QPHY-BroadR-Reach

BroadR-Reach/100Base-T1 Automotive Ethernet
Serial Data Compliance Software

Instruction Manual

December, 2019

Relating to:

XStreamDSO™ v.8.9.x.x and later
QualiPHY v.8.9.x.x and later
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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-BroadR-Reach software option.

Some of the images in this manual may show QualiPHY products other than QPHY-BroadR-Reach, 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:

- **Multiple Data Source Capability**
- **User-Defined Test 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 to help understand device performance distribution, or obtain process related information from the devices under test.

QPHY-BroadR-Reach is an automated test package performing all the normative, real-time oscilloscope tests for sources in accordance with the BroadR-Reach Physical Layer Transceiver Specification for Automotive Applications, v.3.2 and 100Base-T1 Specification, IEEE 802.3bw.

The software can be run on any Teledyne LeCroy oscilloscope with at least 1 GHz bandwidth and a sample rate of at least 10 GS/s.

Required Equipment

- Teledyne LeCroy real-time oscilloscope, installed with:
  - XStreamDSO v.7.3.x.x minimum* with an activated QPHY-BroadR-Reach option key
  - QualiPHY software v.7.3.x.x with an activated QPHY-BroadR-Reach component
  - JTA2, SDAII, or SDAIII software option**
  - XWEB option if using a WaveRunner Xi series oscilloscope

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

**Note: JTA2 functionality is standard on all Zi class oscilloscopes or later

- Two pairs of SMA cables of equal length (one is for the Distortion Test)
- 1 GHz differential probe (for probing the TX_TCLK)
- Two SMA-BNC adapters (depending on oscilloscope used)
- Automatic Waveform Generator (for Distortion Test)
- Ethernet test waveform, such as Teledyne LeCroy TF-ENET-B

Note: 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.
Remote Host Computer Requirements

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

- **Operating System:**
  - Windows 7 Professional
  - Windows 10 Professional
- **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.
  - 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)

See [Set Up Remote Control](#) for configuration instructions.
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.

Install Base Application

Download the latest version of the QualiPHY software from:

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

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 a 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

The serial data compliance components are factory installed as part of the main application in your oscilloscope and are individually activated through the use of 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 Dual Monitor Display

Teledyne LeCroy recommends running QualiPHY on an oscilloscope equipped with Dual Monitor Display capability. This allows the waveform and measurements to be shown on the oscilloscope LCD display while the QualiPHY application and test results are displayed on a second monitor.

See the oscilloscope Operator's Manual or Getting Started Manual for instructions on setting up dual monitor display.
Set Up Remote Control
QualiPHY software can be executed from a remote host computer, controlling the oscilloscope through a LAN Connection. To set up remote control:

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

Configure Oscilloscope for Remote Control
1. From the 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 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 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 the QPHY session to choose the correct connection.
QualiPHY tests the oscilloscope connection when starting a test. The system warns you if there is a connection problem.
Using QualiPHY

This section provides an overview of the QualiPHY user interface and general procedures. For detailed information about the QPHY-BroadR-Reach software option, see QPHY-BroadR-Reach Testing.

Accessing the Software

Once QualiPHY is installed and activated, it can be accessed from the oscilloscope menu bar by choosing Analysis > QualiPHY, or by double-clicking the QualiPHY desktop icon on a remote computer.

The QualiPHY wizard dialog illustrates the overall software flow, from general set up through running individual compliance tests. Work from left to right, making all desired settings on each sub-dialog.

The sub-dialogs are organized into tabs each containing configuration controls related to that part of the process. These are described in more detail in the following sections.

If Pause on Failure is checked, QualiPHY prompts to retry a measure whenever a test fails.

Report Generator launches the manual report generator dialog.

The Exit button at the bottom of the wizard dialog closes the QualiPHY application.

Figure 1. QualiPHY wizard dialog and Standard selection menu
General Setup
The first sub-dialog contains general system settings. These remain in effect for each session, regardless of Standard, until changed.

Connection tab
Shows IP Address of the test oscilloscope (local host 127.0.0.1 if QualiPHY is run from the oscilloscope). The Scope Selector allows you to choose the oscilloscope used for testing when several are connected to the QualiPHY installation. See Set Up Remote Control for details.

Session Info tab
Optional information about the test session that may be added to reports, such as: Operator Name, Device Under Test (DUT), Temperature (in °C) of the test location, and any additional Comments. There is also an option to Append Results or Replace Results when continuing a previous session. To optimize report generation, enter at least a DUT name at the beginning of each session.

Report tab
Global settings related to automatic report generation. Choose:

- Reporting behavior of:
  - “Ask to generate a report after tests,” where you’ll be prompted to create a new file for each set of test results.
  - “Never generate a report after tests,” where you'll need to manually execute the Report Generator to create a report.
  - “Always generate a report after tests,” to autogenerate a report of the latest test results.
- Default report output type of XML, HTML, or PDF.
- A generic Output file name, including the full path to the report output folder.

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

Report Generator launches the Report Generator dialog, which contains the same settings as the Report tab, only applied to individual reports.

Advanced tab
This tab launches the X-Replay Mode dialog. See X-Replay Mode.

About tab
Information about your QualiPHY installation.
QualiPHY Test Process

Once general system settings are in place, these are the steps for running test sessions.

**Set Up Test Session**

1. Connect the oscilloscope to the DUT. See QPHY-BroadR-Reach Testing Physical Setup.
2. Access the QualiPHY software to display the wizard dialog.
3. If running QualiPHY remotely, click **General Setup** and open the **Scope Selector** to select the correct oscilloscope connection.
4. If you have more than one component activated, click **Standard** and select the desired standard to test against. Otherwise, your one activated component will appear as the default selection.
   
   **Note:** Although all the QualiPHY components appear on this dialog, only those selected when installing QualiPHY are enabled for selection.
5. Click the **Configuration** button and select the test configuration to run. These pre-loaded configurations are set up to run all the tests required for compliance and provide a quick, easy way to begin compliance testing. See QPHY-BroadR-Reach Test Configurations for a description of your configurations.

   You can also create custom configurations for internal compliance tests by copying and modifying the pre-loaded configurations. See Customizing QualiPHY for details.
6. **Close** the Edit/View Configuration dialog to return to the wizard dialog.
Run Tests

1. On the wizard dialog, click **Start** to begin testing.

   When tests are in progress, this button changes to **Stop**. Click it at any time to stop the test in process. You’ll be able to resume from the point of termination or from the beginning of the test.

2. Follow the pop-up window prompts. QualiPHY guides you step-by-step through each of the tests described in the standard specification, including diagrams of the connection to the DUT for each required test mode.

3. When all tests are successfully completed, both progress bars on the wizard dialog are completely green and the message “All tests completed successfully” appears. If problems are encountered, you’ll be offered options to:
   - **Retry** the test from the latest established point defined in the script
   - **Ignore and Continue** with the next test
   - **Abort Session**
**Generate 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 once a test is run.

The Report Generator offers the same selections as the Report tab, only applied to each report individually, rather than as a system setting. This enables you to save reports for each test session, rather than overwrite the generic report file. 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.

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

Create custom test configurations by copying one of the standard configurations and modifying it. The pre-loaded configurations cannot be modified.

**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 with the defined name.

   **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:** When any configuration is changed, the Save As button at the bottom of the Configuration tab becomes active. When a custom configuration is changed, the Save button also becomes active to apply the changes to the existing configuration, rather than make another copy.
Select Tests
On the Test Selector tab, check the tests that make up the configuration. Each test is defined by the BroadR-Reach standard. A description of each test is displayed when it is selected.

To loop an individual test or group of tests, select it from the list, then choose to loop indefinitely until stopped or enter the number of repetitions. When defining a number of repetitions, enter the number of repetitions before enabling the checkbox.

Figure 3. Configuration Test Selector tab
**Edit Variables**

The Variable Setup tab contains a list of test variables. See [QPHY-BroadR-Reach Variables](#) for a description of each.

To modify a variable:

1. Select the variable on the Variable Setup tab, then click **Edit Variable**. (You can also choose to Reset to Default at any time.)

2. The conditions of this variable appear on a pop-up. Choose the new condition to apply.
**Edit Test Limits**

The Limits tab shows the Limit Set currently associated with the configuration. Any limit set can be associated with a custom configuration by selecting it in this field.

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:

1. On the Limits tab, click **Limits Manager**.
2. With the default set selected, click **Copy Set** and enter a name.
   
   **Note**: You can also choose to copy and/or modify another custom set that has been associated with this configuration.

3. 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 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 BroadR-Reach 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. Select the session and choose Report > Create Report from the menu bar.

- 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.

![Figure 4. X-Replay Mode window](image)
QPHY-BroadR-Reach Testing

Test Preparation
Before beginning any data acquisition or test, warm the oscilloscope for at least 20 minutes.
Calibration is performed automatically 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.

Required Test Modes
The QPHY-BroadR-Reach script requires that you place the DUT (Device Under Test) in 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.

Physical Setup
If using the TF-ENET-B test fixture, do the following:

1. If the oscilloscope has BNC inputs, connect BNC-SMA adapters to C2 and C3.
2. Place the TF-ENET-B board in front of or next to the oscilloscope. Ensure it is close enough that
   the SMA cables will reach.
3. Connect the SMA cables to the J33 and J54 outputs at one end to the CH4 section of the TF-
   ENET-B board.
4. Connect the other end of each cable to oscilloscope C2 and C3. The positive end should be
   connected to C2, and the negative end should be connected to C3.
5. Connect the RJ45 end of the UTP/RJ45 adapter (an example of such adapter is shown below)
   to the J64 input on the CH4 section of the TF-ENET-B board.

Figure 5. Example of RJ45/UTP adapter
Due to the variety of potential connectors on the UTP cable, the operator may choose to create an SMA Breakout fixture which will mate with their connector.

![Example of custom SMA breakout fixture](image)

*Figure 6. Example of custom SMA breakout fixture*

**QPHY-BroadR-Reach Test Configurations**

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

- **All Tests on Live Data, Single-ended, Input A**
  This configuration performs all tests 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.

- **Demo of All Tests**
  This configuration performs a demonstration of all QPHY-BroadR-Reach 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.
QPHY-BroadR-Reach Test Descriptions

These are the standard BroadR-Reach compliance tests.

For additional information about the tests supported by QPHY-BroadR-Reach please refer to the BroadR-Reach Physical Layer Transceiver Specification For Automotive Applications, v.3.2 and 100Base-T1 Specification. The descriptions in the following tests will refer to various sections of this document.

**Test Mode 1 - Droop**

This test measures transmitter output droop as defined in Section 5.4.1 of the specification. The test requires that the DUT be placed in Test Mode 1.

**What Is Measured**

The magnitude of both the positive and negative droop is measured with respect to the initial peak value after the zero crossing and the value 500 ns after the initial peak. A passing droop value must be less than 45.0%.

![Figure 7. Definition of Droop](image)

The oscilloscope is set to the maximum sample rate, 200 ns/div, and to trigger on a negative edge. The acquired signal has two bits of enhanced resolution (ERES) applied to it in order to limit the bandwidth of the oscilloscope to a value which is suitable for this measurement. The initial peak is measured on both the +1 (Vpk+) and -1 (Vpk-) symbols. The initial peak is determined by measuring the maximum or minimum value on a gated portion of the waveform. The droop value is measured 500 ns from the initial peak on both the +1 (Vd+) and -1 (Vd-) symbols. The droop for each symbol is calculated by $100 \times \left( \frac{V_d}{V_{pk}} \right) \%$. The calculated droop values are then compared to 45.0% using pass/fail testing.
Figure 8 – Transmitter Output Droop

Shown on the screen:

- F1 is the input differential signal that is being measured

In the Measure table:

- t1 is the zero crossing time of the positive edge and t2 is the zero crossing time of the negative edge.
- Vpk+ is the maximum value of input signal and Vpk- is the minimum value of input signal.
- Vdrooped+ is the value 500 ns after the maximum value and Vdrooped- is the value 500 ns after the minimum value.
- Droop+ is the droop calculated on the +1 symbol and Droop- is the droop calculated on the -1 symbol.
- Q7 compares Droop+ to 45.0% and Q8 compares the Droop- to 45.0%.
**Test Mode 2 - Transmitter Jitter & Clock Frequency (Master)**

This test measures MDI output jitter, J_TXOUT, as defined in Section 5.4.3 of the specification, and transmit clock frequency as defined in Section 5.4.5 of the specification. The test requires that the DUT be placed in Test Mode 2.

**What Is Measured**

The RMS of J_TXOUT is calculated and compared to 50 ps. Using the same acquired signal, the symbol rate is also measured, and the rise and fall times are calculated for informational purposes.

**Test Methodology**

The oscilloscope is set to acquire 1 ms at 10 GS/s relative to an unjittered reference, resulting in 10 Mpts. By sampling in this manner, very low frequency components are filtered out. The acquired signal has two bits of enhanced resolution (ERES) applied to it in order to limit the bandwidth of the oscilloscope to a value which is suitable for this measurement. The RMS value of the jitter track for the acquired signal is calculated. The calculated value is then compared to 50 ps using pass/fail testing. The bit rate (half of the symbol rate) of the acquired signal is also measured and the compared to 33.3 MHz +/- 100 ppm using pass/fail testing. Lastly, the 10%-90% rise and fall times are calculated for informational purposes.

![Figure 9. Transmitter Jitter (Master) and Transmit Clock Frequency](image_url)

Shown on the screen:

- F1 is the input differential signal which the measurements will be performed on
- F2 is a TIE-track of input signal.

In the Measure table:

- P1 is a RMS of the jitter track.
- P2 is the rise time (10%-90%) of input signal and P3 is the fall time (10%-90%) of input signal.
- P4 is the bitrate (half the symbol rate) of input signal.
- Q2 is compares the RMS value of the jitter track to 50 ps.
- Q5 compares the bitrate to 33.3 MHz +/- 3.33 mHZ (100 ppm).
**Test Mode 3- Transmitter Jitter (Slave)**

This test measures slave jitter, TX_TCLK, as defined in Section 5.4.3 of the specification, and transmit clock frequency as defined in Section 5.4.5 of the specification. The test requires that the Slave is receiving valid signals from a compliant PHY operating as the Master and is configured as shown below. The DUT must be placed in Test Mode 3.

![Diagram](image.png)

*Figure 10. Transmitter Jitter (Slave) and Transmit Clock Frequency setup*

**What Is Measured**

The RMS of TX_TCLK is calculated and should be less than 0.01 UI. Using the same acquired signal, the symbol rate is also measured, and the rise and fall times are calculated for informational purposes.

**Test Methodology**

The oscilloscope captures a 1 ms acquisition at 10 GS/s relative to an unjittered reference resulting in 10 Mpts. By sampling in this manner, very low frequency components are filtered out. The acquired signal has two bits of enhanced resolution (ERES) applied to it in order to limit the bandwidth of the oscilloscope to a value which is suitable for this measurement. The RMS value of the jitter track for the acquired signal is calculated. The calculated value is then compared to 0.01 UI using pass/fail testing. The bit rate (half of the symbol rate) of the acquired signal is also measured and the compared to 33.3 MHz +/- 50 ppm using pass/fail testing. Lastly, the 10%-90% rise and fall times are calculated for informational purposes.
Shown on the screen:

- F1 is the input differential signal that is being measured.
- F2 is a TIE-track of input signal.

In the Measure table:

- P1 is a RMS of the jitter track.
- P2 is the rise time (10%-90%) of input signal and P3 is the fall time (10%-90%) of input signal.
- P4 is the bitrate (half the symbol rate) of input signal.
- Q2 is compares the RMS value of the jitter track to 150 ps.
- Q5 compares the bitrate to 33.3 MHz +/- 3.33 mHZ (100 ppm).
**Test Mode 4 - Distortion**

This test measures the peak distortion of the transmitter and checks to see if it is within the limits defined in Section 5.4.2 of the specification. The DUT is required to be placed in Test Mode 4.

**What Is Measured**
The oscilloscope captures a 200 µs waveform at 10 GS/s. The acquired waveform is processed by a procedure following the pseudo-code provided in the specification used to obtain the distortion values for all ten sample phases.

**Disturbing Sine Wave Setup**
This test can be run with or without a disturbing sine wave as defined by the variable, “Use disturber?”

If a disturbing sine wave is used, the connection diagram will prompt you to use the 1000Base-T Template Test section of the TF-ENET-B. This section of the test fixture allows the DUT to be subjected to the disturbing sine wave but allows very little of the disturbing sine wave to reach the oscilloscope.

![Figure 12. Connection diagram for Transmitter Distortion Test using TF-ENET-B](image-url)
The disturbing sine wave shall be applied with the following characteristics.

![Figure 13. Disturbing Sine Wave characteristics](image)

To generate the disturbing sine wave using a dual-channel waveform generator, apply a 180-degree phase shift to create a differential sine wave.

To verify the amplitude of the disturbing sine wave the following procedure can be used:

1. Set F1 to the Difference of C2 and C3
2. Set P1 to be the Peak to Peak of F1
3. Adjust the Amplitude of the disturbing sine wave until the Peak to Peak reads 2.7 V.
**Test Methodology**

The oscilloscope captures a single 200 microsecond waveform of 2 MS at 10GS/s or 4 MS at 20 GS/s. A precise value of the symbol rate is determined and using digital resampling, a record of approximately equal duration but with samples at exactly 10 Samples per symbol period. A procedure following the pseudo-code provided in the specification is used to obtain the distortion values for all ten sample phases.

**Note:** while the disturber removal part of the procedure is followed, and additional procedure is also implemented to remove a disturber signal that is not exactly 1/6 of the symbol rate (as it is common for the test setup to be inexact in this regard). Nonetheless the disturber source should be within 10 ppm of the exact frequency.

![Figure 14. Transmitter Distortion](image)

Shown on the screen: **Errors** is the positive pulse used for the test from the run of +1 symbols.

In the Measure table: **Distortion** (P5) is measured distortion value for the 10th instance. The measured value for each phase is reported as **Distortion at phase x**. The recoded results will indicate whether a disturber was used. This test is considered passing if the **Overall Max** Distortion value is less than 15 mV.
Test Mode 5 – PSD & Peak Differential Output
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 for informational purposes. The DUT is required to be placed in Test Mode 5.

PSD Test

What Is Measured
A 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 1 Mpts at 10 GS/s. The PSD is calculated by performing a FFT on the acquired signal. A boxcar filter of length 60 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. P1 measures the maximum of the FFT for informational purposes. The test will run until a passing result is measured or 300 sweeps have been performed.

Figure 15. Transmitter Power Spectral Density (PSD)

Shown on this screen:
- F2 is a Power Spectrum of the input signal with a Boxcar filter applied to it.

In the Measure table:
- P1 is the maximum value of the Power Spectrum.
- Q1 checks to see if the Power Spectrum is contained by the mask.
QPHY-BroadR-Reach Variables

General Variables

Acquire Live Data
When TRUE, the script will perform a new acquisition after setting the horizontal scale.
You can set this to FALSE if the waveform(s) being tested are in Memories.

Demo Mode
When On, tests are run as a demonstration using saved waveforms that are automatically recalled into Memories as needed. The user is shown connection diagrams and prompts so as to experience the tests as if run on live data. Default is Off.

Note: Waveforms for this demo are stored in the QPHY-BroadR-Reach script file.

Differential Data Source
Differential source signal to be tested when using a differential probe or equivalent. Signal Is Differential should be set to TRUE. Valid sources include C1-C4, M1-M4, and F1-F4.

Input Row
Input used on oscilloscopes with both low- and high-bandwidth inputs per channel. Input A is the default.

Saved Waveform Path
Full path to the root folder in which waveform data will be saved after each test. The default D:\ path assumes QualiPHY is run from the oscilloscope. If you are running QualiPHY remotely, or if you change the path, be sure the directory is accessible to the oscilloscope and is not “Read Only.”

Note: The path must end with a backslash \, as subfolders will be appended to it.

Save waveforms?
Specifies whether or not to store waveform files in the Saved Waveform Path directory following each test. Default is No.

Signal Is Differential
Set to TRUE when using a differential probe or equivalent, or FALSE when using two, single-ended inputs.

When FALSE, the oscilloscope will calculate the difference between the + signal and the - signal to serve as the differential signal.

+ Data Source
Source used for the positive side of a pair of singled-ended inputs. Default is C2.

- Data Source
Source used for the negative side of a pair of singled-ended inputs. Default is C1.

Pause After Test to Review Results
When On, 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 Off, the script will continue to its conclusion without pause, except when a change in Test Mode requires it.
**Test Mode 3 Variables**

**TX_TCLK Source**
Source of the Slave TX_TCLK signal. If the DUT does not have access to TX_TCLK, Test Mode 3 may be used.

Valid values are C1-C4 and M1-M4. Default is C4.

**Test Mode 4 Variables**

**Use disturber?**
The BroadR-Reach specification requires a disturbing sine wave, Vd, to be applied to the test fixture during the Test Mode 4 Distortion test. Choose Yes if a baud/6 disturber signal is applied; otherwise, No.

**Note:** Vd should be 11.1111 MHz and have a differential amplitude of 2.7 V as seen by the transmitter.

**Use external reference clock?**
According to the BroadR-Reach specification, both the disturbing sine wave generator and the oscilloscope sampling clock should be frequency locked to the device's bit rate, or the data needs to be resampled to exactly the right number of samples per bit.

To use an external reference clock, choose Yes, derive a 10 MHz reference from the DUT's clock, and connect it to both the oscilloscope and the disturbing sine wave generator. When set to No, the script will resample the signal as an alternative to using an external reference clock.

**Note:** If you are using a disturbing sine wave and resampling changes the frequency by more than a few ppm, you may need to compensate by changing the frequency of the disturbing sinewave, so it will be correct after resampling.

**QPHY-BroadR-Reach Limit Sets**
The default installation of QPHY-BroadR-Reach contains only one limit set, called “Default”. The limits in this set are those specified by the BroadR-Reach Physical Layer Transceiver Specification For Automotive Applications, v.3.2 and 100Base-T1 Specification.
Appendix A: Manual Deskewing Procedure

The following procedure demonstrates how to manually deskew two oscilloscope channels and cables using the differential data signal, with no need for any T connector or adapters.

Warm the oscilloscope for at least a half-hour before proceeding. This procedure should be run again if the temperature of the oscilloscope changes by more than a few degrees.

1. Connect a differential data signal to C1 and C2 using two approximately matching cables. Set up the oscilloscope to use the maximum sample rate. Set the timebase for a few repetitions of the pattern (at least a few dozen edges).

   ![Diagram of Cables and Channels]

2. On the C3 menu, check Invert. Now C1 and C2 should look the same.

3. Using the Measure Setup, set P1 to measure the Skew of C1, C2. Turn on Statistics (Measure menu). Write down the mean skew value after it stabilizes. This mean skew value is the addition of Data skew + cable skew + channel skew.

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

   ![Diagram of Cables and Channels after Swap]

5. Write down the mean skew value after it stabilizes. This mean skew value is the addition of (- Data skew) + cable skew + channel skew.

6. Add the two mean skew values and divide the sum in half:

   \[
   \frac{[\text{cable skew + channel skew}]}{2}
   \]

7. Set the resulting value as the Deskew value in C1 menu.

8. Restore the cable connections to their Step 1 settings (previous). Press the Clear Sweeps button on the oscilloscope. The mean skew value should be approximately zero - that is the data skew. Typically, results are <1ps given a test fixture meant to minimize skew on the differential pair.

9. On the C2 menu, clear the Invert checkbox and turn off the parameters.
In the previous procedure, we used the default setup of the Skew parameter (which is detecting positive edges on both signals at 50%). We also inverted C2 in order to make C1 and C2 both have positive edges at the same time.

Alternately, we could have not inverted C2 and instead selected the Skew Clock 2 tab in the P1 parameter menu and set the oscilloscope to look for negative edges on the second input (C2). However, we believe that the previous approach is much more aesthetically pleasing on the display, as it shows C1 and C2 with the same polarity.