QPHY-MultiGBase-T1 and QPHY-MultiGBase-T1-TDR

Multi-Gigabit Ethernet Compliance Test Software Instruction Manual

June 2023

Relating to:

MAUI™ Version 10.3.x.x and later

QualiPHY Version 10.3.x.x and later

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QualiPHYMultiGBase-T1Manual.pdf
June 2023

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About This Manual

This manual assumes that you are familiar with using an oscilloscope–in particular the Teledyne LeCroy oscilloscope that will be used with QualiPHY–and that you have purchased the QPHY-MultiGBase-T1 software option.

Some of the images in this manual may show QualiPHY products other than QPHY-MultiGBase-T1, or were captured using different model oscilloscopes, as they are meant to illustrate general concepts only. Rest assured that while the user interface may look different from yours, the functionality is identical.

Introduction

QualiPHY is highly automated compliance test software meant to help you develop and validate the PHY (physical-electrical) layer of a device, in accordance with the official documents published by the applicable standards organizations and special interest groups (SIGs). You can additionally set custom variables and limits to test compliance to internal standards.

QualiPHY is composed of a "wizard" application that enables the configuration and control of separate tests for each standard through a common user interface. Features include:

- **User-Defined Test Limits**: tighten limits to ensure devices are well within the passing region, even if subsequently measured with different equipment.
- **Flexible Test Results Reporting** that includes XML Test Record Generation. Understand device performance distribution or obtain process information from the devices under test.

QPHY-MultiGBase-T1 is an automated test package performing all the normative, real-time oscilloscope tests for sources in accordance with the Open Alliance MultiGBase-T1 PMA Test Suite. The software can be run on any Teledyne LeCroy oscilloscope that meets the following requirements:

- For 2.5 gigabit testing: 3 GHz bandwidth, 10 GS/s sample rate
- For 5 gigabit testing: 6 GHz bandwidth, 20 GS/s sample rate
- For 10 gigabit testing: 13 GHz bandwidth, 40GS/s sample rate

QPHY-MultiGBase-T1-TDR performs all the TDR tests required by the standard using a WavePulser 40iX High-speed Interconnect Analyzer.

Software Installation and Setup

QualiPHY is a Windows-based application that can be configured with one or more serial data compliance components. Each compliance component is purchased as a software option.

Oscilloscope Requirements

Hardware

The software can be run on any Teledyne LeCroy real-time oscilloscope that meets the following bandwidth (BW) and sample rate (SR) requirements:

- For 2.5 gigabit testing: 3 GHz bandwidth, 10 GS/s sample rate
- For 5 gigabit testing: 6 GHz bandwidth, 20 GS/s sample rate
- For 10 gigabit testing: 13 GHz bandwidth, 40GS/s sample rate

While not required, we recommend running QualiPHY on an oscilloscope equipped with Dual Monitor Display capability. This allows the waveforms and measurements to be shown on the oscilloscope LCD display, while the QualiPHY application and test results are displayed on the second monitor.

See the oscilloscope *Operator's Manual* for instructions on setting up dual monitor display.

Software

The oscilloscope must be installed with:

- MAUI v.10.3.x.x minimum* with an activated QPHY-MultiGBase-T1 option key
- QualiPHY v.10.3.x.x minimum with an activated QPHY-MultiGBase-T1 component
- SDAIII/SDAIII-CompleteLinq with activated option key

Note: The versions listed above are the minimum versions required for this product. MAUI and QualiPHY software versions must match, so upgrade your version of QualiPHY if you have upgraded your oscilloscope firmware. The QualiPHY software may be installed on a remote PC, but all other software must be run on the oscilloscope.

Other Required Equipment

See the sections on oscilloscope and TDR testing for specific requirements.

Install QualiPHY Application

Download the latest version of the QualiPHY software from:

teledynelecroy.com/support/softwaredownload/ under Oscilloscope Downloads > Software Utilities

The application can be installed on either the test oscilloscope or on a remote host computer. For remote execution, see Set Up Remote Control.

If the oscilloscope is not connected to the Internet, copy the installer onto a USB memory stick then transfer it to the oscilloscope desktop or a folder on the D:\ drive to execute it.

Run **QualiPHYInstaller.exe** and follow the installer prompts. Choose all the components you plan to activate. If you omit any components now, you will need to update the installation to activate them later.

By default, the oscilloscope appears as local host when QualiPHY is executed on the oscilloscope. Follow the steps under Add Connection to QualiPHY to check that the IP address is 127.0.0.1.

Activate Components in MAUI

The serial data compliance components are factory installed as part of the oscilloscope application (MAUI) and are individually activated using an alphanumeric code uniquely matched to the oscilloscope's serial number. This option key code is what is delivered when purchasing a software option.

To activate a component on the oscilloscope:

1. From the menu bar, choose Utilities > Utilities Setup.
2. On the Options tab, click Add Key.
3. Use the Virtual Keyboard to Enter Option Key, then click OK.

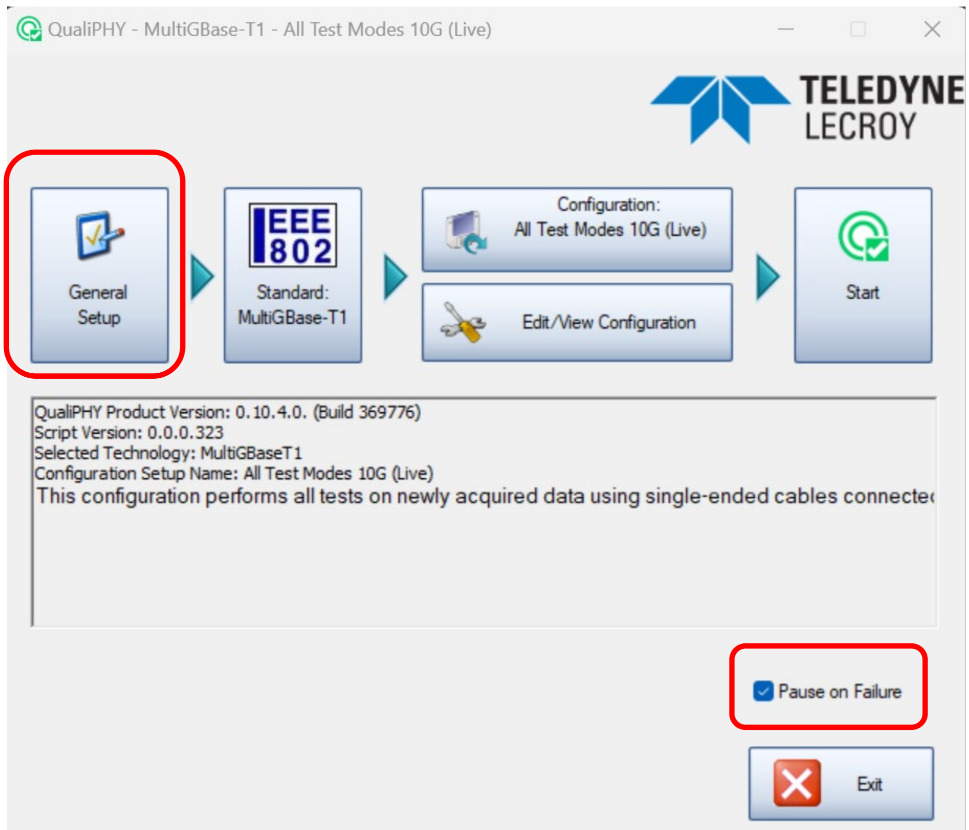
   If activation is successful, the key code now appears in the list of Installed Option Keys.
4. Restart the oscilloscope application by choosing File > Exit, then double-clicking the Start DSO icon on the desktop.

Set Up the QualiPHY Application

The following general settings will persist with each test session you run in QualiPHY. We recommend these be made as part of initial installation.

1. To begin, access QualiPHY by either:
   - Choosing **Analysis > QualiPHY** from the oscilloscope menu bar
   - Double-clicking the **QualiPHY desktop icon** on a remote computer or oscilloscope desktop.
2. When **Pause on Failure** is checked (default), QualiPHY will pause execution whenever a test fails and prompt you to make corrections before retrying a measurement. Deselect this if you wish to allow tests to continue to conclusion without interruption.

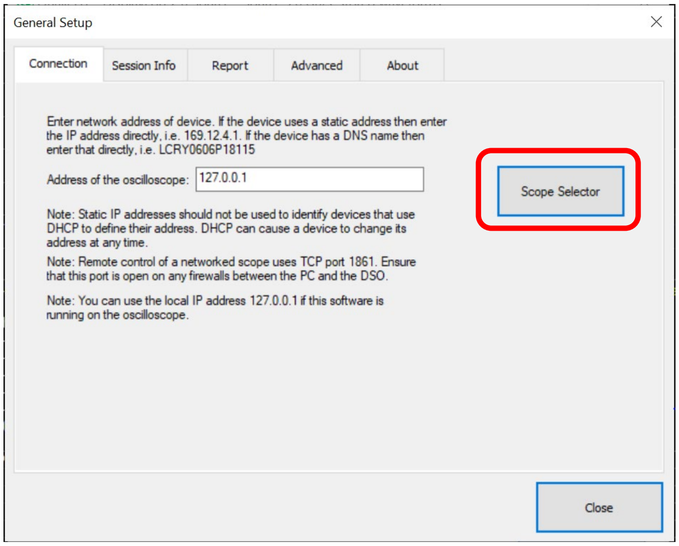
   Note: The script will still pause when it is necessary to manually change the test mode or cabling, etc.



3. On the Wizard, click the **General Setup** button to continue.

Connection Tab

4. The Connection tab shows the Address of the oscilloscope is local host 127.0.0.1 when QualiPHY is run from the oscilloscope. If you are running QualiPHY from a remote computer, enter the network IP address of the oscilloscope to which QualiPHY is currently connected.



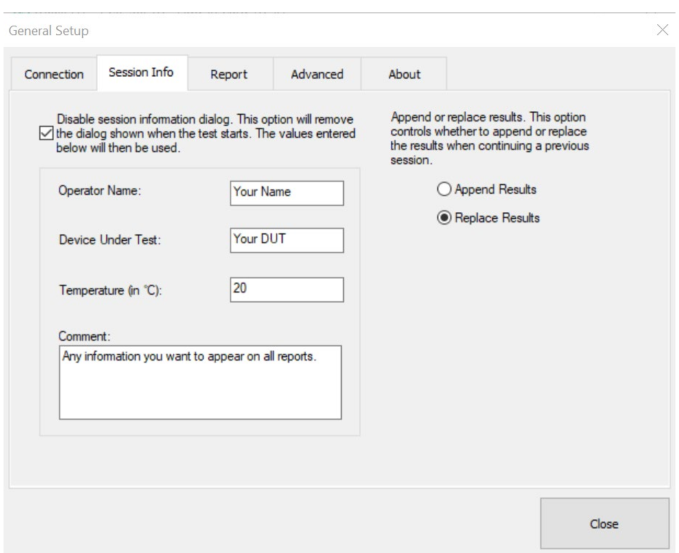
The Scope Selector button allows you to choose the oscilloscope used for testing when several are connected to a QualiPHY application run on a remote host. See Set Up Remote Control for details.

Session Info tab

5. The Session Info tab contains information that appears on reports, such as: Operator Name, Device Under Test (DUT) name, Temperature (in °C) of the test location, and any additional Comments.

   Check Disable session information dialog to use these global settings on all reports and enter the Operator and DUT information. Otherwise, you will be presented with a dialog at the start of each session that overrides these settings.

   Also choose to Append Results or Replace Results (overwrite) when continuing a previous test session.

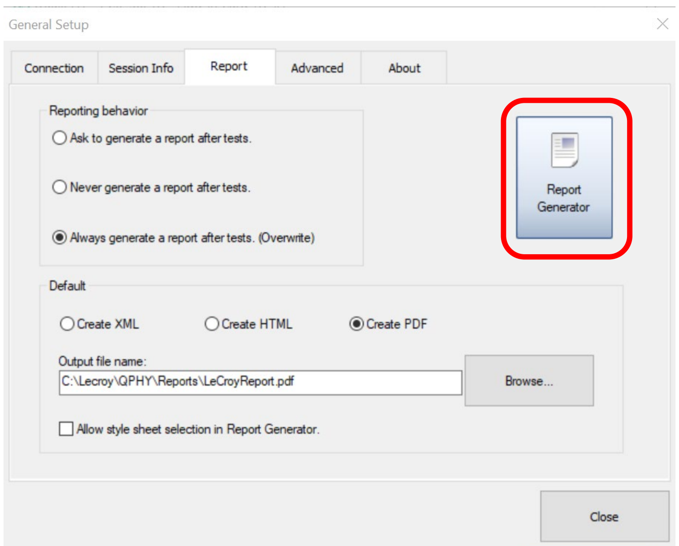


Report tab

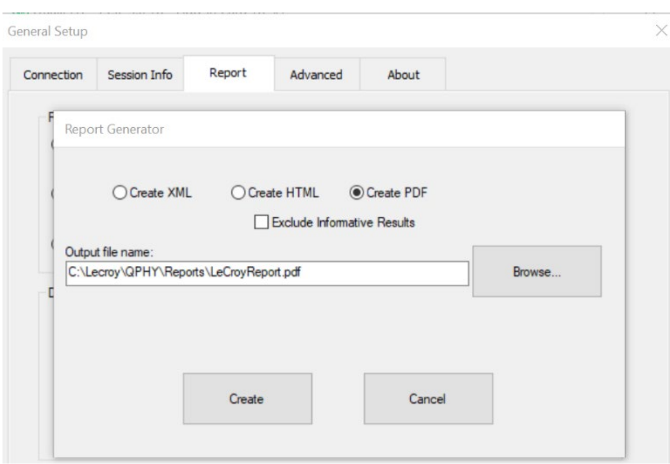
6. The Report tab contains settings related to report generation. Choose a Reporting behavior of:
    - Ask to generate a report after tests—to be prompted to create a new file for each set of test results.
    - Never generate a report after tests—to manually execute the Report Generator.
    - Always generate a report after tests—to autogenerate a report of the latest test results.

   Choose a Default report output file format of XML, HTML, or PDF.

   Optionally, check Allow style sheet selection in Report Generator to enable the use of a custom .xslt when generating XML and HTML reports. The path to the .xslt is entered on the Report Generator dialog.



The Report Generator button launches the Report Generator dialog, which contains the same settings as the Report tab, only applied to individual reports. This dialog appears automatically at the conclusion of each test group if you have selected "Ask to generate a report after tests."



Set Up Remote Control (optional)

Usually, the oscilloscope is the host computer for the QualiPHY software, and all models that meet the acquisition requirements will also meet the host system requirements. However, the QualiPHY software can be executed from a remote host computer.

Note: All other required software, such as Seasim, must be run from the oscilloscope.

To run QualiPHY remotely:

- The oscilloscope must be connected to a LAN and assigned an IP address (fixed or dynamic).
- The host computer must be on the same LAN as the oscilloscope.

Remote Host Computer Requirements

If you wish to run the QualiPHY software from a remote computer, these minimum requirements apply:

- Windows 10 Professional operating system
- 1 GHz or faster processor
- 1 GB (32-bit) or 2 GB (64-bit) of RAM
- Ethernet (LAN) network capability
- Hard Drive:
    - At least 100 MB free to install the wizard application
    - Up to 2 GB per standard installed to store the log database (each database grows from a few MB to a maximum of 2 GB)

Configure Oscilloscope for Remote Control

1. From the oscilloscope menu bar, choose Utilities → Utilities Setup...
2. Open the Remote tab and set Remote Control to TCP/IP.
3. Verify that the oscilloscope shows an IP address.

Add Oscilloscope Connection to QualiPHY

1. On the host PC, download and run QualiPHYInstaller.exe.
2. Start QualiPHY and click the General Setup button.
3. On the Connection tab, click Scope Selector.
4. Click Add and choose the connection type. Enter the oscilloscope IP address from Step 3 above. Click OK.
5. When the oscilloscope is properly detected, it appears on the Scope Selector dialog. Select the connection and click OK.

   QualiPHY is now ready to control the oscilloscope.

Select Oscilloscope Connection

Multiple oscilloscopes may be accessible to a single remote host. In that case, go to General Setup and use the Scope Selector at the start of each session to choose the correct connection.

QualiPHY tests the oscilloscope connection when starting a test. The software warns you if there is a connection problem.

MultiGBase-T1 Oscilloscope Testing

If you are new to QualiPHY, review Using QualiPHY to understand the conventions of the user interface.

Required Equipment

In addition to the oscilloscope, you'll need the following to run the MultiGBase-T1 oscilloscope tests:

- One pair of SMA cables of equal length
- One pair of SMA-BNC adapters (depending on oscilloscope used)
- 500 MHz differential probe (for probing the TX_TCLK)
- Automotive Ethernet breakout fixture, either:
  - SMA connector board, such as Teledyne LeCroy TF-AUTO-ENET-SMA

    OR
  - Connector-specific adapter, such as Teledyne LeCroy TF-AUTO-HMTD, TF-AUTO-MATENET or TF-AUTO-MINI50

Note: The TF-AUTO-ENET kit includes the required SMA connector board, SMA cables and SMA-BNC adapters. . You may require a custom SMA breakout fixture to use TF-ENET-B if your twisted pair cable does not have an RJ45 compatible output.

Note: Connector-specific adapters are required for 10 Gb testing.

Oscilloscope Test Preparation

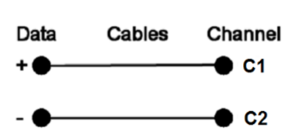
Check Required Test Modes

The MultiGBase-T1 script requires that you place the DUT (Device Under Test) into the required test modes. The script will prompt you to do so before each specific test, but it is recommended that you ensure the DUT is capable of being placed in the required test modes before beginning testing.

Deskew

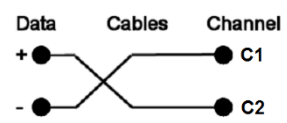
Deskewing input channels is important for test accuracy. The following procedure demonstrates how to manually deskew two oscilloscope channels and cables using the differential data signal, with no need for any additional T-connector or adapters. This can be done once the temperature of the oscilloscope is stable. The oscilloscope should be warmed up for at least 20 min. before proceeding. Run the procedure again if the oscilloscope temperature changes by more than a few degrees.

1. Connect a differential data signal to C1 and C2 using two approximately matching cables.

2. Set maximum sample rate at a timebase sufficient for a few repetitions of the pattern (a few dozen edges).
3. On the C2 setup dialog, check Invert. Now C1 and C2 should look the same.
4. Using the My Measure setup dialogs, set P1 to measure the **Skew of C1, C2**. Turn on **Statistics** (main Measure dialog).
5. Record the mean Skew value after it stabilizes by adding: Data skew + cable skew + channel skew.

6. Swap the cable connections on the Data source side (on the test fixture), then press the Clear Sweeps button on the oscilloscope (to clear the accumulated statistics, since we changed the input).



7. Record the mean Skew value after it stabilizes by adding: (-Data skew) + cable skew + channel skew.
8. Add the two mean Skew values and divide the sum in half:

$$\frac{[\text{Data skew} + \text{cable skew} + \text{channel skew}] + [(\text{-Data skew}) + \text{cable skew} + \text{channel skew}]}{2}$$

The above formula simplifies to:

[cable skew + channel skew]

9. Enter the resulting value into the Deskew field on the C1 setup dialog.
10. Restore the cable connections to their Step 1 settings, then press the Clear Sweeps button on the oscilloscope.

    The mean Skew value should be approximately zero - that is the data skew. Typically, results are <1 ps, given that a test fixture is meant to minimize skew on the differential pair.
11. On the C2 setup dialog, clear the Invert checkbox.
12. Turn off the measurement parameters.

We used the default setup of the Skew parameter (which is detecting positive edges on both signals at 50%), and inverted C2 to make C1 and C2 both have positive edges at the same time. Alternately, we could have selected the Skew Clock 2 tab and set the oscilloscope to look for negative edges on the second input (C2). However, we believe this approach is more intuitive, as it shows C1 and C2 with the same polarity.

Oscilloscope Test Setup

TF-AUTO-ENET-SMA

TF-AUTO-ENET-SMA is the recommended fixture when testing MultiGBase-T1 compliance up to 5 Gb.

For Test Mode 1

If the Tx TCLK is accessible on the Mater and/or Slave, a differential probe can be used to connect directly to the TX_TCLK. Otherwise, the same setup as Test Modes 2, 5 and 6 can be used.

For Test Modes 2, 4, 5 and 6

Solder the DUT's twisted pair cable to the SMA connector board. The twisted pair cable should be kept as short as possible to minimize the loss through the cable.

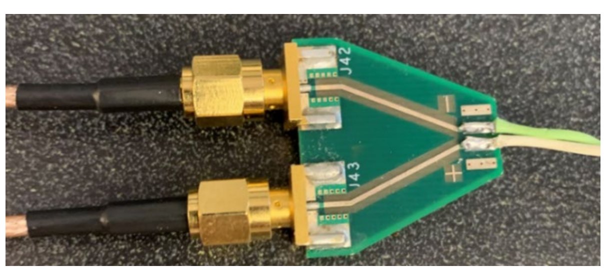


Figure 1. Twisted pair soldered to TF-AUTO-ENET-SMA connector board.

Other Automotive Test Fixtures

As an alternative to connecting directly to the unshielded twisted pair, you can use the TF-AUTO-HMTD, TF-AUTO-MINI50 or TF-AUTO-MATENET adapters to connect the DUT to the oscilloscope. This is required for 10 Gb testing.

Figure 2: TF-AUTO-HMTD (left), TF-AUTO-MINI50 (center) and TF-AUTO-MATENET (right).

The adapters have very good RF characteristics and can be used for transmitter (Tx) testing according to the Open Alliance specification.

Each has one connector (m) on the automotive side and two, 3.5 mm SMA-compatible connectors (f) on the instrument side. To avoid damaging the 3.5 mm connectors, use only high-quality cables with SMA, 3.5 mm or 2.92 mm connectors (m) to connect to the fixtures.

> Note: The automotive connectors have a limited number of mating cycles. Therefore, they should be regularly inspected and, if necessary, the entire adapter should be replaced. Contact Service for replacement.

Model	Specifications
TF-AUTO-HMTD	Bandwidth: >13 GHz Return Loss, typical: >10 dB @ 13 GHz Mode Conversion, typical: >70 dB @ 20 MHz, >61 dB @ 80 MHz, >48 dB @ 600 MHz, >40 dB @ 1 GHz, >30 dB @ 4 GHz
TF-AUTO-MINI50	Bandwidth: >2.5 GHz Return Loss, typical: >10 dB @ 2.5 GHz Mode Conversion, typical: >70 dB @ 20 MHz, >61 dB @ 80 MHz, >48 dB @ 600 MHz, >40 dB @ 1 GHz
TF-AUTO-MATENET	Bandwidth >2.5 GHz Return Loss, typical > 10dB @ 2.5 GHz Mode Conversion, typical: >70 dB @ 20 MHz, >61 dB @ 80 MHz, > 48 dB @600 MHz, >40 dB @ 1 GHz

The automotive-side connectors have different bandwidths, and not all adapters are suitable for all speeds of Automotive Ethernet compliance testing. Consult the table below for compatibility with your Ethernet standard.

	10Base-T1S/L	100Base-T1	1000Base-T1	2.5GBase-T1	5GBase-T1	10GBase-T1
TF-AUTO-HMTD	✓	✓	✓	✓	✓	✓
TF-AUTO-MINI50	✓	✓	✓	✓	--	--
TF-AUTO-MATENET	✓	✓	✓	✓	--	--

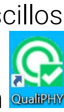
TF-ENET-B

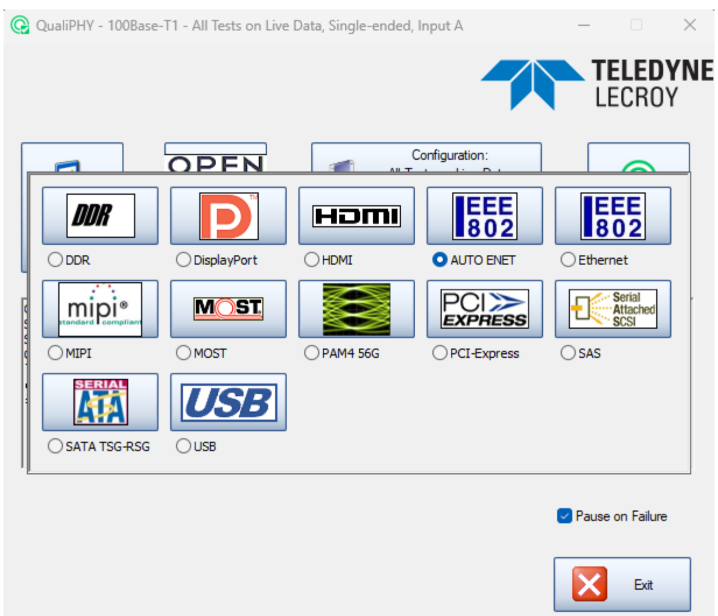
If using the TF-ENET-B test fixture, connect the RJ45 end of the RJ45-UTP (Unshielded Twisted Pair) adapter (an example is shown below) to the J64 input on the CH4 section of the TF-ENET-B board.

Figure 3. Example of RJ45/UTP adapter

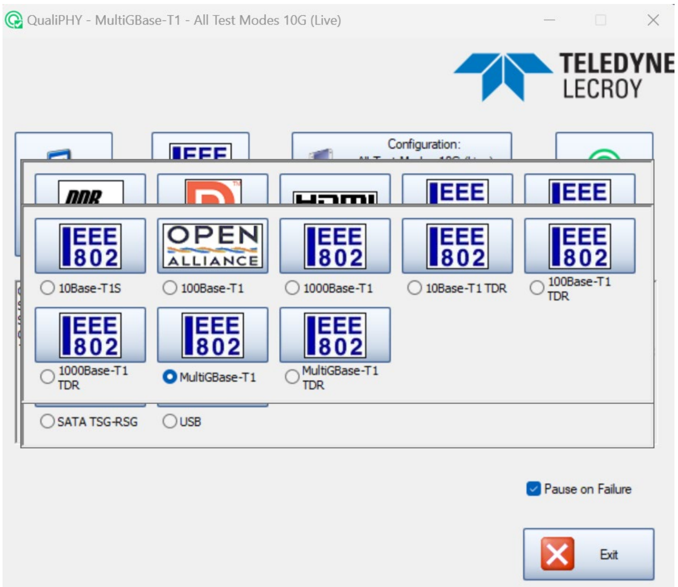
Initiating MultiGBase-T1 Test Sessions

Follow these steps to begin a new MultiGBase-T1 oscilloscope test session in QualiPHY:

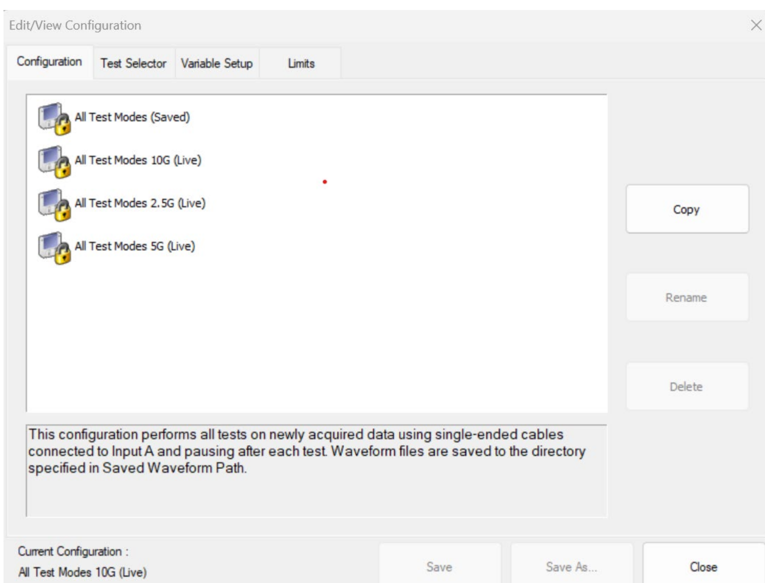
1. Access QualiPHY by either:
   - Choosing Analysis > QualiPHY from the oscilloscope menu bar
   - Double-clicking the QualiPHY desktop icon  on a remote computer or oscilloscope desktop.
2. Open the QualiPHY wizard, select the Standard button and choose IEEE 802 AUTO ENET:



3. Choose the component (test type) you wish to run—for example, **MultiGBase-T1 (oscilloscope)**:

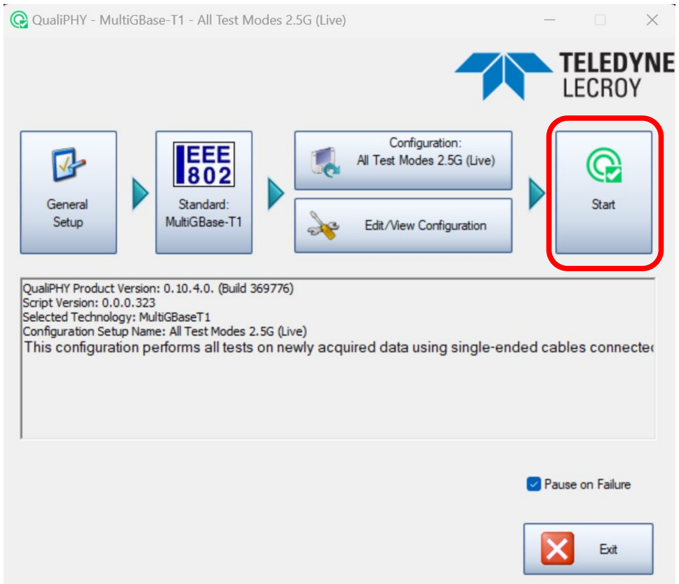


4. On the Wizard, click the **Configuration** or Edit/View Configuration button and select the test configuration you wish to run. Different configurations are designed to set key variables as required by different test scenarios.



Note: Standard configurations are locked and cannot be changed. However, if you need to change any tests or test variables, click Edit/View Configuration and make modifications on the Test Selector and Variable Setup tabs. You will be prompted to Save a copy. Select the copied configuration to run. See Customizing QualiPHY for more information on creating custom configurations.

5. Click the **Start** button on the QualiPHY wizard.



6. Follow instructions to set up the test equipment on configuration dialogs/diagrams as they appear.

MultiGBase-T1 Oscilloscope Test Configurations

Test configurations include variable settings, limit sets, and test selections. See MultiGBase-T1Oscilloscope Test Variables for a description of each variable and its default value.

All Test Modes (Saved)

This configuration performs a demonstration of all MultiGBase-T1 oscilloscope tests using waveforms stored with the script. All variables are set to their defaults, except that Demo Mode is set to "Yes".

The demonstration will pause to display connection diagrams, as if in an actual test. When prompted, just click "OK" to continue. Waveforms are not saved.

All Test Modes 10G (Live)

This configuration performs all tests at 10G data rate on newly acquired data using single-ended cables connected to Input A and pausing after each test. Waveform files are saved to the directory specified in Saved Waveform Path.

All Test Modes 2.5G (Live)

This configuration performs all tests at 2.5G data rate on newly acquired data using single-ended cables connected to Input A and pausing after each test. Waveform files are saved to the directory specified in Saved Waveform Path.

All Test Modes 5G (Live)

This configuration performs all tests at 5G data rate on newly acquired data using single-ended cables connected to Input A and pausing after each test. Waveform files are saved to the directory specified in Saved Waveform Path.

MultiGBase-T1 Oscilloscope Tests

For additional information about the tests supported by QPHY-MultiGBase-T1, please refer to the Open Alliance MultiGBase-T1 PMA Test Suite. The descriptions in the following tests will refer to various sections of this document.

For all tests, the Scaling parameter S shown in specification table 5.1.1b for is used:

Table 1: Specification Table 5.1.1b—Definition of Scaling parameter (S)

PHY type	S
10GBASE-T1	1
5GBASE-T1	0.5
2.5GBASE-T1	0.25

Test 149.5.2.1 – Maximum Output Droop

This test measures transmitter output droop as defined in Section 5.1.1 of the specification. The test requires that the DUT be placed in Test Mode 1.

What Is Measured

Droop is calculated after measuring the voltage 4 ns after the initial zero crossings (V_{init}) and the voltage 16 ns after the zero crossing (V_{delay}). The difference $V_d = V_{init} - V_{delay}$. Droop = V_d/V_{init} * 100%. This is performed on both the positive and negative peaks of the waveform. A passing droop value must be less than 15%.

Test Methodology

The oscilloscope is set to acquire five waveforms of 100 ns at 40 GS/s /S (Scaling parameter (S) as defined in Table 5.1.1b). The initial peak is measured on both the +1 (Vpk+) and -1 (Vpk-) symbols at 4 ns after the 50% of the rising / falling edge. The droop value is measured 16 ns from the initial peak on both the +1 (Vd+) and -1 (Vd-) symbols. The droop for each symbol is calculated by 100 x (Vd/Vpk). The calculated droop values are then compared to 15% using pass/fail testing.

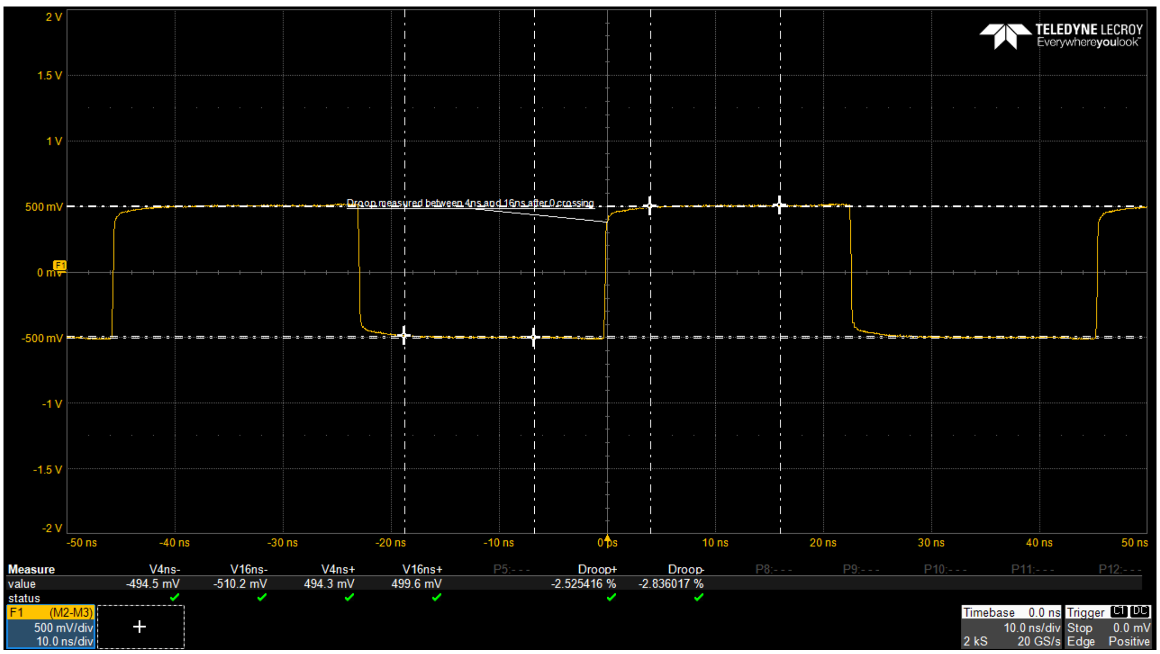


Figure 4. Transmitter Output Droop test

Shown on the screen, F1 is the input differential signal that is being measured.

In the Measure table:

- V4ns- is the value at 4 ns after 50% of the falling edge
- V16ns- is the value at 16 ns after 50% of the falling edge
- V4ns+ is the value at 4 ns after 50% of the rising edge
- V16ns+ is the value at 4 ns after 50% of the rising edge
- Droop+ is the droop calculated on the +1 symbol
- Droop- is the droop calculated on the -1 symbol.

Test 149.5.2.2 Transmitter Linearity

This test measures transmitter linearity as defined in Section 5.1.2 of the specification. The test requires that the DUT be placed in Test Mode 4 while the PHY shall transmit a continuous PAM4 signal with PRBS13Q pattern.

What Is Measured

The transmitter linearity verify that the transmitter Signal-to-noise and distortion ratio (SNDR) exceeds the specified amount.

SNDR is calculated using the following equation:

$$SNDR = 10 \times \log_{10}\left(\frac{{P_{max}}^2}{({\sigma_e}^2) + ({\sigma_n}^2)}\right)$$

Where:

P_{max} is the peak of the linear fit pulse response of the measured PRBS13Q output waveform.

σ_e is the standard deviation of the linear fit error (i.e., Distortion).

σ_n is the RMS deviation from the average voltage value measured at locations of consecutive identical symbol transmission (i.e., Noise).

Test Methodology

The oscilloscope is set to acquire a waveform of 50 µs at 40 GS/s /S (Scaling parameter (S) as defined in Table 5.1.1b). The SNDR is calculated based on IEEE Std 802.3™-2018, subclause 120D.3.1.6- SNDR.

- For 2.5GBASE-T1 PHY type the SNDR shall exceed 35 dB.
- For 5GBASE-T1 PHY type the SNDR shall exceed 36 dB.
- For 10GBASE-T1 PHY type the SNDR shall exceed 38 dB.

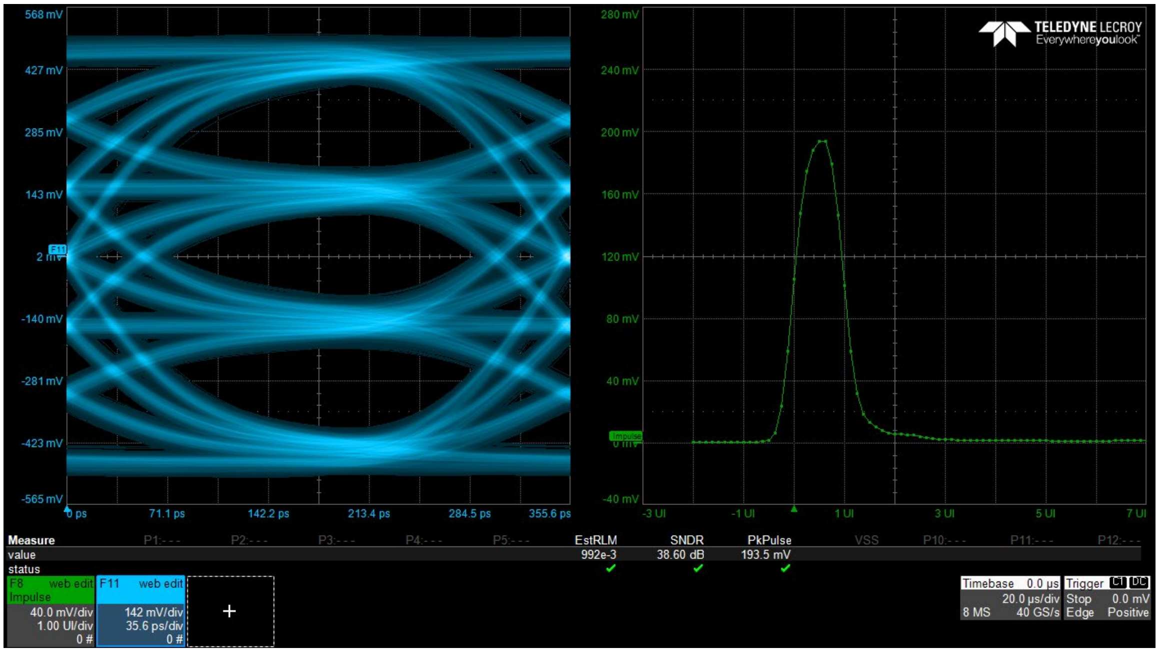


Figure 5: Transmitter Linearity test

Shown on the screen,

- F11 is the PAM4 eye diagram of the input signal
- F8 is the calculated pulse response

In the Measure table:

- P6 is relative level match RLM of the PAM4 signal (only for information)
- P7 is the SNDR
- P8 is the peak of the linear fit pulse response Pmax (only for information).

Test 149.5.2.3.1 – Transmitter Timing Jitter

This test measures RMS TIE jitter and Pk-Pk TIE jitter on the transmit symbol clock TX_TCLK175 when the DUT is configured as MASTER or SLAVE as defined in Section 5.1.3 of the specification. The DUT is required to be placed in Test Mode 1.

What Is Measured

Case 1 – MASTER transmitter timing jitter

RMS TIE jitter measured on the TX_TCLK175 when the DUT is configured as MASTER shall be less than 1/S ps. Additionally, the Pk-Pk TIE jitter measured on the TX_TCLK175 when the DUT is configured as MASTER shall be less than 10/S ps. Scaling parameter (S) is defined in Table 5.1.1b.

Case 2 – SLAVE transmitter timing jitter

RMS TIE jitter measured on the TX_TCLK175 when the DUT is configured as SLAVE shall be less than 2/S ps. Additionally, the Pk-Pk TIE jitter measured on the TX_TCLK175 when the DUT is configured as SLAVE shall be less than 20/S ps. Scaling parameter (S) is defined in Table 5.1.1b.

Test Methodology

Case 1 – MASTER transmitter timing jitter

Configure the DUT so that it is operating in transmitter test mode 1, forced to MASTER. Configure the Link Partner (although not mandatory for this test case) to SLAVE mode. Connect the DUT *TX_TCLK175* to the oscilloscope, using an active probe (a differential probe is recommended). The oscilloscope is set to acquire five waveforms of 200 µs at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b).

The clock signal is first processed through a 200 MHz bandpass filter, then the jitter of the clock signal is measured in reference to an ideal, unjittered clock signal. The jitter track and histogram are calculated from this measurement to determine the RMS and Peak to Peak TIE jitter. The calculated value is then compared to 1/S ps for RMS and 10/S ps for Peak-to Peak pass/fail testing (Scaling parameter (S) is defined in Table 5.1.1b).

Case 2 – SLAVE transmitter timing jitter

Configure the DUT so that it is operating in transmitter test mode 1, forced to SLAVE. Configure the Link Partner to MASTER mode. Connect the DUT *TX_TCLK175* to the oscilloscope, using an active probe (a differential probe is recommended). The oscilloscope is set to acquire 5 waveforms of 200µs at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b).

The clock signal is first processed through a 200 MHz bandpass filter, then the jitter of the clock signal is measured in reference to an ideal, unjittered clock signal. The jitter track is calculated from one single acquisition, and the value from all measurements are accumulated in the TIE histogram to determine the RMS and Pk-Pk TIE jitter. The calculated value is then compared to 2/S ps for RMS and 20/S ps for Peak-to Peak pass/fail testing (Scaling parameter (S) is defined in Table 5.1.1b).

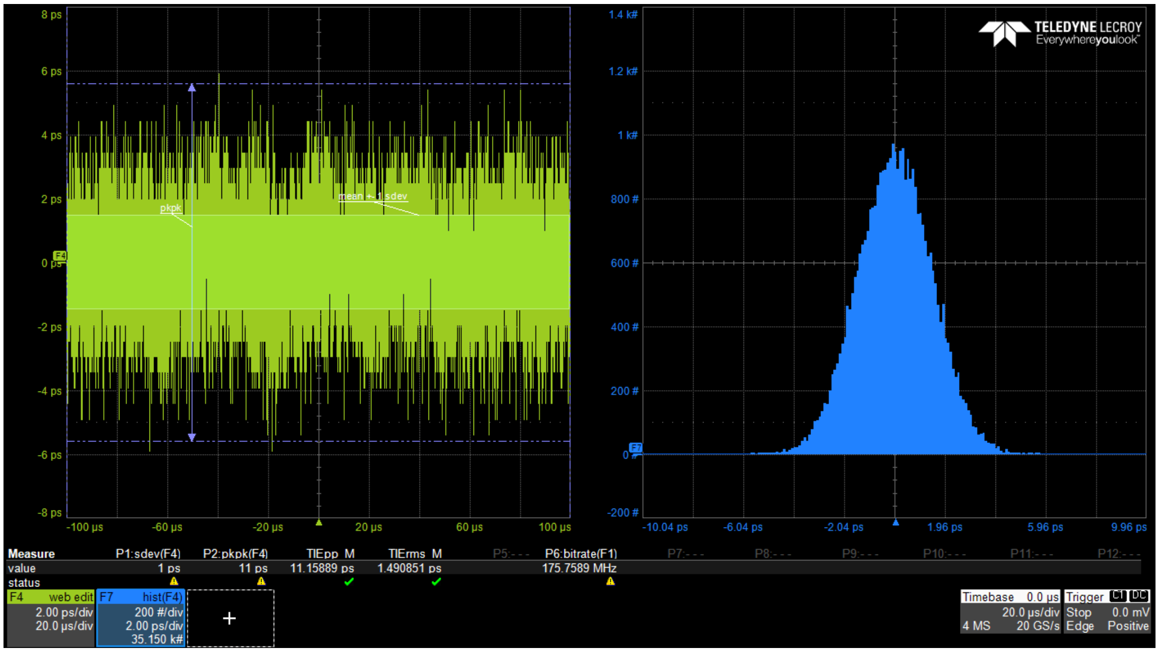


Figure 6: Transmitter Timing Jitter test (Master or Slave)

Shown on the screen:

- F4 is a TIE track of the filtered input signal
- F7 is a TIE histogram of the filtered input signal.

In the Measure table:

- P1 is the sdev of the jitter measured on the TIE track of the acquisition (for information only)
- P2 is the Pk-Pk of the jitter measured on the TIE track of the acquisition (for information only)
- P3 is the RMS of the jitter measured on the accumulated TIE histogram
- P4 is the Pk-Pk of the jitter measured on the accumulated TIE histogram.

Test 149.5.2.3.2. RJ Transmit MDI Random Jitter (Master)

This test measures random jitter on the MDI interface as defined in Section 5.1.4. of the specification. The DUT is required to be placed in Test Mode 2 (TX_TCLK_175 test pattern).

What Is Measured

When configured in the test mode 2 the DUT generates a clock signal with 175.78125 MHz (TX_TCLK_175) on the MDI interface. The RMS TIE jitter and Pk-Pk random jitter is measured on the filtered TX_TCLK_175 test pattern on the MDI interface using a 200MHz band pass filter before performing the jitter measurement. The oscilloscope is set to acquire 5 waveforms of 200µs at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b).

Test Methodology

Configure the DUT so that it is operating in transmitter test mode 2. Connect the MDI output to the oscilloscope, using a test fixture. The oscilloscope is set to acquire one waveform of 1 ms at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b).

The TX_TCLK_175 signal is first processed through a 200 MHz bandpass filter, then the jitter of the signal is measured in reference to an ideal, unjittered clock signal. The jitter track is calculated from one single acquisition and the value from all measurements are accumulated in the TIE histogram to determine the RMS and Pk-Pk TIE jitter. The calculated value is then compared to 1/S ps for RMS and 10/S ps for Peak-to Peak pass/fail testing (Scaling parameter (S) is defined in Table 5.1.1b).

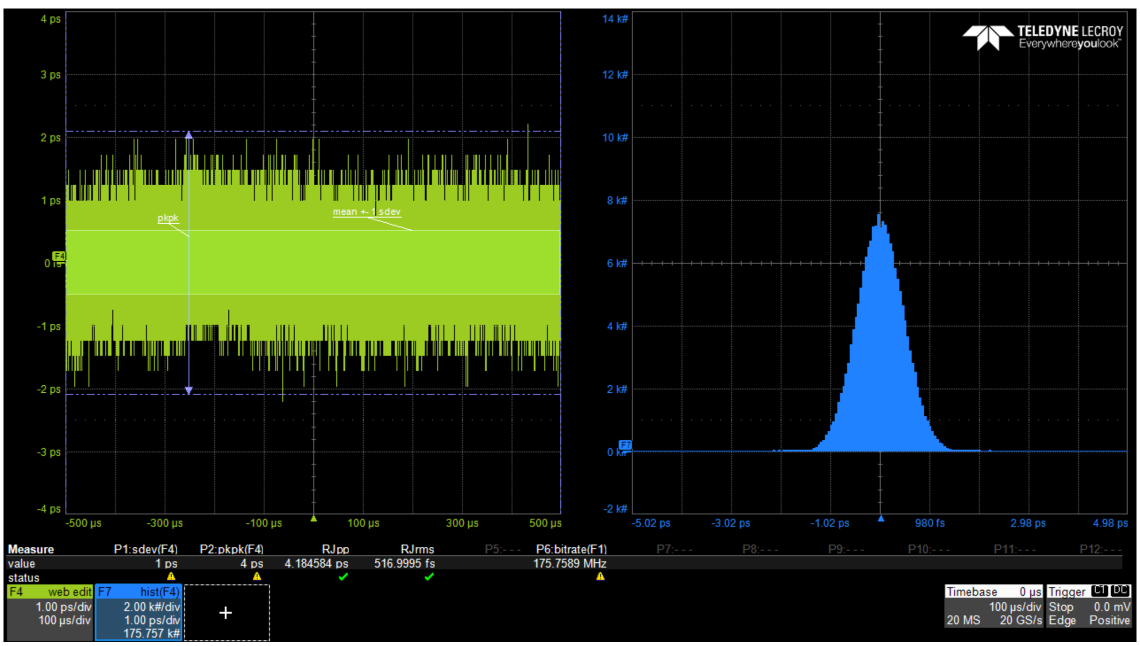


Figure 7: Transmitter MDI Random Jitter test

Shown on the screen:

- F4 is a TIE track of the filtered input signal
- F7 is a TIE histogram of the filtered input signal.

In the Measure table:

- P1 is the sdev of the jitter measured on the TIE track of the acquisition (only for information).
- P2 is the Pk-Pk of the jitter measured on the TIE track of the acquisition (only for information).
- P3 is the RMS of the jitter measured on the accumulated TIE histogram.
- P4 is the Pk-Pk of the jitter measured on the accumulated TIE histogram.

Test 149.5.2.3.2. DJ Transmit MDI Deterministic Jitter (Master)

This test measures deterministic jitter on the MDI interface as defined in Section 5.1.5. of the specification. The DUT is required to be placed in Test Mode 2 - JP03A test pattern.

What Is Measured

When configured in the test mode 2 JP03A, the DUT generates a repeating {0,3} sequence on the MDI interface.

On the signal the TIE is measured, and a cumulative distribution function CDF is calculated from the TIE histogram. On basis of the CDF function, two values J5 and J6 are determined: J5 as the difference between τ-HPF at the (1–0.5 × 10–5) and (0.5 × 10-5) probabilities, respectively, and J6 as the difference between τ-HPF at the (1–0.5 × 10–6) and (0.5 × 10-6) probabilities, respectively. DJ is calculated from J5 and J6 using the formula: DJpk-pk = –9.3098 *J5 + 10.3098 * J6.

Test Methodology

Configure the DUT so that it is operating in transmitter test mode 2 JP03A. Connect the MDI output to the oscilloscope, using a test fixture. The oscilloscope is set to acquire five waveforms of 1 ms at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b). The TIE is measured, and the cumulative distribution function CDF is calculated first for the extrapolated J5 value and on a second run for the extrapolated J6 value. The DJ is then calculated from the J5 and J6 value.

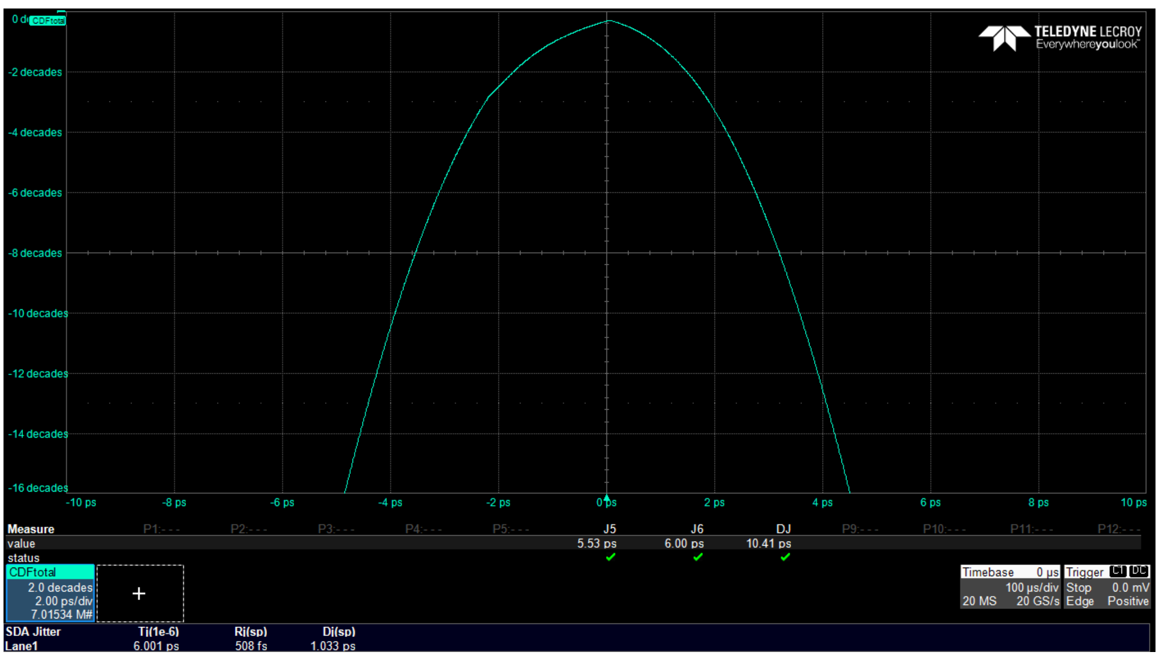


Figure 8: Pk-Pk Deterministic Jitter (DJpk-pk) test

Shown on the screen, CDF is the cumulative distribution function CDF calculated from the TIE.

In the Measure table:

- P6 is the jitter value for J5
- P7 is the jitter value for J6
- P8 is the calculated DJ value.

Test 149.5.2.3.2. DJ MDI Even-Odd Deterministic Jitter

This test measures the Even Odd jitter on the MDI interface as defined in Section 5.1.5. of the specification. The DUT is required to be placed in Test Mode 2 - JP03B test pattern.

What Is Measured

When configured in the test mode 2 JP03B the DUT generates a repeating 62 symbol sequence on the MDI interface. Even-odd jitter is defined to be half of the magnitude of the difference between the mean width of the positive pulse and the mean width of the negative pulse. EOJ is calculated using the below formula:

$$EOJ = \frac{\sum_{j=1}^{20} \Delta T(2j) - \sum_{j=1}^{20} \Delta T(2j-1)}{40}$$

Where:

$$\Delta T(j) = \begin{pmatrix} Tzc(j+10) - Tzc(j+9) & 1 \le j \le 20 \\ Tzc(j+19) - Tzc(j+18) & 21 \le j \le 40 \end{pmatrix}$$

Test Methodology

Configure the DUT so that it is operating in transmitter test mode 2 JP03B. Connect the MDI output to the oscilloscope, using a test fixture. The oscilloscope is set to acquire one waveform of 1 ms at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b).

For this parameter the TIE measurements are analyzed to determine an average TIE value for each bit in the repeating JP03B pattern. Corresponding TIE measurements of each iteration of the pattern are averaged. A list of pattern dependent TIE values for the JP03B pattern is extracted from these values and the EOJ_{pp} value is calculated using the formula described above.

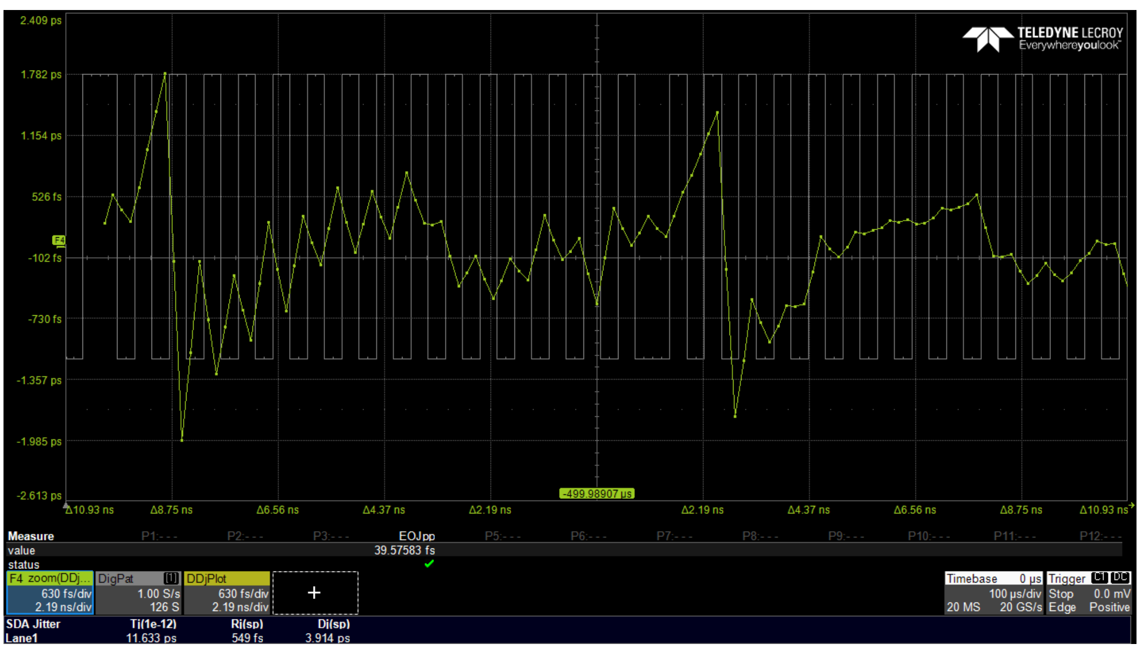


Figure 9: Pk-Pk Even Odd Jitter (EOJ_{pp}) test

Shown on the screen:

- F4 is a zoom of the DDjPlot, which is the data-dependent TIE from which the EOJ_{pp} is calculated
- DigPat shows the repeating data pattern

In the Measure table, P4 is the Pk-Pk Even Odd Jitter, EOJ_{pp}

Test 149.5.2.4 – Transmitter Power Spectral Density (PSD) and Power

This test calculates the Power Spectral Density (PSD) of the transmitter and checks if it is outside the mask defined in Section 5.4.4 of the specification. The test also measures the maximum PSD value. The DUT is required to be placed in Test Mode 5.

What Is Measured

An FFT of the acquired signal is calculated and then averaged using a boxcar filter. The FFT is then tested against the provided mask in Figure 5.5 of Section 5.4.4.

Test Methodology

The oscilloscope is set to acquire five waveforms of 1 ms at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b). The PSD is calculated by performing an average of the FFT on the acquired signals. A 1MHz filter is applied to the FFT. A pass/fail mask test is then performed using the PSD and the specified mask. A passing result indicates that the entire PSD is contained within the mask. P2 measures the maximum of the FFT.

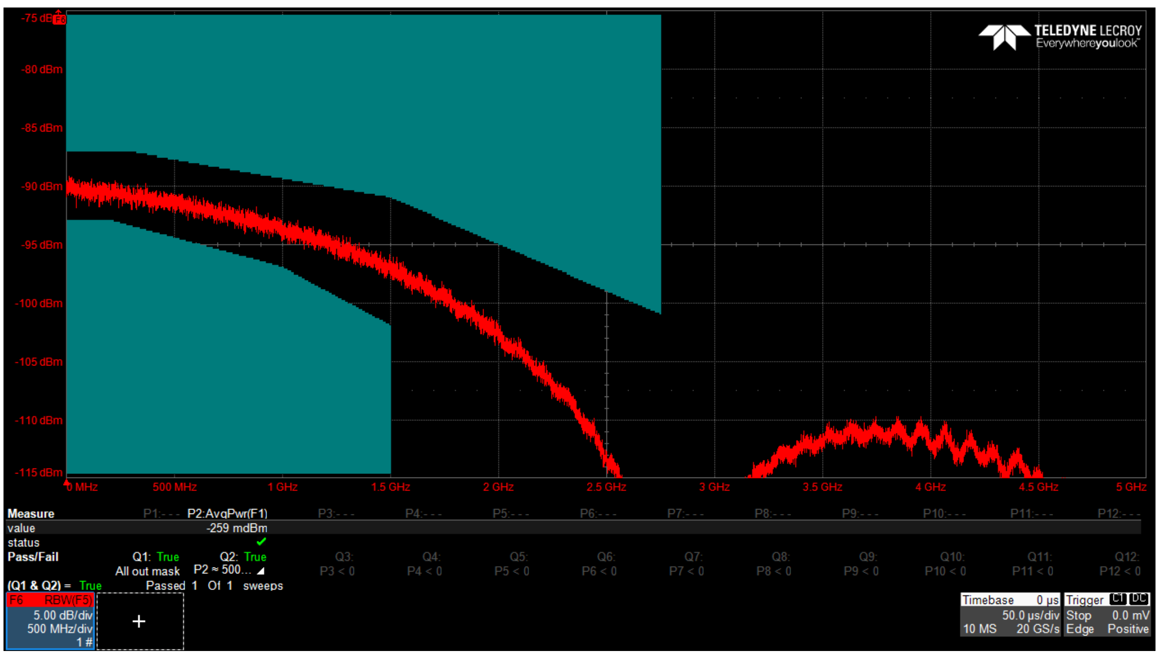


Figure 10: Transmitter Power Spectral Density (PSD) test

Shown on the screen, F2 is a Power Spectrum of the input signal with a 1MHz filter applied to it.

In the Measure table:

- P2 is the maximum value of the Power Spectrum.
- Q1 checks to see if the Power Spectrum is contained by the mask.
- Q2 checks if the maximum value of the spectrum is in the range of 0.500dBm and 1.5dBm

Test 149.5.2.5 Transmitter Peak Differential Output

This test checks that the peak-to-peak differential amplitude does not exceed the specified amount. The DUT is required to be placed in Test Mode 5.

What Is Measured

This test measures the peak differential output voltage of the transmitter at the MDI interface.

Test Methodology

The oscilloscope is set to acquire one waveform of 500 µs at 40 GS/s /S (Scaling parameter (S) is defined in Table 5.1.1b). The differential signal is calculated, and peak-to-peak is measured using the PkPk parameter.

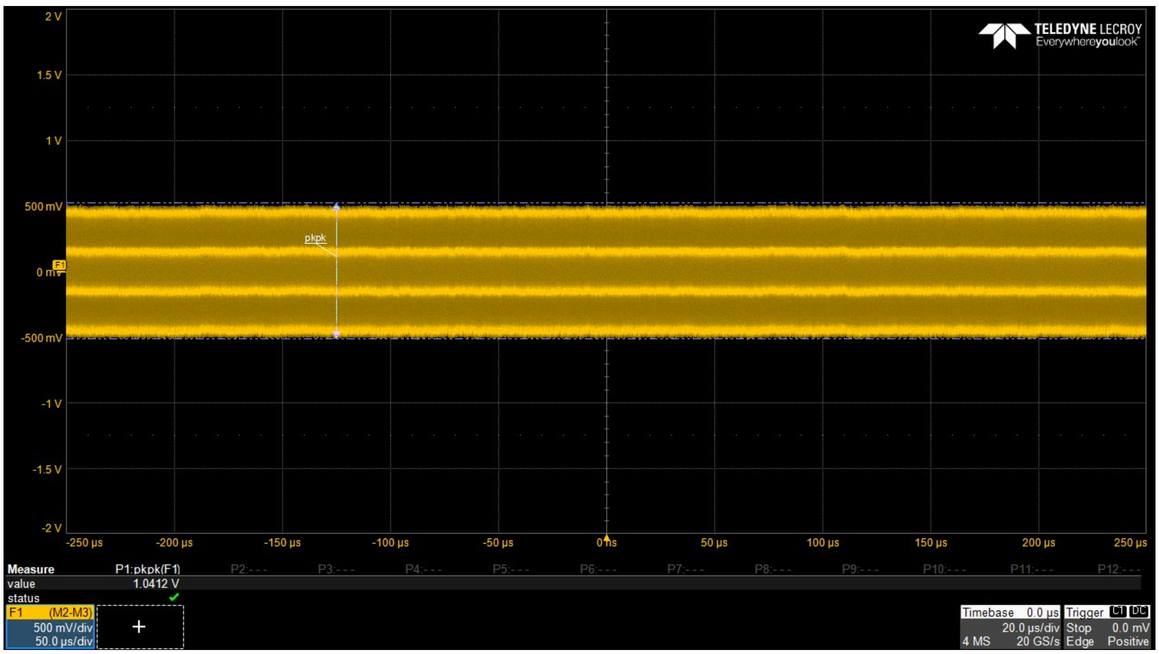


Figure 11: Transmitter Peak Differential Output test

Shown on the screen, F1 is the calculated differential signal.

In the Measure table, P1 is the peak-to-peak value.

Test 149.5.2. Transmitter Clock Frequency

This test checks that the Transmitter Clock Frequency does not exceed the specified amount. The DUT is required to be placed in Test Mode 2 - JP03A.

What Is Measured

This test measures the Transmitter Clock Frequency at the MDI interface.

Test Methodology

The oscilloscope is loading back the acquired Test Mode 2 – JP03A waveforms. The differential signal is calculated, and the bit rate is measured using the bit rate parameter. From the bit rate the transmitter clock rate and the offset to the nominal transmitter clock rate is calculated.

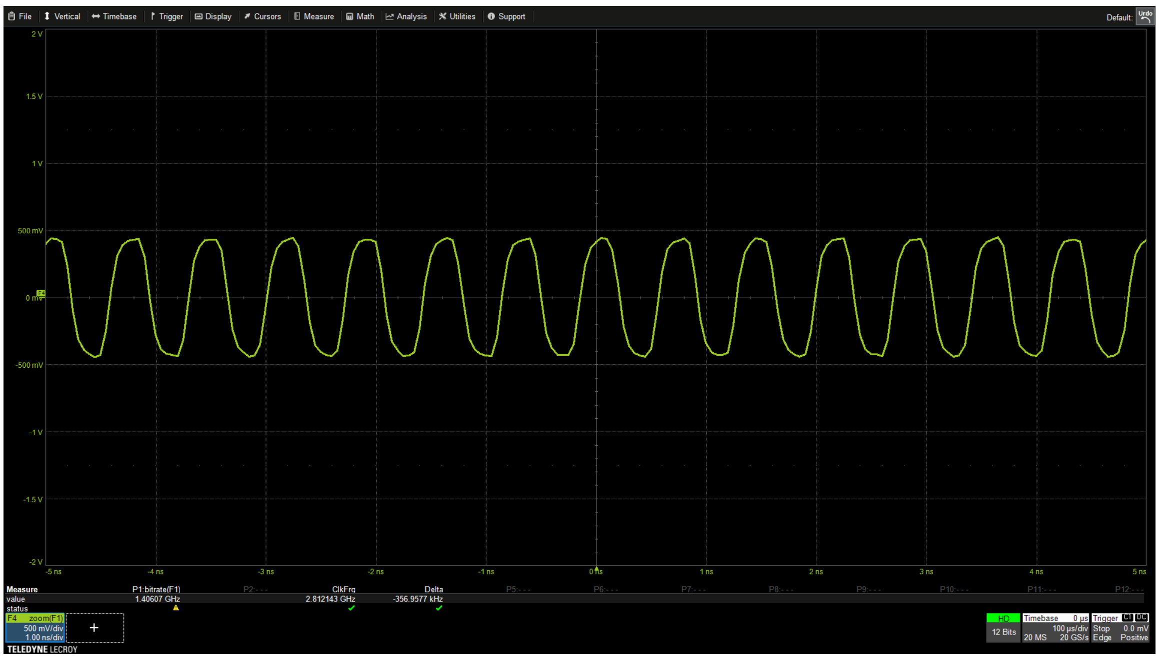


Figure 12. Transmitter Peak Differential Output test

Shown on the screen, F4, which is a zoom of the differential signal from Test Mode 2 - JP03A signal.

In the Measure table,

- P1 is the measured Bit Rate
- P3 is the calculated Transmitter Clock Frequency
- P4 is the calculated offset from the nominal Transmitter Clock Frequency

MultiGBase-T1 Oscilloscope Test Variables

Basic Variables

+ Signal Channel

Oscilloscope channel used to input the positive side of the differential pair of traffic from the DUT.

On a WavePro HD, please set this to C2. For Mode 4 tests, we sample 2.5 Gb/s waveforms at 20 GS/s, which requires 2-channel mode. For 5 Gb/s waveforms, we always sample at 20 GS/s.

- Signal Channel

Oscilloscope channel used to input the negative side of the differential pair of traffic from the DUT.

On a WavePro HD, please set this to C3. For Mode 4 tests, we sample 2.5 Gb/s waveforms at 20 GS/s, which requires 2-channel mode. For 5 Gb/s waveforms, we always sample at 20 GS/s.

Use differential probe for Mode 1?

If set to “Yes”, then also set the Differential Probe Channel to be used for Mode 1 clock tests.

If set to “No”, then plus channel and minus channel are assumed to be used.

Differential Probe Channel

When "Use differential probe for Mode 1?" is set to "Yes", this variable specifies the channel used for Mode 1 clock tests.

Note that:

- 2.5 Gb/s waveforms are sampled at 10 GS/s, except for Mode 4 tests, which are sampled at 20 GS/s.
- 5 Gb/s waveforms are sampled at 20 GS/s, which requires 2-channel mode on a WavePro HD. In this case, change the Differential Probe Channel to C2 or C3.
- 10 Gb/s waveforms are sampled at 40 GS/s, which cannot be done on a WPHD.

When "Use Diff probe for Mode 1?" is set to "No", this variable has no effect.

Pause after tests to review?

When “Yes”, the script will pause after each test so that results can be viewed on the oscilloscope display by the user. The user will be prompted to continue the test after each pause.

When “No,” the script will continue to its conclusion without pause, except when a change in Test Mode requires it.

Run using saved waveforms?

When “Yes”, tests are run using previously saved waveforms stored in the <Saved Waveform Path>\SourceWaveforms (without the timestamp) subfolder.

You will still be prompted with connection diagrams based on other variable selections.

Saved Waveform Path

Specify the path to the root oscilloscope folder where waveform files are saved and recalled during the test. This path is emptied of waveforms at the beginning of each run that acquires new waveforms.

Waveforms acquired for individual tests are saved permanently in subfolders of this path named: \<DUTname>\<datestamp>_<timestamp>

Mask Path

Specify the full path to the oscilloscope folder where the MultiGBase-T1 masks reside. This defaults to oscilloscope D:\Masks.

PSD Number of Averages

The script averages more than 1 ms of data at the Minimum setting when running the Power Spectral Density test. You can change this to:

- 2x: Twice as many averages as Minimum
- 4x: Four times as many averages as Minimum
- 8x: Eight times as many averages as Minimum

More averages should reduce the thickness of the PSD line.

Test Speed

Select the speed at which to test the next time the script runs:

- 2.5 Gb/s waveforms, choose 2.5GBASE-T1
- 5 Gb/s waveforms, choose 5GBASE-T1
- 10 Gb/s waveforms, choose 10GBASE-T1

Testing Master of Slave?

Select whether you are testing a Master or Slave device.

Note: TXTimingJitter limits are different for Master and Slave.

Host Program Control Variables

Enable Host Program Control?

Choose “Yes” to enable Host Program Control using Sync file.

Sync File Path

Specify the full path to the Sync file to be used for Host Program Control.

MultiGBase-T1 Oscilloscope Test Limit Sets

The MultiGBase-T1 script contains only one limit set, called “MultiGBase-T1”. The limits in this set are those specified by the *Open Alliance MultiGBase-T1 PMA Test Suite*.

MultiGBase-T1 TDR Testing

The MultiGBase-T1 compliance tests in this section are performed using a VNA or TDR instrument. QualiPHY supports testing with the Teledyne LeCroy WavePulser 40iX High-speed Interconnect Analyzer. QualiPHY should be installed on the same PC as is used to drive the WavePulser.

For instructions on setting up and initializing the WavePulser, see the: *WavePulser 40 X High-speed Interconnect Analyzer User Manual*.

Required Equipment

- Teledyne LeCroy WavePulser 40iX with QPHY-MultiGBase-T1-TDR option key installed on its controlling PC

  Note: A WavePulser is required if you wish you use QualiPHY to automate the MDI Return Loss and Channel T1 Link Segment measurements.

- 4 matched SMA cables (standard with WavePulser)
- Automotive Ethernet breakout fixture, such as TF-AUTO-ENET or TF-AUTO-HMTD.

  Important: TF-AUTO-MATENET and TF-AUTO-MINI50 cannot be used because they do not support the MultiGBase-T1 line rate speeds.

TDR Test Preparation

Before beginning any data acquisition or test, connect and warm the instruments for at least 20 minutes.

WavePulser 40iX calibration is performed automatically by the software; no manual calibration is required.

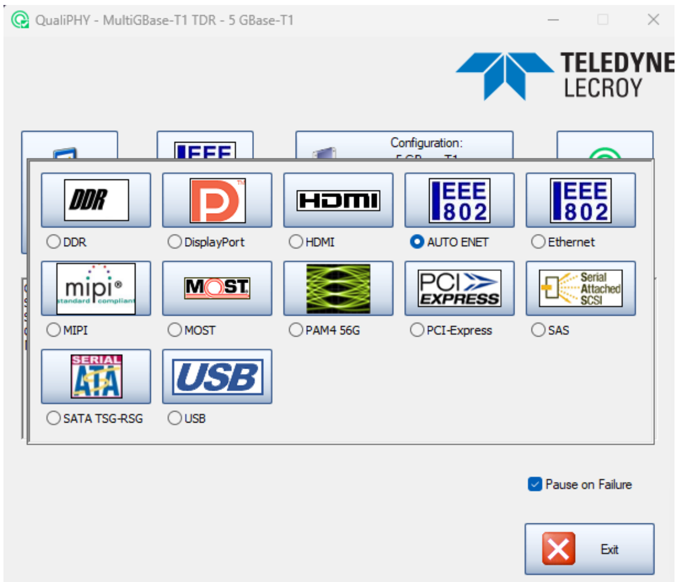
TDR Test Equipment Setup

The QualiPHY script will provide connection diagrams showing the correct probing/cabling, depending on the selected test. See the individual tests below for set up instructions.

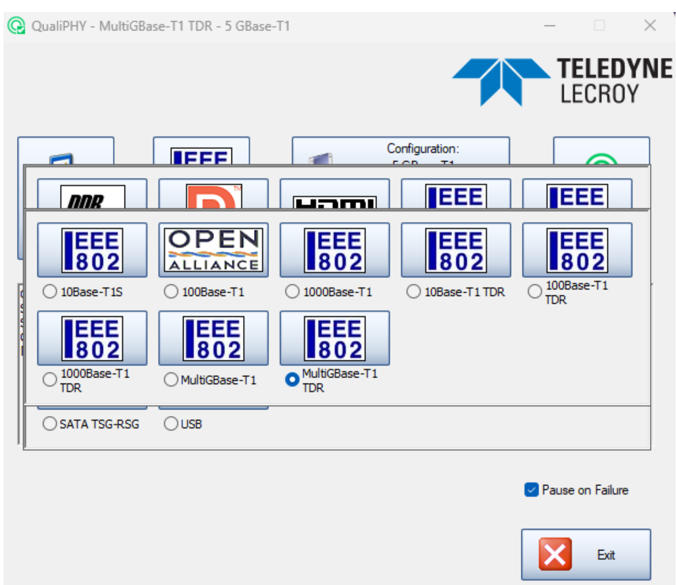
Initiating MultiGBase-T1 TDR Test Sessions

Follow these steps when ready to begin a new MultiGBase-T1 TDR test session in QualiPHY:

1. Access QualiPHY by either:
   - Choosing Analysis > QualiPHY from the oscilloscope menu bar
   - Double-clicking the QualiPHY desktop icon  on a remote computer or oscilloscope desktop.
2. Open the QualiPHY wizard, select the Standard button and choose IEEE 802 AUTO ENET:

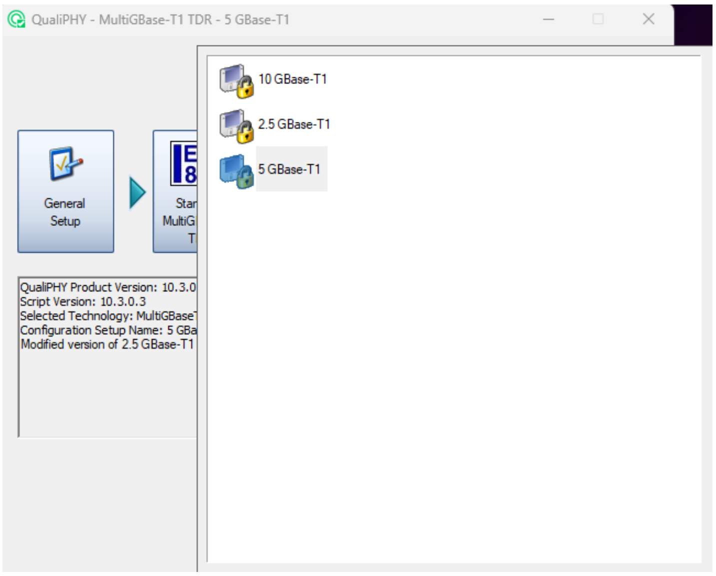


3. Choose the component (test type) you wish to run—MultiGBase-T1 TDR:



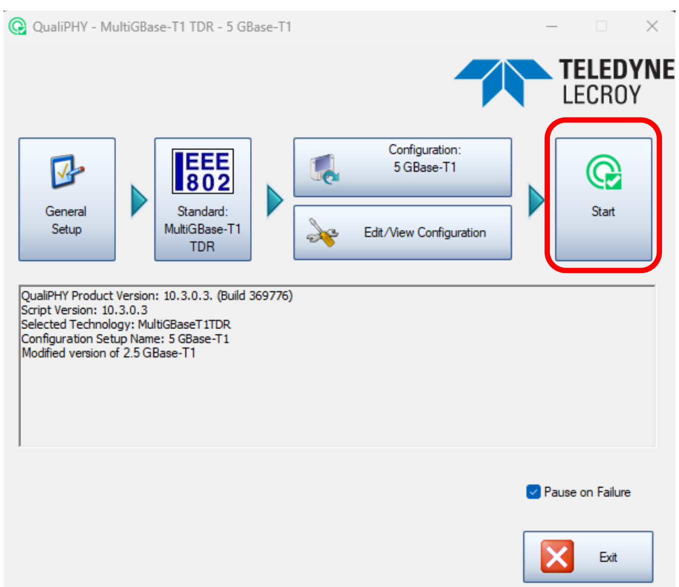
4. On the Wizard, click the **Configuration** or Edit/View Configuration button and select the test configuration you wish to run.

   Different configurations are designed to set key variables as required by different test scenarios. Each TDR configuration sets the speed grade at which all the required compliance tests are performed: 2.5 GB/s, 5 GB/s or 10 GB/s.



Note: Standard configurations are locked and cannot be changed. However, if you need to change any tests or test variables, click Edit/View Configuration and make modifications on the Test Selector and Variable Setup tabs. You will be prompted to Save a copy. Select the copied configuration to run. See [Customizing QualiPHY] for more information on creating custom configurations.

5. After selecting the configuration, click the **Start** button on the QualiPHY wizard.



6. Follow instructions to set up the test equipment on configuration dialogs/diagrams as they appear.

MultiGBase-T1 TDR Tests

MultiGBase-T1-TDR includes MDI S-parameter compliance measurements and shielded twisted pair (STP) link segment compliance measurements for 2.5G, 5G and 10GBASE-T1 Automotive Ethernet.

The TDR tests performed by each configuration at the selected speed include:

- MDI Return Loss
- Channel T1 Link Segment tests, specifically Characteristic Impedance Differential Mode (ZRF), Propagation Delay, Insertion Loss, Return Loss and Longitudinal Conversion Transfer Loss for Cable Assembly in Context of Standalone Communication Channel (SCC)
- Whole Communication Channel tests Propagation Delay, Insertion Loss and Return Loss in Context of SCC

Results for S-parameter values are in dB. Maximum frequencies are:

2.5 Gb/s f_{max}= 1000 MHz

5 Gb/s f_{max}= 2000 MHz

10 Gb/s f_{max}= 4000 MHz

MDI Return Loss S_{dd11} (149.5.3.1)

What Is Measured

This test measures the Return Loss at the Medium Dependent Interface (MDI), which is a measure of the signal power that is reflected due to an impedance mismatch. A compliant MultiGBase-T1 device shall ideally have a differential characteristic impedance of 100 Ω. This is necessary to match the characteristic impedance of the automotive cabling. Any difference in impedance will result in a partial reflection of the transmitted signals.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections. A pass/fail mask test is then performed on the resulting S-parameter trace. A passing result indicates that the entire Return Loss trace (i.e., each frequency) is contained within the mask region. This confirms that the reflected power measured at the MDI is below the conformance limits for each frequency. Different frequency ranges and different pass/fail masks are applicable at the different lane rate speeds 2.5 Gb/s, 5 Gb/s and 10 Gb/s.

Test Setup

Connect Port 1 and Port 2 of the WavePulser to the test fixture as shown.

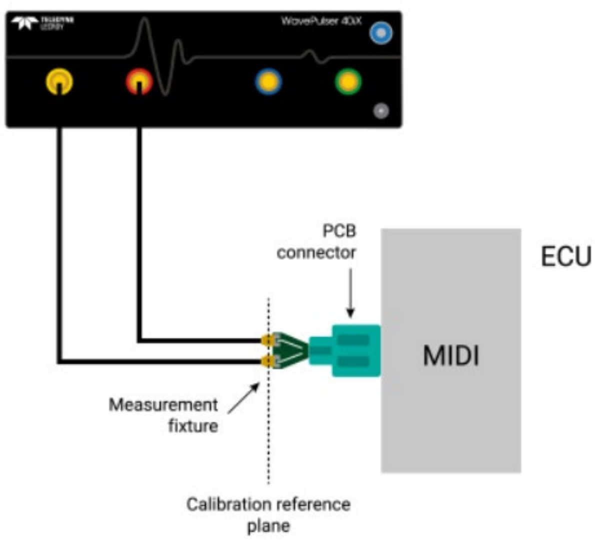


Figure 13. Connection diagram for MDI Return Loss test.

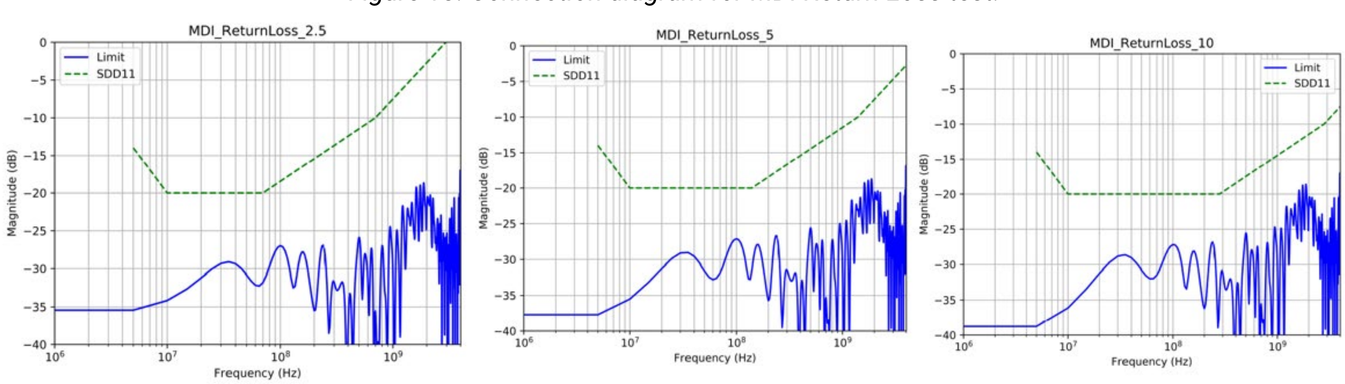


Figure 14. Sdd11 MDI Return Loss traces with limit masks at lane rate speed 2.5 Gb/s, 5 Gb/s and 10 Gb/s.

Requirements for Cables in Context of Standalone Communication Channel (SCC)

The SCC consists of two PCB connectors, cable and up-to-four inline connectors. PCB and inline connectors can be single or multiport type. Multiport connectors provide more than one differential port. If all cable assemblies use low loss case cables, maximum length is up to 15 m with up-to-four inline connectors. If all cable assemblies use standard loss case cables, maximum length is up to 10 m.

The following five tests are performed on cables in context of SCC using the setup shown below.

Test Setup

Connect all four ports of the WavePulser to both sides of the channel using two test fixtures, as shown.

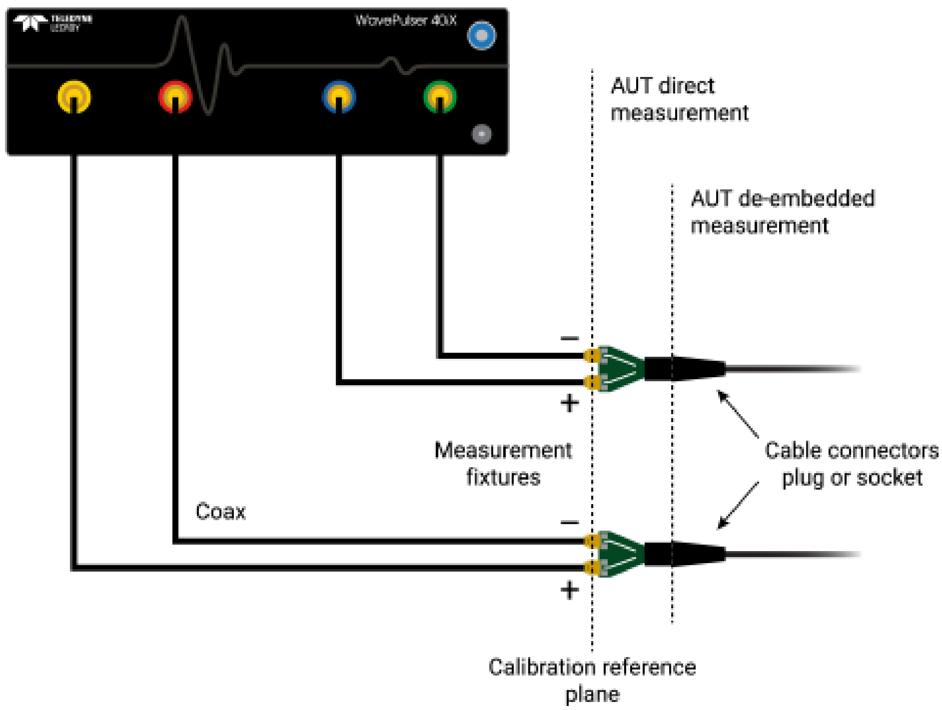


Figure 15. Connection diagram showing measurement setup for standalone communication channel (SCC).

CIDM - Characteristic Impedance Differential Mode, Z_{RF}

What Is Measured

This test measures the Differential Mode Characteristic Impedance of the channel, and it is obtained on the differential Port 1. The de-embedding of the test fixture is optional, while the de-embedding of the cable from WavePulser to the test fixture is mandatory and obtained using the cable de-embedding features of the measurement set-up. The rise time should be set according to the specification, which is 500 ps for all the three speeds, 2.5 Gb/s, 5 Gb/s and 10 Gb/s. The requirement is 100 Ω ± 3% at all speed grades, so differential characteristic impedance must stay within 97 Ω < Z_{RF} < 103 Ω range along the entire channel.

Test Methodology

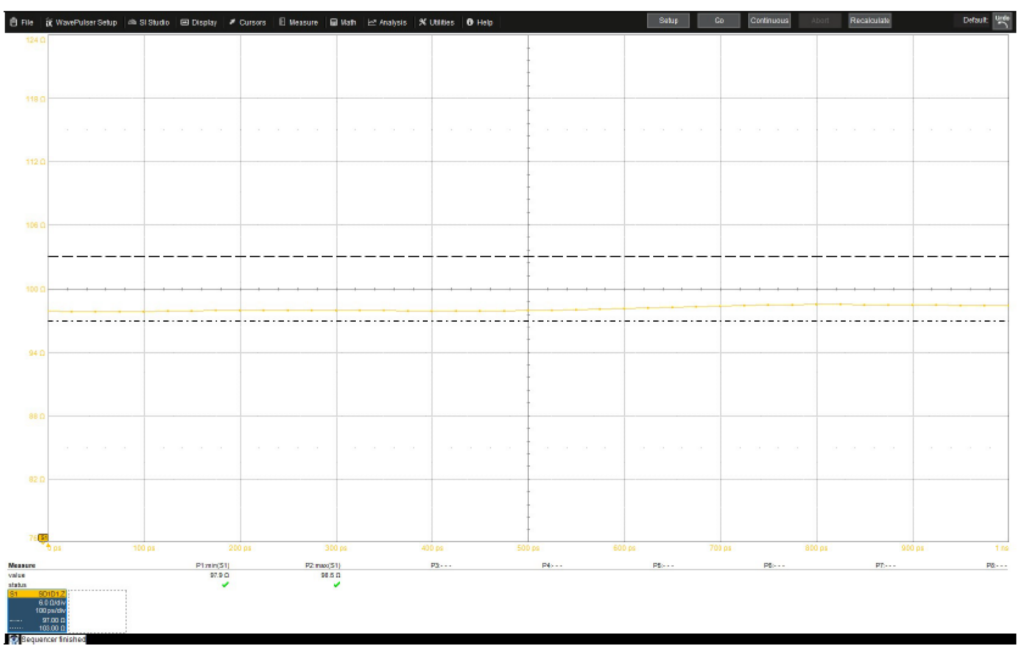
The WavePulser 40iX launches a signal into the channel and measures the reflections over time. Reflections occur because of an impedance mismatch or discontinuity on the transmission line. Characteristic Impedance of the differential line is measured based on the measured reflections. The characteristic impedance profile is a direct measurement, because WavePulser is a Time Domain Reflectometer (TDR).

[Up]

✔ Pass	Measurement:	***Cable Characteristic Impedance, Differential Mode, min***		
	Current Value:	97.86 ohms	Test Criteria:	97.00 ohms <= x <= 103.00 ohms
	Timestamp:	05/17/2023 01:16:47	Limit Name:	Cable_CIDM_min
	Description:	The impedance profile is calculated using 500ps risetime, using the SDD11 S-parameter. The minimum and maximum of the impedance profile is compared to the test limits.		

[Up]

✔ Pass	Measurement:	***Cable Characteristic Impedance, Differential Mode, max***		
	Current Value:	98.53 ohms	Test Criteria:	97.00 ohms <= x <= 103.00 ohms
	Timestamp:	05/17/2023 01:16:48	Limit Name:	Cable_CIDM_max
	Description:	The impedance profile is calculated using 500ps risetime, using the SDD11 S-parameter. The minimum and maximum of the impedance profile is compared to the test limits.		



Cable Impedance, Differential Mode

Figure 16. Characteristic Impedance for differential mode along the entire channel.

Propagation Delay, t_d

What Is Measured

Propagation Delay is the measurement of the electrical length divided by the length of the cable. The length of the cable needs to be entered by the user. The propagation delay requirement is different depending on the use of a low loss case or standard loss case. Total length is up to 15 m when using a low-loss case and up to 10 m when using a standard-loss case. The requirement is ≤ 6 ns/m for a low-loss case and ≤ 9 ns/m for a standard-loss case. Frequency range is different depending on the lane rate speed 2.5 Gb/s, 5 Gb/s or 10 Gb/s.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections and transmission over time. Based on the transmission, more precisely using the step response result view of the Sdd21, the propagation delay is calculated from the expanded phase angle of the S_{dd21} parameter (Differential Insertion Loss) using the equation:

$$t_d = -Phase\ (S_{dd21})/(360 \cdot f)$$

where f is Hz, t_d is s and phase angle is degree.

The propagation delay per meter is calculated using the Propagation Delay measurement obtained as explained above and the DUT length variable. The test limit is a function of the DUT length: 9 ns/m for < 10 m DUT length, 6 ns/m for > 10 m. DUT length must be entered in the test variable setup.

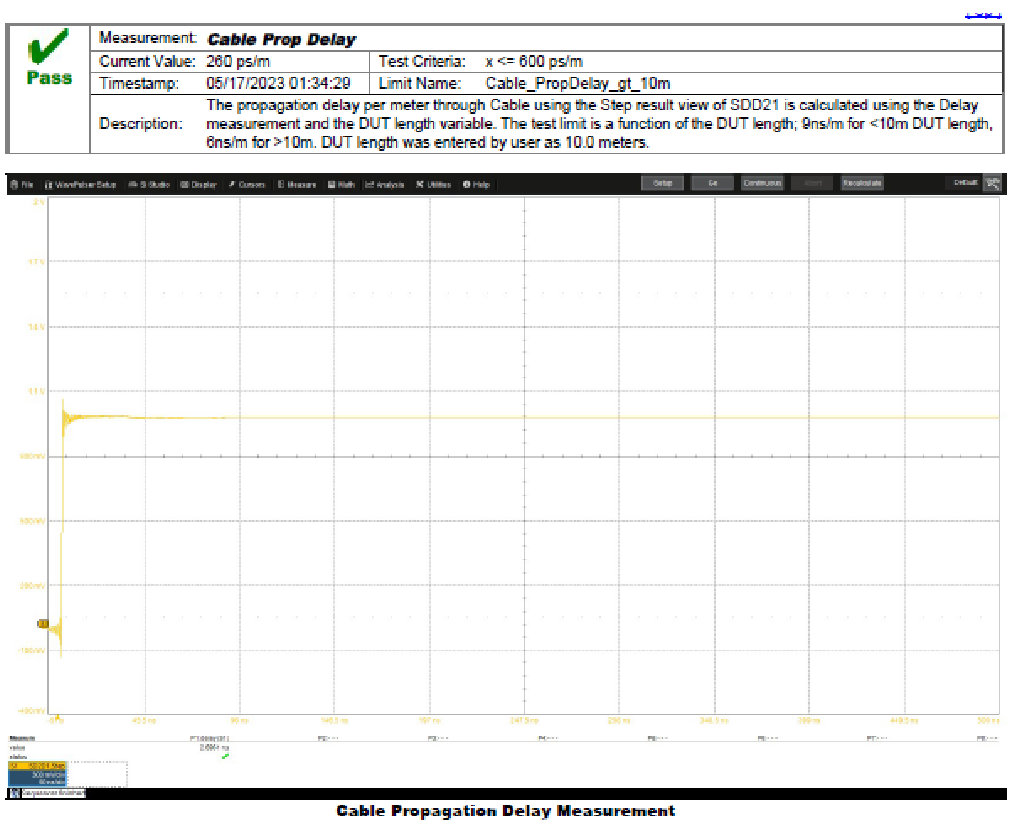


Figure 17. Propagation Delay per meter for a 10 m cable.

Insertion Loss (S_{dd21})

What Is Measured

Differential Insertion Loss using mixed-mode S-parameters is a measure of the loss expressed in dB for a differential signal travelling along the link segment channel. It is frequency dependent; indeed, loss is always larger at higher frequencies. Limits masks are different with respect to the line rate speeds as well as the frequency range. Cables from WavePulser to the test fixtures are automatically de-embedded using the cable de-embedding menu.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections and the transmission over time. Based on the transmission, the S_{dd21} is calculated. The insertion Loss is the value expressed in dB calculated using the formula:

$$\text{Insertion Loss} = -20 \log S_{dd21}.$$

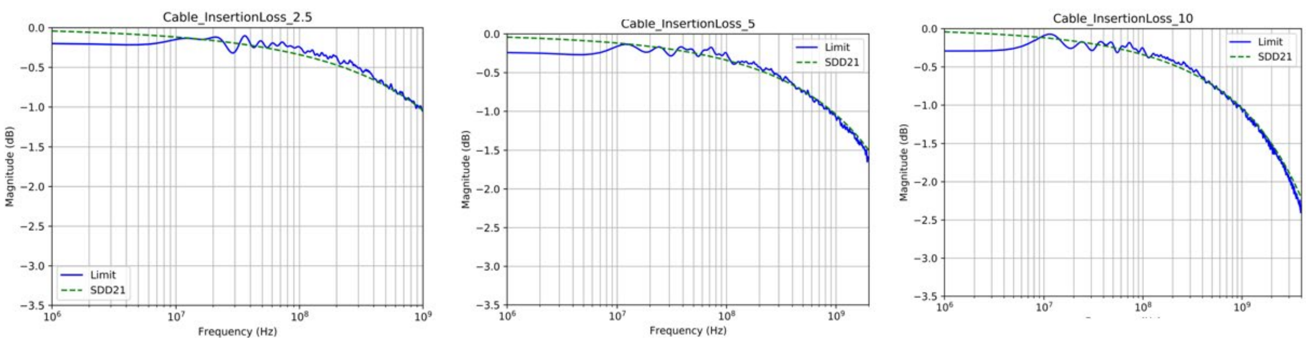


Figure 18. Cable differential Insertion Loss at lane rate speed 2.5 Gb/s, 5 Gb/s and 10 Gb/s.

Return Loss (S_{dd11} and S_{dd22})

What Is Measured

Differential Return Loss on Port 1 and on Port 2 is the measure of the reflections of the differential signal for both sides of the channel, Port 1 and Port 2. More specifically, it is the measure of the power of the differential signal that is reflected due to an impedance mismatch. A compliant MultiGBase-T1 device shall ideally have a differential characteristic impedance of 100 Ω with no reflections. The trace must be below the limit mask for the speed, which means that the reflections must stay below a certain frequency dependent value. This condition is necessary to match the characteristic impedance of the automotive cabling. Any difference in impedance will result in a partial reflection of the transmitted signals.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections over time. The Return Loss expressed in dB is calculated using the formula:

$$\text{Return Loss (dB)} = 10^{*}\log\,(\text{Incident Power (W)}/\text{Reflected Power (W)})$$

Or using dBm the formula is:

$$\text{Return Loss (dBm)} = \text{Incident Power (dBm) -Reflected Power (dBm)}$$

Return Loss is measured for Port 1 and for Port 2.

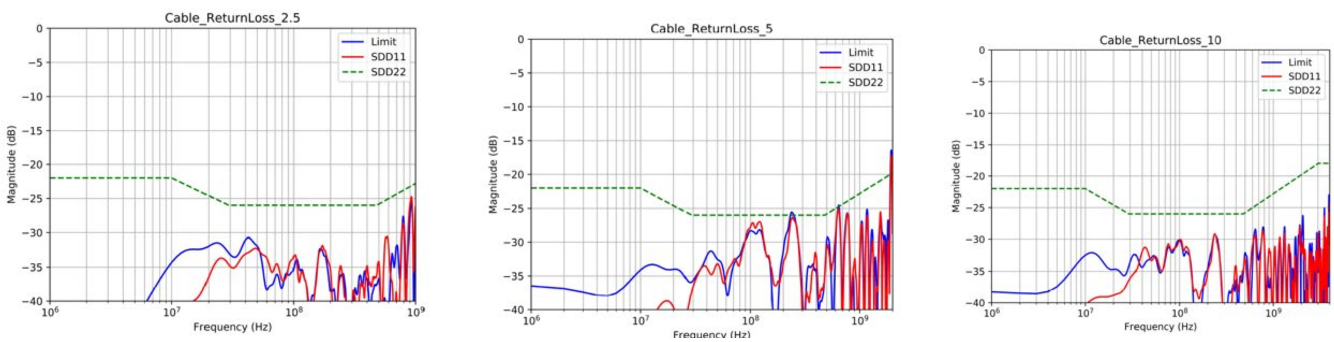


Figure 19. Return Loss Measurements at port 1 and port 2 for 2.5 Gb/s, 5 Gb/s and 10 Gb/s.

LCTL - Longitudinal Conversion Transfer Loss, (S_{dc21} and S_{dc12})

What Is Measured

The Longitudinal Conversion Transfer Loss is an S-parameter measurement of the mode conversion from common mode to differential mode related to the energy transferred from Port 1 to Port 2, and in reverse from Port 2 to Port1, in the Automotive Link Channel. It provides a figure of merit for the interference immunity of the channel. Indeed, any interfering signal is equivalent to injecting a common mode signal on the channel, and the LCTL factor tells you how much of the common mode signal is converted into a differential signal. Eventually, the differential signal generated by the common mode signal (mode conversion) is superimposed on the differential signal used for transferring information on the channel, degrading the channel throughput.

The limit requirement is the same (i.e., ≤ 20 dB) for all speed grades, but the frequency ranges are different depending on the lane rate speeds. More specifically, the frequency (f in MHz) ranges are:

- o 1 ≤ f ≤ 1000 for 2.5 Gb/s
- o 1 ≤ f ≤ 2000 for 5 Gb/s
- o 1 ≤ f ≤ 4000 for 10 Gb/s

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections and the transmission over time. Based on the signal travelling along the channel, WavePulser measured the 2-port mixed-mode S-parameters including S_{dc21} and S_{dc12}. The LCTL is the value in dB of the amplitude of S_{dc21} and S_{dc12}.

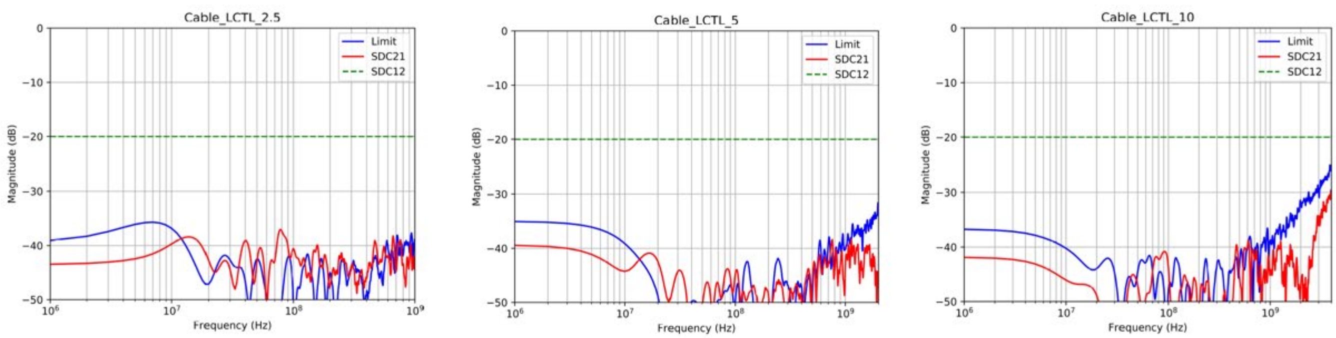


Figure 20. LCTL – Longitudinal Conversion Transfer Loss for 2.5G, 5G and 10G.

Requirements for Whole Communication Channel (WCC) in Context of Standalone Communication Channel (SCC)

The WCC is the complete electrical wired connection (i.e., the wiring harness between two ECUs with Ethernet interfaces). A WCC consists of the standalone communication channel that is used for 2.5 Gb/s, 5 Gb/s and 10 Gb/s Ethernet data or power transmission between the ECUs and other systems.

The following three tests are performed on the whole communication channel using the test setup shown below.

Test Setup

Connect all four ports of WavePulser to both sides of the channel using two test fixtures, as shown.

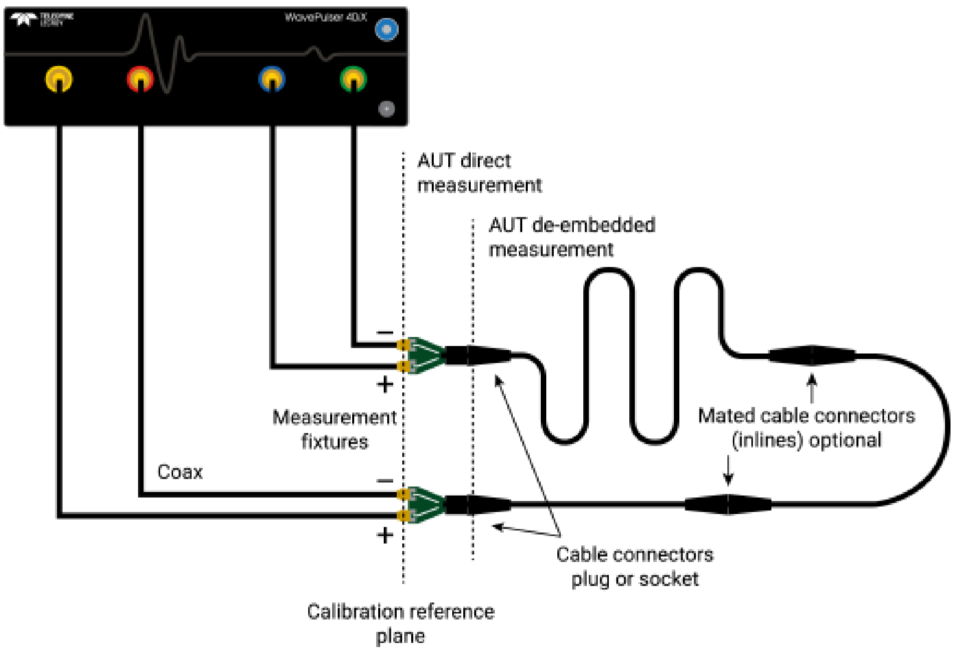


Figure 21. Connection diagram showing measurement setup for whole communication channel (WCC).

Propagation Delay, t_d

What Is Measured

The maximum allowed propagation delay time for the WCC is independent from the length and shall not exceed the requirement of ≤ 94 ns. The frequency range is different depending on the lane rate speed of 2.5 Gb/s, 5 Gb/s or 10 Gb/s. The propagation delay through the WCC is determined from the result of S_{dd21} using the Propagation Delay measurement.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections and transmission over time. The propagation delay is defined as the phase delay of the transmitted signal. It can be calculated from the expanded phase angle of the S_{dd21} parameter (Differential Insertion Loss) using the equation:

$$t_d = -Phase\ (S_{dd21})/(360 \cdot f)$$

where f is Hz, td is s, phase angle is degree.

Figure 22. Propagation Delay through the whole communication channel (WCC).

Insertion Loss (S_{dd21})

What Is Measured

Differential Insertion Loss using mixed-mode S-parameters is a measure of the loss (expressed in dB) for a differential signal travelling along the link segment channel. It is frequency dependent; indeed, loss is always larger at higher frequencies. The limit masks are different in respect to the line rate speed as well as frequency range. Cables from WavePulser to the test fixtures are automatically de-embedded using the cable de-embedding menu.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections over time. Reflection is created when we have an impedance mismatch or discontinuity on the transmission line. Characteristic Impedance of the differential line is measured based on the measured reflections.

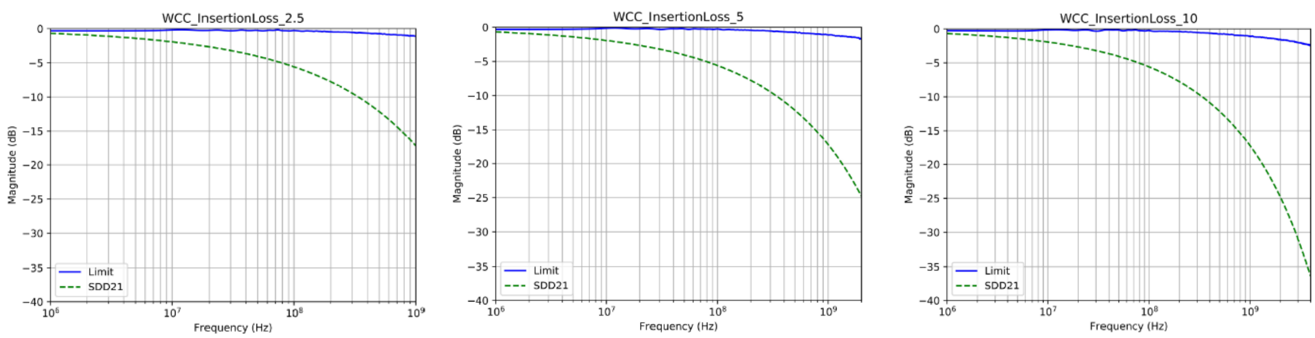


Figure 23. Insertion Loss (S_{dd21}) for Whole Communication Channel (WCC).

Return Loss (S_{dd11} and S_{dd22})

What Is Measured

Differential Return Loss on Port 1 and on Port 2 is the measure of the reflections of the differential signal for both sides of the channel (WCC), Port 1 and Port 2. More specifically, it is the measure of the power of the differential signal that is reflected due to an impedance mismatch. A compliant MultiGBase-T1 device shall ideally have a differential characteristic impedance of 100 Ω with no reflections. The trace must be below the limit mask for the speed, which means that the reflections must stay below a certain frequency dependent value. This condition is necessary to match the characteristic impedance of the automotive cabling. Any difference in impedance will result in a partial reflection of the transmitted signals.

Test Methodology

The WavePulser 40iX launches a signal into the channel and measures the reflections over time. The Return Loss expressed in dB is calculated using the formula:

$$\text{Return Loss (dB)} = 10 * \log \text{(Incident Power (W)/Reflected Power (W))}$$

Or using dBm the formula is:

$$\text{Return Loss (dBm)} = \text{Incident Power (dBm)} - \text{Reflected Power (dBm)}$$

Return Loss is measured for Port 1 and for Port 2.

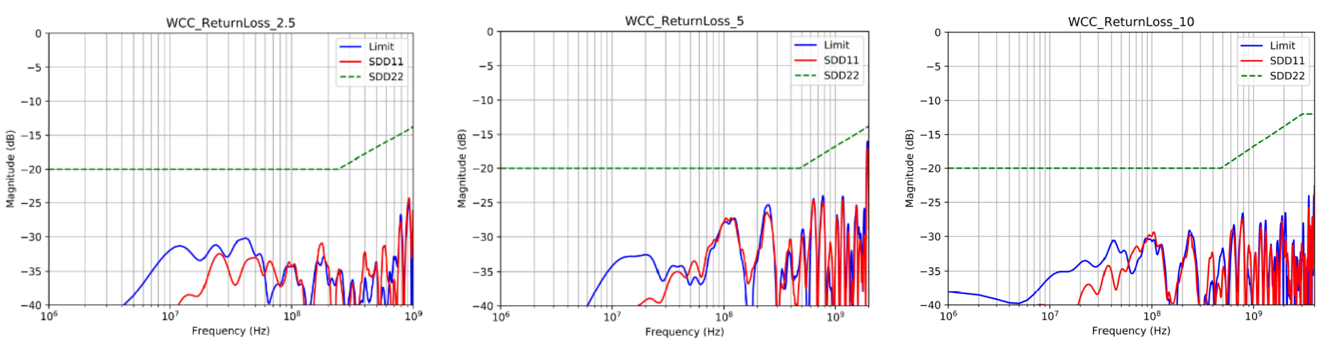


Figure 24. Return Loss (S_{dd11} and S_{dd22}) for Whole Communication Channel (WCC).

MultiGBase-T1 TDR Test Variables

Basic Group

Standard

Select the speeds included in the MultiGBase-T1 requirements. Specifically, 2.5GBase-T1, 5GBase-T1 and 10GBase-T1, with 2.5G, 5G and 10G lane speeds, respectively

Pause after tests to review?

Select Yes to pause after each test to examine the results. Otherwise, No.

Auto Cal Policy

Select a policy for the WavePulser's automatic calibration function:

Always: Calibrate prior to every measurement

Periodically: Calibrate after the amount of time in the Recalibration Time variable

As Required: Calibrate as deemed necessary by the WavePulser software

Recalibration Time

Enter the time in minutes between calibrations when using Periodically as the Auto Cal Policy.

MDI Return Loss (S_{dd11})

These variables configure the WavePulser 40ix for the MDI Return Loss measurements.

End Frequency

Enter the end frequency for the S-parameter measurement.

For compliance testing, set this to 1 GHz for 2.5GBase-T1, 2 GHz for 5GBase-T1 and 4 GHz for 10GBase-T1.

For debug, End Frequency may be set from DC to 4 GHz.

Number of Points

Enter the number of sample points for the S-parameter measurement from DC to End Frequency.

For MDI Return Loss (S_{dd11}) compliance testing, set this to 1,000.

Number of Averages for Cal

Configures Custom sequence control on the WavePulser. Enter the number of seconds of pulsing/sampling for the calibration phase. 5000 pulses are sent each second.

For MDI Return Loss (S_{dd11}) compliance testing, set this to 10.

Number of Averages for DUT

Configures Custom sequence control on the WavePulser. Enter the number of seconds of pulsing/sampling for the DUT measurement phase. 5000 pulses are sent each second.

For MDI Return Loss (S_{dd11}) compliance testing, set this to 10.

Number of Averages for Result

Configures Custom sequence control on the WavePulser. Enter the number of result waveforms to be averaged for the result. For MDI Return Loss (S_{dd11}) compliance testing, set this to 1.

Enable Gating?
Set to Yes to enable time-domain gating for the MDI Return Loss (S_{dd11}) fixture. When set to Yes, the delay and loss variables will be used to shift the Reference Plane.

Delay Value for Differential Port 1
When enable gating is set to Yes, the delay value (ns) defines the shift/delay of the reference plane for differential port1.

Fixture Loss Characteristic (dB/GHz)
When enable gating is set to Yes, the loss of the shift of the reference plane indicated as dB/GHz. Specifically, IL at the maximum frequency divided for the maximum frequency itself.

Requirements for Cables in Contest of Standalone Communication Channel (SCC)
These variables configure the WavePulser 40ix for the TC9 link segment measurements, specifically Characteristic Impedance Differential Mode, Propagation Delay, Insertion Loss, Return Loss, and Longitudinal Conversion Transfer Loss.

DUT Length in Meters (m)
Propagation Delay and Insertion Loss have different requirements depending on the maximum length of the channel (10 m or 15 m). Selecting the maximum length of the measured channel will set the suitable limit requirements.

End Frequency
Enter the end frequency for the S-parameter measurement.

For compliance testing, set this to 1 GHz for 2.5GBase-T1, 2 GHz for 5GBase-T1 and 4 GHz for 10GBase-T1.

For debug, End Frequency may be set from DC to 4 GHz.

Number of Frequency Points
Enter the number of sample points for the S-parameter measurement from DC to End Frequency.

For TC9 compliance testing, set this to 1,000.

Number of Averages for Cal
Configures Custom sequence control on the WavePulser. Enter the number of seconds of pulsing/sampling for the calibration phase. 5000 pulses are sent each second.

For TC9 compliance testing, set this to 10.

Number of Averages for DUT
Configures Custom sequence control on the WavePulser. Enter the number of seconds of pulsing/sampling for the DUT measurement phase. 5000 pulses are sent each second.

For TC9 compliance testing, set this to 10.

Number of Averages for Result
Configures Custom sequence control on the WavePulser. Enter the number of waveforms to be averaged for the result. For TC9 compliance testing, set this to 1.

Enable Gating?
Set to Yes to enable time-domain gating for the fixtures. When set to Yes, the delay and loss variables will be used to shift the Reference Plane.

Delay Value for Differential Port 1

When enable gating is set to Yes, the delay value (ns) defines the shift/delay of the reference plane for differential Port 1.

Fixture Loss Characteristic (dB/GHz)

When enable gating is set to Yes, the loss of the shift of the reference plane indicated as dB/GHz. Specifically, IL at the maximum frequency divided for the maximum frequency itself.

Requirements for Whole Communication Channel in Context of Standalone Communication Channel (SCC)

These variables configure the WavePulser 40ix for the TC9 link segment measurements, specifically Propagation delay, Insertion Loss and Return Loss.

DUT Length in Meters (m)

Propagation Delay and Insertion Loss have different requirements depending on the maximum length of the channel (10 m or 15 m). Selecting the maximum length of the measured channel will set the suitable limit requirements.

End Frequency

Enter the end frequency for the S-parameter measurement.

For compliance testing, set this to 1 GHz for 2.5GBase-T1, 2 GHz for 5GBase-T1 and 4 GHz for 10GBase-T1.

For debug, End Frequency may be set from DC to 4 GHz.

Number of Frequency Points

Enter the number of sample points for the S-parameter measurement from DC to End Frequency.

For TC9 compliance testing, set this to 1,000.

Number of Averages for Cal

Configures Custom sequence control on the WavePulser. Enter the number of seconds of pulsing/sampling for the calibration phase. 5000 pulses are sent each second.

For TC9 compliance testing, set this to 10.

Number of Averages for DUT

Configures Custom sequence control on the WavePulser. Enter the number of seconds of pulsing/sampling for the DUT measurement phase. 5000 pulses are sent each second.

For TC9 compliance testing, set this to 10.

Number of Averages for Result

Configures Custom sequence control on the WavePulser. Enter the number of result waveforms to be averaged for the result. For TC9 compliance testing, set this to 1.

Enable Gating?

Set to Yes to enable time-domain gating for the fixtures. When set to Yes, the delay and loss variables will be used to shift the Reference Plane.

Delay Value for Differential Port 1

When enable gating is set to Yes, the delay value (ns) defines the shift/delay of the reference plane for differential port1.

Fixture Loss Characteristic (dB/GHz)

When enable gating is set to Yes, the loss of the shift of the reference plane indicated as dB/GHz. Specifically, IL at the maximum frequency divided for the maximum frequency itself.

MultiGBase-T1 TDR Test Limit Sets

The MultiGBase-T1-TDR script contains only one limit set, called “Default”. The limits in this set are those specified by the *Open Alliance MultiGBase-T1 PMA Test Suite* and *Channel and Component Requirements for Fully Shielded 1000BASE-T1 and 2.5G/5G/10GBase-T1 Link Segment Version 1.0 (27 December 2022)*.

Using Host Program Control Mode

Host Program Control Mode (HPC) is a feature that allows QualiPHY to be started by a user's host program with several arguments. Once running, a simple "Sync File" protocol is used by QualiPHY to signal the host program.

When the QualiPHY script requires action from the host program, it writes a User Sync File to the disk in .xml format containing several tags. QualiPHY then pauses execution and waits. The host program should set the requested DUT parameters or test system configuration, respond as necessary, then delete the User Sync File. When QualiPHY sees that the User Sync File is deleted, it continues execution.

In MultiGBase-T1 script, there are three situations when a Sync File is written out:

1. When the user host program needs to change what signals are connected to the oscilloscope (typically utilized in systems involving an RF switch)
2. When the user host program needs to change the signal type output from the DUT (e.g., the signal's character rate)
3. When an error condition has occurred

To use Host Program Control Mode, the following considerations should be considered.

Preparing Special Configuration for Host Control Mode

In QualiPHY, create a custom Configuration that has the variables configured in the way you will need them when you run in Host Program Control Mode. Make sure you save the configuration after editing the variables so that it will be available to refer to when you startup QualiPHY via command line.

Variables that need to be considered to run in HPC are:

- Host Program Control sync filename
    - Definition: Use to specify sync file path.
    - Default: C:\MultiG_sync_file.xml
    - Comments: Just use default unless conflict.
- Use Host Program Control?
    - Definition: Set to "Yes" to use the Host Program Control feature, "No" otherwise.
    - Default: No
    - Comment: When set to "Yes", QualiPHY will pause execution after it creates a sync file and while it is waiting for the sync file to be deleted.

Host Program Elements Needed to Control the QualiPHY Script

Launching QualiPHY (XReplay.exe)

The Host program needs to launch the QualiPHY application (the actual program is named XReplay.exe) with the following command line, including arguments for MultiGBase-T1:

```
C:\Program Files(x86)\LeCroy\XReplay\XReplay.exe -A -R -E -WIZARD
-TECH:AUTO-ENET\MultiGBaseT1 -CONFIG:HostProgramControlTests -N:IP Address
```

The path shown above is where the XReplay.exe program (QualiPHY) is placed by the installer.

Arguments are:

`-A`	Stops all manual user interaction. (Always use)
`-R`	Causes the test script (DP in this case) to be run automatically. (Always use)
`-E`	Automatically exit when test script is done executing. (Always use)
`-WIZARD`	Required.
`-TECH:AUTO-ENET\MultiGBaseT1`	Sets the technology to test, MultiGBase-T1
`-CONFIG:HostProgramControlTests`	Sets the name of the configuration that will be used; HostProgramControlTests.
`-N:`*`IP Address`*	IP address of the oscilloscope: If QualiPHY is running on the oscilloscope, set to *localhost*. If QualiPHY is not running on the oscilloscope, set to *Host ID* or *IP Address* of the oscilloscope.

Monitoring for QualiPHY Termination

The host program needs to continuously test to see if the QualiPHY process still exists, to be able to know when the QualiPHY test script has completed and take appropriate action.

File Transfer Synchronization

The host synchronization consists of three parts:

1. Waiting for C:\ MultiG_sync_file.xml (or another name specified in configuration) to be written by QualiPHY.
2. Reading the file and performing the required actions.
3. Deleting C:\ MultiG_sync_file.xml to signal QualiPHY that the operation is complete.

Renaming the Test Report

The test report that is created by the QualiPHY test script is always created with the same name (for example, D:\QPHY\Reports\LeCroyReport.pdf). For this reason, it needs to be renamed after QualiPHY (XReplay.exe) terminates to avoid overwriting it the next time QualiPHY is run.

Note: The report path is C:\LeCroy\QPHY\Reports if QualiPHY is installed on a remote PC instead of the oscilloscope.

Sample Host Program

This sample Python host program performs all the essential tasks involved in launching and synchronizing with the QualiPHY MultiGBase-T1 test script. It is shown below and referred to in the text following it.

```
import time
import os
import shutil
import subprocess
import xml.etree.ElementTree as ET
import ctypes


def mbox(title, text, style = 0):
    '''
    message box with ok
    '''
    return ctypes.windll.user32.MessageBoxA(0, text, title, style)


def main():
    SyncFilePath = r'D:\QPHY\MultiG_sync_file.xml'
    args_list = [r'C:\Program Files (x86)\LeCroy\XReplay\XReplay.exe', r'-A', r'-
R', r'-E', r'-WIZARD', r'-TECH:AUTO-ENET\MultiGBaseT1', r'-CONFIG:Host Program
Control Tests', r'-N:127.0.0.1']
    process =
subprocess.Popen(args_list,stdout=subprocess.PIPE,stderr=subprocess.PIPE,
shell=True)
    time.sleep(1)
    while process.poll() is None:
        time.sleep(1)
        if os.path.isfile(SyncFilePath) == True:
            file = open(SyncFilePath, 'r')
            xmlstring = file.read()
            file.close()
            root = ET.fromstring(xmlstring)
            #print XML tags
            print 'Check XML tags'
            for child in root:
                print (child.tag)
            #print tag if text exists
            print 'Check XML text'
```

```
            for child in root:
                if child.text != None:
                    print (child.text)
            #send prompt if connectionsReq has text
            print 'Pause if connection change required'
            for child in root:
                if child.tag == 'connectionsReq':
                    if child.text != None:
                        mbox('Pause for connections', child.text)
                    else:
                        print 'No Connections required'
            #send prompt if error detected
            print 'Pause if error detected'
            for child in root:
                if child.tag == 'error':
                    if child.text != None and child.text!= '0':
                        mbox('Error!!', child.text)
            ###other actions based on XML may be performed here###
            try:
                os.remove(SyncFilePath)
            except:
                pass
    args_list_report = [r'C:\Program Files (x86)\LeCroy\XReplay\XReplay.exe',r'-
D',r'-WIZARD']
    process =
subprocess.Popen(args_list_report,stdout=subprocess.PIPE,stderr=subprocess.PIPE,
shell=True)
    time.sleep(1)
    print 'Generating Report...'
    while process.poll() is None:
        time.sleep(3)
    # Check for report and rename if present
    ReportPathSource = r'D:\Qphy\Reports\LeCroyReport_Auto.pdf'
    ReportPathDest = r'D:\Qphy\Reports\MultiGBaseT1_Test_Results.pdf'
    if os.path.isfile(ReportPathSource) == True:
        try:
            shutil.move(ReportPathSource, ReportPathDest)
```

```
        except:
            print 'Error renaming report'
    else:
        print 'File not found'
    done = "Host Program Control python example script complete"
    return done
end = main()
print end
```

HPC Sync File

Sync File Tags

The Host Program Control synchronization file includes the following tags:

- connectionsReq: describes the connections that should be made.
  - When instructed to, connect bert output channels to the oscilloscope input channels.
  - Example: "**`C1, C2, Data_Out1, Data_Out1-bar`**"
- error: includes an error code. Refer to the "detail" field for information about the error.
- detail: gives additional information, especially in situations where the error code is 0, which would indicate an issue. Example: "No trigger: Trigger timed out. Is signal present and trigger set correctly?"

Sample XML Sync Files

Request to change the connections


```
<TestConfig>

<connectionsReq>C1, C2, Data_Out1, Data_Out1-bar</connectionsReq>

<detail>Connect a matched pair of 1-meter high quality SMA cables from the Data
Output1 and Data Output1-bar outputs of the Noise Module to the channels configured
in the variables dialog (C1 and C2).</detail>

<error>0</error>

</TestConfig>
```


Request to check error condition


```
<TestConfig>

<connectionsReq/>

<detail>No trigger: Trigger timed out. Is signal present and trigger set
correctly?</detail>

<error>3</error>

</TestConfig>
```

Using QualiPHY

This section provides an overview of the QualiPHY user interface and general procedures.

QualiPHY Test Process

1. Before beginning any test or data acquisition, warm the oscilloscope for at least 20 minutes.

   Oscilloscope calibration is automatically performed by the oscilloscope software; no manual calibration is required. The calibration procedure will be run again if the temperature of the oscilloscope changes by more than a few degrees.

2. Launch the QualiPHY wizard and working from left to right, select your Standard, technology Component and test Configuration.

3. Click Start and follow the connection diagrams/dialog prompts to connect the oscilloscope to the DUT and other test equipment.

4. As you work, continue to follow the software prompts to change cabling, DUT output test patterns, etc. and continue.

   When all tests are successfully completed, both progress bars on the wizard dialog are completely green and the message “All tests completed successfully” appears.

5. If you have Pause on Failure checked, you’ll be prompted to restart failed tests after correcting errors.

   If problems are encountered, choose to:

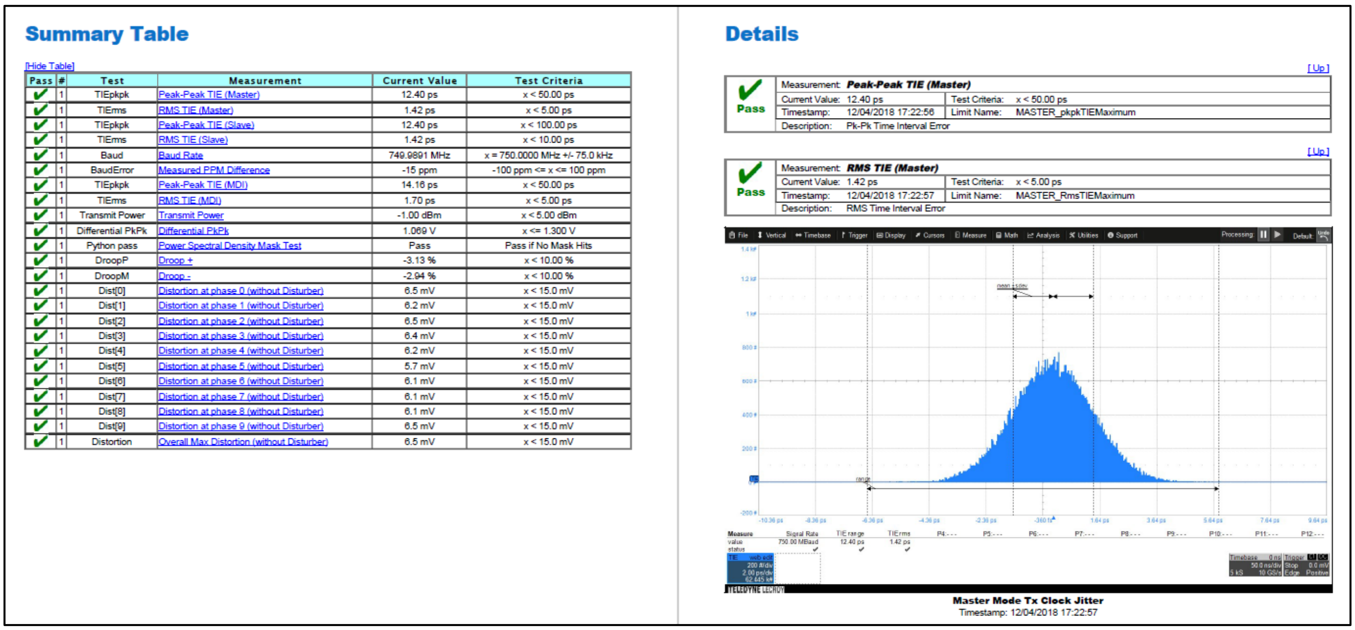
   - Retry the test from the latest established point defined in the script
   - Ignore and Continue with the next test
   - Abort Session

Generating Reports

The QualiPHY software automates report generation. On the wizard dialog, go to General Setup > Report to pre-configure reporting behavior. You can also manually launch the Report Generator from the wizard dialog after a test is completed.

The Report Generator offers the same selections as the Report tab, only applied to each report individually, rather than as a system setting. There are also options to link a custom style sheet (.xslt) to the report, or to Exclude Informative Results.

The Test Report includes a summary table with links to the detailed test result pages.



Summary Table

[Hide Table]

Pass	#	Test	Measurement	Current Value	Test Criteria
✔	1	TIEpkpk	Peak-Peak TIE (Master)	12.40 ps	x < 50.00 ps
✔	1	TIErms	RMS TIE (Master)	1.42 ps	x < 5.00 ps
✔	1	TIEpkpk	Peak-Peak TIE (Slave)	12.40 ps	x < 100.00 ps
✔	1	TIErms	RMS TIE (Slave)	1.42 ps	x < 10.00 ps
✔	1	Baud	Baud Rate	749.9891 MHz	x = 750.0000 MHz +/- 75.0 kHz
✔	1	BaudError	Measured PPM Difference	-15 ppm	-100 ppm <= x <= 100 ppm
✔	1	TIEpkpk	Peak-Peak TIE (MDI)	14.16 ps	x < 50.00 ps
✔	1	TIErms	RMS TIE (MDI)	1.70 ps	x < 5.00 ps
✔	1	Transmit Power	Transmit Power	-1.00 dBm	x < 5.00 dBm
✔	1	Differential PkPk	Differential PkPk	1.069 V	x <= 1.300 V
✔	1	Python pass	Power Spectral Density Mask Test	Pass	Pass if No Mask Hits
✔	1	DroopP	Droop +	-3.13 %	x < 10.00 %
✔	1	DroopM	Droop -	-2.94 %	x < 10.00 %
✔	1	Dist[0]	Distortion at phase 0 (without Disturber)	6.5 mV	x < 15.0 mV
✔	1	Dist[1]	Distortion at phase 1 (without Disturber)	6.2 mV	x < 15.0 mV
✔	1	Dist[2]	Distortion at phase 2 (without Disturber)	6.5 mV	x < 15.0 mV
✔	1	Dist[3]	Distortion at phase 3 (without Disturber)	6.4 mV	x < 15.0 mV
✔	1	Dist[4]	Distortion at phase 4 (without Disturber)	6.2 mV	x < 15.0 mV
✔	1	Dist[5]	Distortion at phase 5 (without Disturber)	5.7 mV	x < 15.0 mV
✔	1	Dist[6]	Distortion at phase 6 (without Disturber)	6.1 mV	x < 15.0 mV
✔	1	Dist[7]	Distortion at phase 7 (without Disturber)	6.1 mV	x < 15.0 mV
✔	1	Dist[8]	Distortion at phase 8 (without Disturber)	6.1 mV	x < 15.0 mV
✔	1	Dist[9]	Distortion at phase 9 (without Disturber)	6.5 mV	x < 15.0 mV
✔	1	Distortion	Overall Max Distortion (without Disturber)	6.5 mV	x < 15.0 mV

Details

[Up]

Pass				
✔ Pass	Measurement:	***Peak-Peak TIE (Master)***		
	Current Value:	12.40 ps	Test Criteria:	x < 50.00 ps
	Timestamp:	12/04/2018 17:22:56	Limit Name:	MASTER_pkpkTIEMaximum
	Description:	Pk-Pk Time Interval Error		

[Up]

Pass				
✔ Pass	Measurement:	***RMS TIE (Master)***		
	Current Value:	1.42 ps	Test Criteria:	x < 5.00 ps
	Timestamp:	12/04/2018 17:22:57	Limit Name:	MASTER_RmsTIEMaximum
	Description:	RMS Time Interval Error		

Master Mode Tx Clock Jitter

Timestamp: 12/04/2018 17:22:57

Figure 25. QualiPHY report summary and detail pages.

Reports are output to the folder D:\QPHY\Reports, or C:\LeCroy\QPHY\Reports if QualiPHY is installed on a remote PC.

You can add your own logo to the report by replacing the file *\QPHY\StyleSheets\CustomerLogo.jpg.

The recommended maximum size is 250x100 pixels at 72 ppi, 16.7 million colors, 24 bits. Use the same file name and format.

Customizing QualiPHY

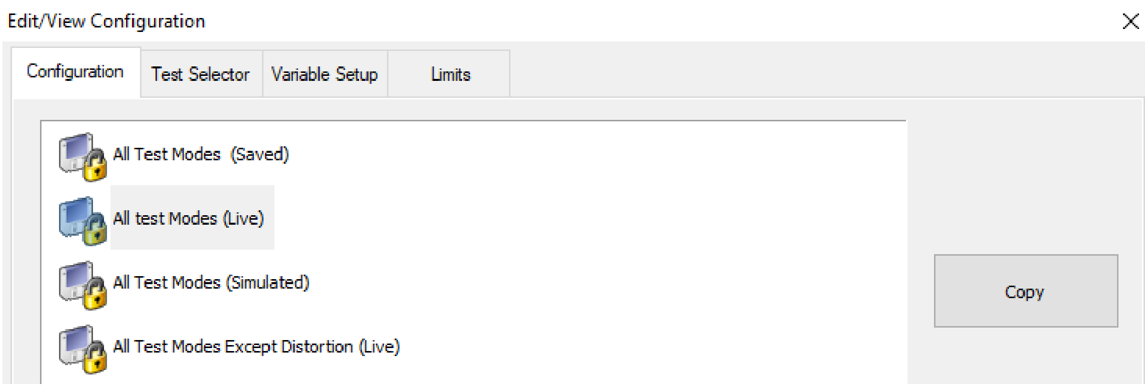
The pre-loaded configurations cannot be modified. However, you can create your own test configurations by copying one of the pre-loaded configurations and modifying it.

Note: This may also be required when you need to modify a variable from one of the standard configurations, such as Saved Waveform Path.

Copy Configuration

1. Access the QualiPHY wizard dialog and select a **Standard**.
2. Click **Edit/View Configuration** and select the configuration upon which to base the new configuration. This can be a pre-loaded configuration or another copy.
3. Click **Copy** and enter a name and description. Once a custom configuration is defined, it appears on the Configuration tab followed by "(Copy)."

   Note: Until you enter a new name, the new configuration is shown followed by "(Copy)".

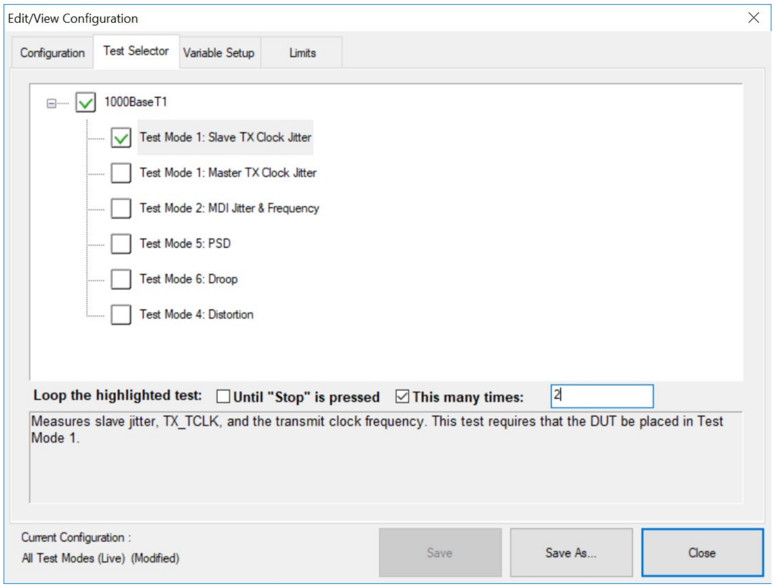
   

4. Select the new, custom configuration and follow the procedures below to continue making changes.

   Note: If any part of a configuration is changed, the Save As button becomes active on the bottom of the dialog. If a custom configuration is changed, the Save button will also become active to apply the changes to the existing configuration, rather than create a new one.

Select Tests

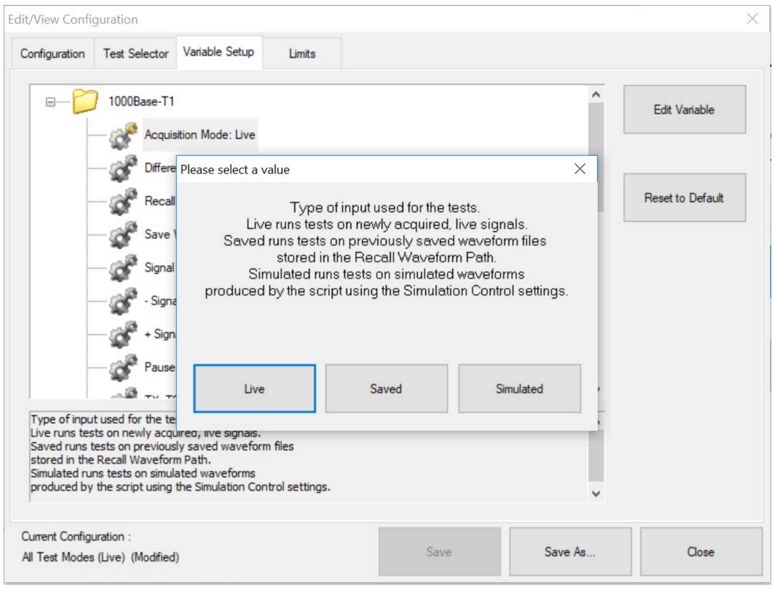
5. On the Test Selector tab, check the tests that make up the configuration. Each test is defined by the standard. A description of each test is displayed when it is selected.



Edit Variables

The Variable Setup tab contains a list of test variables. To modify a variable:

6. Select the variable on the Variable Setup tab, then click Edit Variable. (You can also choose to Reset to Default at any time.)
7. The conditions of this variable appear on a pop-up. Select or enter the new condition to apply.



Edit Test Limits

The Limits Manager shows the settings for every test limit in a limit set. Those in the default set are the limits defined by the standard. To create a custom limit set:

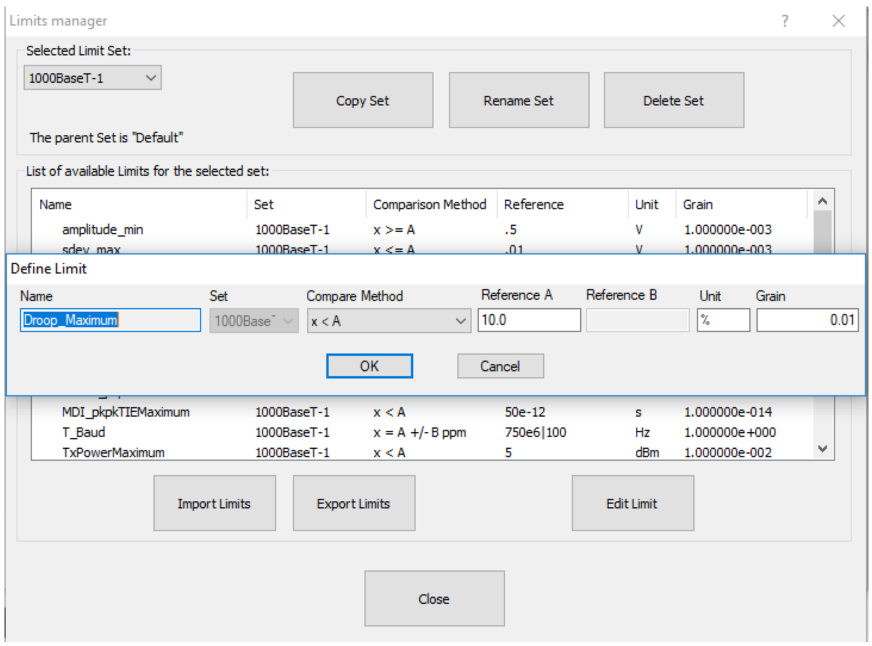
8. On the Limits tab, click **Limits Manager**.
9. With the default set selected, click **Copy Set** and enter a name for the new limit set.

   Note: You can also copy and modify another custom set that has been associated with this configuration.

10. Double click the limit to be modified, and in the pop-up enter the new values.

    You can also **Import Limits** from a .csv file. Navigate to the file location after clicking the Import Limits button.

    Tip: Likewise, Export Limits creates a .csv file from the current limit set. You may wish to do this and copy it to format the input .csv file.

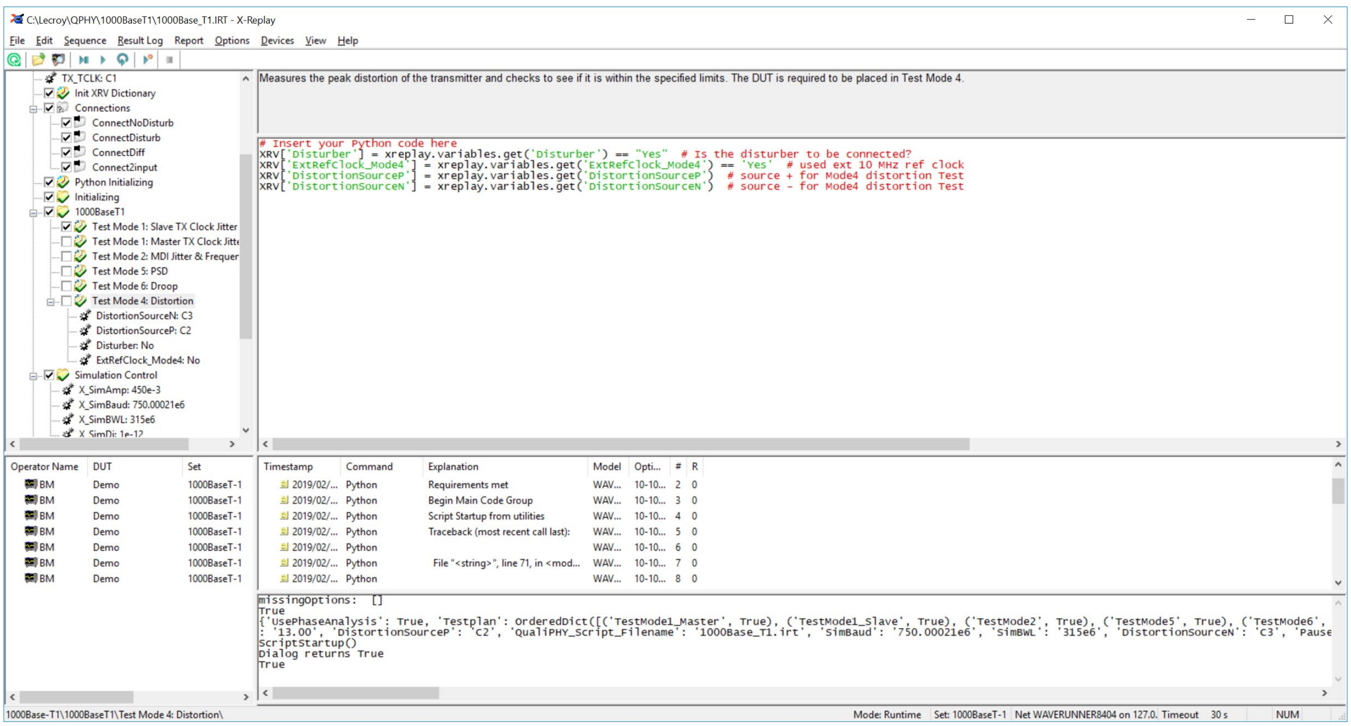


X-Replay Mode

The X-Replay mode window is an advanced ("developer") view of QualiPHY. The tree in the upper-left frame enables you to navigate to processes in the test script, in case you need to review the code, which appears in the upper-right frame.

Two other particularly useful features are:

- A list of recent test sessions in the lower-left frame. While you can only generate a report of the current test session in the QualiPHY wizard, in X-Replay Mode you can generate a report for any of these recent sessions. Right-click on the session and choose Create Report from context menu.
- The QualiPHY log in the bottom-right frame. The frame can be split by dragging up the lower edge. The bottom half of this split frame now shows the raw Python output, which can be useful if ever the script needs debugging.



Appendix A: Waveform File Naming Convention

QPHY-MultiGBase-T1 saves the waveforms from each acquisition using a specific file naming convention. This name definition allows the user to re-run any acquisition to recreate specific test results.

When running QPHY- MultiGBase-T1 in Demo mode (i.e., using saved waveforms), test variables need to be set up appropriately prior to running to let QualiPHY know which waveform files should be recalled.

File names consist of:

<channel><test_polarity><index>

<channel>: This is channel used for acquisition. When running in Demo mode, this portion of the waveform file name must match the channel setup for the test.

--<test>_<polarity>: This is the name of the test (according to the table below) and polarity of the waveform.

--<index>: This is the file number. Some tests need multiple waveforms to run.

For example, the waveform file C2—Droop_p—00001.trc is file one acquired from C2, the positive input for the Maximum Output Droop test.

Table 2: Test Waveform File Names

Test Number	Name in Specification	<test> Name in File
149.5.2.1	Maximum Output Droop	Droop
1 149.5.2.2	Transmitter Linearity (SNDR)	Linearity
1 149.5.2.3.1	Transmitter Timing Jitter Master	TxJitter_Master
1 149.5.2.3.1	Transmitter Timing Jitter Slave	TxJitter_Slave
1 149.5.2.3.2.RJ	Transmitter MDI RJ in Master mode	TxRj
1 149.5.2.3.2.DJ	Transmit MDI Deterministic Jitter in master mode	JP03a
1 149.5.2.3.2.DJ	Transmit MDI DJ Even-Odd Jitter	JP03b
1 149.5.2.4	Transmitter Power Spectral Density (PSD)	PSD
1 149.5.2.5	Transmitter Peak Differential	PSD

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