R&S®RTP-K114/-K115
DisplayPort Compliance Test
User Manual

1179764002
Version 01

ROHDE&SCHWARZ
Make ideas real

This document describes the DisplayPort Compliance Test Procedures of the following options:

- R&S®RTP-K114 DisplayPort (DP) 1.4a compliance test (1803.6903.02)
- R&S®RTP-K115 Embedded DisplayPort (eDP) 1.4b/1.5 compliance test (1803.6910.02)

Muehldorfstr. 15, 81671 Muenchen, Germany
Phone: +49 89 41 29 - 0
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

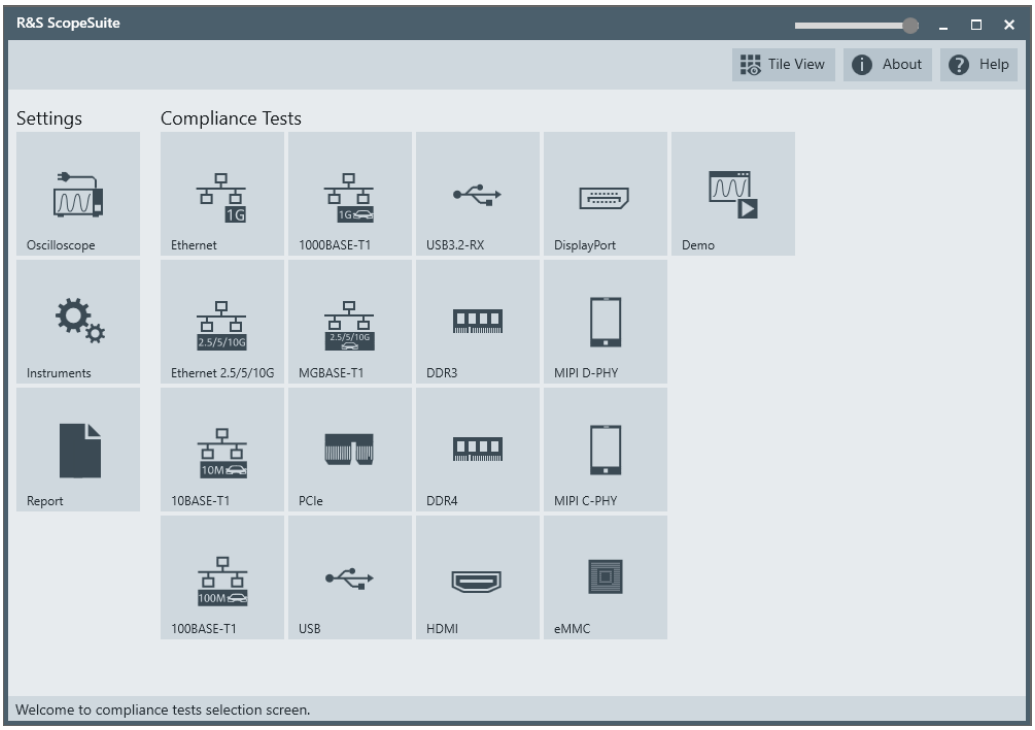
1179.7640.02 | Version 01 | R&S®RTP-K114/-K115

Throughout this manual, R&S® is indicated as R&S.

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.

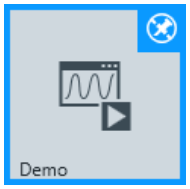


Figure 1-1: Unpin icon

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

DisplayPort 1.4

For DisplayPort 1.4 compliance tests, the following test equipment is needed:

- R&S RTP with 4 channels and minimum 16 GHz bandwidth
- R&S RTP-K114 DisplayPort 1.4 compliance test option (required option, installed on the R&S RTP)
- Additional R&S RTP options:
  - Option R&S RTP-K133 or R&S RTP-K134 Advanced jitter and noise
  - Option R&S RTP-K137 Advanced eye analysis
  - Option R&S RTP-K141 high-speed serial patter trigger
- For measuring Main-Link signals you need one of the following:

  For one lane measurements:
  - 1 differential probe with SMA module and 16 GHz bandwidth, e.g R&S ZM160 with RT-ZMA40.
  - 2 SMA cables

  For dual lane measurements:
  - 2 differential probes with SMA module and 16 GHz bandwidth, e.g R&S ZM160 with RT-ZMA40.
  - 4 SMA cables
- For measuring AUX CH signal:
  - 1 differential probe, e.g R&S ZM160 and 1 SMA module R&S RT-ZMA40
  - 2 single-ended probes with at least 500MHz bandwidth
- Test fixtures:
  - DisplayPort AUX controller: recommended Unigraf UCD-323 for full DUT automated control
  - Auxiliary Control test Adapter: recommended Wilder Technologies Auxiliary Control Test Adapter or equivalent
  - Embedded DisplayPort test Adapter: recommended Wilder Technologies EDP-TPA40L or equivalent
- Optional for return loss tests: vector network analyzer with frequency range from 50MHz to 12GHz, eg. R&S ZNB, R&S ZNC, R&S ZND or R&S ZVA.
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTP.

Embedded DisplayPort 1.4b/1.5

For Embedded DisplayPort 1.4b/1.5 compliance tests, the following test equipment is needed:

- R&S RTP with 4 channels and minimum 16 GHz bandwidth
- R&S RTP-K115 EDP 1.4 compliance test option (required option, installed on the R&S RTP)
- Additional R&S RTP options:
  - Option R&S RTP-K133 or R&S RTP-K134 Advanced jitter and noise
  - Option R&S RTP-K137 Advanced eye analysis
- For measuring Main-Link signals you need one of the following:

  For one lane measurements:
  - 1 differential probe with SMA module and 16 GHz bandwidth, e.g R&S ZM160 with RT-ZMA40.
  - 2 SMA cables

  For dual lane measurements:
  - 2 differential probes with SMA module and 16 GHz bandwidth, e.g R&S ZM160 with RT-ZMA40.
  - 4 SMA cables
- For measuring AUX CH signal:
  - 1 differential probe, e.g R&S ZM160 and 1 SMA module R&S RT-ZMA40
  - 2 single-ended probes with at least 500MHz bandwidth
- Test fixtures:
  - DisplayPort AUX controller: recommended Unigraf UCD-323 for full DUT automated control
  - Auxiliary Control test Adapter: recommended Wilder Technologies Auxiliary Control Test Adapter or equivalent
  - Embedded DisplayPort test Adapter: recommended Wilder Technologies EDP-TPA40L or equivalent
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTP.

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.
- 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 10

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:

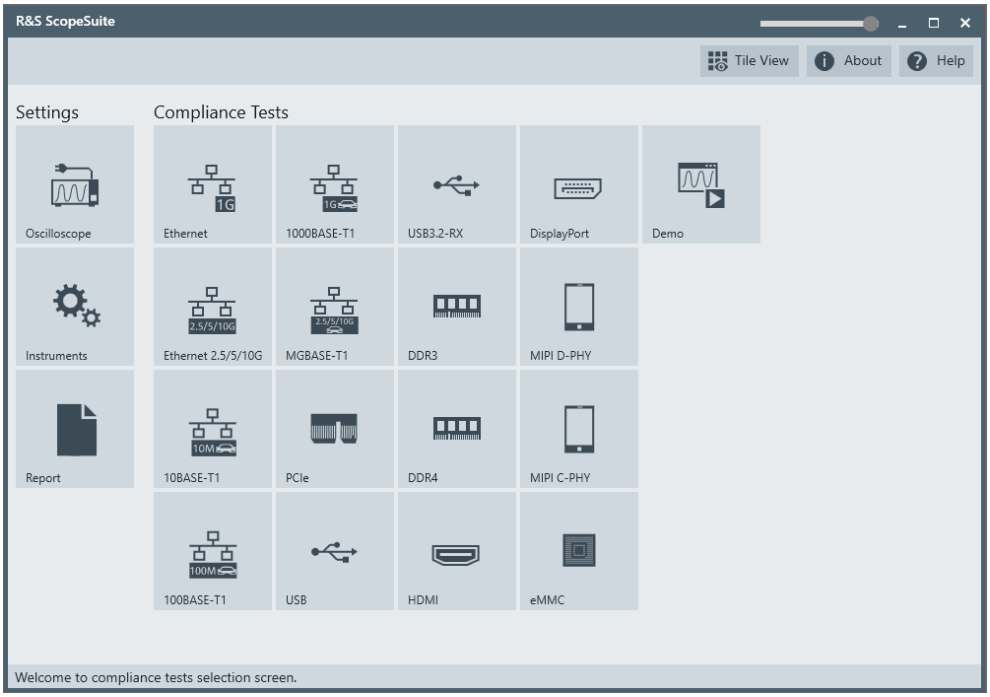
► In the "Apps" dialog, open the "Compliance" tab.

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 9. The R&S ScopeSuite software needs the IP address of the oscilloscope to establish connection.

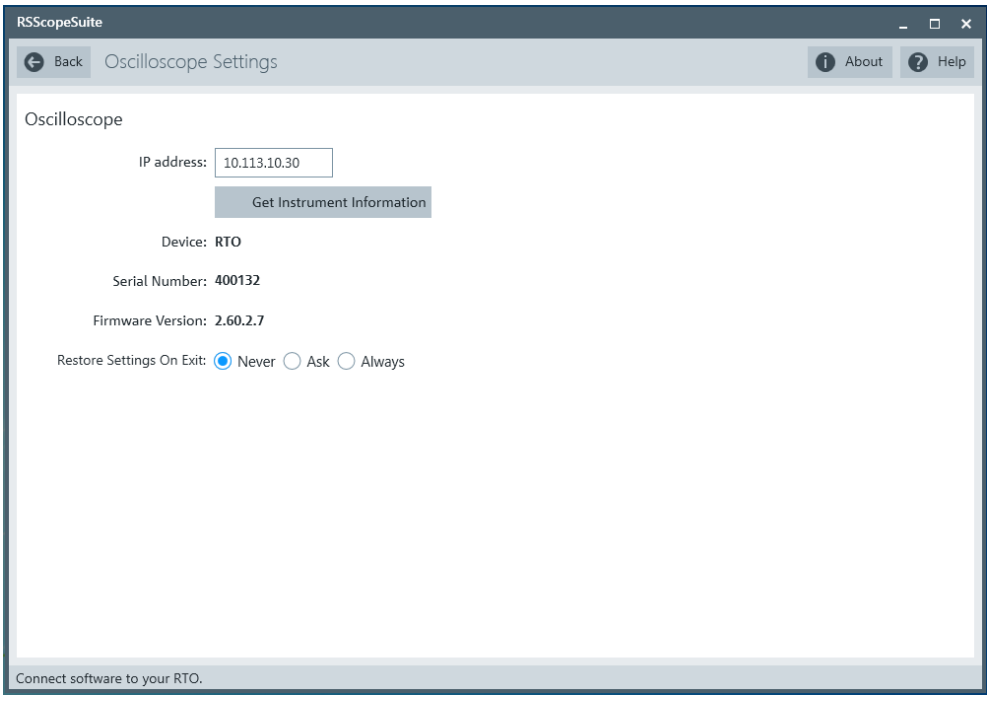
1. Start the R&S RTP.
2. Start the R&S ScopeSuite software.
3. Click "Settings" > "Oscilloscope".



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 vector network analyzer

The vector network analyzer (VNA) is required to perform Ethernet return loss measurements.

Similar to the AWG, the VNA can be used in automatic or manual mode. You can use the automatic mode only with supported instruments. A LAN connection and a VISA installation on the computer that is running the R&S ScopeSuite is required. If the R&S ScopeSuite is installed on the R&S RTP, no installation is needed because VISA is already installed on the instrument.

For manual test execution, it is recommended to use one of the listed VNAs. Moreover, any VNA can be used that meets the following requirements:

- S11 parameter measurements are possible
- Can export trace data in Touchstone (`*.s1p`) or `*.csv` format
- Supports frequency range 1 MHz to 500 MHz

In manual mode, you connect the vector network analyzer to the test board and configure the instrument manually.

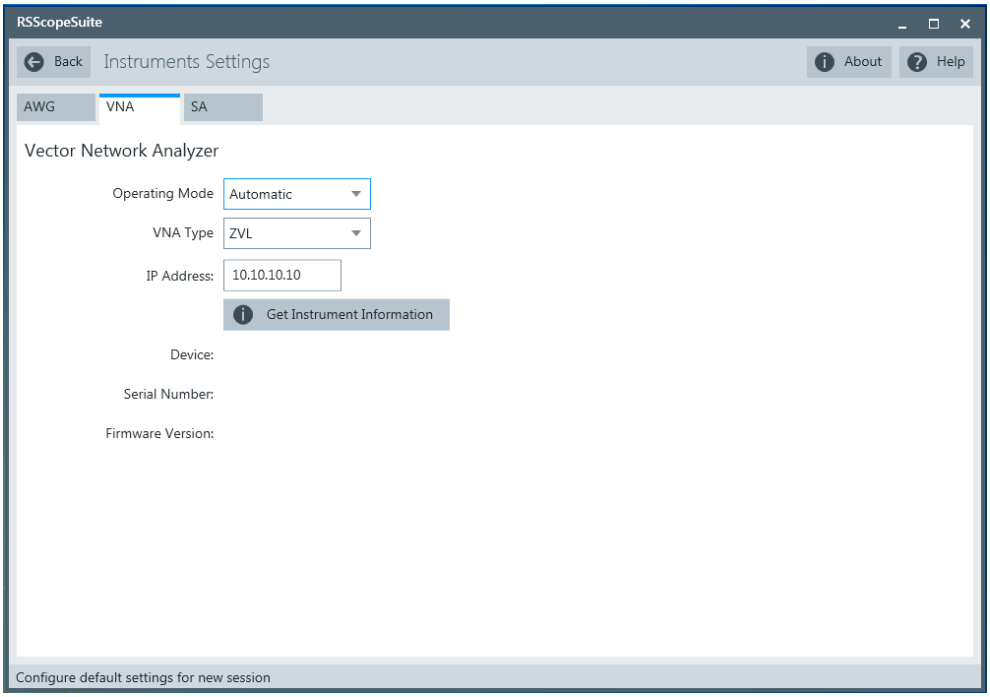
To connect the vector network analyzer for automatic testing

1. Connect the computer and the VNA and set up the LAN connection, see Chapter 2.3, "Setting up the network", on page 9.
2. In the R&S ScopeSuite, click "Instruments".
3. Click the "VNA" tab.
4. Select the "Automatic" operating mode.
5. Select the "VNA Type" and enter its IP address.
6. Click "Get Instrument Information".

The computer or R&S RTP connects with the instrument and retrieves the instrument data.

To connect the vector network analyzer for automatic testing

1. Connect the computer and the VNA. Set up the LAN connection, see Chapter 2.3, "Setting up the network", on page 9.
2. In the R&S ScopeSuite, click "Instruments".
3. Click the "VNA" tab.
4. Select the "Automatic" operating mode.
5. Select the "VNA Type" and enter its IP address.



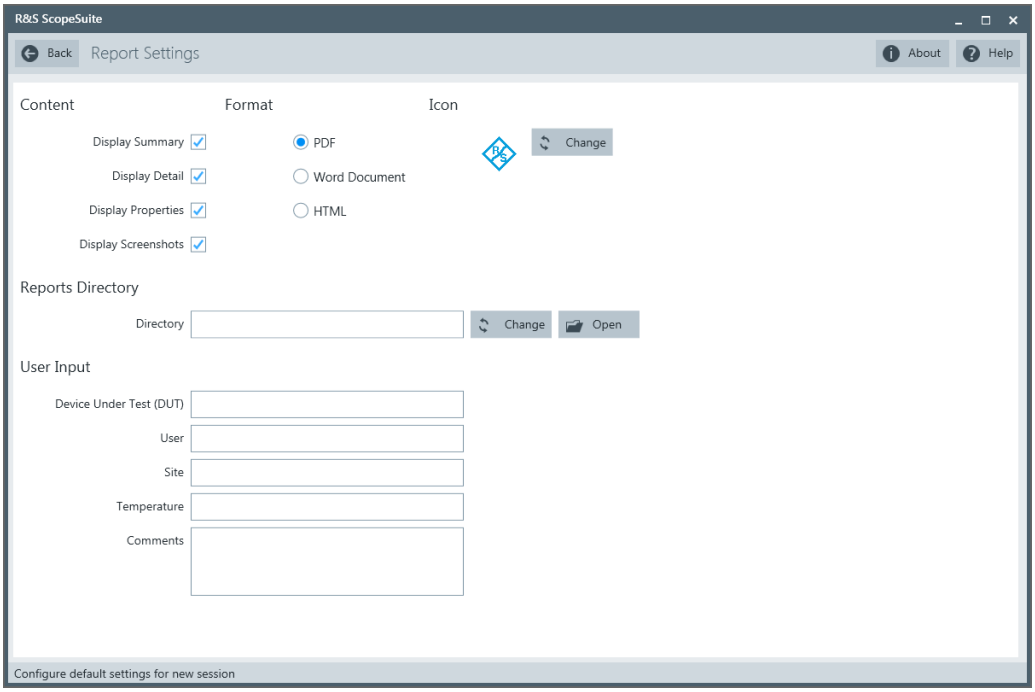
6. Click "Get Instrument Information".

   The computer or R&S RTP connects with the instrument and retrieves the instrument data.

2.7 Report configuration

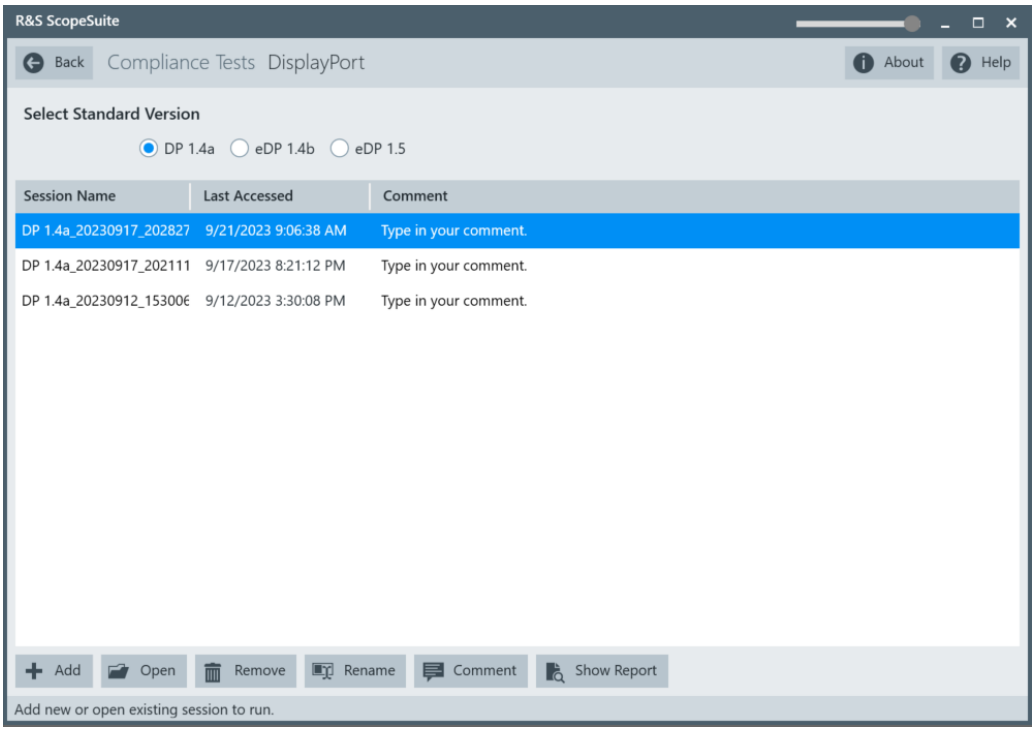
In the "Report Configuration" menu, you can select the format of the report and the details to be included in the report. You can also select an icon that is displayed in the upper left corner of the report.

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".

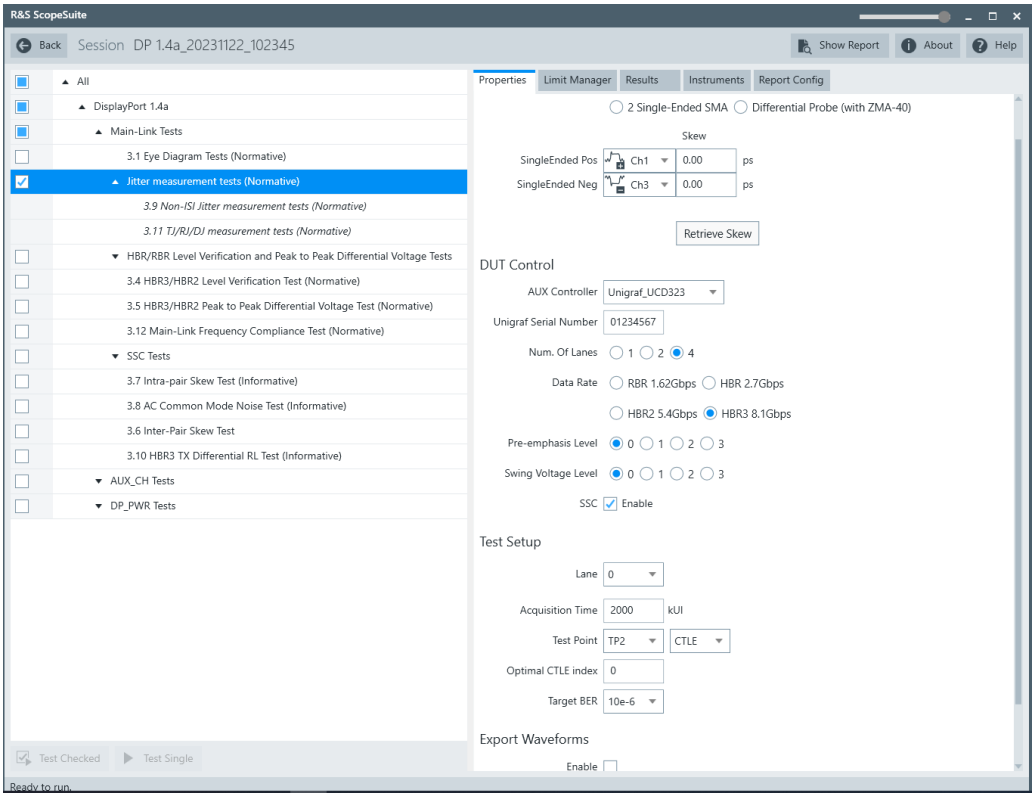
To show a report for a test session

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:
   - "DisplayPort"
2. Open a test session, see Chapter 3.1, "Starting a test session", on page 15.
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 18.
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 13.
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 18.
- "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

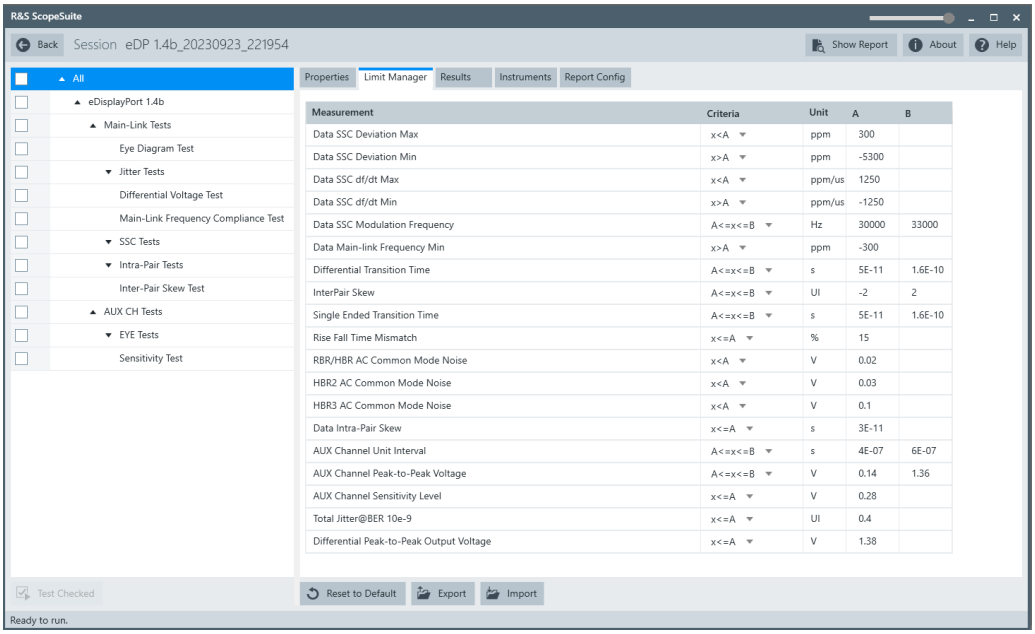
The "Limit Manager" shows the measurement limits that are used for compliance testing.

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 Initiating the test

To perform compliance tests, the device under test is connected to the test board in a test-specific way. Using a probe, the test board is connected with the R&S RTP. The probe connections are test-specific. The R&S ScopeSuite guides you step-by-step through the connection setup and the test sequence.

1. Set the test setup on a nonconductive, static-approved work surface.
2. In the R&S ScopeSuite window, select the compliance test.
3. Open a test session, see Chapter 3.1, "Starting a test session", on page 15.
4. Check the test configuration settings and adjust, if necessary. See: Chapter 3.2, "Configuring the test", on page 16.

5. Click "Test Checked" for starting all checked test cases or "Test Single" for starting only the selected test case.
   The R&S ScopeSuite test wizard explains the following individual setup steps. A test description can be found in the "R&S Test Procedures" manual for the selected compliance test.

   The R&S ScopeSuite test wizard explains the following individual setup steps. A detailed test description can be found in the following chapters:
   - Chapter 4, "DP 1.4a", on page 27
   - Chapter 5, "eDP 1.4b, eDP 1.5 tests", on page 59

3.4 Getting test results

For each test, the test data - report, diagrams and waveform files - is saved in the following folder:
`%ProgramData%\Rohde-Schwarz\RSScopeSuite\3.0\Sessions\<Protocolgroup>\<Protocol>\<Session_Name>`.

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 13). 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".

3.5 Starting DisplayPort tests

Before you run the test, complete the following actions:

- LAN connection of the oscilloscope and the computer running the R&S ScopeSuite, see Chapter 2.5, "Connecting the R&S RTP", on page 10
- VNA connection for Transmitter and Receiver Return Loss tests, see Chapter 2.6, "Connecting the vector network analyzer", on page 12.

1. Select "DisplayPort" in the R&S ScopeSuite start window.
2. In the "Session Selection" dialog, set the "Select Standard Version" standard. The following "Types" are available:
   - "DP 1.4a"
   - "eDP 1.4b"
   - "eDP 1.5"
3. Add a new test session.
4. Open the session. For details, see Chapter 3.1, "Starting a test session", on page 15.
5. Check the test configuration settings. Adjust, if necessary. See:
   - Chapter 3.6, "DisplayPort configuration", on page 20
   - Chapter 3.2.1.1, "Limit manager", on page 18
6. Select/check the test cases 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.

3.6 DisplayPort configuration

The test configuration consists of some DisplayPort specific configuration settings that depend on the selected standard version: "DP 1.4 a" or "eDP 1.4b/eDP1.5".

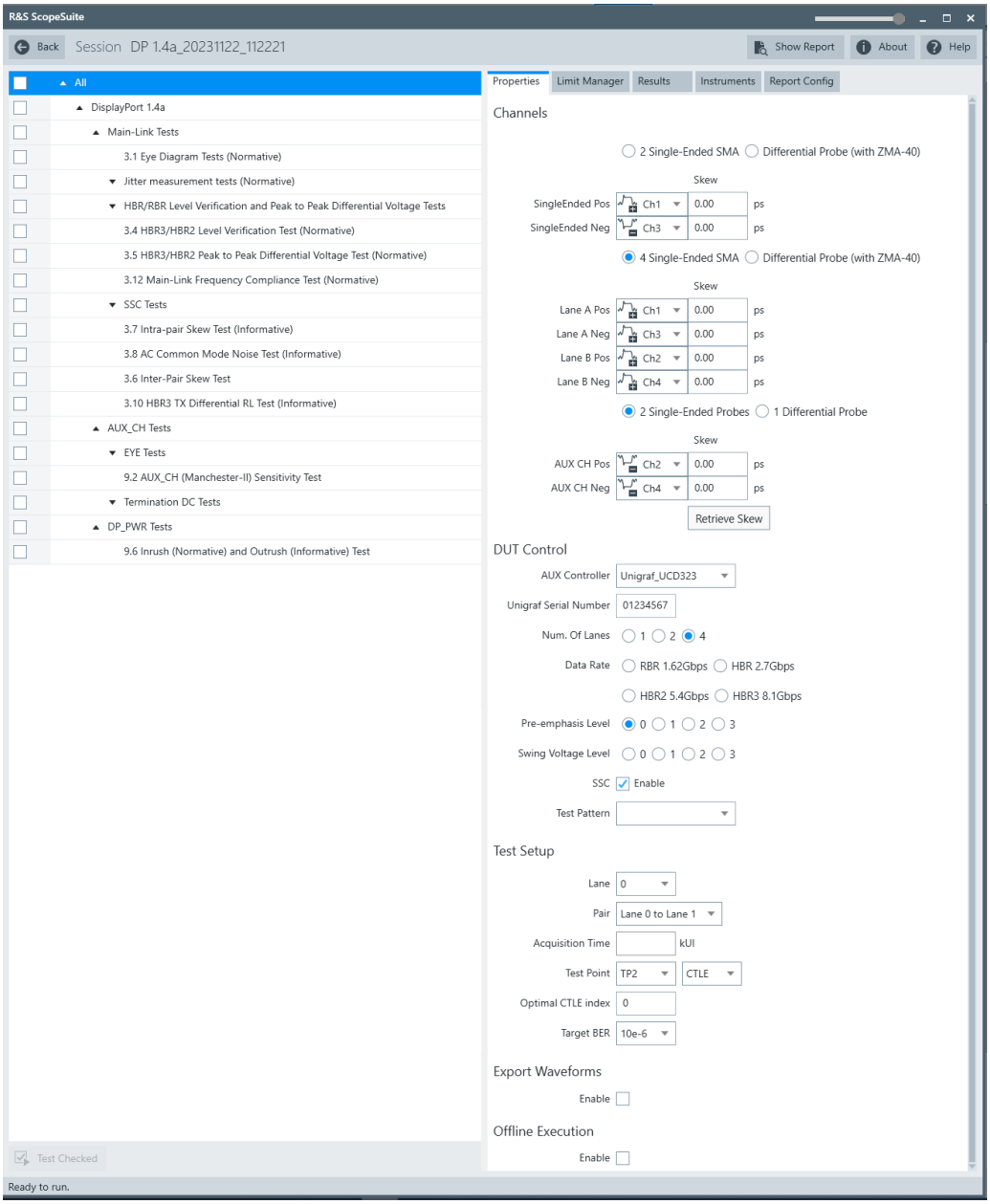


Figure 3-1: Configuration settings for DP 1.4A

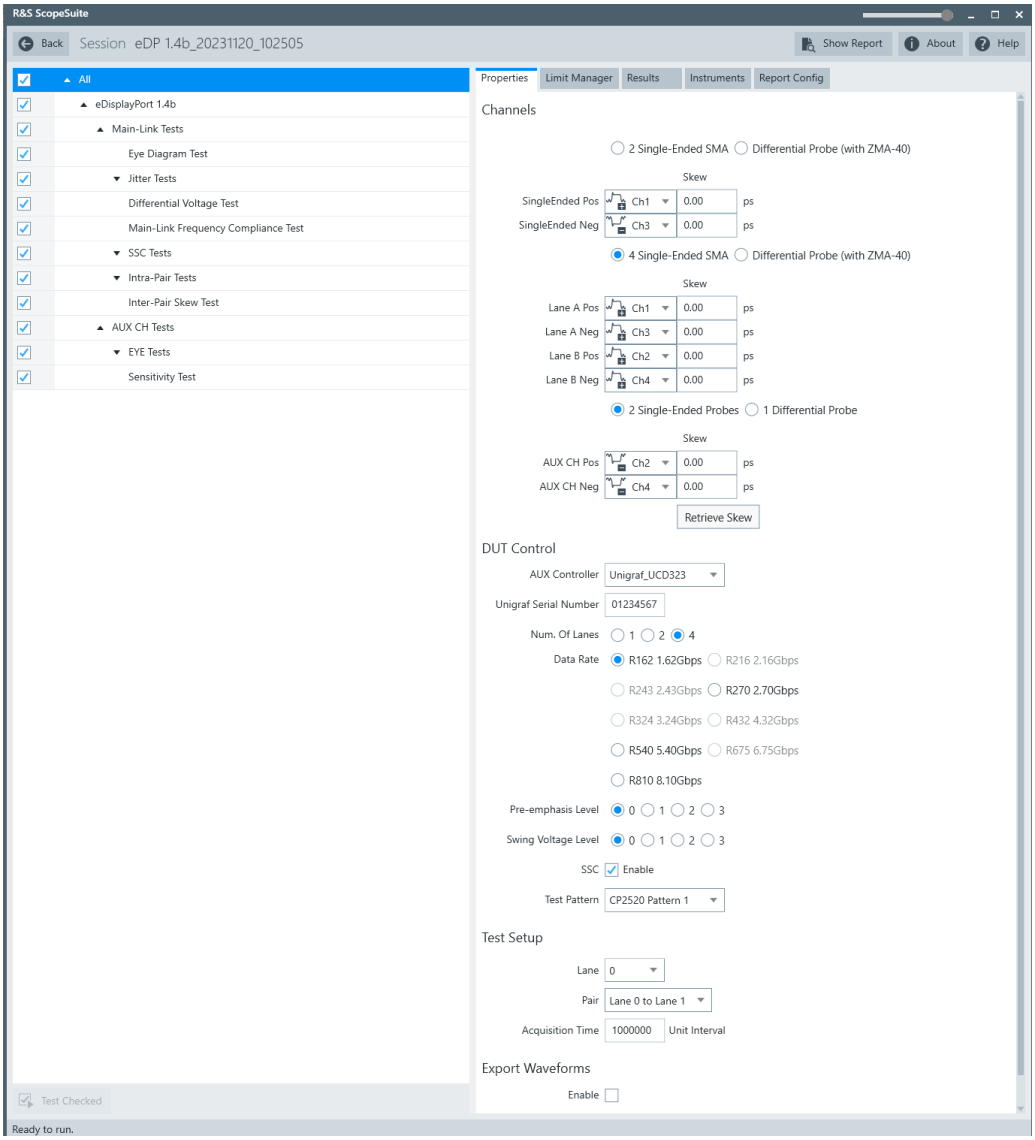


Figure 3-2: Configuration settings for eDP 1.4b/ eDP 1.5

Channels

In the "Channels" section you can select the channel of the probes used for the test setup and set the skew for each channel.

The skew compensates signal propagation differences between channels caused by the different length of cables, probes, and other sources.

You can set a fixed value or retrieve the skew value from the oscilloscope.

Num. of lanes

Selects the number of maximum lanes of the DUT for the main-link lanes. Available are 1, 2 or 4 lanes.

Lane

Selects the lane that is to be tested.

Pair
For inter-pair skew tests, specifies which pair of lane is under test.

AUX Controller, Unigraf Serial Number
Selects the model of the auxiliary channel (AUX) controller that is used for the measurements.

For Unigraf UCD323, select "Unigraf_UCD323". Also set the "Unigraf Serial Number" to enable the DP Sink operation.

For any other AUX controller model, select "Manual".

Data Rate
Sets the maximum supported data rate.

Supported data rates for DisplayPort:
- RBR (reduced bit rate): 1.62 Gbits/lane
- HBR (high bit rate): 2.70 Gbits/lane
- HBR2: 5.40 Gbits/lane
- HBR3: 8.10 Gbits/lane

Supported data rates for eDP 1.4b/ eDP 1.5:
- R162: 1.62 Gbits/lane
- R216: 2.16 Gbits/lane
- R270: 2.70 Gbits/lane
- R324: 3.24 Gbits/lane
- R432: 4.32 Gbits/lane
- R540: 5.40 Gbits/lane
- R810: 8.10 Gbits/lane

Test Point
Selects the test point.

Acquisition Time
Selects the length of signal to be analyzed in unit intervals. This setting is available for Eye tests and Jitter Tests.

Test Pattern
Selects the test pattern to be tested. Available are "D10.2", "PRBS7", "CP2520 Pattern1", "CP2520 Pattern 3 (TPS4)".

Optimal CTLE index
Sets an optimal continuous time linear equalizer (CTLE) index.

Number of bits
Sets the number of bits.

SSC
If enabled, only acquisitions that support spread spectrum clocking (SSC) is tested.

Pre-emphasis level
Selects a pre-emphasis level, the pre-emphasizing of the first bit of the continuous signal.

Available are the following predefine values for 0 to 3:

- 0: 0dB
- 1: 3dB
- 2: 6dB
- 3: 9dB

Swing voltage level
Selects a swing voltage level, the adjustment of the output signals amplitude.

Available are the following predefined values for 0 to 3:

- 0: 400mV
- 1: 600mV
- 2: 800mV
- 3: 1200mV

Device power type
Selects if the device is a "Power provider" or "Power consumer".

Export Waveforms
Enables you to export a waveform. You can later load the waveforms to run the tests in the offline mode, see "Offline Execution" on page 25.

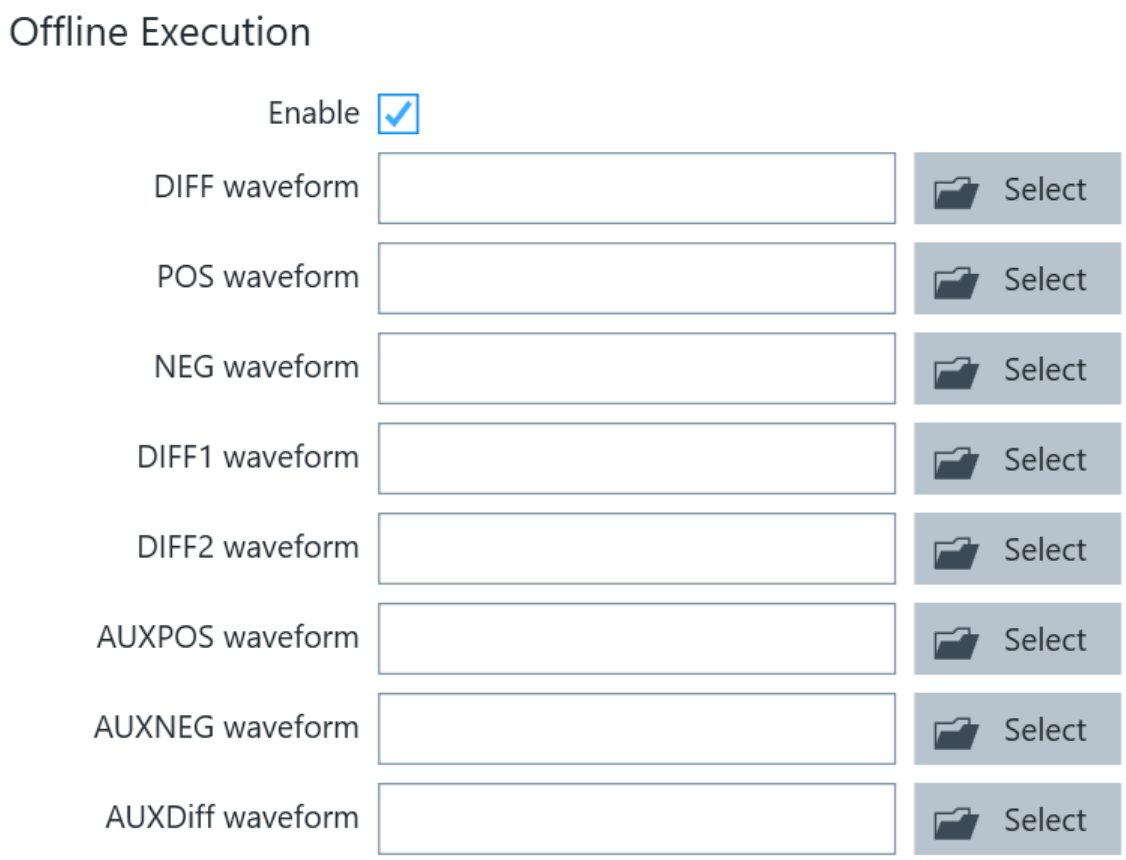
You can define an export directory, or use the default one:

```
\Rohde-Schwarz\RSScopeSuite\5.35.0\Waveforms\DisplayPort\
[DisplayPort14a or EDisplayPort14b or EDisplayPort15]\
<SessionName>
```

For example:

```
MyDocuments\Rohde-Schwarz\RSScopeSuite\5.35.0\Waveforms\
DisplayPort\DisplayPort14a\DP14a_20230910_144116
```

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 DP 1.4a

4.1 Test patterns

The following test patterns are used:

	Link rate	Test pattern
Eye & Jitter tests	RBR, HBR	PRBS7
Eye & Jitter tests	HBR2	CP2520 pattern 1, D10.2
Eye & Jitter tests	HBR3	CP2520 pattern 3
Differential voltage	All link rates	Custom pattern
Main link frequency	All link rates	D10.2
Spread spectrum clocking	All link rates	D10.2
Intra-Pair/Inter-Pair skew	All link rates	PRBS7
AC common mode noise test	RBR, HBR, HBR2	PRBS7
	HBR3	CP2520 pattern 3
HBR3 TX differential RL test	HBR3	PRBS7

4.2 Main-Link tests

4.2.1 Test equipment

The following equipment is needed for performing main link DisplayPort compliance tests.

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and minimum bandwidth 16 GHz	1
Probes	R&S ZM160 with R&S RT-ZMA40	2
	SMA cables	2/4
Advanced jitter analysis	Option R&S RTP-K133 or R&S RTP-K134 Advanced jitter and noise	1
DisplayPort AUX controller	Unigraf's UCD-3233 or equivalent	1
Auxiliary control test adapter	Wilder Technologies auxiliary control test adapter or equivalent	1

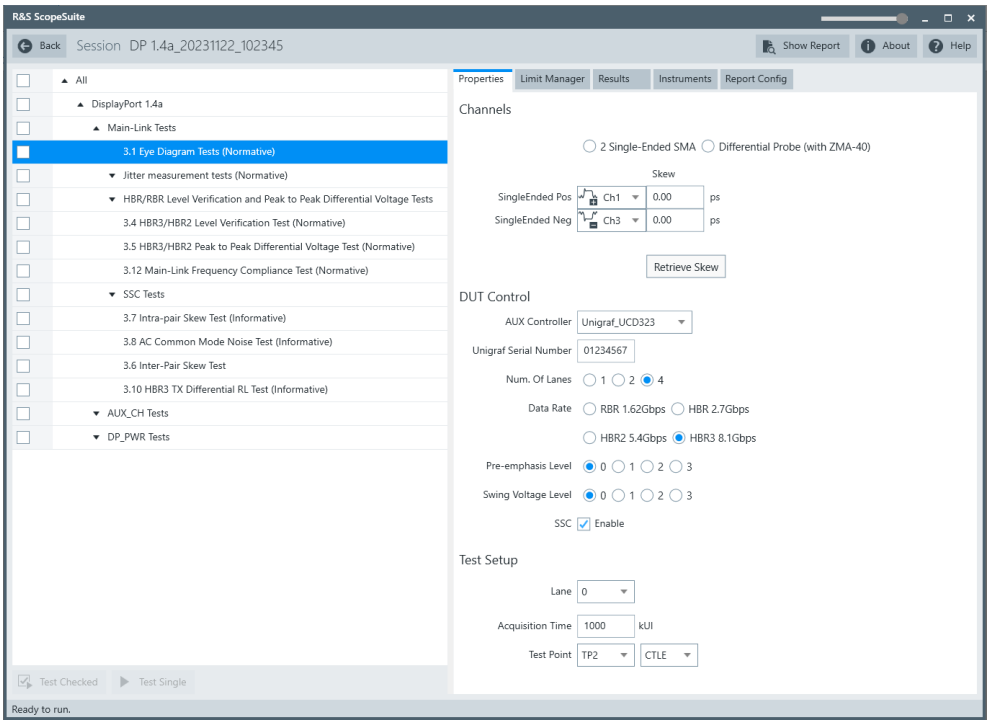
Item	Description, model	Quantity
Embedded DisplayPort test adapter	Wilder Technologies EDP-TPA40L or equivalent	1
DUT	Any DisplayPort source device	1

4.2.2 Eye diagram tests (normative)

The purpose of the test is to verify that the timing variables and amplitude trajectories support the overall DP system objectives of BER in data transmission.

4.2.2.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Eye Diagram Tests (Normative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.2.2 Measurements

Eye source: Differential lane signal with appropriate filter applied.

Link rate	Test point	Filter
HBR3	TP3_CTLE	HBR3 reference equalizer + Cable Model
HBR3	TP3_CTLE	HBR3 reference equalizer
HBR2/HBR	TP2	No filter applied
HBR2	TP3_EQ	HBR2 reference equalizer + cable model
HBR	TP3_EQ	HBR2 reference equalizer + cable model
RBR	TP2/TP3	No filter applied

Reference signal: Recover the reference clock using a 2nd order PLL with closed-loop tracking bandwidth and damping factor specified in Table 1 PLL 2nd order clock recovery.

Table 4-1: PLL 2nd order clock recovery

Link rate	Closed-loop tracking bandwidth (MHz)	Damping factor
HBR3	15	1.00
HBR2	10	1.00
HBR	10	1.51
RBR	5.4	1.51

HBR3 reference equalizer

The HBR3 reference equalizer transfer function is given by:

$$H(s) = A_{ac} \times \omega_{p2} \times [s + (A_{dc}/A_{ac}) \times \omega_{p1}] / (s + \omega_{p1}) \times (s + \omega_{p2})$$

where:

- A_{ac} = 3.5 dB
- A_{dc} = Integer within the range of 0 through - 8 dB, inclusive, in steps of 1 dB
- ω_{p1} = 3.03 GHz
- ω_{p2} = 5.60 GHz

HBR2 reference equalizer

The HBR2 reference equalizer transfer function is given by:

$$H(s) = \frac{\omega_{p1}\omega_{p2}\omega_{p3}}{\omega_z} \cdot \frac{s + \omega_z}{(s + \omega_{p1})(s + \omega_{p2})(s + \omega_{p3})}$$

The magnitude is given by:

$$H\left|(j\omega)\right| = \frac{\omega_{p1}\omega_{p2}\omega_{p3}}{\omega_z}.\frac{\sqrt{\omega^2+\omega_z^2}}{\sqrt{\omega^2+\omega_{p1}^2}\sqrt{\omega^2+\omega_{p2}^2}\sqrt{\omega^2+\omega_{p3}^2}}$$

Where:

- $\omega_z = 2\pi(0.64 \text{ x}10^{9})$ for upstream device compliance
- $\omega_{p1} = 2\pi(2.7 \text{ x}10^{9})$
- $\omega_{p2} = 2\pi(4.5 \text{ x}10^{9})$
- $\omega_{p3} = 2\pi(13.5 \text{ x}10^{9})$

HBR reference equalizer

The HBR reference equalizer transfer function is given by:

$$H(s) = \frac{\omega_{p1}\omega_{p2}}{\omega_z}.\frac{s+\omega_z}{(s+\omega_{p1})(s+\omega_{p2})}$$

The magnitude is given by:

$$H\left|(j\omega)\right| = \frac{\omega_{p1}\omega_{p2}}{\omega_z}.\frac{\sqrt{\omega^2+\omega_z^2}}{\sqrt{\omega^2+\omega_{p1}^2}\sqrt{\omega^2+\omega_{p2}^2}}$$

Where:

- $\omega_z = 2\pi(0.725 \text{ x}10^{9})$ for upstream device compliance
- $\omega_{p1} = 2\pi(1.35 \text{ x}10^{9})$
- $\omega_{p2} = 2\pi(2.5 \text{ x}10^{9})$

HBR3/HBR2 mask

The figure below shows a passing mask test for an HBR3 signal.

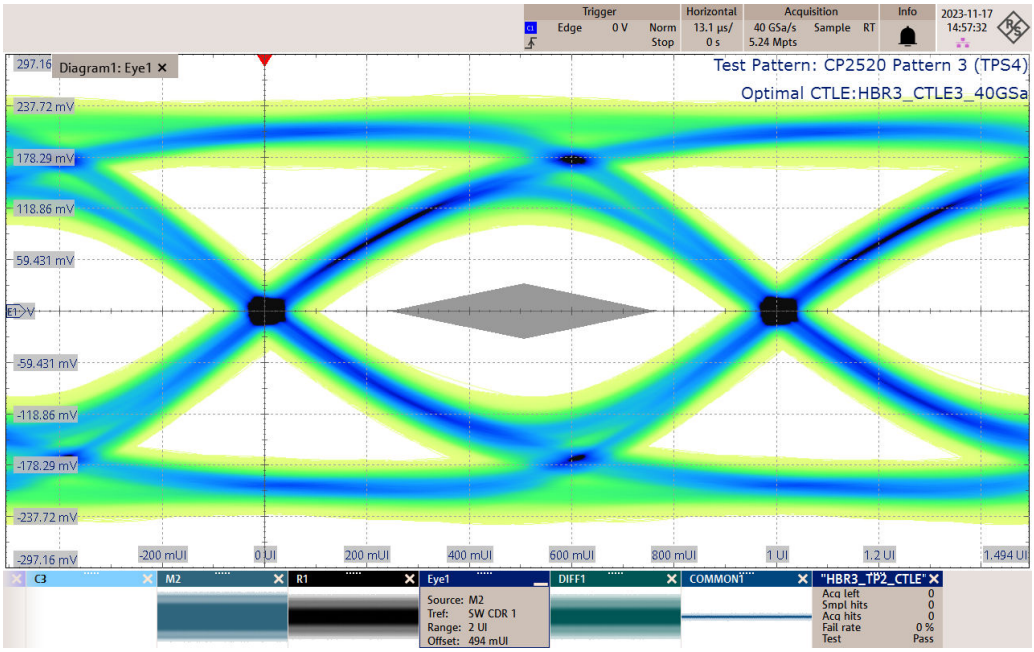


Figure 4-1: Pass mask test for an HBR3 signal

HBR/RBR mask

The figure below shows a passing mask test for an RBR signal.

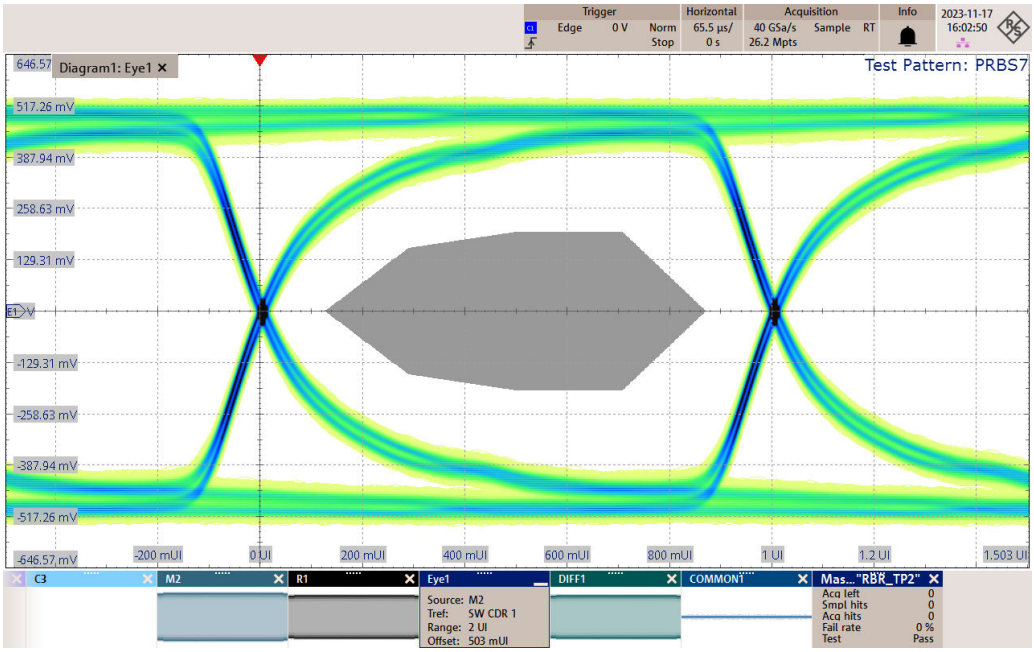


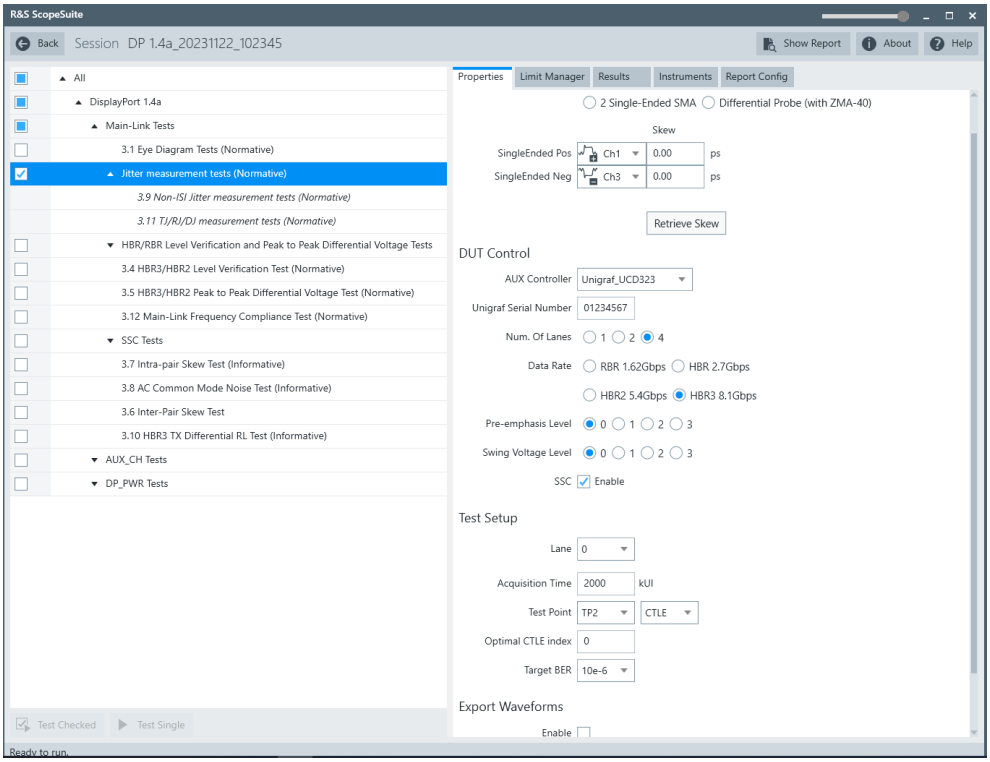
Figure 4-2: Pass mask test for an RBR signal

4.2.3 Jitter measurement tests (normative)

These tests evaluate the Total Jitter and Deterministic Jitter that accompany the data transmission. This measurement is a data time interval error (Data-TIE) jitter measurement.

4.2.3.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Jitter Measurement Tests (Normative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.3.2 Measurements

Using dual-direct Model equivalent method to discompose the jitter components from the differential lane signal. The appropriate equalization is applied as explained in Eye test section.

Reference clock

Recover the reference clock using a 2nd order PLL with closed-loop tracking bandwidth and damping factor specified in PLL 2nd order clock recovery.

Total jitter, deterministic jitter, random jitter

The total jitter is the peak-to-peak phase variation in the 0-V differential crossing point, measured at a 10e-9 BER for all link rates. It is estimated with the following equation:

$TJ=DJ_{dd} + n \times RJ_{dd}$

Where:

DJ_{dd} is the deterministic jitter.

RJ_{rms} is the random jitter, a standard deviation value of an idealized pure noise process.

N for link rate < 8.1 Gbit/s = 12, to accommodate a $1x10^{-9}$ BER value

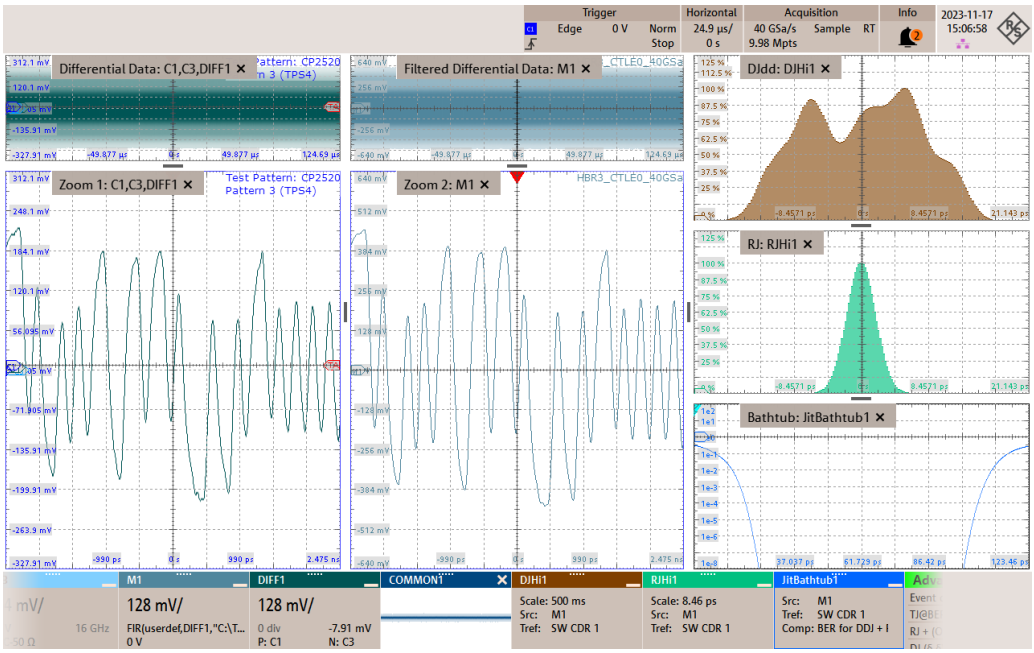
N for link rate > = 8.1 Gbit/s = 12, to accommodate a $1x10^{-9}$ BER value

Non ISI jitter

Non-ISI Jitter can be computed using the following equation:

$Jitter_{NON\_ISI}=TJ - Jitter_{ISI}$

The following diagram shows the decomposition of the jitter components:

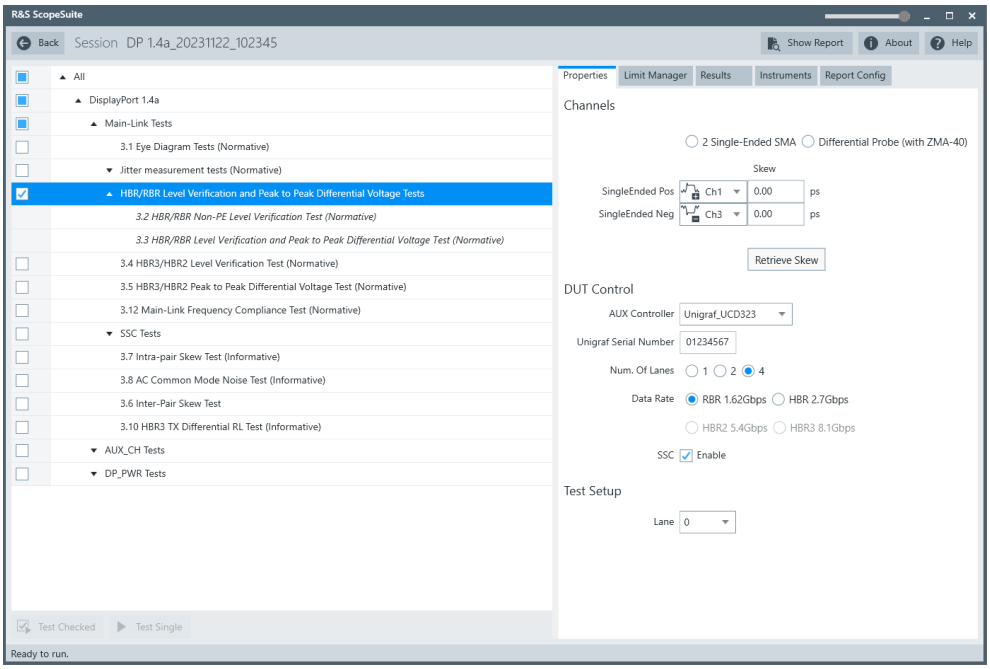


4.2.4 HBR/RBR level verification and peak to peak differential voltage tests

This test to ensure that for a DP device that supports RBR and HBR, the voltage swing levels are monotonic and the pre-emphasis settings are accurate.

4.2.4.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "HBR/RBR Level Verification and Peak to Peak Differential VoltageTests".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.4.2 Measurements

The DUT should be configured to output PRBS7 pattern.

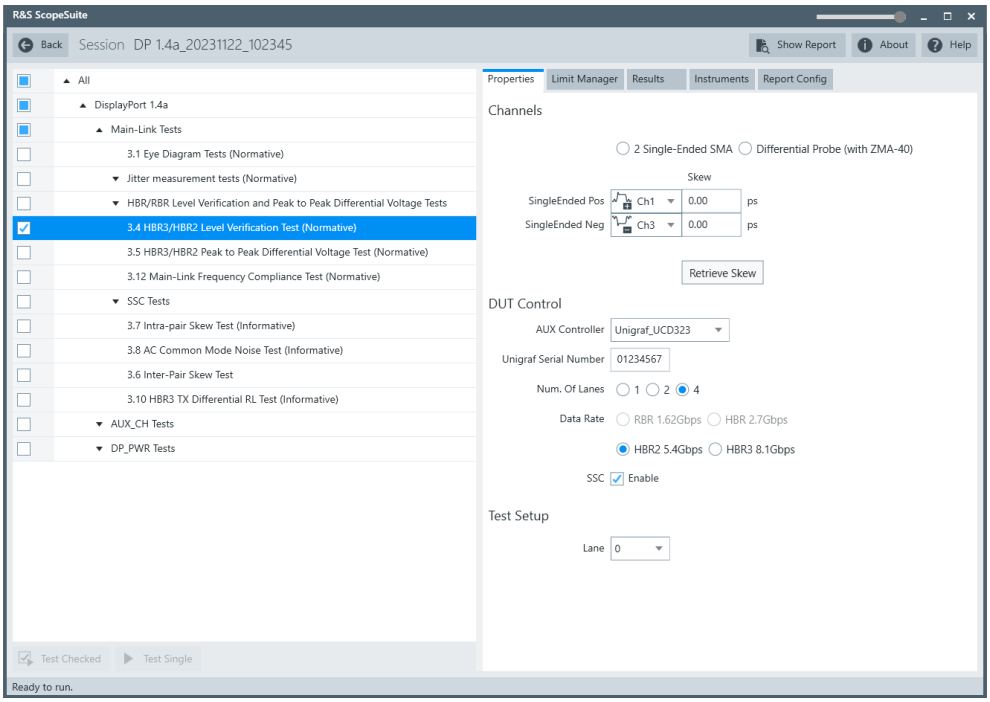
HBR/RBR Non-PE level verification tests are performed while pre-emphasis set to 0. HBR/RBR PE level verification and maximum differential peak-to-peak voltage test while varying the pre-emphasis.

4.2.5 HBR3 /HBR2 level verification (normative)

The purpose of this test is to verify that the system budget is adhered to.

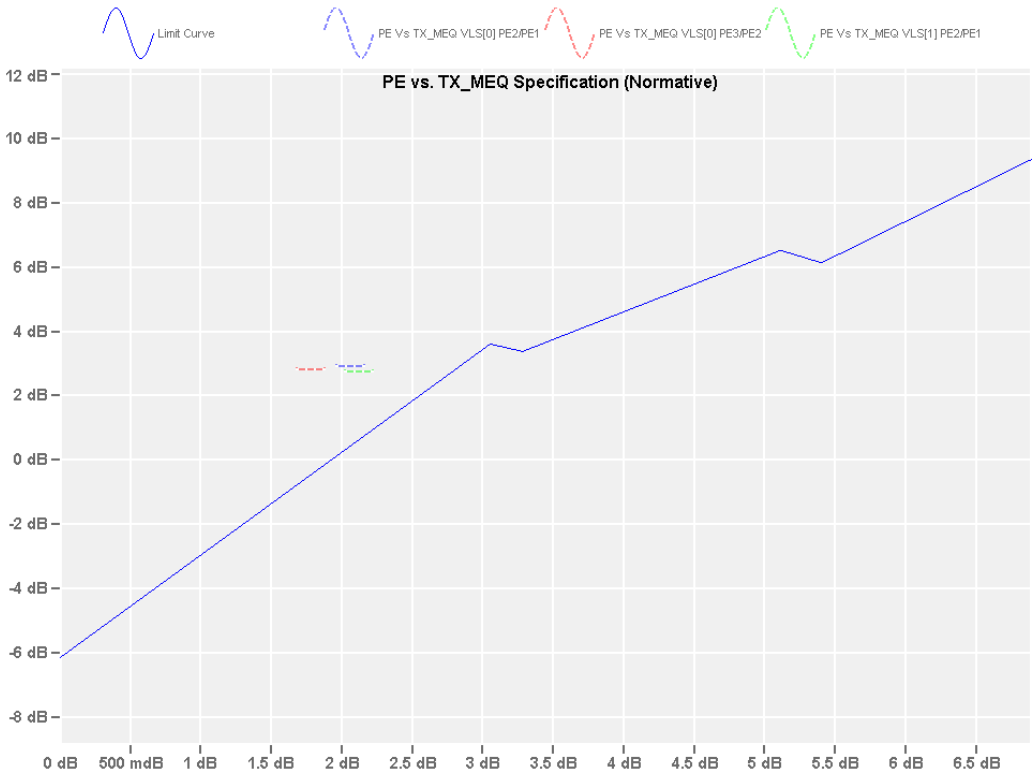
4.2.5.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "HBR3 /HBR2 Level Verification (Normative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.5.2 Measurements

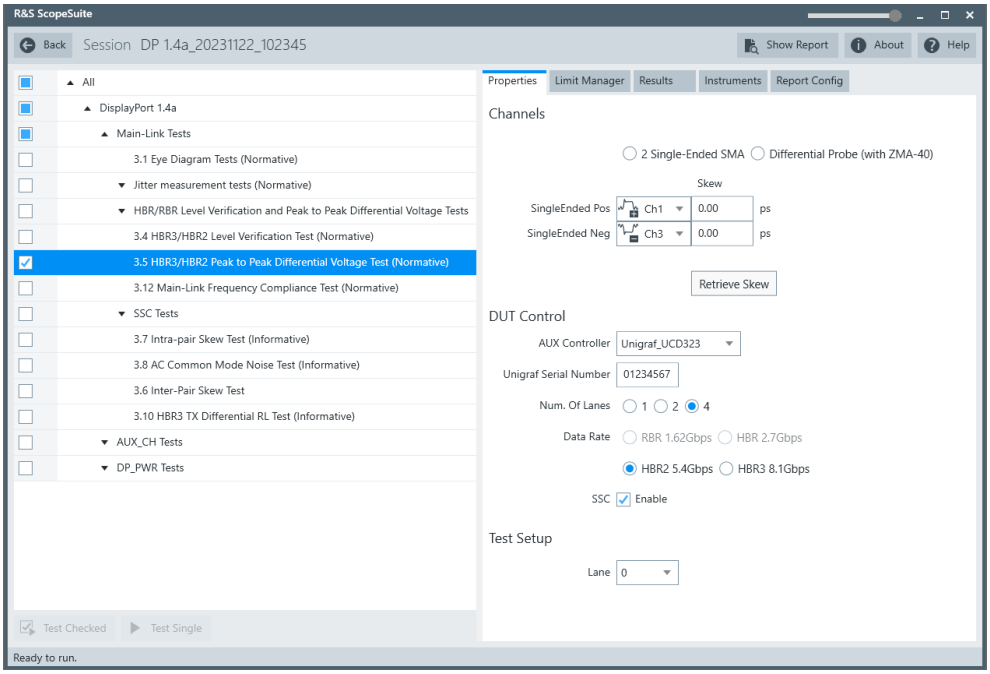


4.2.6 HBR3/HBR2 peak to peak differential voltage test (normative)

The purpose of this test is to verify that the peak-to-peak voltage accompanying the data transmission is within the limits defined by the DP1.4A Electrical Requirements Test Specification.

4.2.6.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "HBR3 /HBR2 Peak to Peak Differential Voltage Test (Normative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

Measurements

The peak-to-peak voltage for transition and non-transition voltage levels is calculated using the following equations:

$$V_{N\_LvIX\_PP} = V_{N\_LvIX\_H} - V_{N\_LvIX\_L}$$

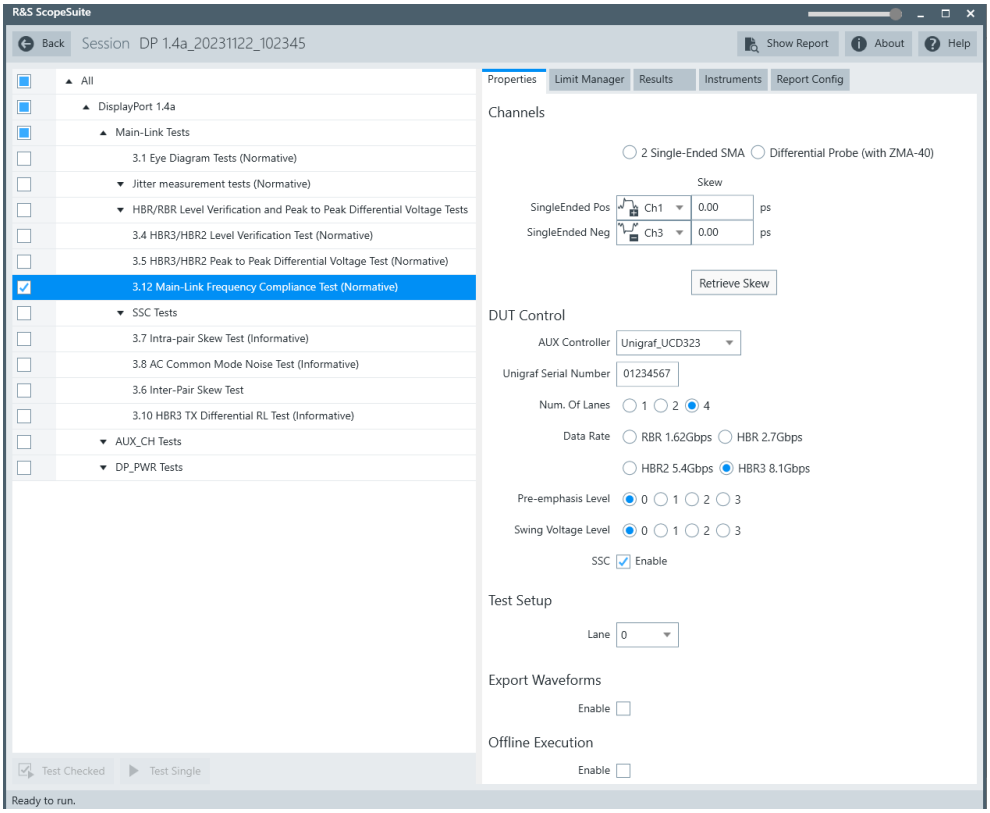
$$V_{T\_LvIX\_PP} = V_{T\_LvIX\_H} - V_{T\_LvIX\_L}$$

4.2.7 Main-link frequency compliance test (normative)

The purpose of this test is to verify that under any condition the average transfer rate does not exceed the minimum or maximum frequency range as defined by the DP1.4A Electrical Requirements Test Specification.

4.2.7.1 Performing the tests

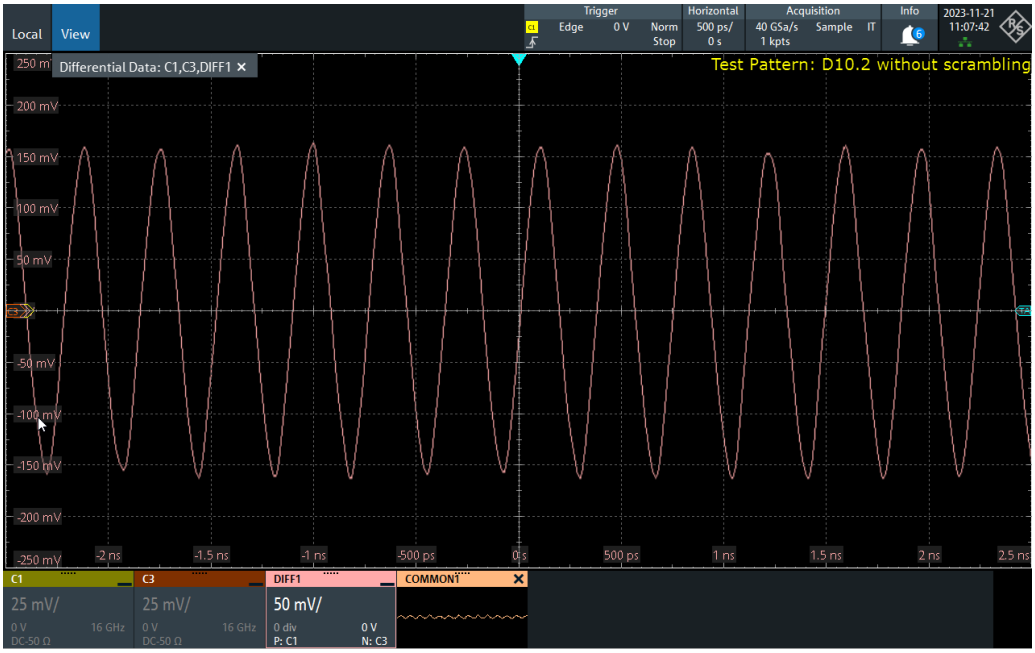
1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Main-link Frequency Compliance Test (Normative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.7.2 Measurements

The DUT is set to transmit D10.2 pattern, which consists of alternate 1 bit and 0 bits to simulate clock-liked signal as shown in figure below.

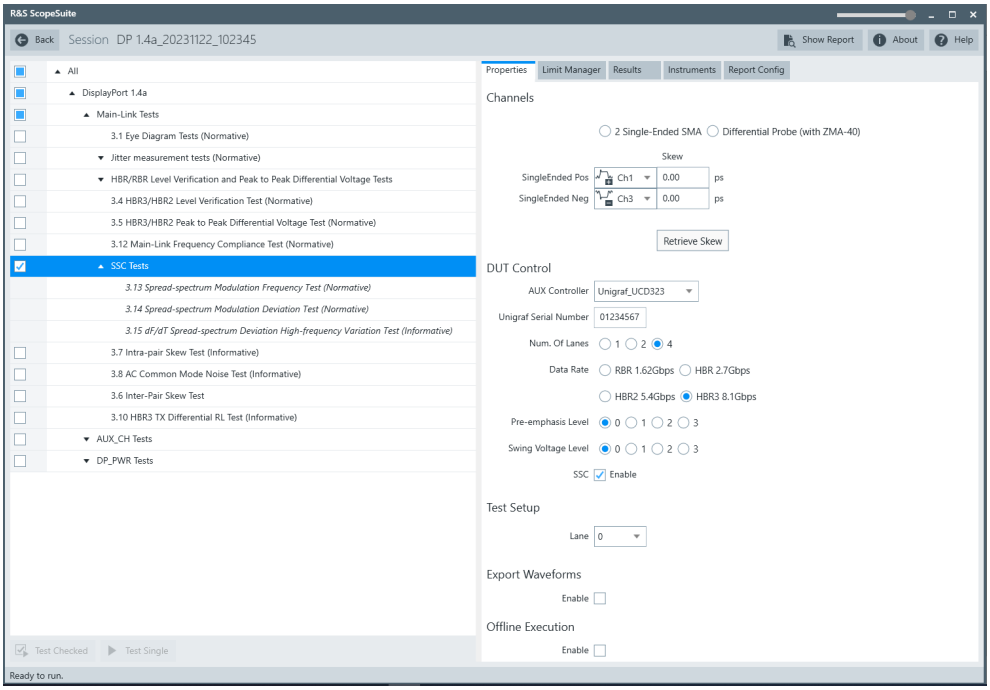


4.2.8 SSC tests

This test evaluates the range of the transmitter signal's SSC down spreading (in ppm). The SSC profile shall not include frequency deviations that exceed 1250ppm/us. SSC modulation frequency and validate that the frequency is within specification limits.

4.2.8.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "SSC Tests".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

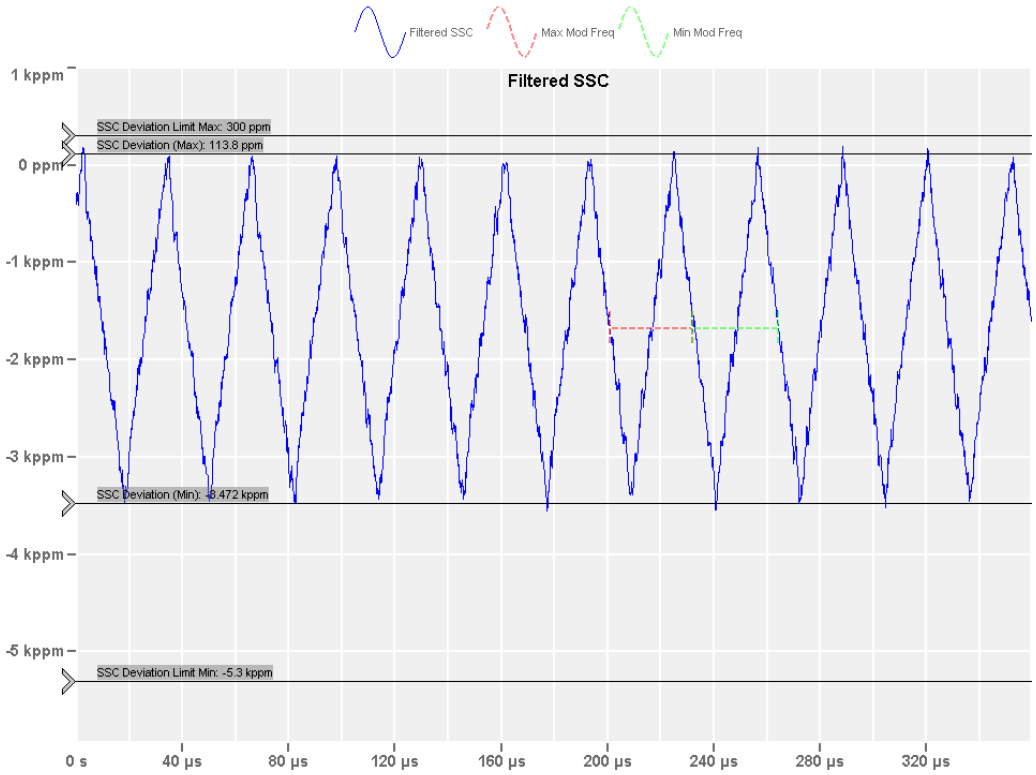
4.2.8.2 Measurements

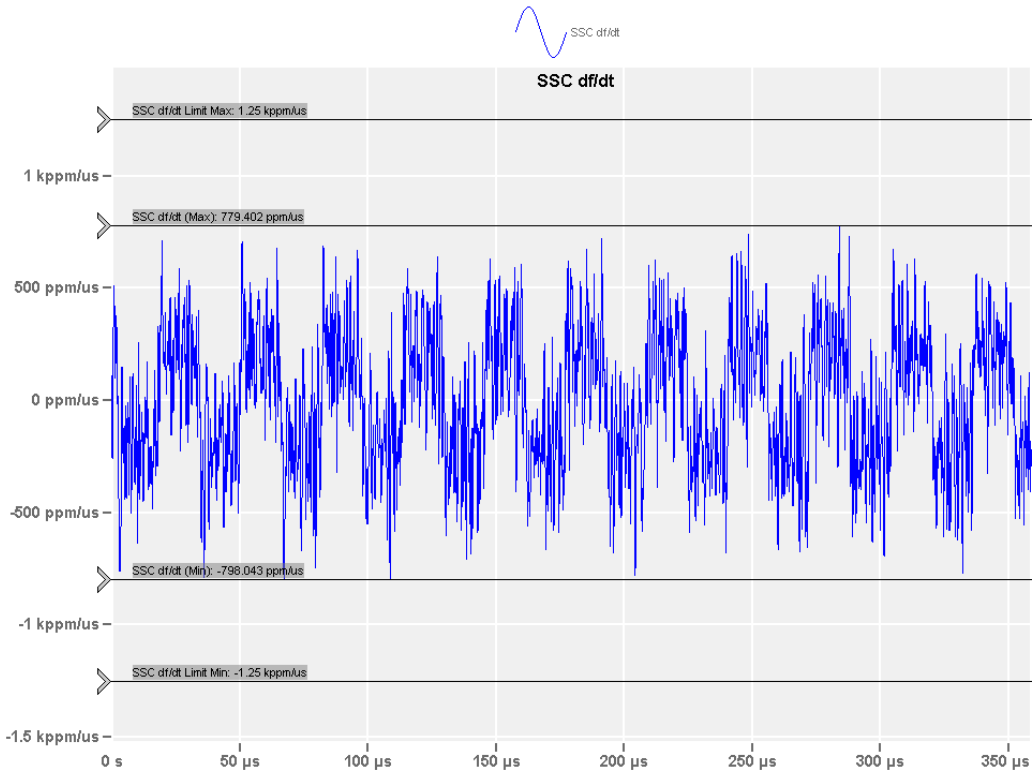
The DUT is configured to output test pattern D10.2 which consist of alternate 1 bit and 0 bits to simulate clock like signal.

Difference between successive 0v crossing times of the differential lane waveform is measured as UI values.

Instantaneous frequency of the clock signal is measured as the inverse value of the UI values computed. A 0.222us average window filtering is applied to remove the high frequency noise.

The filtered clock frequency is used to analyze modulation rate and deviation as shown in the picture below:


Filtered SSC
Max Mod Freq
Min Mod Freq
Filtered SSC
1 kppm
0 ppm
-1 kppm
-2 kppm
-3 kppm
-4 kppm
-5 kppm
SSC Deviation Limit Max: 300 ppm
SSC Deviation (Max): 113.8 ppm
SSC Deviation (Min): -3.472 kppm
SSC Deviation Limit Min: -5.3 kppm
0 s
40 µs
80 µs
120 µs
160 µs
200 µs
240 µs
280 µs
320 µs


SSC df/dt
SSC df/dt
SSC df/dt Limit Max: 1.25 kppm/us
1 kppm/us
SSC df/dt (Max): 779.402 ppm/us
500 ppm/us
0 ppm/us
-500 ppm/us
SSC df/dt (Min): -798.043 ppm/us
-1 kppm/us
SSC df/dt Limit Min: -1.25 kppm/us
-1.5 kppm/us
0 s
50 µs
100 µs
150 µs
200 µs
250 µs
300 µs
350 µs

Spread spectrum modulation frequency test

The SSC modulation frequency test evaluates the frequency of the SSC modulation and validates that the frequency lies within the specification limits of the DP1.4A Electrical Requirements Test Specification.

Spread-spectrum modulation deviation test

The SSC modulation deviation test evaluates the range of SSC down-spreading of the transmitter signal in parts per million (ppm).

One of the requirements of spread spectrum clocking is that the sink receiver follows the instantaneous frequency of the transmitter signal. This test measures the range of frequency deviation with SSC. The more the frequency deviates from the standard limits, the higher are the risks of interoperability in DP1.4a sources.

dF/dT spread-spectrum deviation high-frequency variation test

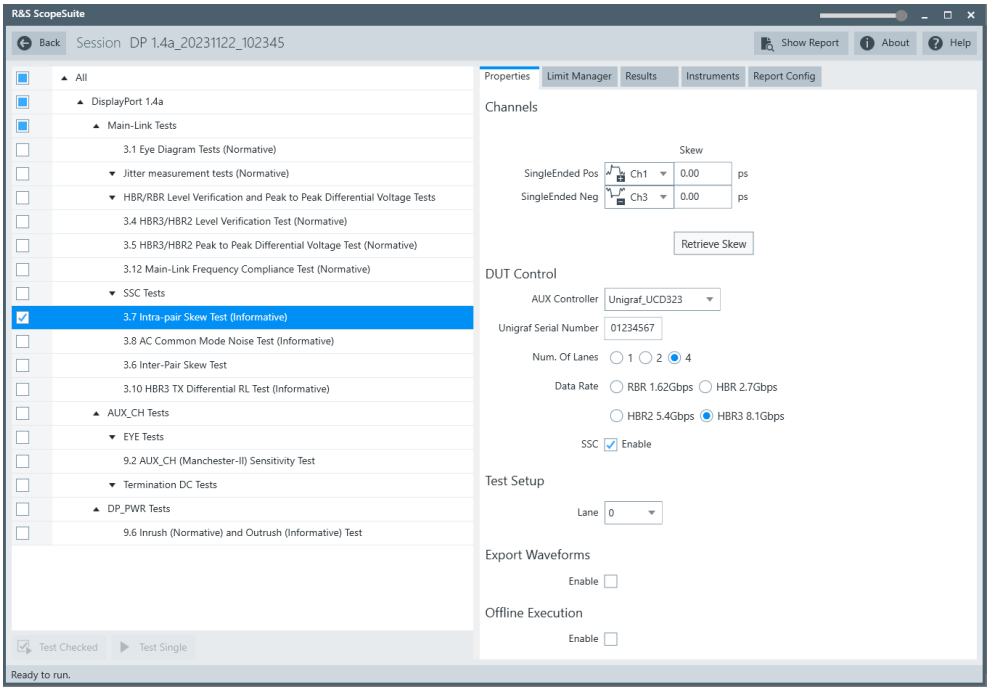
The objective of this test is to verify that the SSC profile does not include any frequency deviation that exceeds 1250 ppm/µsec. This test includes the use of the 2nd order Butterworth lowpass filter with a 3dB corner frequency of 1.98MHz.

4.2.9 Intra-pair skew test (informative)

This test evaluates the skew between respective sides of a differential data lane in a DP interface.

4.2.9.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Intra-pair Skew Test (Informative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.9.2 Measurements

Waveforms of both signal polarities on one lane are simultaneously captured using two single-ended measurement channels. The rising edge of the data true signal (D+) is compared with the complement's (D-) falling edges, and the rising edge of the complement is compared to the falling edge of the data true signal. The time of transition is found by determining when the waveform crosses the transition amplitude.

Each lane is composed of two single-ended signals D+ and D-. For each D+ and D- signal, the average value over the 0.6 to 0.75UI region past the edge of the V_H and V_L is found.

For D+, measure VH+, VL+. For D-, measure VH-, VL-.

$$V_{Transition\_D+} = \frac{V_{H+} + V_{L+}}{2}$$

$$V_{Transition\_D-} = \frac{V_{H-} + V_{L-}}{2}$$

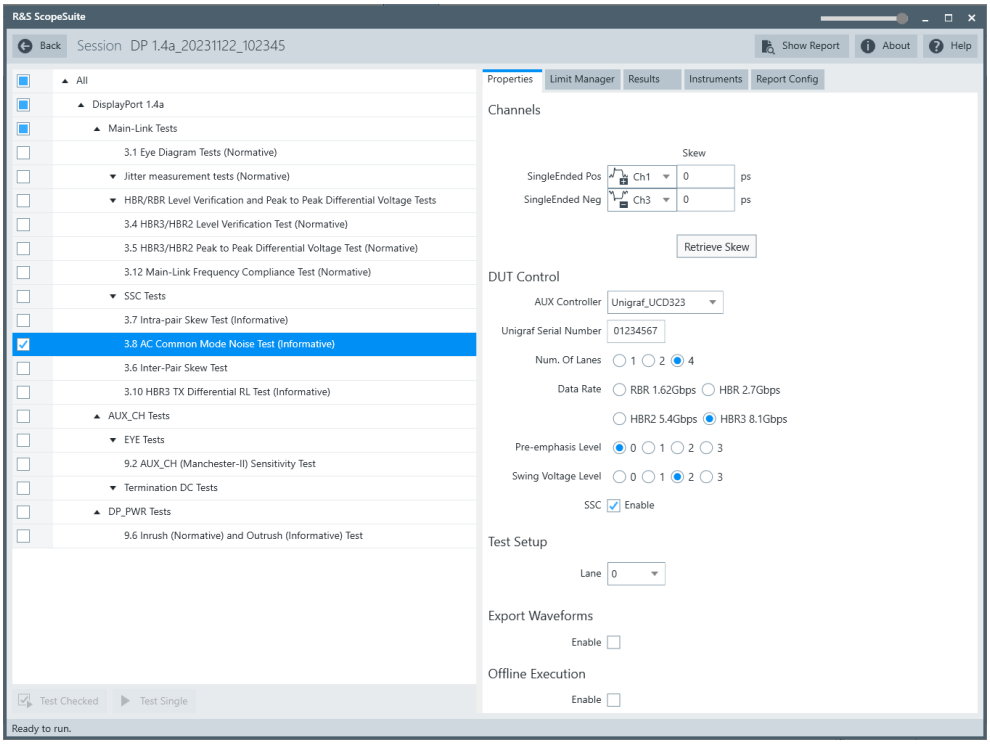
$$IntraPairSkew = \{1/NumEdges\} \Sigma \{[(T_{Trans\_D+\_High} - T_{Trans\_D-\_Low}) + (T_{Trans\_D+\_High} - T_{Trans\_D-\_Low})]/2\}$$

4.2.10 AC common mode noise test (informative)

The purpose of this test is to report the common mode noise (unfiltered RMS) present in the main link differential pairs. You can use these measurements to predict the EMI/RFI performance of the channels.

4.2.10.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "AC Common Mode Noise Test (Informative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.10.2 Measurements

The common mode noise is measured for each supported lane. The common mode noise is calculated from the signal's single-ended plus and single-ended minus signals with the following equation:

$$V_{TX-AC-CM} = \frac{V_{TX-PLUS} + V_{TX-MINUS}}{2}$$

The value of the common mode noise RMS is calculated with the following equation:

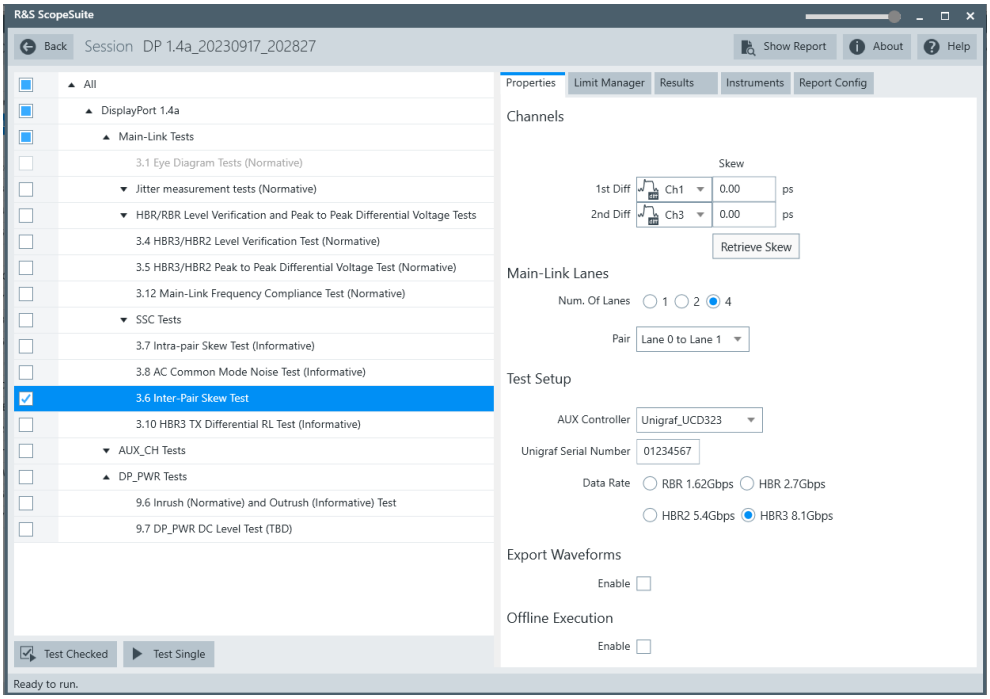
$$V_{TX-AC-CM\_RMS} = \left[\frac{X_1^2 + X_2^2 + X_3^2 + ... + X_n^2}{n}\right]^{0.5}$$

4.2.11 Inter-pair skew test

This test evaluates the skew (time delay) between respective sides of the differential main link lanes in the DP interface.

4.2.11.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Inter-pair Skew Test".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.11.2 Measurements

The software captures waveforms from 2 lanes simultaneously while the DUT is outputting PRBS7 or a DUT dependent custom pattern. The inter-pair skew is regarded as the time difference between the lanes for a common point that is found at the waveform.

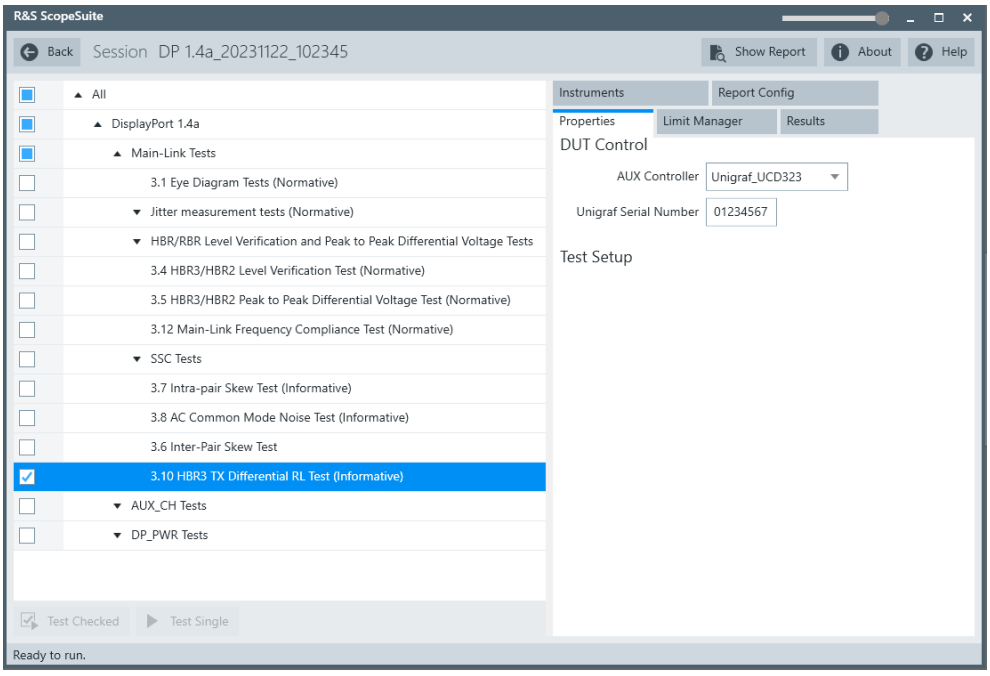
$$InterLaneSkew = \{1/NumEdges\} \Sigma |T_{Transition\_LaneA} - T_{Transition\_LaneB}| - NominalSkew$$

4.2.12 HBR3 TX differential RL test (informative)

The purpose of this test is to verify that differential return loss of an HBR3-capable transmitter is within the limits defined by the DP1.4A Electrical Requirements Test Specification.

4.2.12.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "HBR3 TX Differential RL Test (Informative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.

5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.2.12.2 Measurements

The test requires a vector network analyzer. For details on how to set up the VNA refer to Connecting the vector network analyzer.

The differential return loss is measured and compared to the pass criteria:

$$SDD22(f) = \begin{cases} -6.5, 0.05 < f_{GHz} \leq 3 & (dB) \\ -1.5 + 8.3 \times log_{10}(\frac{f_{GHz}}{12}), 3 < f_{GHz} \leq 12 & (dB) \end{cases}$$

4.3 AUX_CH tests

The group of tests evaluate if the AUX_CH waveforms are within the DisplayPort specification limits.

4.3.1 Test equipment

The following equipment is needed for performing main link DisplayPort compliance tests.

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and minimum bandwidth 16 GHz	1
Probes	R&S ZM160 with R&S RT-ZMA40	2
	SMA cables	2/4
DisplayPort AUX controller	Unigraf's UCD-3233 or equivalent	1
Auxiliary control test adapter	Wilder Technologies auxiliary control test adapter or equivalent	1
Embedded DisplayPort test adapter	Wilder Technologies EDP-TPA40L or equivalent	1
DUT	Any DisplayPort source device	1

4.3.2 Test setup

The following graphics show the test setup for the AUX channel test measurements.

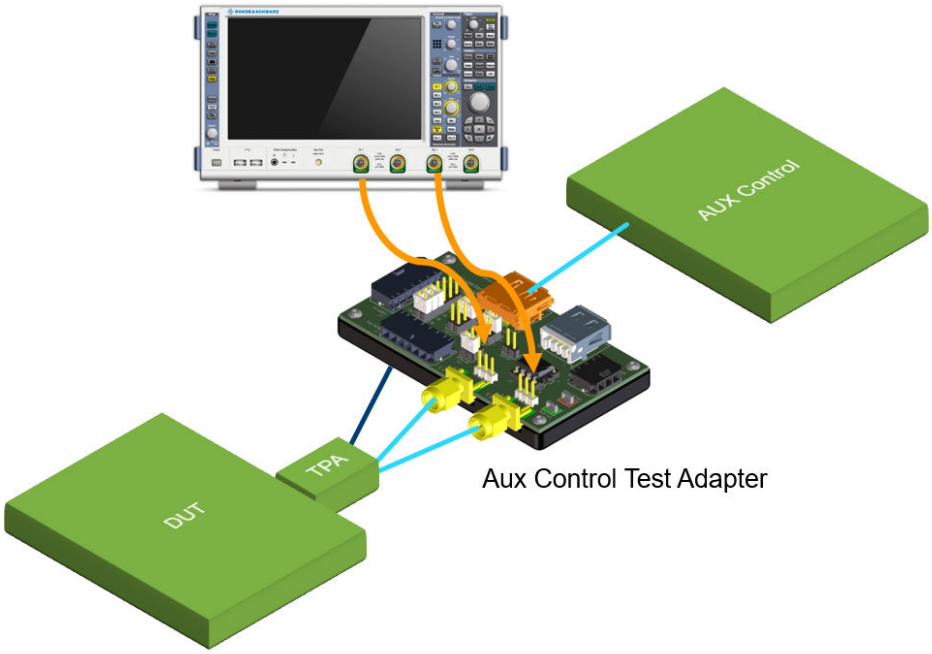


Figure 4-3: AUX channel test setup with 2 single-ended probes

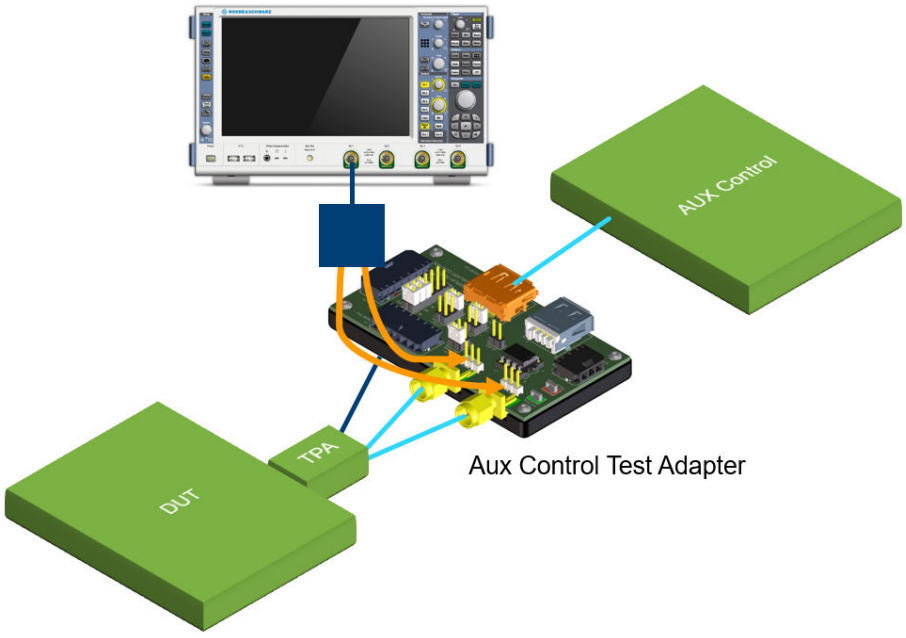


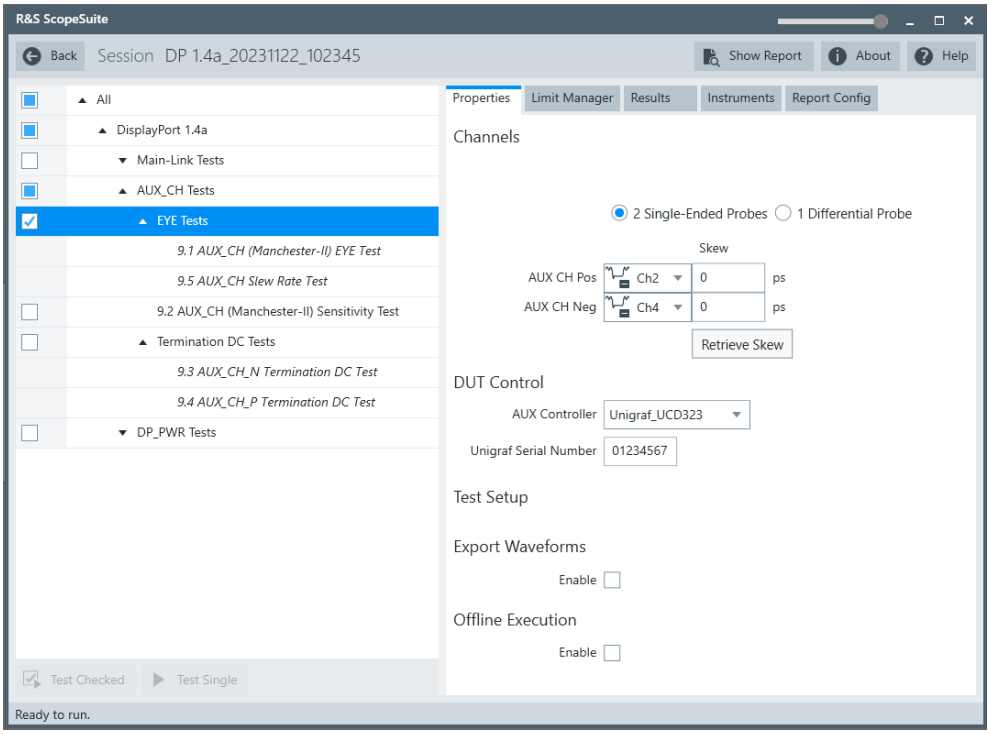
Figure 4-4: AUX channel test setup with 1 differential probe

4.3.3 Eye tests

This test verifies that the timing variables and amplitude trajectories of the AUX_CH waveform support DisplayPort BER system objectives in data transmission.

4.3.3.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "AUX_CH Tests" > "Eye tests".

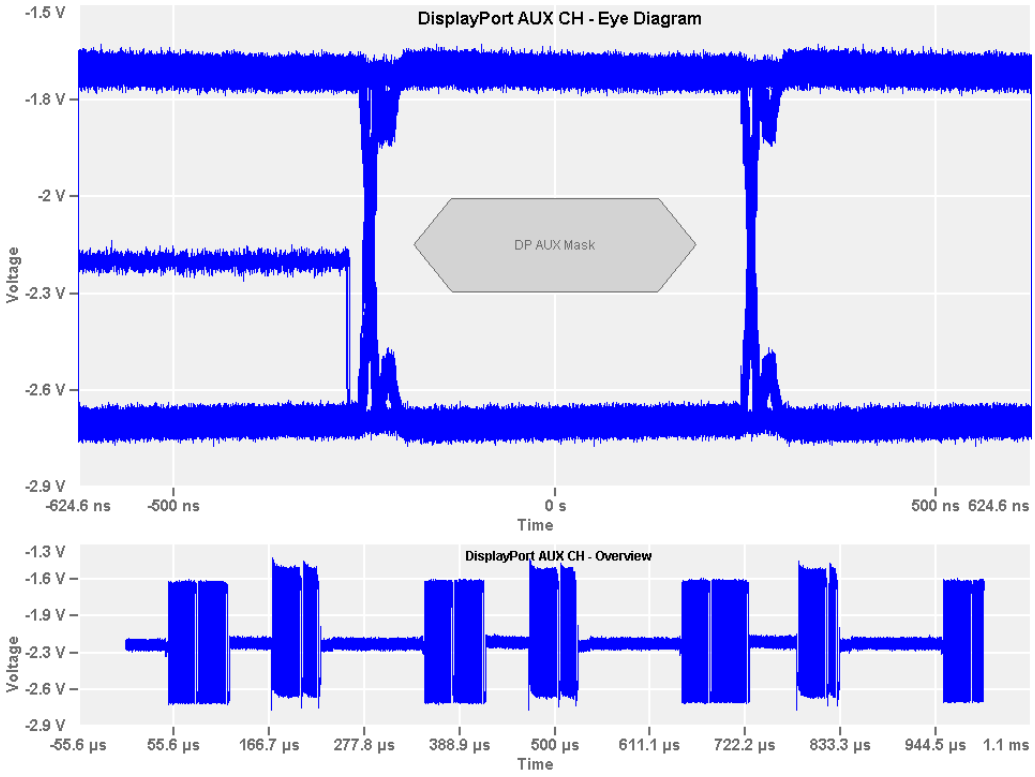


3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.3.3.2 Measurements

The software collects the waveform containing AUX CH data transaction. A simple decoding is applied to separate the signal. Only signal transmitted from source DUT is used to construct the eye diagram.

The following figure shows an eye diagram that passed the mask test:

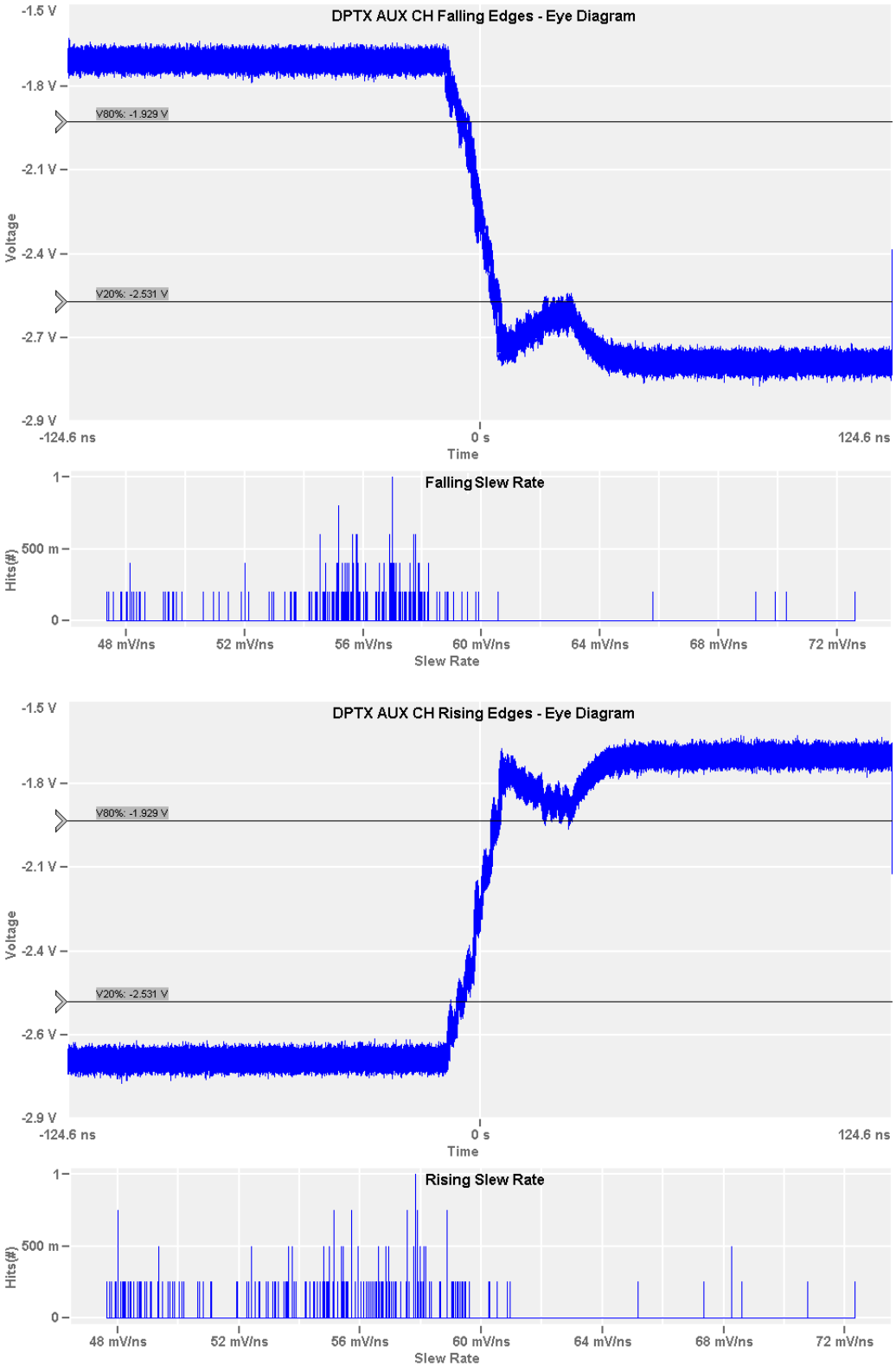


4.3.6.2 AUX_CH slew rate test

This test evaluates the AUX_CH waveform, to ensure that the slew rate of the transition edges stays within the DisplayPort specification.

The software collects the waveform containing AUX CH data transaction. A simple decoding is applied to separate the signal. Only rising and falling edges of signal transmitted from source DUT are used to measure the slew rate. Slew rates are calculated by measuring time needed of rising edges to transit from 20% to 80% of final peak-peak voltage and time needed for falling edges to transit from 80% to 20% of the final Peak-Peak voltage.

Collective of rising and falling edges are shown in the figures below respectively.

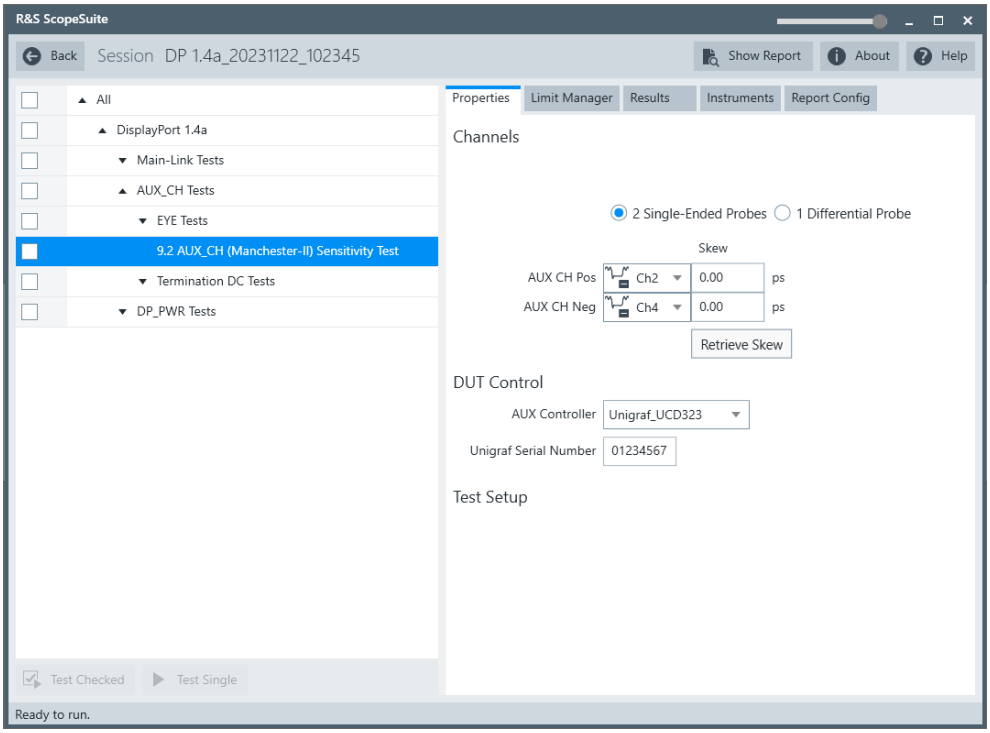

DPTX AUX CH Falling Edges - Eye Diagram
-1.5 V
-1.8 V
-2.1 V
-2.4 V
-2.7 V
-2.9 V
V80%: -1.929 V
V20%: -2.531 V
Voltage
-124.6 ns
0 s
124.6 ns
Time
Falling Slew Rate
1
500 m
0
Hits(#)
48 mV/ns
52 mV/ns
56 mV/ns
60 mV/ns
64 mV/ns
68 mV/ns
72 mV/ns
Slew Rate
DPTX AUX CH Rising Edges - Eye Diagram
-1.5 V
-1.8 V
-2.1 V
-2.4 V
-2.6 V
-2.9 V
V80%: -1.929 V
V20%: -2.531 V
Voltage
-124.6 ns
0 s
124.6 ns
Time
Rising Slew Rate
1
500 m
0
Hits(#)
48 mV/ns
52 mV/ns
56 mV/ns
60 mV/ns
64 mV/ns
68 mV/ns
72 mV/ns
Slew Rate

4.3.4 AUX_CH (Manchester-II) sensitivity test

This test evaluates minimum voltage swing the receiver part of the source DUT is able to response to.

4.3.4.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "AUX_CH Tests" > "AUX_CH (Manchester-II) Sensitivity Test".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

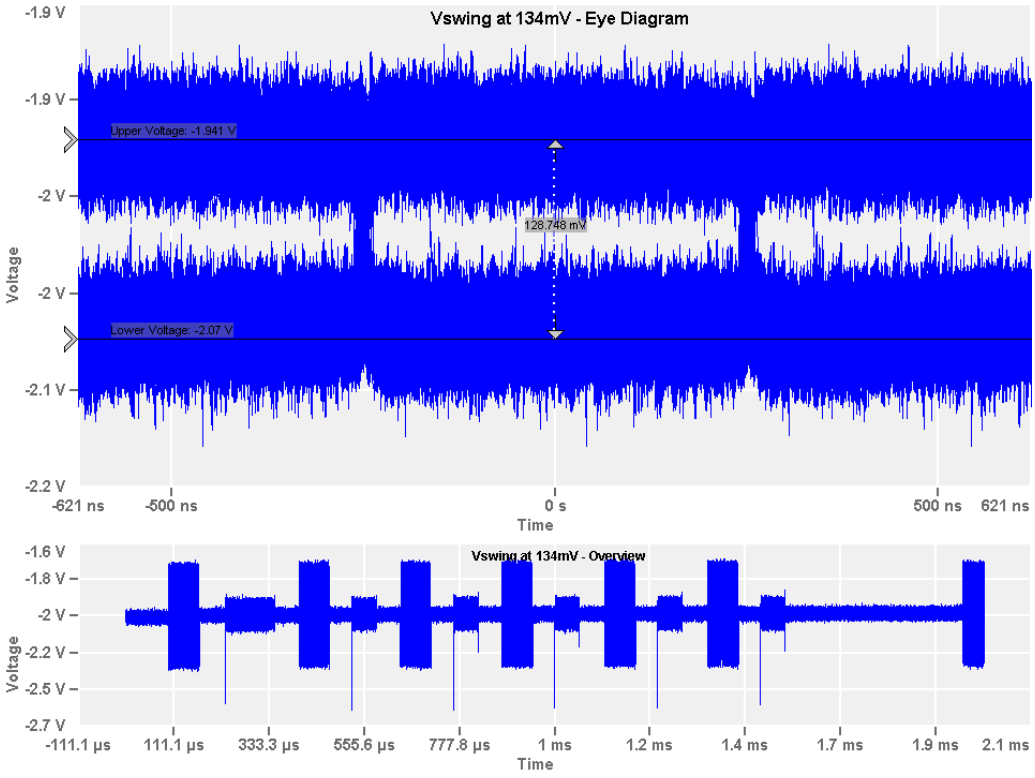
4.3.4.2 Measurements

This test requires a DP AUX controller that is able to change the voltage swing of the AUX CH.

The software iterates through various voltage swing values while commanding the AUX controller to induce a normal AUX transaction. For each swing value iterate, the software inspects if the transaction is indeed acknowledged by the DUT. The smallest

swing value of the AUX CH for which the source DUT is still able to respond is the minimum sensitivity level of the DUT.

The figure below shows the minimum voltage swing the source DUT is able to response to.

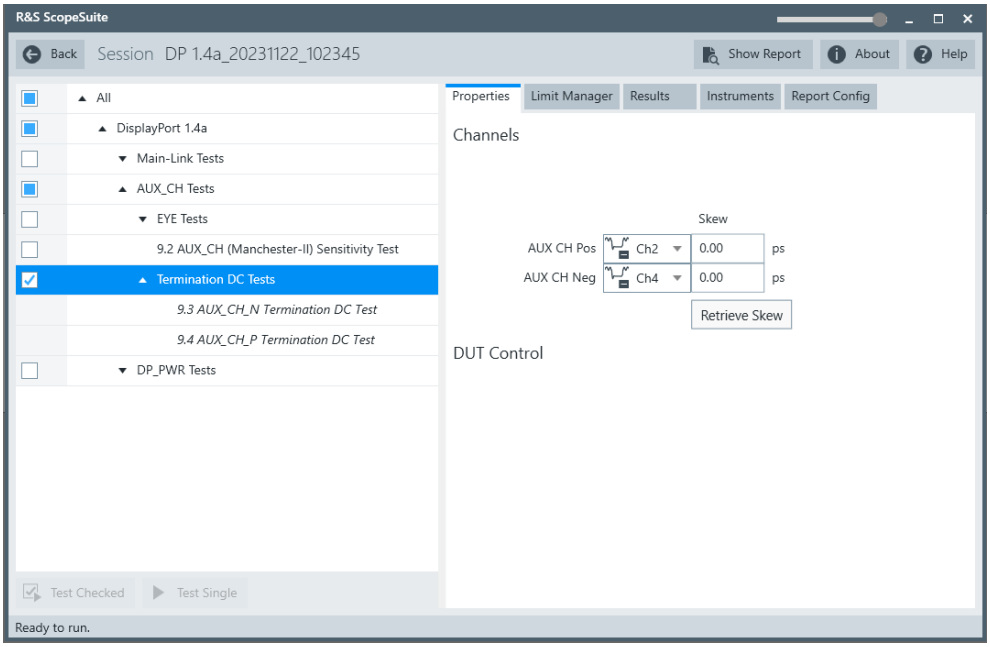


4.3.5 Termination DC tests

The termination DC test measures the form of AUX_CH_N and AUX_CH_P. The purpose of this test is to verify that the DC voltage from

4.3.5.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "AUX_CH Tests" > "Termination DC Tests".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.3.5.2 Measurements

AUX_CH_N termination DC test

The DC voltage from AUX_CH_N to GND on the link's source side is measured when a 1-MΩ resistance is connected from AUX_CH_N to GND.

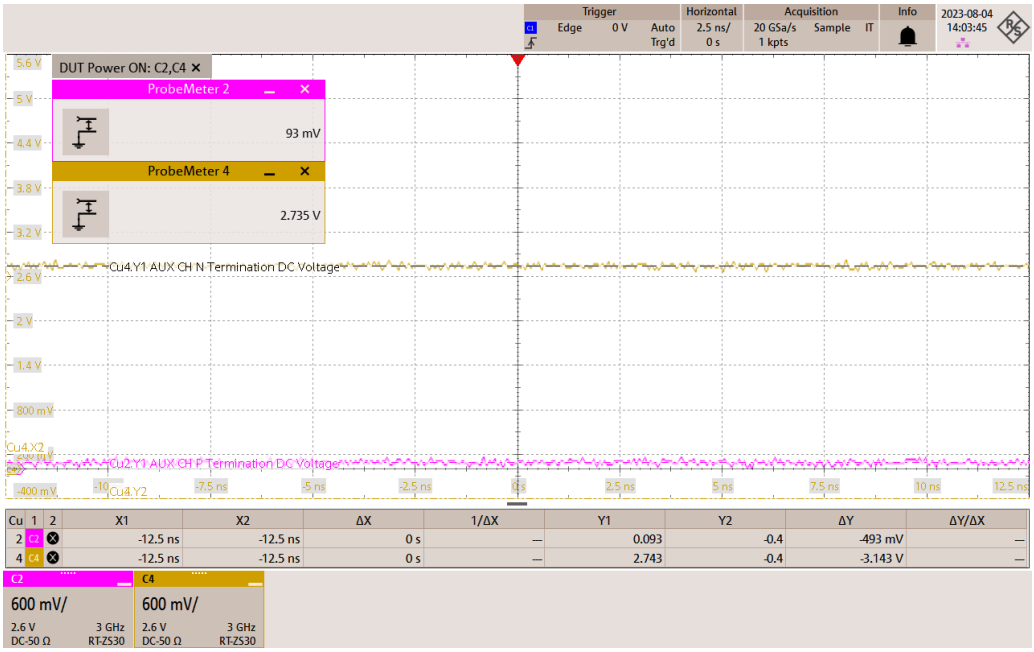


Figure 4-5: AUX_CH_N termination DC test with power on

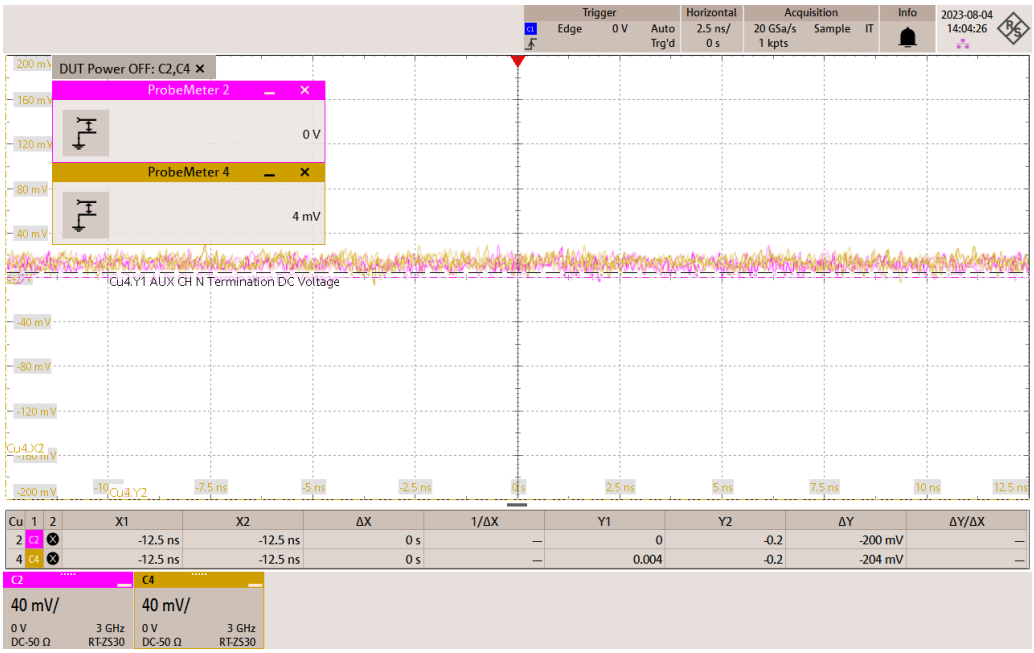


Figure 4-6: AUX_CH_N termination DC test with power off

AUX_CH_P termination DC test

The DC voltage from AUX_CH_P to GND on the link's source side is measured when a 1-MΩ resistance is connected from AUX_CH_P to a 3.3-VDC termination voltage.

4.4 DP_PWR tests

4.4.1 Test equipment

The following equipment is needed for performing main link DisplayPort compliance tests.

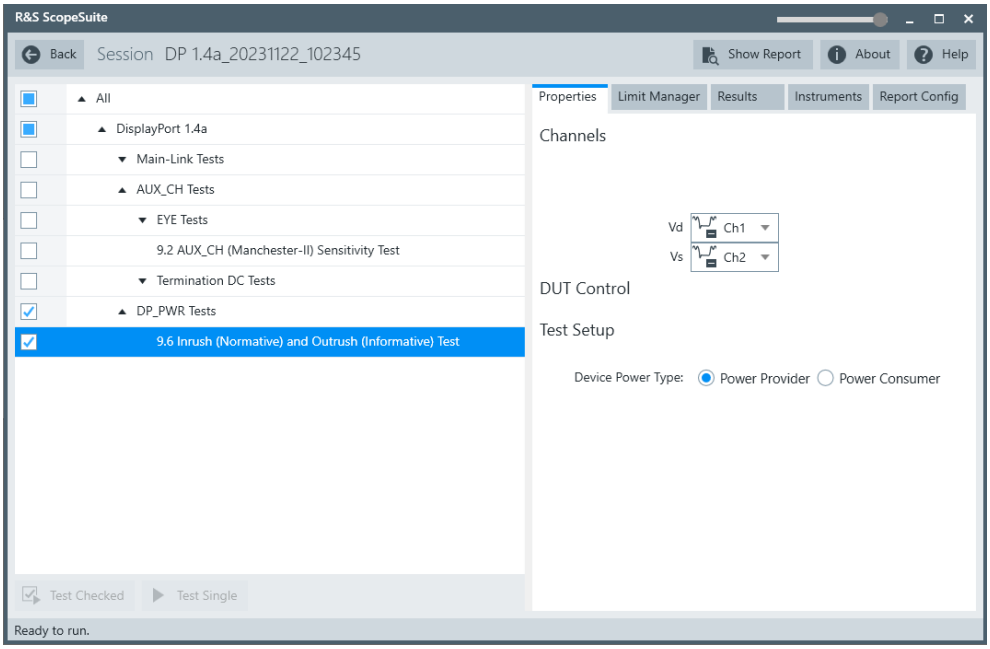
Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and minimum bandwidth 16 GHz	1
Active probe	Minimum bandwidth: 500MHz Minimum Input Impendence: 100kohm	2
		2/4
Inrush/Outrush test fixture	V-Prime DP Inrush/Outrushtest fixture or equivalent	
DUT	Any DisplayPort source device	1

4.4.2 Inrush (normative) and outrush (informative) test

The purpose of this test is to verify that the inrush energy at the power supply input of a power-consuming DUT and the inrush tolerance at the power supply output of a power-providing DUT system-dependent operation is maintained during a hot Plug event.

4.4.2.1 Performing the tests

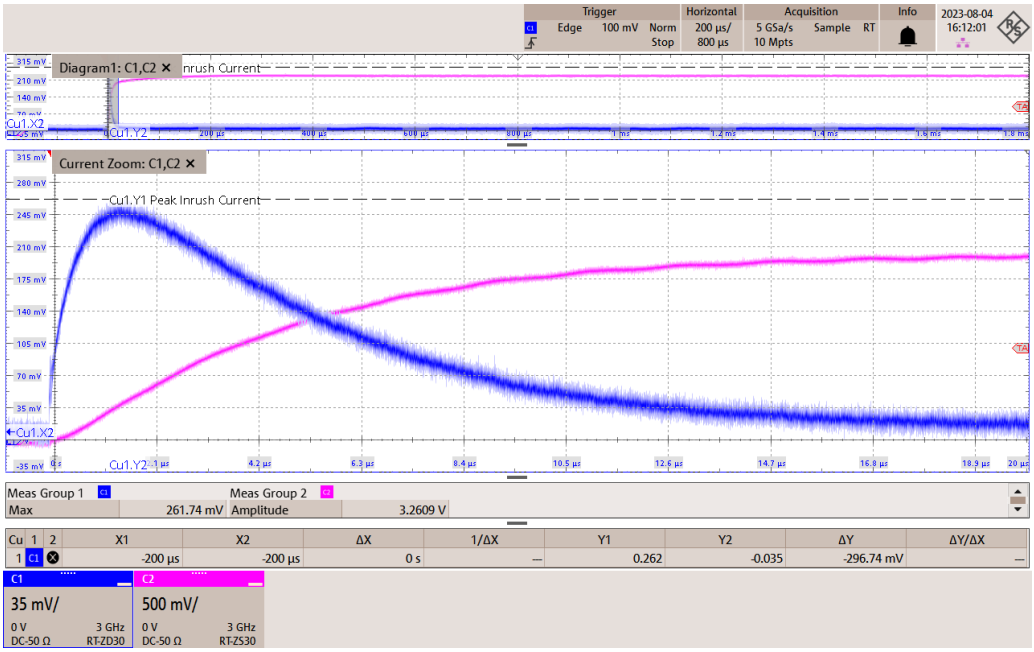
1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "AUX_CH Tests" > "Inrush (Normative) and Outrush (Informative) Test".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

4.4.2.2 Measurements

If a power-consuming device has excessive inrush, this may cause a power-providing device to fail. A power-consuming device shall not exceed this inrush energy. A power-providing device shall be able to handle this amount of inrush energy.


Trigger
Edge 100 mV Norm
Stop
Horizontal
200 µs/
800 µs
Acquisition
5 GSa/s Sample RT
10 Mpts
Info
2023-08-04
16:12:01
Diagram1: C1,C2
nrush Current
Cu1.X2
Cu1.Y2
Current Zoom: C1,C2
Cu1.Y1 Peak Inrush Current
Meas Group 1
Max 261.74 mV
Meas Group 2
Amplitude 3.2609 V
Cu 1 2 X1 X2 ΔX 1/ΔX Y1 Y2 ΔY ΔY/ΔX
1 -200 µs -200 µs 0 s – 0.262 -0.035 -296.74 mV –
C1
35 mV/
0 V 3 GHz
DC-50 Ω RT-ZD30
C2
500 mV/
0 V 3 GHz
DC-50 Ω RT-ZS30

5 eDP 1.4b, eDP 1.5 tests

5.1 Main-Link tests

The purpose of the Main-Link tests is to verify that the eDP source device under test is outputting signal that complies with the eDP 1.4b or eDP 1.5 Standard.

5.1.1 Test equipment

The following equipment is needed for performing main link eDP 1.4b, eDP 1.5 compliance tests.

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and minimum bandwidth 16 GHz	1
Probes	R&S ZM160 with R&S RT-ZMA40	2
	SMA cables	2/4
Advanced jitter analysis	Option R&S RTP-K133 or R&S RTP-K134 Advanced jitter and noise	1
DisplayPort AUX controller	Unigraf's UCD-3233 or equivalent	1
Auxiliary Control test adapter	Wilder Technologies Auxiliary control test adapter or equivalent	1
Embedded DisplayPort test adapter	Wilder Technologies EDP-TPA40L or equivalent	
DUT	Any eDP source device	1

5.1.2 Test patterns

The following test patterns are used:

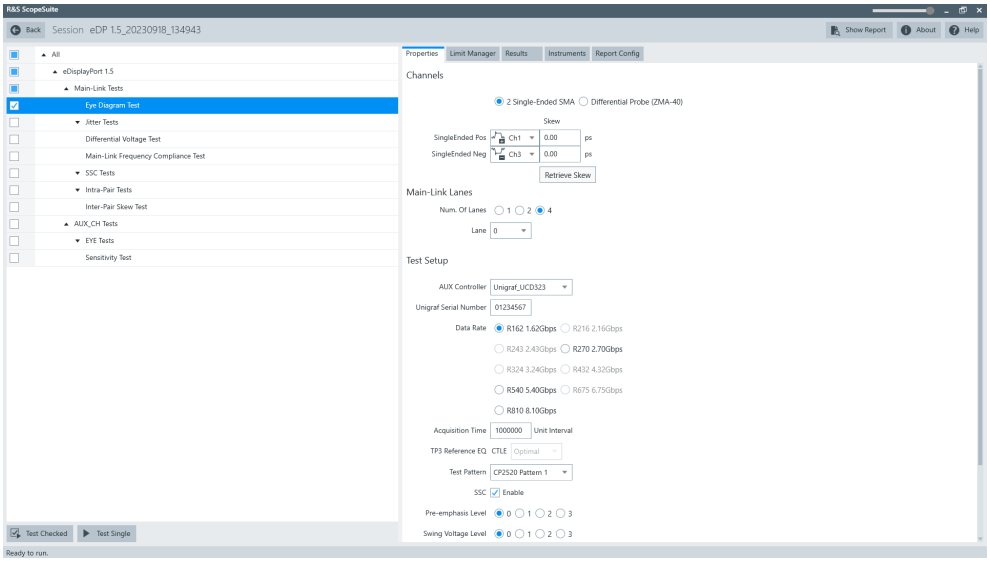
	Link rate	Test pattern
Eye & Jitter tests	2.7 Gbps	PRBS7
Eye & Jitter tests	> 2.7 Gbit/s and ≤ 5.4 Gbps	CP2520 pattern 1
Eye & Jitter tests	> 5.4 Gbit/s and ≤ 8.1 Gbps	CP2520 pattern 3
Differential voltage	All link rates	Custom pattern
Main link frequency	All link rates	D10.2
Spread spectrum clocking	All link rates	D10.2
Intra-Pair/Inter-Pair skew	All link rates	PRBS7

5.1.3 Eye diagram tests

The purpose of the test is to ensure that timing variables and amplitude trajectories support the overall DP system objectives of BER in data transmission.

5.1.3.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Eye Diagram Tests".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.1.3.2 Measurements

For Link rate < 5.4Gbps (eDP 1.4b & eDP 1.5):

Construct an eye diagram for the lane under test using the following condition:

Eye source: Differential lane signal with link rate-appropriate TP3_EQ Reference Equalizer applied.

Reference signal: Recover the reference clock using a 2nd order PLL with closed-loop tracking bandwidth and damping factor as specified in PLL 2nd order clock recovery.

Table 5-1: PLL 2nd order clock recovery

Link rate	Closed-loop tracking band-width (MHz)	Damping factor
> = 5.4Gbps	15	1.0
> 2.7 Gbps and < 5.4 Gbps	10	1.0
> 1.62 Gbps and < = 2.7 Gbps	10	1.51
< =1.62Gbps	5.4	1.51

The figure below shows a pass case for eye test:

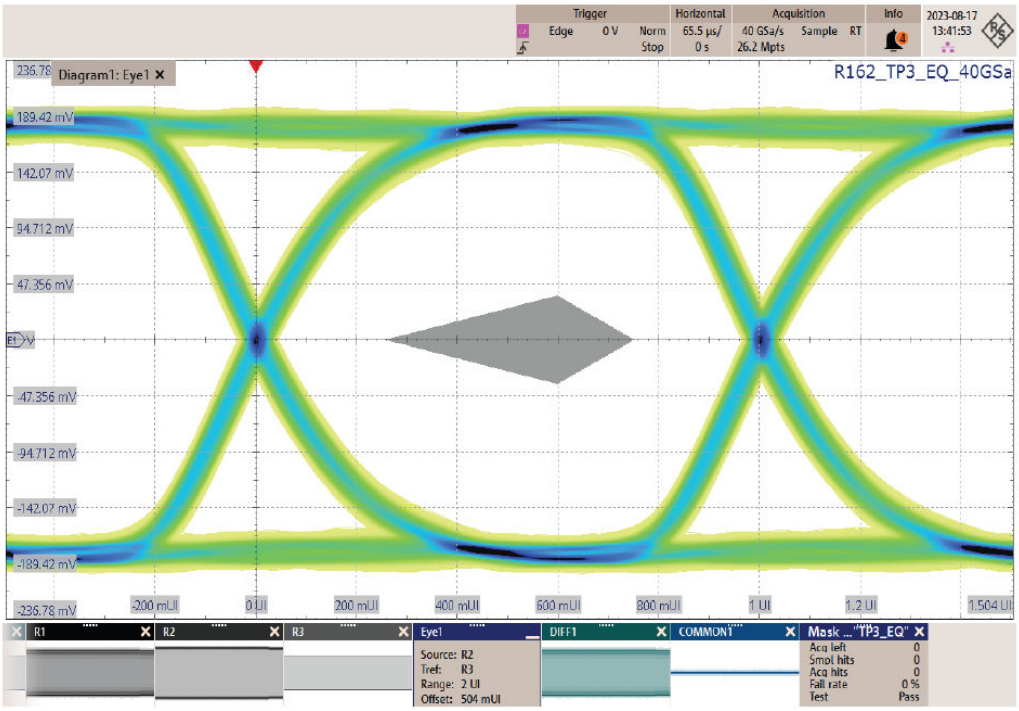


Figure 5-1: Eye test with pass criteria

For Link Rate > 5.4Gbps (eDP 1.5):

Construct an eye diagram for the lane under test using the following condition:

Eye Source: Differential lane signal with link rate-appropriate HBR3 CTLE Reference applied.

Reference Signal: Recover the reference clock using a 2nd Order PLL with closed-loop tracking bandwidth and damping factor specified in PLL 2nd order clock recovery.

The figure below shows a pass case for eye test:

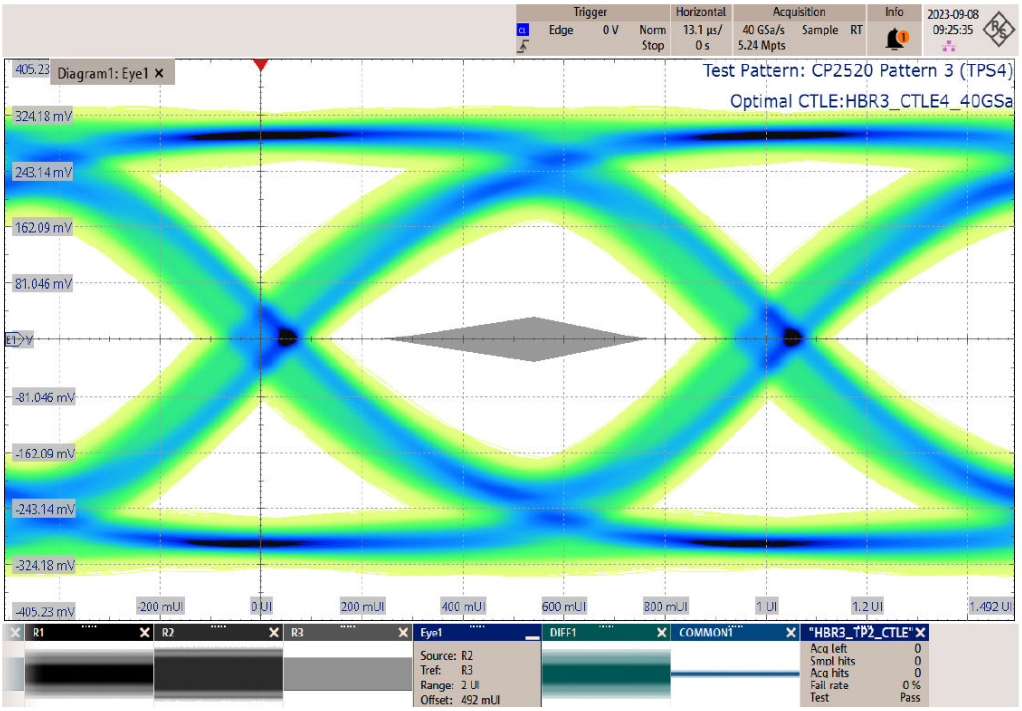


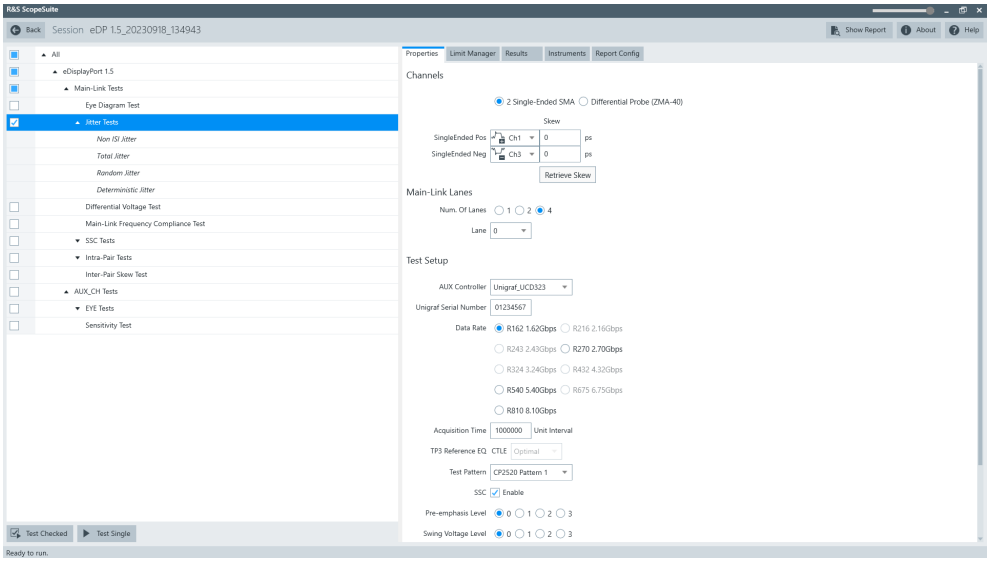
Figure 5-2: Eye test with pass criteria for eDP 1.5

5.1.4 Jitter tests

These tests evaluate the Total Jitter and Deterministic Jitter that accompany the data transmission. This measurement is a data time interval error (Data-TIE) jitter measurement.

5.1.4.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Jitter Tests".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.1.4.2 Measurements

The following measurements are performed:

- "Non ISI Jitter"
- "Total Jitter"
- "Random Jitter"
- "Deterministic Jitter"

Using Dual-Direct Model equivalent method to discompose the jitter components from the differential lane signal. The appropriate equalization is applied.

Total Jitter, Deterministic Jitter, Random Jitter

The total jitter is the peak-to-peak phase variation in the 0-V differential crossing point, measured at a 10e-9 BER for all link rates.It is estimated with the following equation:

$TJ=DJ_{dd} + n \times RJ_{dd}$

Where:

DJ_{dd} is the deterministic jitter

RJ_{rms} is the random jitter, a standard deviation value of an idealized pure noise process.

N for link rate < 8.1 Gbit/s = 12, to accommodate a $1x10^{-9}$ BER value

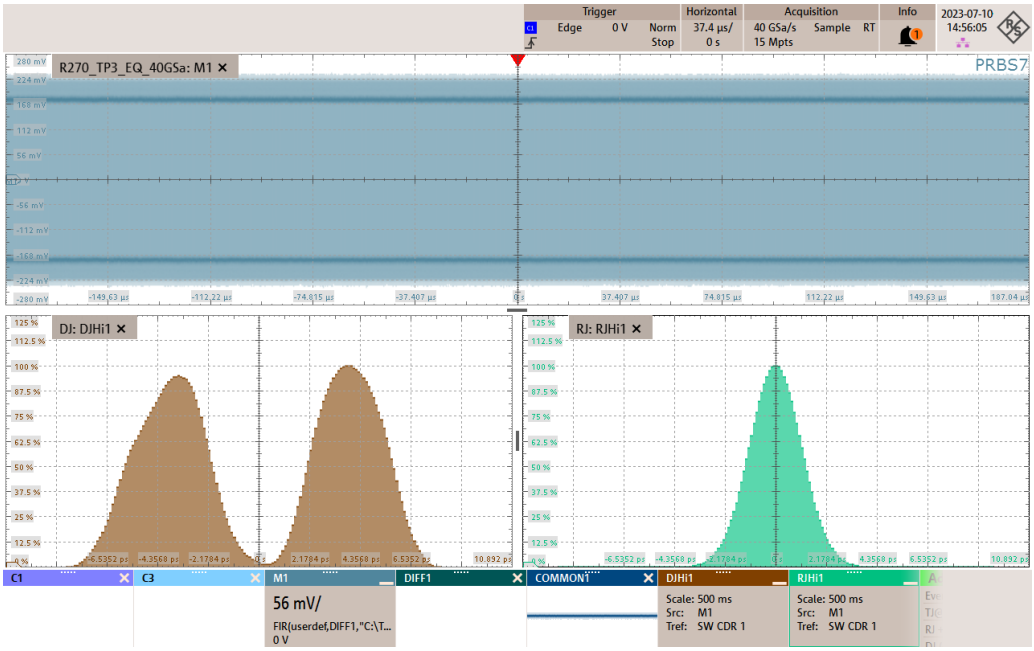
N for link rate > = 8.1 Gbit/s = 12, to accommodate a $1x10^{-9}$ BER value

Non ISI Jitter

Non ISI Jitter can be computed using the following equation:

$Jitter_{NON\_SIS}=TJ - Jitter_{ISI}$

The following diagram shows the decomposition of the jitter components:

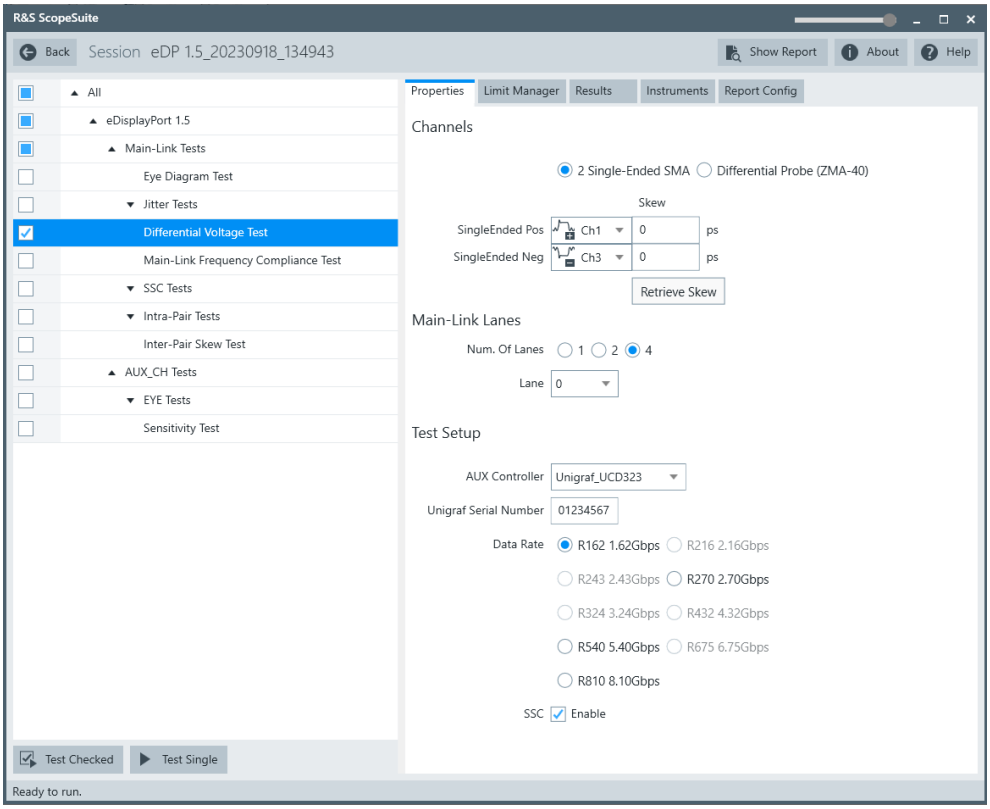


5.1.5 Differential voltage test

This test measures differential voltages on transition and non-transition levels when the DUT is operating at the different voltage and pre-emphasis settings.

5.1.5.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Differential Voltage Test".

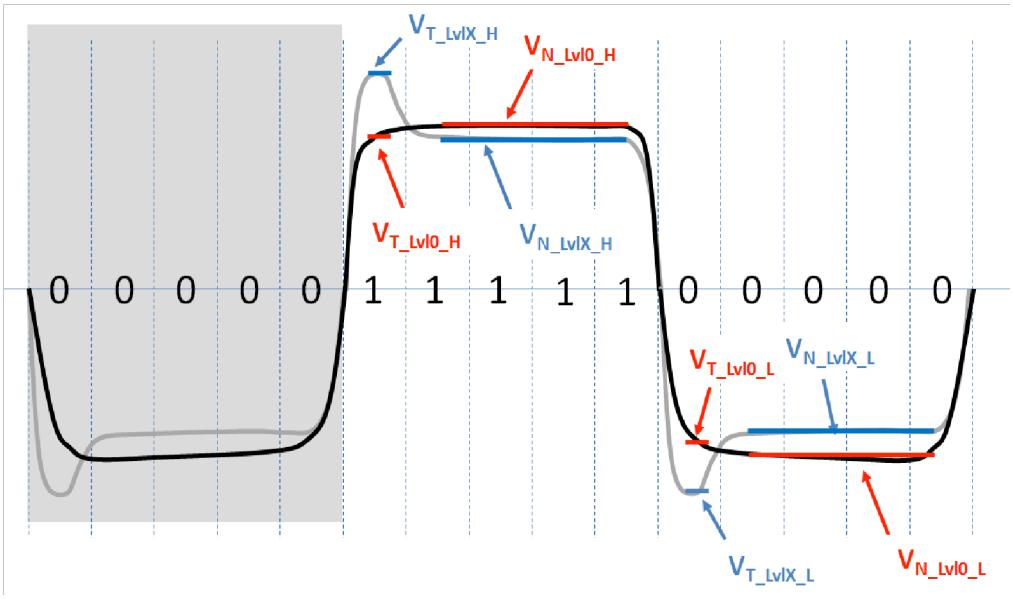


3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.1.5.2 Measurements

The DUT is configured to transmit a custom pattern which consists of 111110000 bit pattern.

Transition voltages ($V_{T\_LvlX\_H}$, $V_{T\_LvlX\_L}$) are the average value measured at 0.4 to 0.7 UI of the 5 consecutive bits while non-transition voltage ($V_{N\_LvlX\_H}$. $V_{N\_LvlX\_L}$) are the average values measure from 2.5 to 4.5 UI of the consecutive bits.

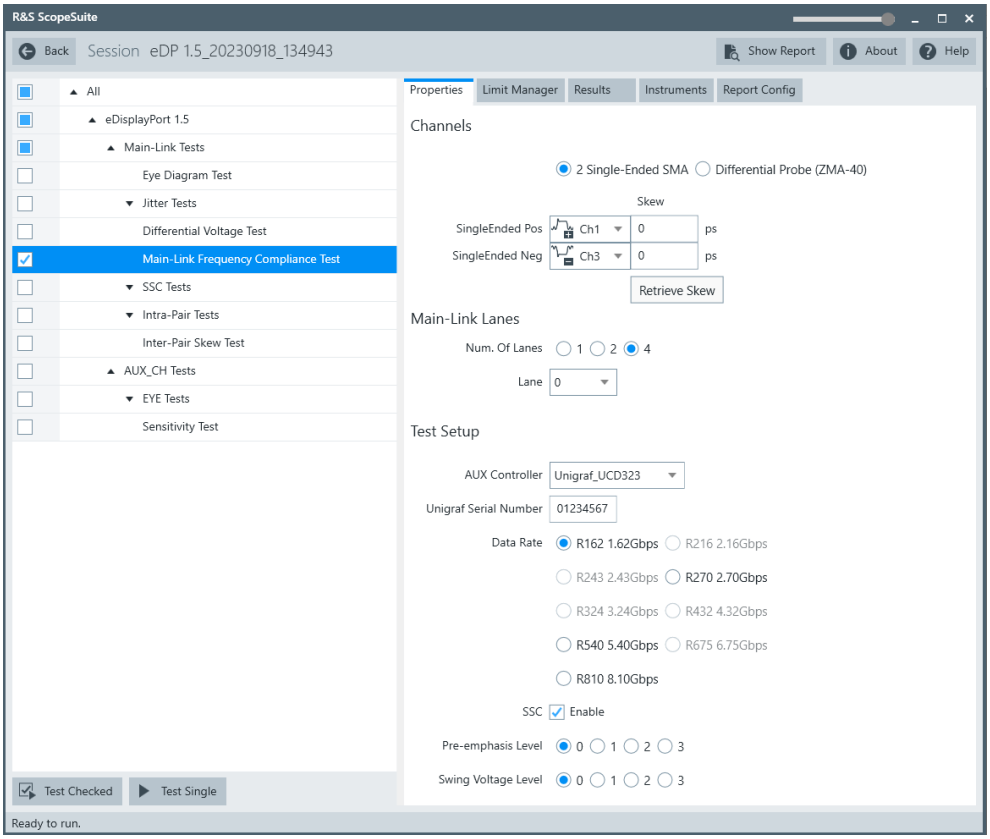


5.1.6 Main-link frequency compliance test

This test ensures that the average data rate under all conditions does not exceed the minimum or maximum link rate set by the specification.

5.1.6.1 Performing the tests

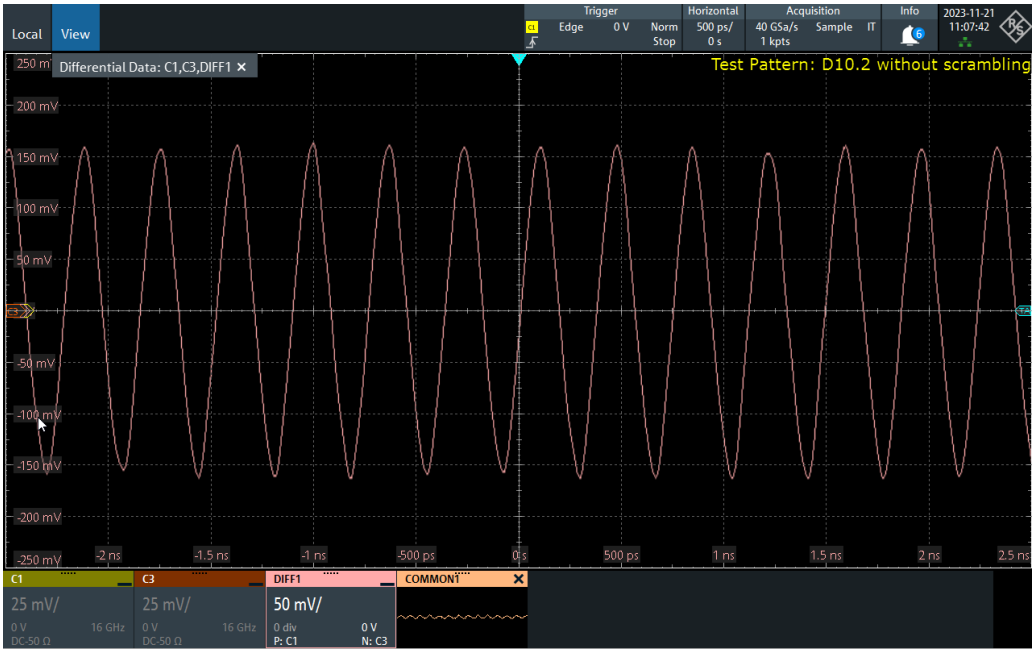
1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Main-link Frequency Compliance Test".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.1.6.2 Measurements

The DUT is set to transmit D10.2 pattern, 2 which consist of alternate 1 bit and 0 bits to simulate clock-liked signal as shown in figure below:



The software measures and reports frequency of the clock-liked signal.

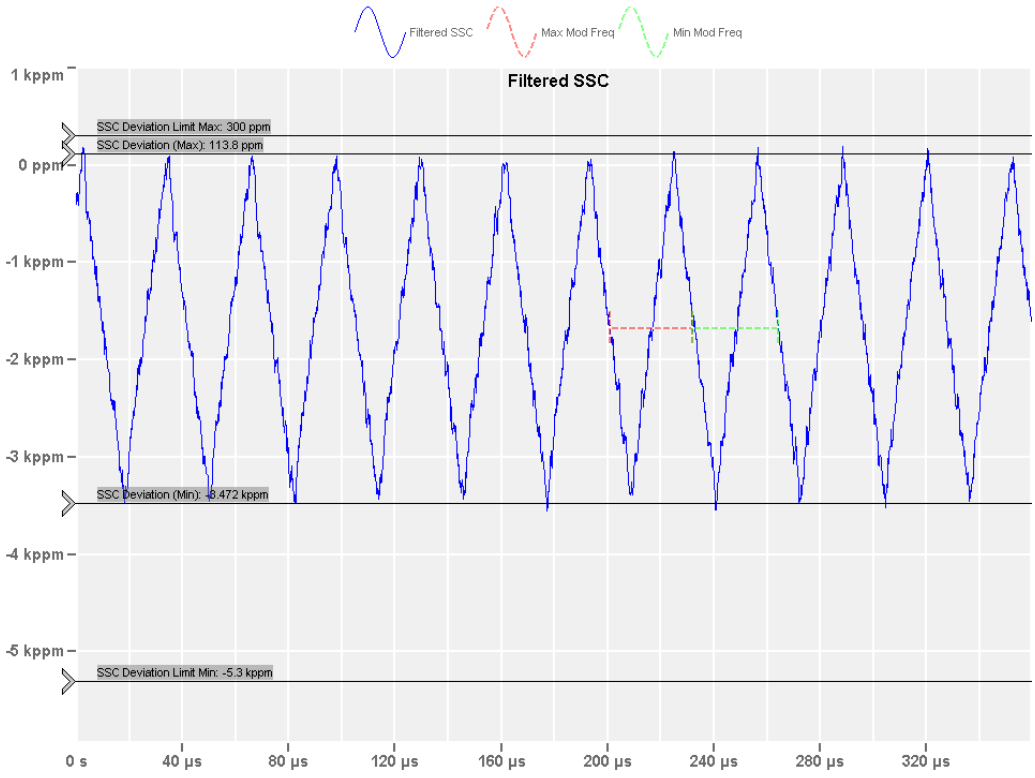


Figure 5-3: Main-link frequency with SSC enabled

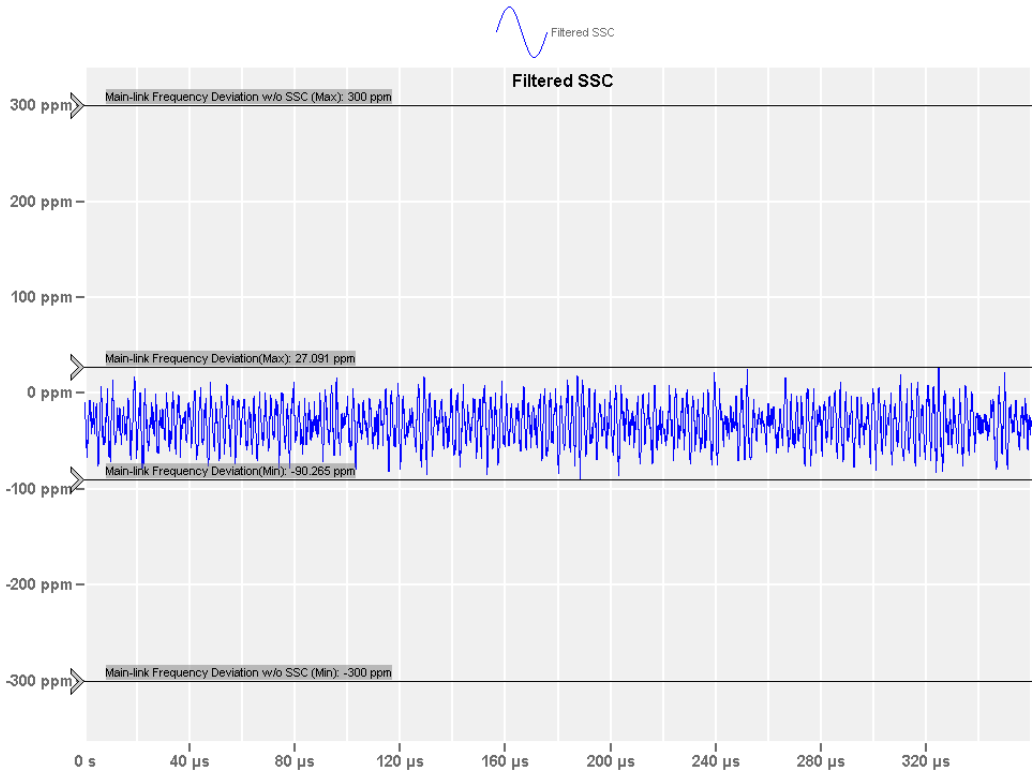


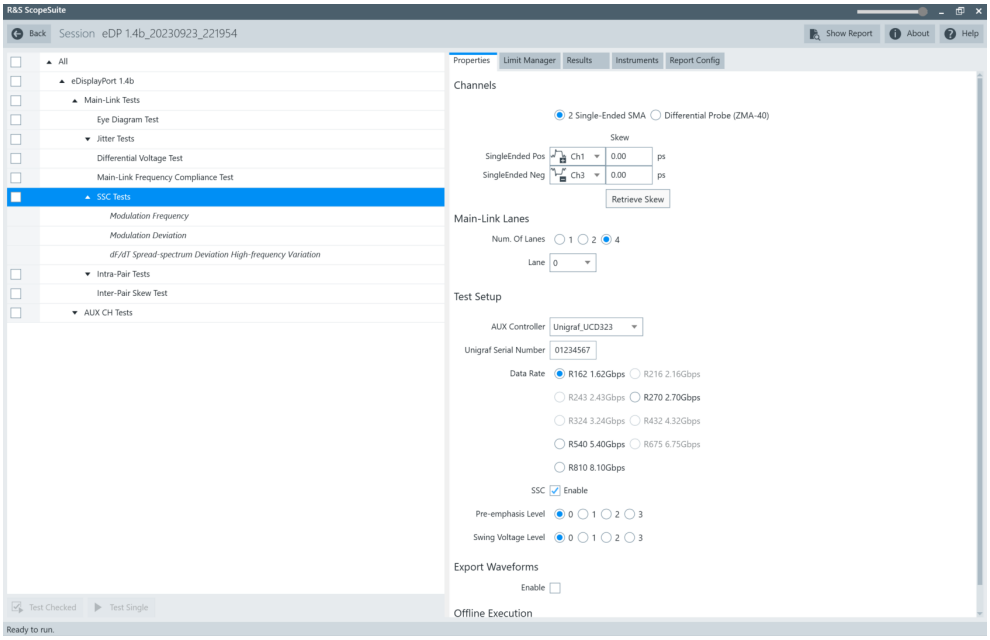
Figure 5-4: Main-link frequency with SSC disabled

5.1.7 SSC tests

This test evaluates the range of the transmitter signal's SSC down spreading (in ppm). The SSC profile shall not include frequency deviations that exceed 1250 ppm/us.

5.1.7.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "SSC Tests".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

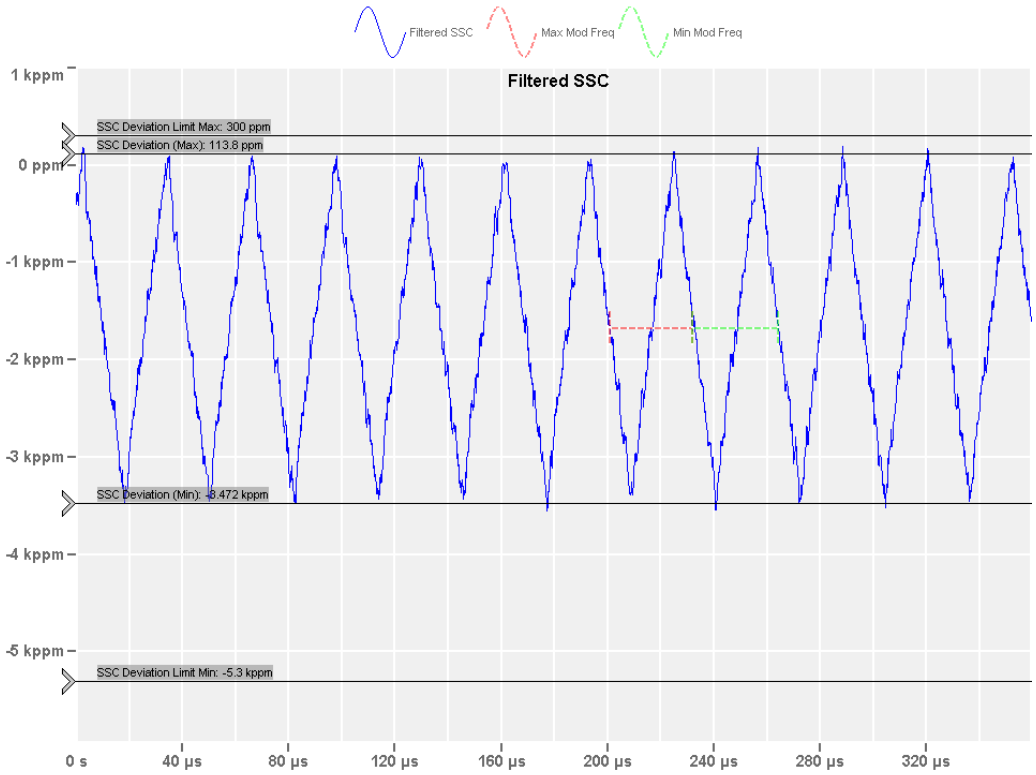
5.1.7.2 Measurement

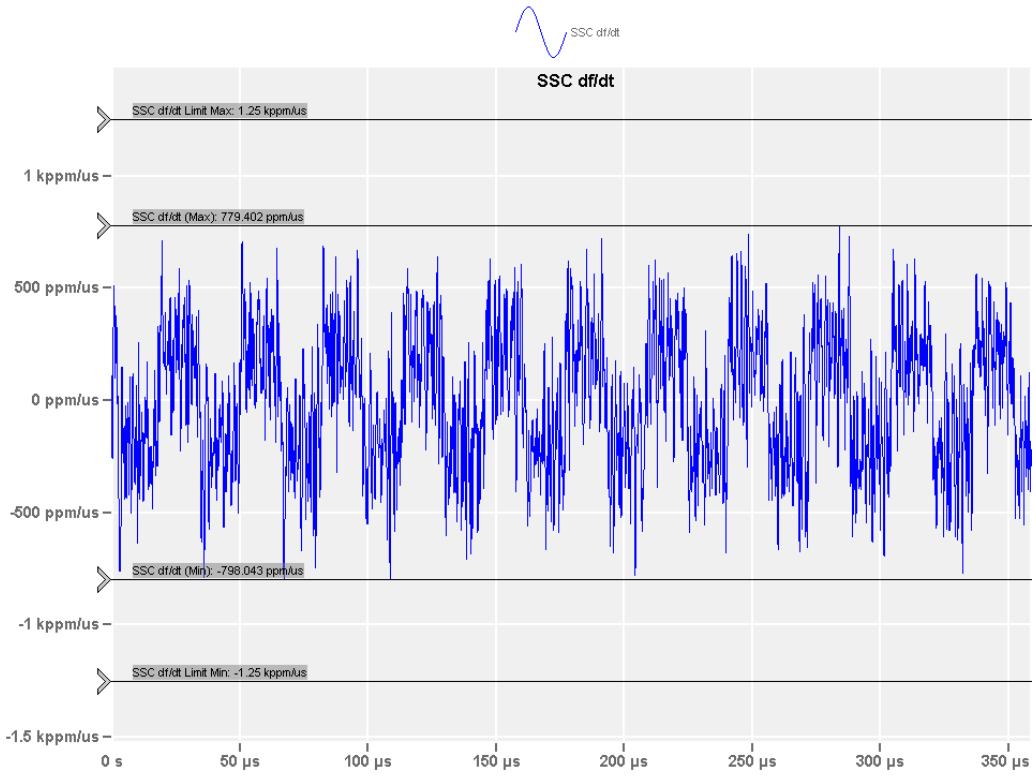
The DUT is configured to output test pattern D10.2 which consist of alternate 1 bit and 0 bits to simulate clock like signal.

The difference between the successive 0v crossing times of the differential lane waveform are measured as UI values.

Instantaneous frequency of the clock signal is measured as the inverse value of the UI values computed. A 0.222us average window filtering is applied to remove the high frequency noise.

The filtered clock frequency is used to analyze the modulation rate and deviation as shown in the picture below:


Filtered SSC
Max Mod Freq
Min Mod Freq
Filtered SSC
1 kppm
0 ppm
-1 kppm
-2 kppm
-3 kppm
-4 kppm
-5 kppm
SSC Deviation Limit Max: 300 ppm
SSC Deviation (Max): 113.8 ppm
SSC Deviation (Min): -8.472 kppm
SSC Deviation Limit Min: -5.3 kppm
0 s
40 µs
80 µs
120 µs
160 µs
200 µs
240 µs
280 µs
320 µs

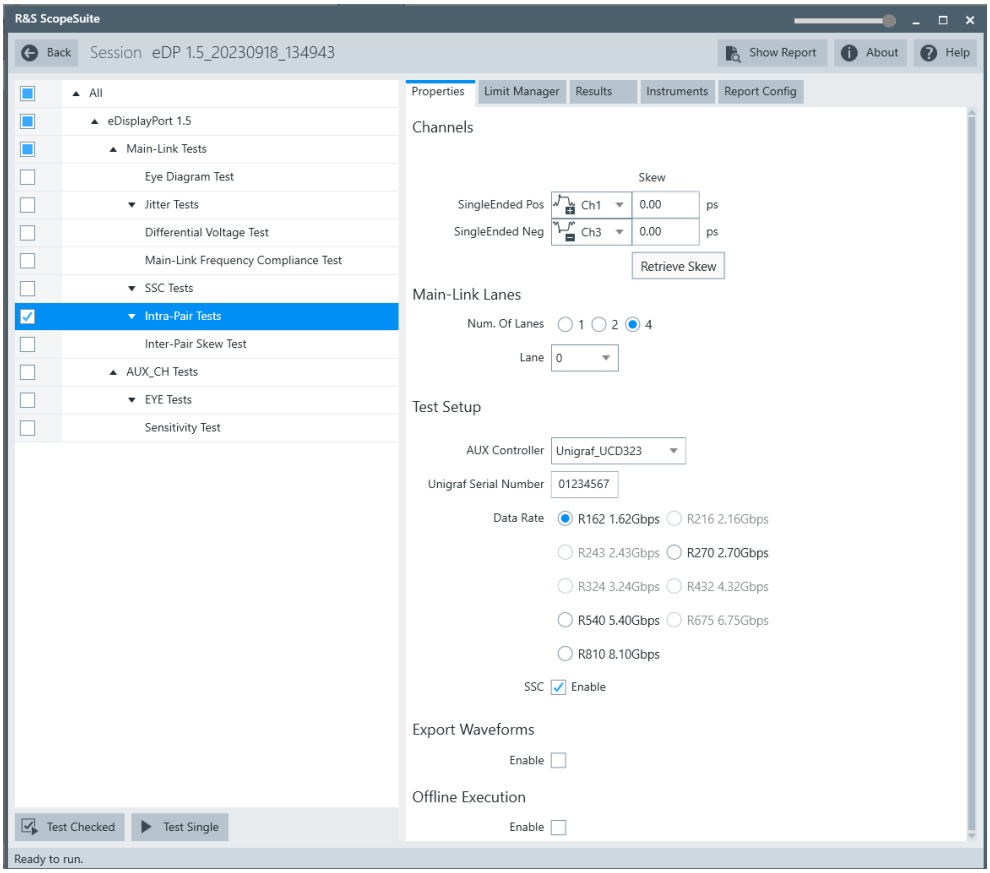

SSC df/dt
SSC df/dt
SSC df/dt Limit Max: 1.25 kppm/us
1 kppm/us
SSC df/dt (Max): 779.402 ppm/us
500 ppm/us
0 ppm/us
-500 ppm/us
SSC df/dt (Min): -798.043 ppm/us
-1 kppm/us
SSC df/dt Limit Min: -1.25 kppm/us
-1.5 kppm/us
0 s
50 µs
100 µs
150 µs
200 µs
250 µs
300 µs
350 µs

5.1.8 Intra-pair skew test

This test evaluates the skew between respective sides of a differential data lane in a Dipslay Port interface.

5.1.8.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Intra-pair Skew Test (Informative)".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.1.8.2 Measurements

Waveforms of both signal polarities on one lane are simultaneously captured using two single-ended measurement channels. The rising edge of the data true signal (D+) is

compared with the complement's (D-) falling edges, and the rising edge of the complement is compared to the falling edge of the data true signal. The time of transition is found by determining when the waveform crosses the transition amplitude.

Each lane is composed of two single-ended signals D+ and D-. For each D+ and D- signal, the average value over the 0.6 to 0.75UI region past the edge of the V_H and V_L is found:

$$V_{Transition\_D+} = \frac{V_{H+} + V_{L+}}{2}$$

$$V_{Transition\_D-} = \frac{V_{H-} + V_{L-}}{2}$$

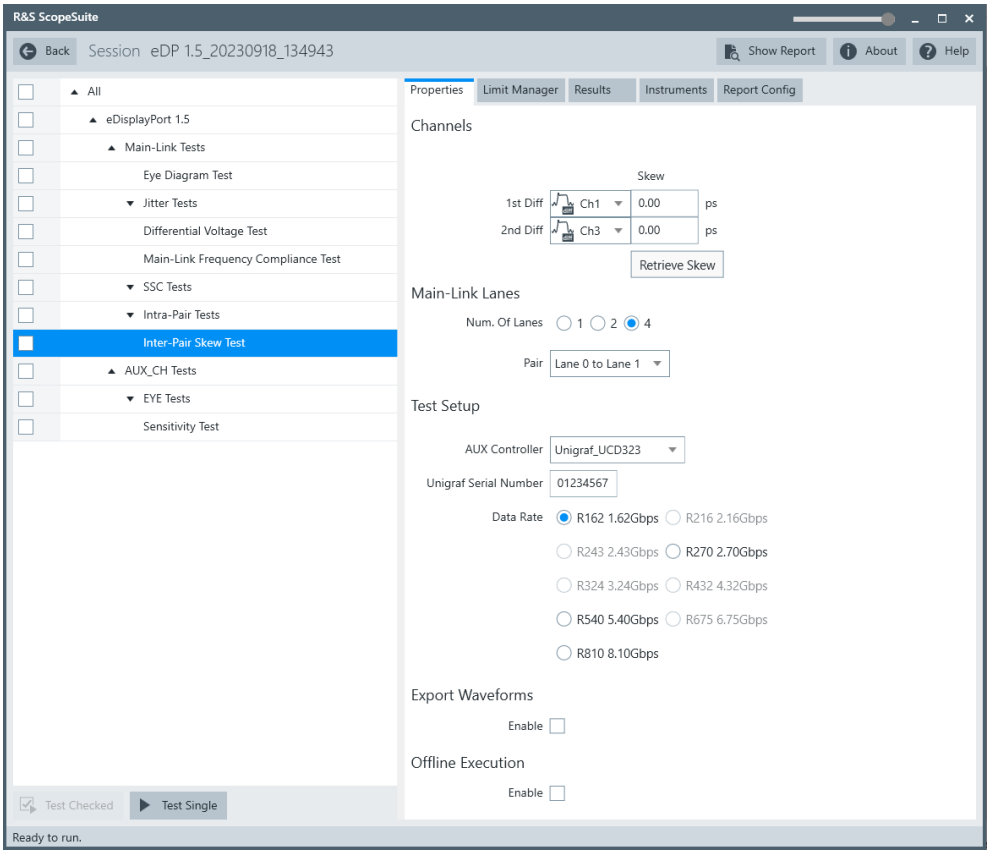
$$IntraPairSkew = \{1/NumEdges\} \Sigma \{[(T_{Trans\_D+\_High} - T_{Trans\_D-\_Low}) + (T_{Trans\_D+\_High} - T_{Trans\_D-\_Low})]/2\}$$

5.1.9 Inter-pair skew test

This test evaluates the skew (time delay) between respective sides of the differential main link lanes in the DisplayPort interface.

5.1.9.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "Main-Link Tests" > "Inter-pair Skew Test".



3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.1.9.2 Measurements

The measurement only applies to DUT with either 2 or 4 lanes.

The software captures waveforms from 2 lanes simultaneously while the DUT is outputting PRBS7. The inter-pair skew is regarded as the time difference between the lanes for a common point that is found at the waveform. At least 100 measurements are needed to pass the test.

$$InterLaneSkew = \{1/NumEdges\}\,\Sigma\,|T_{Transition\_LaneA} - T_{Transition\_LaneB}| - NominalSkew$$

5.2 AUX_CH tests

The group of tests evaluate if the AUX_CH waveforms are within the DisplayPort specification limits.

5.2.1 Test equipment

Item	Description, model	Quantity
Rohde & Schwarz oscilloscope	R&S RTP with 4 channels and minimum bandwidth 16 GHz	1
Probes	R&S ZM160 with R&S RT-ZMA40	1
	Active Probe with minimum bandwidth of 500 MHz and minimum Input impendence: 100kohm	2
Embedded DP test adapter	Wilder Technologies's EDP-TPA40L or equivalent	1
DP auxiliary control test adapter	Wilder Technologies' DPI-TPA-A or equivalent	1
DP AUX control	Unigraf's UCD-3233 or equivalent	1
DUT	Any eDP source device	1

5.2.2 Test setup

The following graphic show the test setup for the AUX channel test measurements.

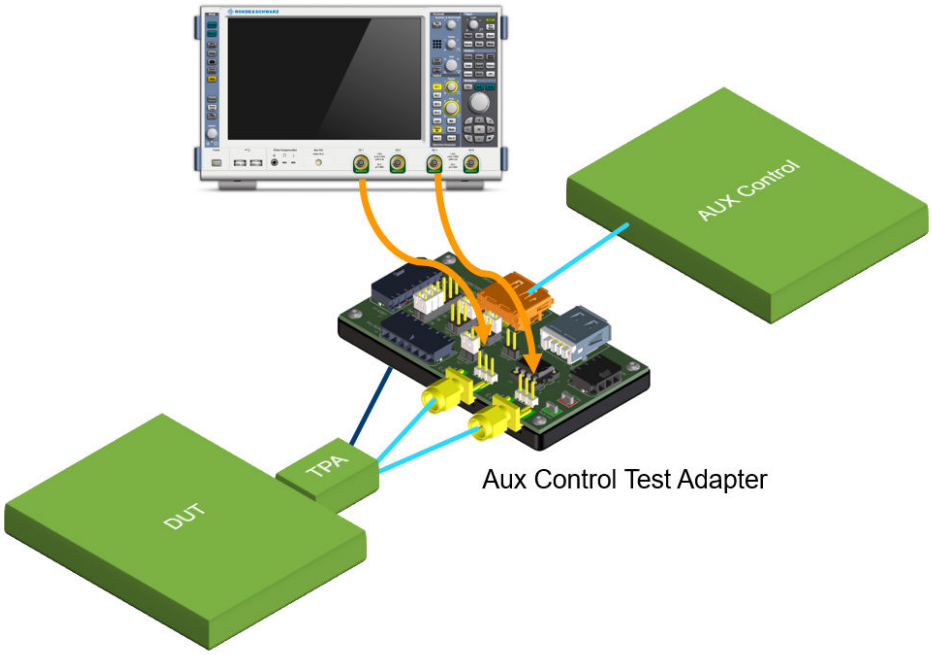


Figure 5-5: AUX channel test setup with 2 single-ended probes

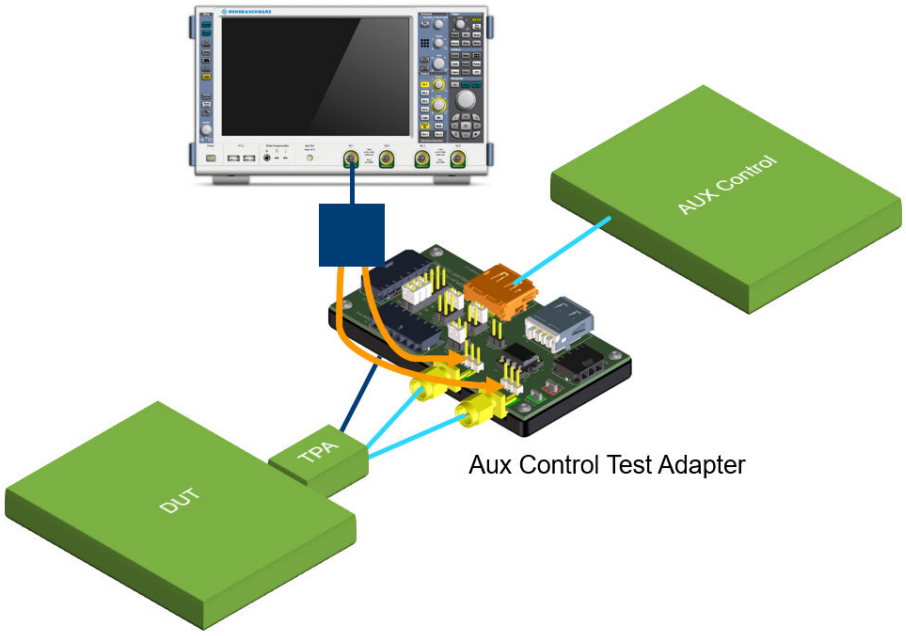


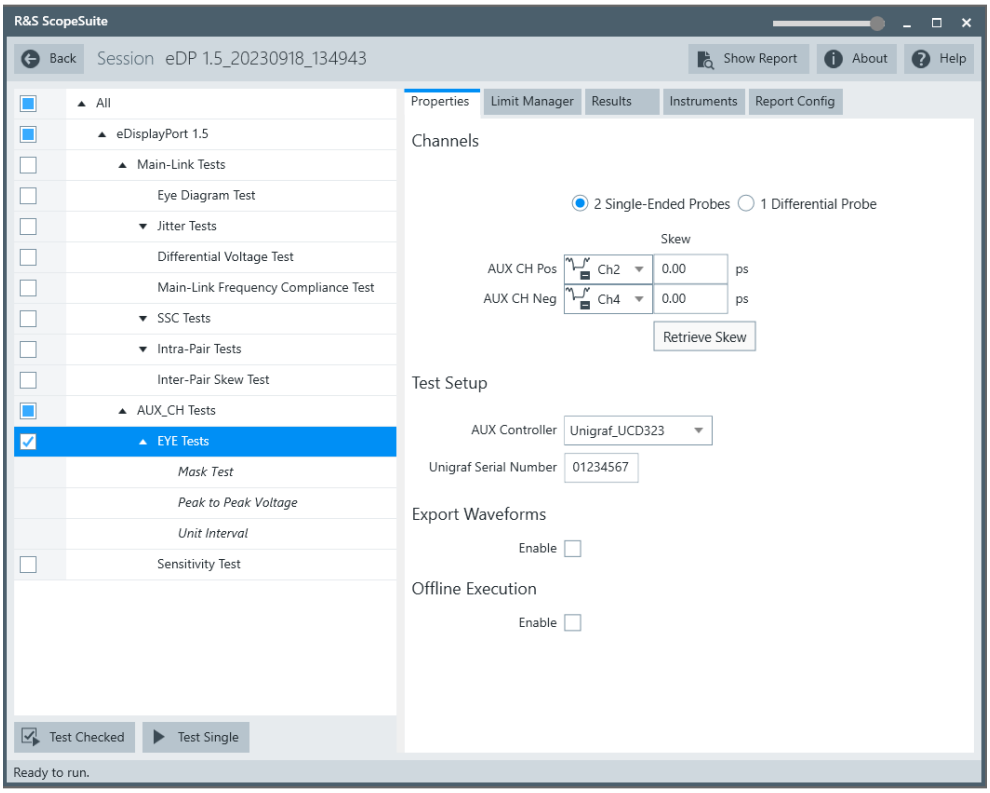
Figure 5-6: AUX channel test setup with 1 differential probe

5.2.3 Eye tests

This test verifies that the timing variables and amplitude trajectories of the AUX_CH waveform support DisplayPort BER system objectives in data transmission.

5.2.3.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "AUX_CH Tests" > "Eye tests".

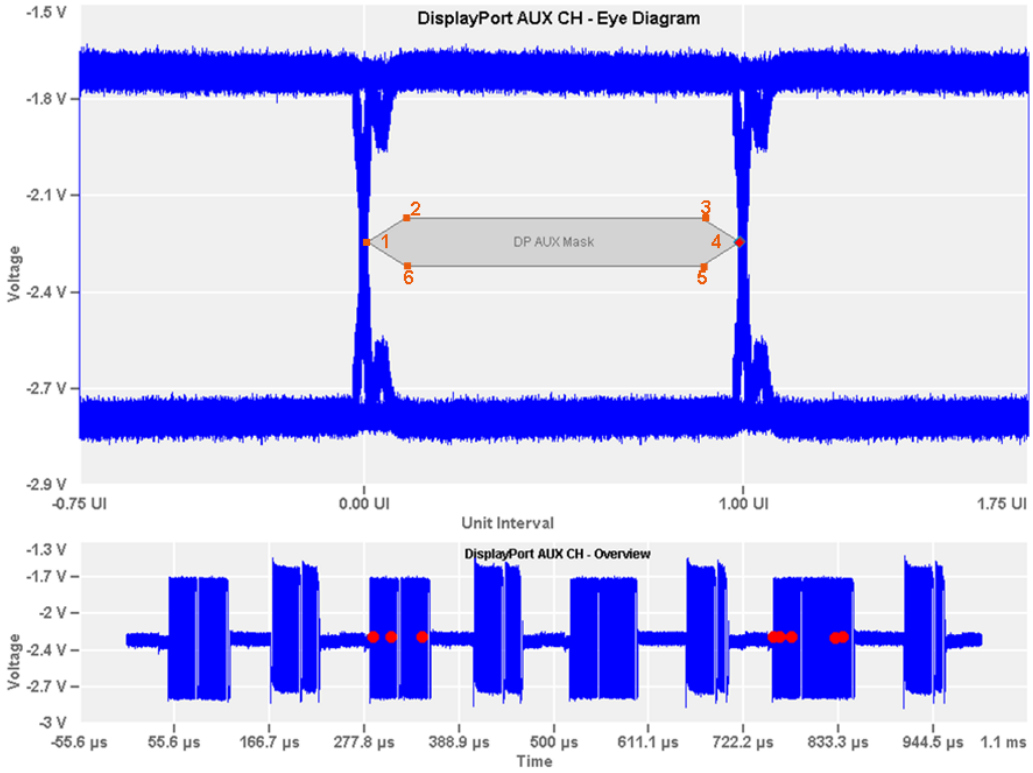


3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.2.3.2 Mask test

This test verifies that the timing variables and amplitude trajectories of the AUX_CH waveform support DisplayPort BER system objectives in data transmission.

The software collects the waveform containing AUX CH data transaction. A simple decoding is applied to separate the signal. Only signal transmitted from source DUT are used to construct the eye diagram.

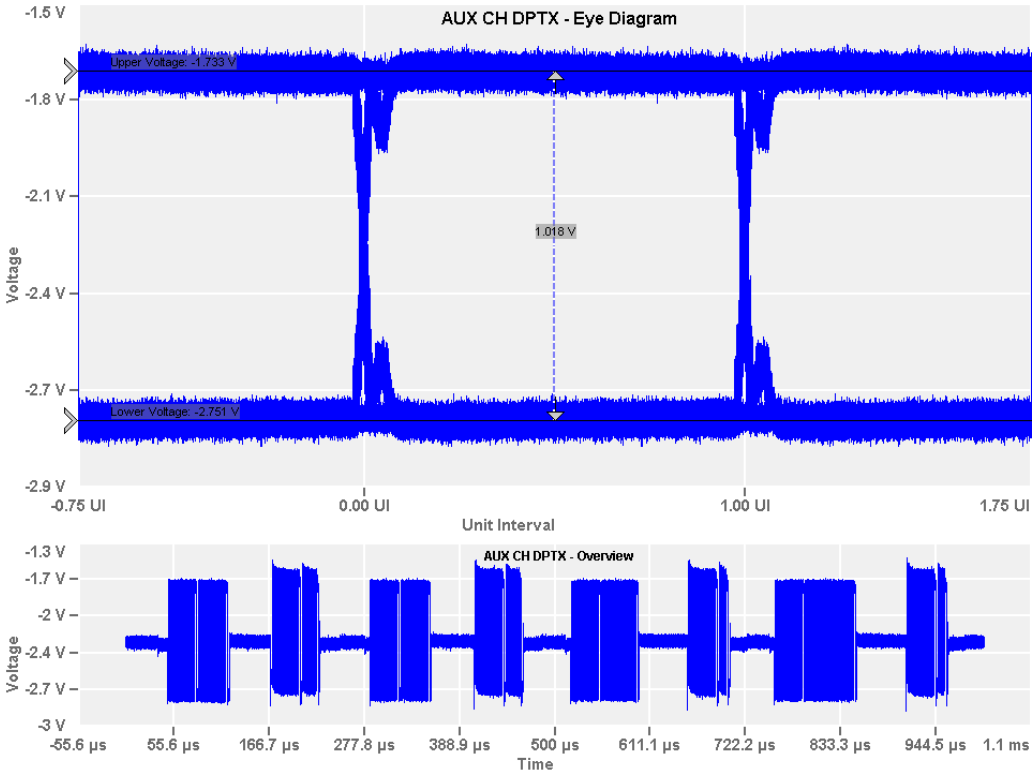


5.2.3.3 Peak to peak voltage

This test verifies that the peak-to-peak voltage of the AUX_CH waveform, stays within the limits defined by the DisplayPort specification.

The software collects the waveform containing AUX CH data transaction. A simple decoding is applied to separate the signal. Only the signal transmitted from the source DUT is used to construct the eye diagram. Only waveform data within 40% to 60% of the unit interval of each bit used. The peak-to-peak voltage is defined as the difference between the average of upper half to of the waveform data and the lower half.

The following figure shows the upper voltage, lower voltage and the difference between the 2 voltages.



5.2.3.4 Unit interval

This test verifies that the overall variation of the Manchester transaction Unit Interval for the AUX_CH waveform stays within the DisplayPort specification limits.

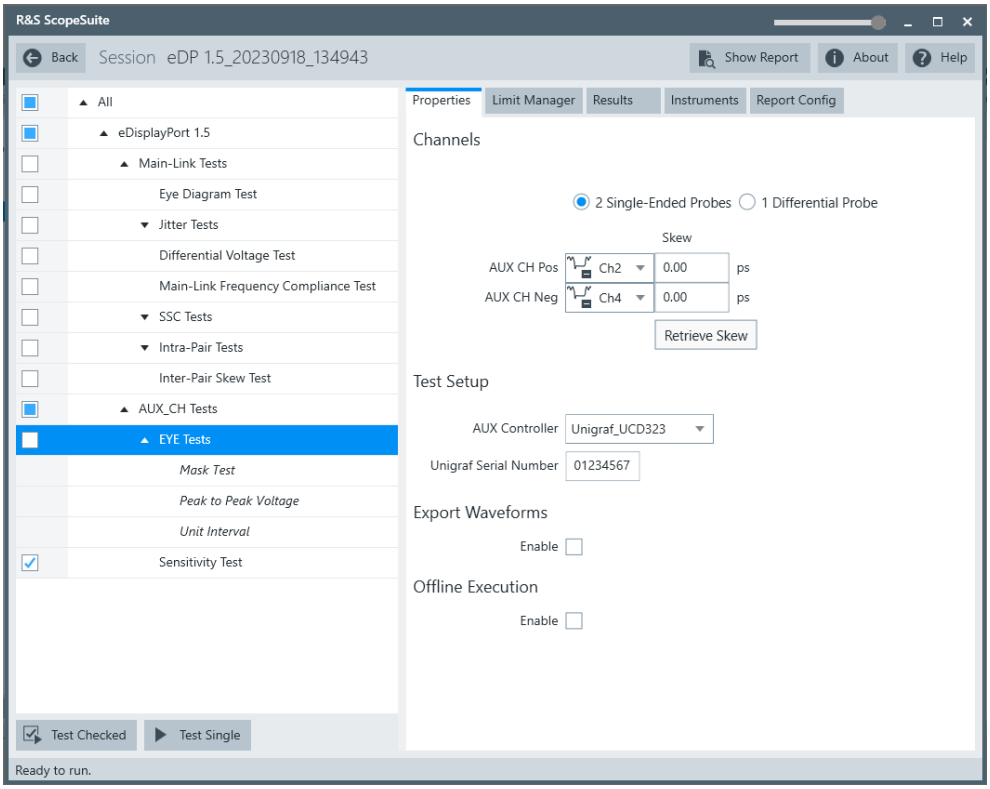
The software collects the waveform containing AUX CH data transaction. A simple decoding is applied to separate the signal. Only signals transmitted from the source DUT are used. Unit interval of the signal is measured by collecting all edges and estimate a uniform clock pulse that best fits the separated signal.

5.2.4 Sensitivity test

This test evaluates the minimum voltage swing that the receiver part of the source DUT is able to respond to.

5.2.4.1 Performing the tests

1. Start the test as described in Chapter 3.5, "Starting DisplayPort tests", on page 20.
2. Select "AUX_CH Tests" > "Sensitivity test".



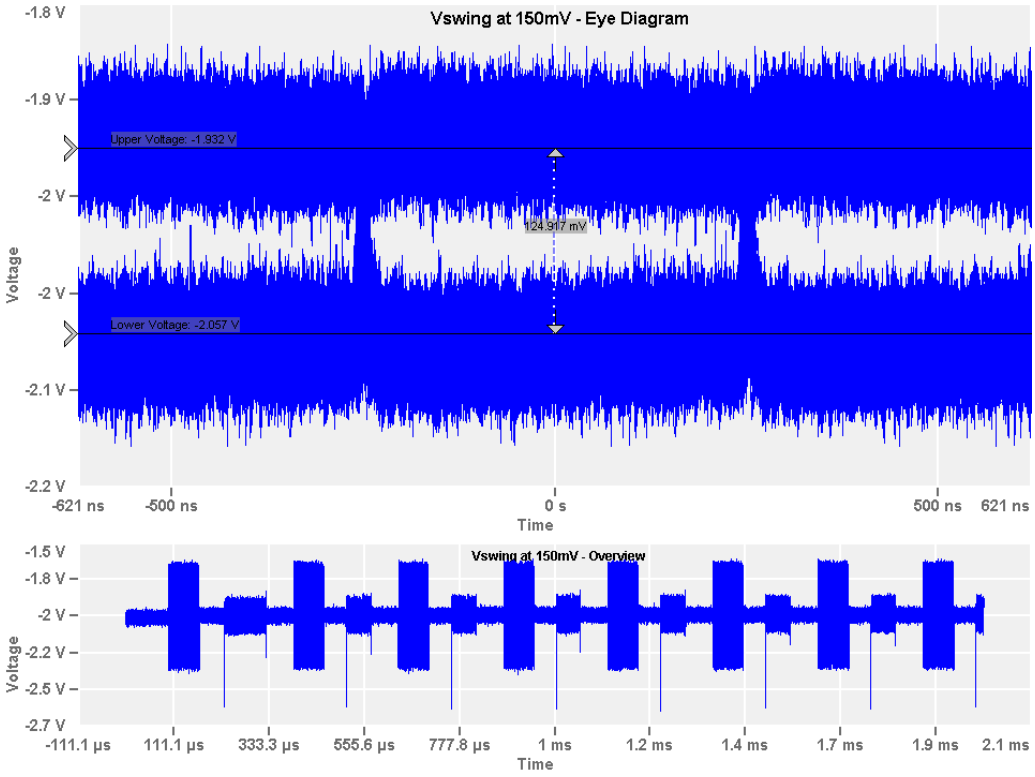
3. Click "Test Single".
4. Follow the instructions of the step-by step guide.
   When you have finished all steps, the compliance test runs automatically.
5. You can also run the test in offline mode, using downloaded waveforms. For details, see "Offline Execution" on page 25.

5.2.4.2 Measurements

This test requires a DP AUX controller that is able to change the voltage swing of the AUX CH.

The software iterates through various voltage swing values while commanding the AUX controller to induce a normal AUX transaction. For each swing value, the software inspects if the transaction is acknowledged by the DUT. The smallest swing value of the AUX CH for which the source DUT is still able to respond, is the minimum sensitivity level of the DUT.

The figure below shows the minimum voltage swing the source DUT is able to respond to.


Vswing at 150mV - Eye Diagram
-1.8 V
-1.9 V
-2 V
-2 V
-2.1 V
-2.2 V
Upper Voltage: -1.932 V
Lower Voltage: -2.057 V
124.917 mV
Voltage
-621 ns
-500 ns
0 s
500 ns
621 ns
Time
Vswing at 150mV - Overview
-1.5 V
-1.8 V
-2 V
-2.2 V
-2.5 V
-2.7 V
Voltage
-111.1 µs
111.1 µs
333.3 µs
555.6 µs
777.8 µs
1 ms
1.2 ms
1.4 ms
1.7 ms
1.9 ms
2.1 ms
Time