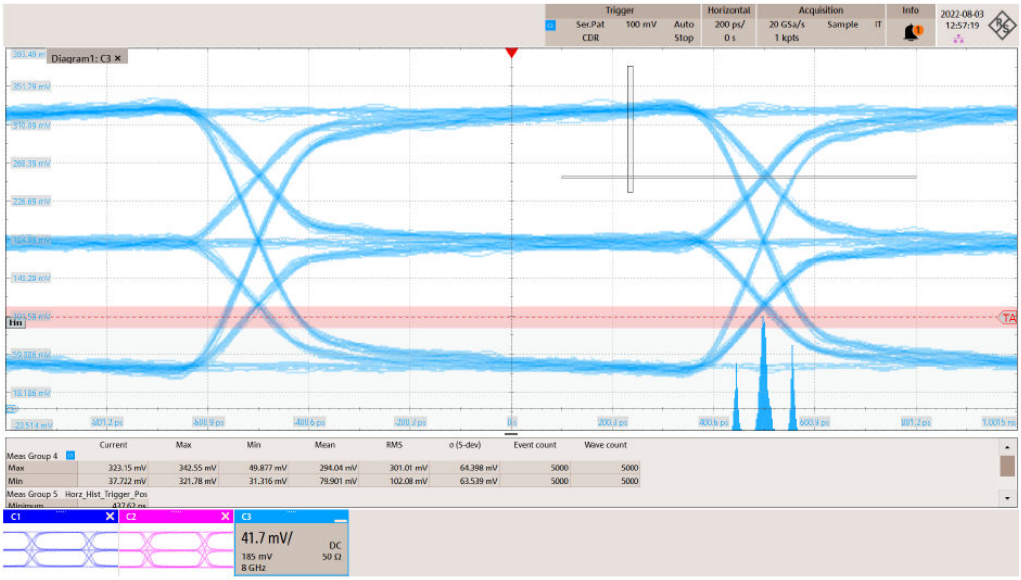
VOHHS(VA)



VOHHS(VB)



VOHHS(VC)



4.6.3.4 1.2.21 HS-TX eye diagram

This test case applies to both CPHY versions 1.2 and 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the DUT's HS-TX meets the requirements of the Transmitter Eye Diagram specification.

Measurements

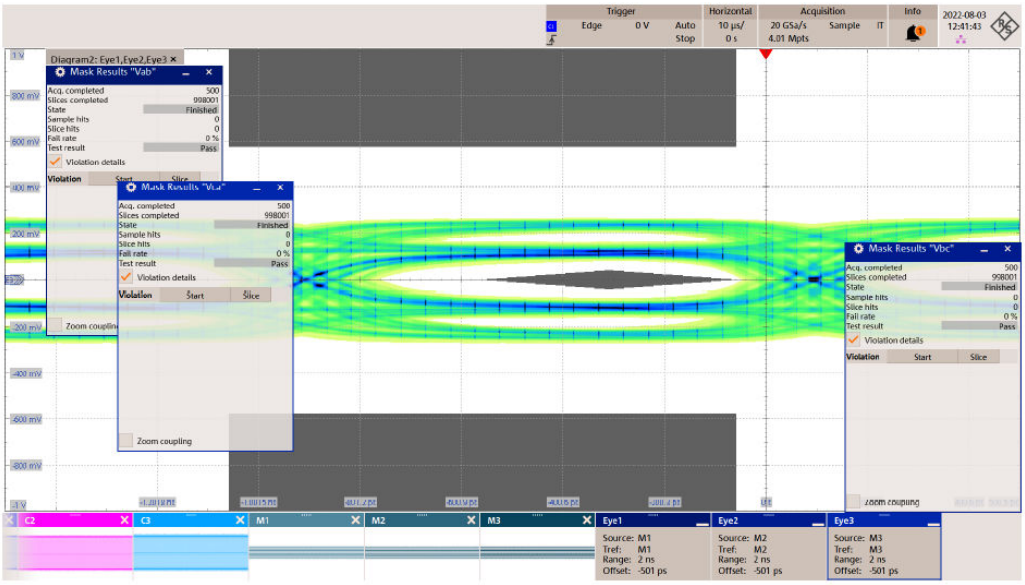
This test is applicable for all operating symbol rates.

For all three differential waveforms and for all Lanes verify that the DUT has no mask hits. One incursion into the prorated mask is allowed, if a prorated masks is used. More than one incursion into the prorated mask is rated as fail.

Section 10 of the C-PHY Specification defines the Transmitter Eye Diagram requirements. Based on the operating symbol rate, two different eye diagrams are defined that are specified at the end of the reference channel.

For devices with maximum operating symbol rates ≥1 Gsps, a diamond shaped eye diagram is specified. For devices with maximum operating symbol rates < 1 Gsps, a hexagonal shaped eye diagram is specified.

Eye Diagram



4.6.3.5 1.2.22 - HS-TX UI jitter ($UI\_Jitter_{PEAK\_TX}$)

This test case applies to CPHY versions 2.1. The test case can be run for "Normal HS" mode.

The purpose of this test is to verify that the DUT's HS-TX meets the requirements of the Transmitter UI Jitter specification.

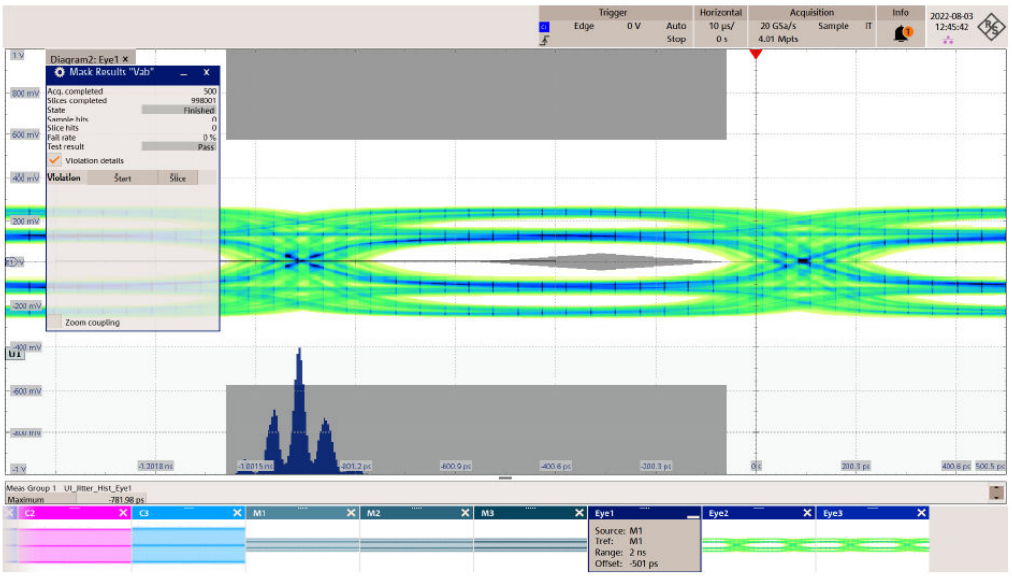
Measurements

This test is applicable for the "HS symbol rates" above 2.5 Gsps.

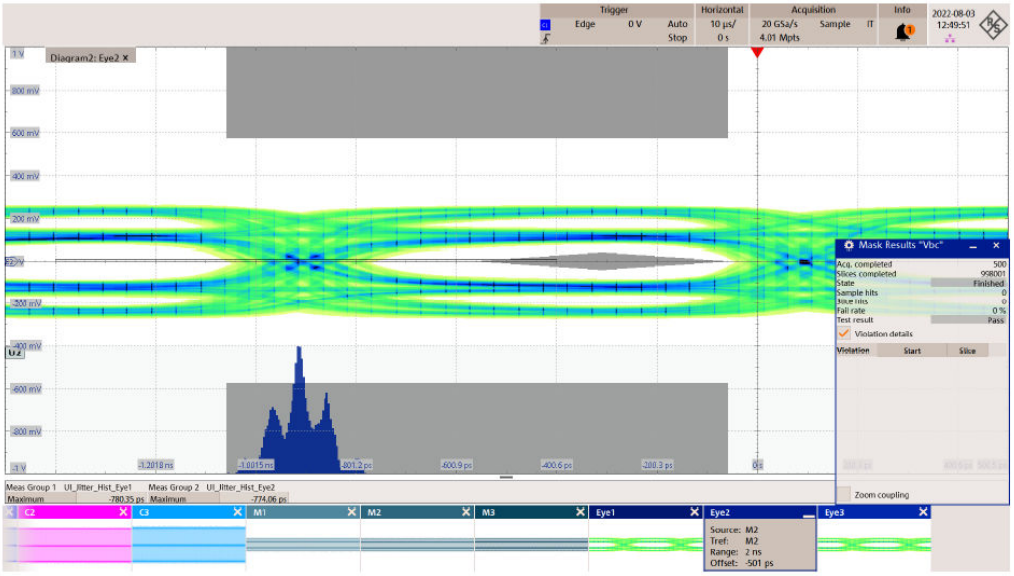
Section 10 of the C-PHY Specification defines the High-Speed Timing requirements. Included in these requirements is a requirement for UI Jitter:

for all Lanes verify that the UI_Jitter_{PEAK} value is less than the $UI\_Jitter_{PEAK\_TX}$ maximum limits.

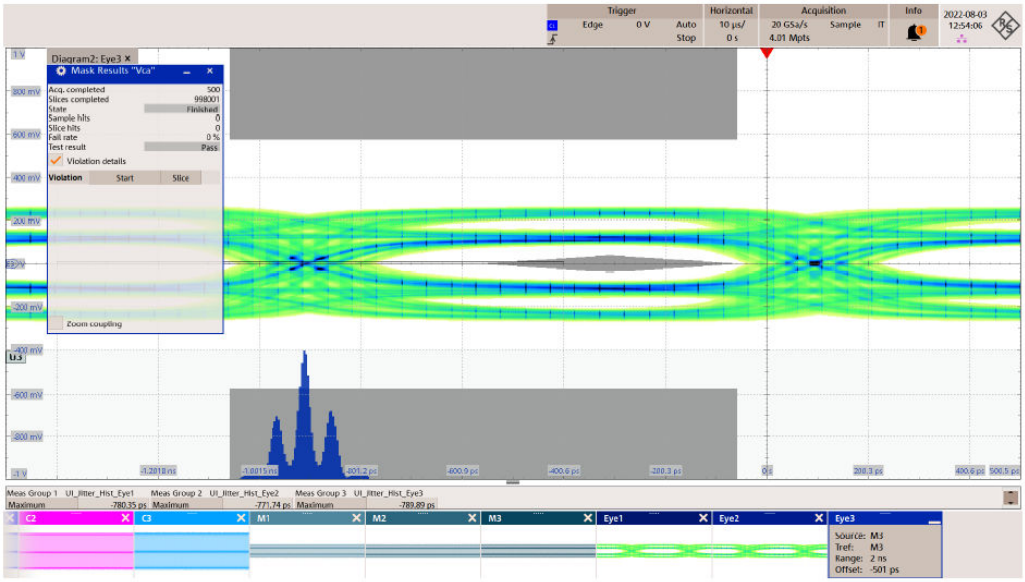
UIchan(AB)_Tx



UIchan(BC)_Tx



UIchan(CA)_Tx


Trigger
Horizontal
Acquisition
Info
Diagram2: Eye3
Mask Results "Vca"
Violation details
Violation
Start
Slice
Zoom coupling
C2
C3
M1
M2
M3
Eye1
Eye2
Eye3