



QPHY-SATA Serial ATA Serial Data Operator's Manual

Revision A – February, 2008

Relating to the Following Release Versions:

- **Software Option Rev. 5.3**
- **SATA Script Rev. 1.2**
- **Style Sheet Rev. 1.2**

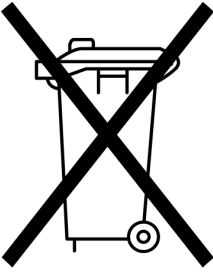
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INTRODUCTION

QPHY-SATA is a software package designed to capture, analyze, and report measurements in conformance with Serial ATA II electrical specification standards. A current copy of the specification can be found at www.serialata.org.

The Serial ATA International Organization (SATA-IO) Interoperability Program outlined a list of tests a product must meet in order to gain acceptance to the integrator's list. QPHY-SATA covers those tests appropriate for real-time oscilloscopes.

SATA II has two speeds (Gen1 at 1.5Gb/s and Gen2 at 3.0Gb/s) and at each speed there are three different configurations or usage modes:

- **i** = internal
- **m** = "Short" Backplane and External Desktop Applications
- **x** = "Long" Backplane and Data Center Applications (not covered by the Interoperability Program)

Compatibility

QPHY-SATA is a software option compatible with the following LeCroy X-Stream oscilloscopes:

- SDA 6000, 6000A (4x10 GS/s, 2x20 GS/s)
- SDA 6020 (4x20 GS/s)
- SDA 9000 (4x20 GS/s at 6 GHz bandwidth, 2x40 GS/s at 9 GHz bandwidth)
- SDA 11000 (4x20 GS/s at 6 GHz bandwidth, 2x40 GS/s at 11 GHz bandwidth)
- SDA 13000 (4x20 GS/s at 6 GHz bandwidth, 2x40 GS/s at 13 GHz bandwidth)

Because the SATA specification for Gen1 and Gen2 data rate is 1.5Gb/s and 3.0Gb/s, respectively, oscilloscope bandwidths less than 6 GHz for Gen1 and 11 GHz for Gen2, are not recommended. The SATA specification requires at least 10 GHz bandwidth for certain Gen2 measurements.

SATA Test Fixture

Test fixtures are required to connect the signal under test to the oscilloscope running the QPHY-SATA software. A fixture kit is available from LeCroy (part number TF-SATA) and consists of the test fixture and two 30-inch cables with SMA connectors. They provide a means to probe the product under test via a standard SMA connector interface. The same fixture is compatible with both Gen1 and Gen2 SATA standards.

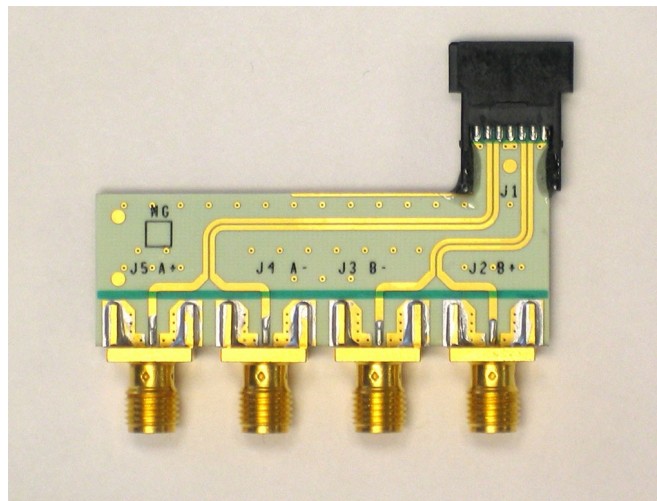


Figure 1. TF-SATA Test Fixture



SETUP AND INSTALLATION

The following test equipment is required to perform SATA tests.

Equipment Available from LeCroy

- Real Time Digital Oscilloscope: LeCroy SDA 6000A, SDA 6020, SDA 9000, SDA 11000 or SDA 13000 with firmware release 5.2.2.1 or later, and software option package ASDA-J Advanced Serial Data Analysis
- LeCroy Serial ATA Test Fixture: TF-SATA
- 50Ω Coax Cable with SMA Male Connectors, qty = 2 (supplied with test fixture)
- SMA 6dB attenuators, qty = 2 (required for compliance testing)
- BIST initiator

Additional Equipment

- Product Under Test: Disk drive or other device equipped with SATA-approved connector
- 1 Channel Arbitrary Waveform Generator (for OOB tests)
- 50Ω Coax Cable with SMA Male Connectors, qty = 3 (in addition to the 2 listed above, for OOB tests)

Recommended Equipment for BIST initiator

- LeCroy SAS Tracer/Trainer 3G 1 Port Analyzer/Exercise System (SS001APA-X) to place the product under test (PUT) into the required test mode includes:
 - CATC platform
 - SAS Tracer 3G 1 Port Module
 - SAS Trainer 3G Traffic Generator Module
- Host Computer with SAS Tracer/Trainer Version 2.8 or later software loaded, and a USB 2.0 port
- 1 USB cable type-A (m) to type-B (m)
- 2 Serial ATA cables

QUALIPHY COMPLIANCE TEST PLATFORM

QualiPHY is LeCroy's unique compliance test framework which leads the user through the compliance tests. QualiPHY displays connection diagrams to ensure tests run properly, automates the oscilloscope setup, and generates full compliance reports.

QualiPHY makes SATA compliance testing easy and fast. QualiPHY is designed to use the TF-SATA test fixture.

The QualiPHY software application automates the test and report generation.

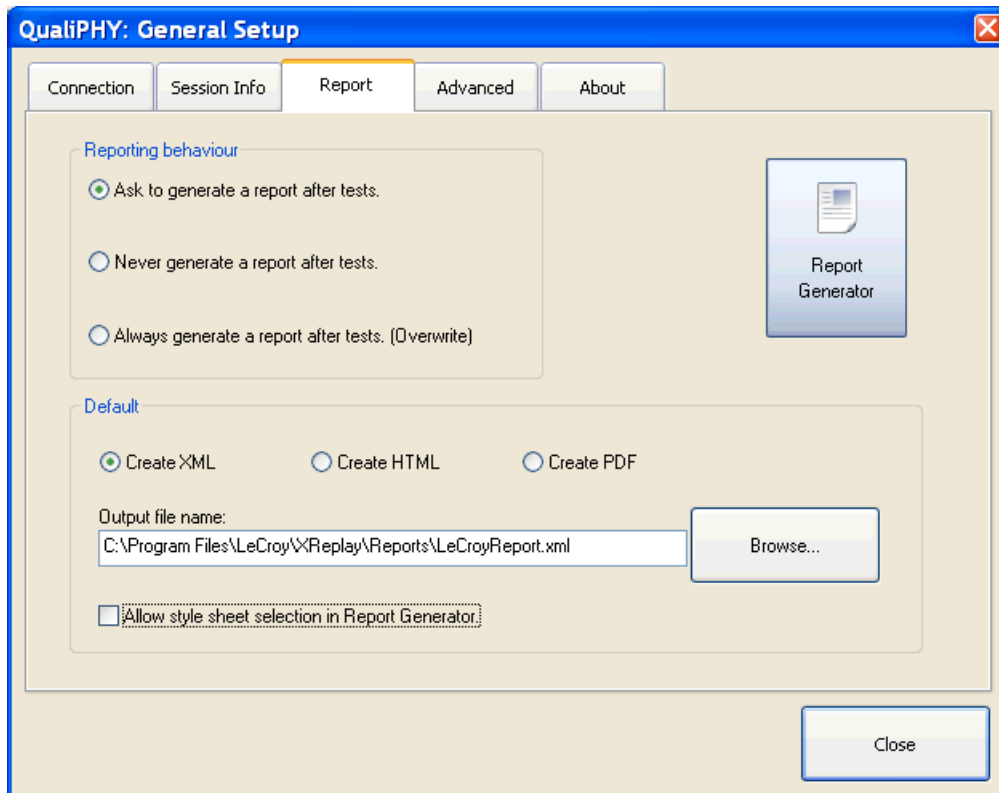


Figure 2. Report menu in QualiPHY General Setup

See the *QualiPHY Operator's Manual* for more information on how to use the QualiPHY framework.



SATA PHY, TSG, OOB Test Report

Overall result: **Pass**

DUT: Demo
 Comment: Gen2
 Time of test: 11/30/2007 18:17:29
 Operator: chris
 Temperature: 0° C

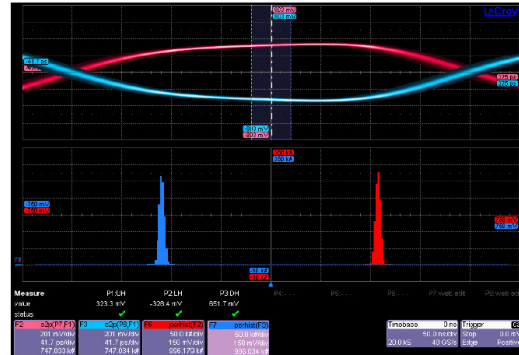
Configuration in use: Demo of 3.0 Gb/s tests without SSC
 Limits in use: Gen2
 Standard in use: SATA PHY, TSG, OOB
 Oscilloscope Name: LCRY0409N11978 Model: SDA11000
 Oscilloscope Serial #: LCRY0409N11978
 Computer:

Oscilloscope firmware version: 5.2.2.1 (Build 100943)
 QualiPHY core version: 5.2.1.0 (Build 100974)
 QualiPHY script version: 1.1.5
 Stylesheet version: 1.1

Waveform path on oscilloscope: D:\Waveforms\SATA

Summary Table

Pass	Test	Measurement	Current Value	Test Criteria
[i]	PHY-01	Unit Interval Min	333.295 ps	Informational Only
[i]	PHY-01	Unit Interval Max	333.347 ps	Informational Only
[i]	PHY-01	Unit Interval Mean	333.318 ps	333.217 ps <= n <= 335.117 ps
[i]	PHY-02	ISI	45.17 ppm	-350.00 ppm <= n <= 350.00 ppm
[i]	TSG-01	LH HFTP	323.3 mV	Informational Only
[i]	TSG-01	RH HFTP	-328.4 mV	Informational Only
[i]	TSG-01	DH HFTP	651.7 mV	>= 400.0 mV
[i]	TSG-01	LM MFTP	302.7 mV	Informational Only
[i]	TSG-01	RM MFTP	-307.3 mV	Informational Only
[i]	TSG-01	DM MFTP	610.0 mV	>= 400.0 mV
[i]	TSG-01	ALBIP	299.3 mV	Informational Only
[i]	TSG-01	RLBIP	-305.8 mV	Informational Only

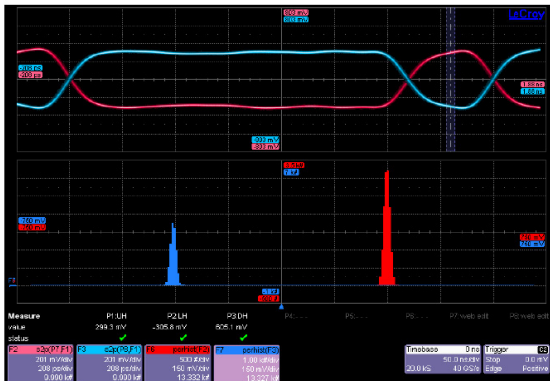


TSG-01: VDiffMin HFTP
 Timestamp: 11/30/2007 18:18:56

Test TSG-01 - Differential Output Voltage MFTP

[i]	Measurement:	LM MFTP
	Limit Name:	InfoOnlyV
	Current Value:	302.7 mV
	Test Criteria:	Informational Only
	Timestamp:	11/30/2007 18:19:42
	TXnWaveform:	File: C3IL_MFTP_3G.trc
	TXpWaveform:	File: C2IL_MFTP_3G.trc
	pattern:	MFTP

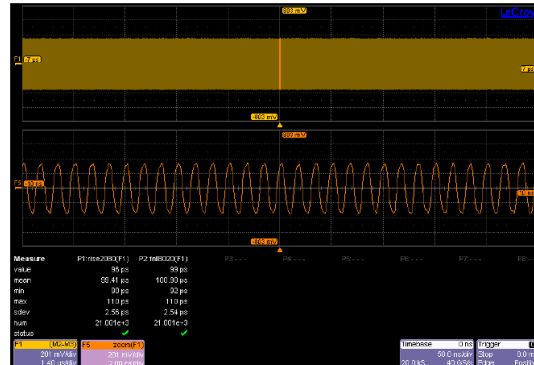
[i]	Measurement:	RM MFTP
	Limit Name:	InfoOnlyV
	Current Value:	-307.3 mV
	Test Criteria:	Informational Only
	Timestamp:	11/30/2007 18:19:42
	TXnWaveform:	File: C3IL_MFTP_3G.trc
	TXpWaveform:	File: C2IL_MFTP_3G.trc
	pattern:	MFTP



TSG-01: VDiffMin LBP
 Timestamp: 11/30/2007 18:20:54

[i]	Measurement:	DL MFTP
	Limit Name:	supi
	Current Value:	0.0 m
	Test Criteria:	Informational Only
	Timestamp:	11/30/2007 18:19:52
	TXnWaveform:	File: C3IL_MFTP_3G.trc
	TXpWaveform:	File: C2IL_MFTP_3G.trc
	pattern:	MFTP

[i]	Measurement:	pl MFTP
	Limit Name:	supi
	Current Value:	0.0 m
	Test Criteria:	Informational Only
	Timestamp:	11/30/2007 18:19:52



TSG-02: Rise/Fall Time
 Timestamp: 11/30/2007 18:19:00

Test TSG-02 - Rise/Fall Time LFTP

[i]	Measurement:	TX Rise LFTP
	Limit Name:	InfoOnlySec
	Current Value:	102.314 ps
	Test Criteria:	Informational Only
	Timestamp:	11/30/2007 18:20:32
	TXnWaveform:	File: C3IL_LFTP_3G.trc
	TXpWaveform:	File: C2IL_LFTP_3G.trc
	pattern:	LFTP

[i]	Measurement:	TX Fall LFTP
	Limit Name:	InfoOnlySec
	Current Value:	103.324 ps
	Test Criteria:	Informational Only
	Timestamp:	11/30/2007 18:20:32

Figure 3. The Test Report includes a summary table with links to the detailed test results

Oscilloscope Option Key Installation

An option key must be purchased to enable the QPHY-SATA option. Call LeCroy Customer Support to place an order and receive the code.

Enter the key and enable the purchased option as follows:

1. From the oscilloscope menu select **Utilities** → **Utilities Setup...**
2. Select the **Options** tab and click the **Add Key** button.
3. Enter the **Key Code** using the on-screen keyboard.
4. Restart the oscilloscope to activate the option after installation.

Typical (Recommended) Configuration

QualiPHY software can be executed from the oscilloscope or a host computer. The first step is to install QualiPHY. Please refer to the *QualiPHY Operator's Manual* for installation instructions.

LeCroy recommends running QualiPHY on an oscilloscope equipped with Dual Monitor Display capability (Option DMD-1 for oscilloscopes where this is not standard). 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.

By default, the oscilloscope appears as a local host when QualiPHY is executed in the oscilloscope. Follow the steps under **Oscilloscope Selection** (as follows) and check that the IP address is 127.0.0.1.

Remote (Network) Configuration

It is also possible to install and run QualiPHY on a host computer, controlling the oscilloscope with a Network/LAN Connection.

The oscilloscope must already be configured, and an IP address (fixed or network-assigned) must already be established.

Oscilloscope Selection

Set up the oscilloscope using QualiPHY over a LAN (Local Area Network) by doing the following:

1. Make sure the host computer is connected to the same LAN as the oscilloscope. If unsure, contact your system administrator.
2. From the oscilloscope menu, select **Utilities** → **Utilities Setup...**
3. Select the **Remote** tab.
4. Verify the oscilloscope has an IP address and the control is set to TCP/IP.
5. Run QualiPHY in the host computer and click the **General Setup** button.
6. Select the **Connection** tab.
7. Enter the IP address from step 4 (previous).
8. Click the **Close** button.

QualiPHY is now ready to control the oscilloscope.

QualiPHY tests the oscilloscope connection after clicking the **Start** button. The system prompts you if there is a connection problem. QualiPHY's **Scope Selector** function can also be used to verify the connection. Please refer to the **QualiPHY Operator's Manual** for explanations on how to use **Scope Selector** and other QualiPHY functions.

Accessing the QPHY-SATA Software using QualiPHY

This topic provides a basic overview of QualiPHY's capabilities. Please refer to the **QualiPHY Operator's Manual** for detailed information.

Access the QPHY-SATA software using the following steps:

1. Wait for the oscilloscope to start and have its main application running.
2. Launch QualiPHY from the **Analysis** menu if installed on the oscilloscope or from the desktop icon if installed on a host computer.
3. From the QualiPHY main window (as follows), select **Standard**, then **SATA PHY, TSG, OOB** from the pop-up menu (if not already selected). If you check the **Pause on Failure** box (circled) QualiPHY prompts to retry the measure whenever a test fails.

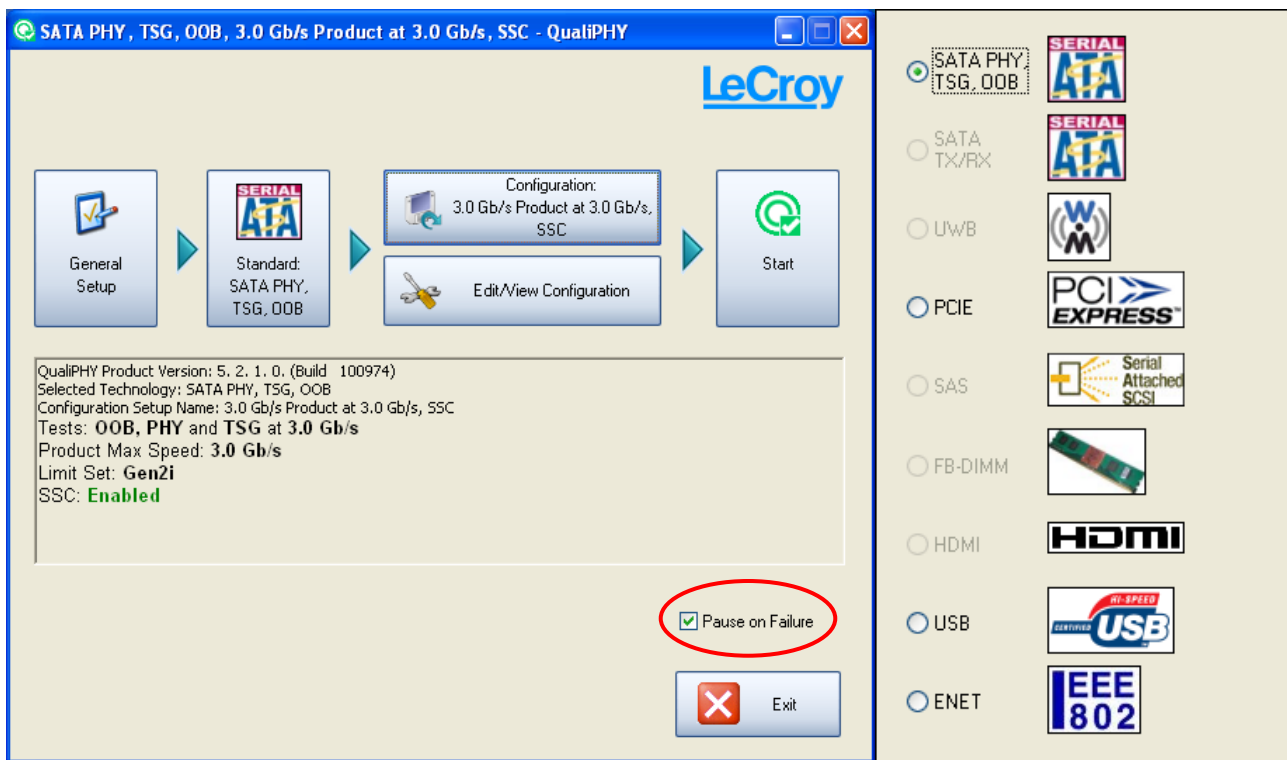


Figure 4. QualiPHY main menu and compliance test Standard selection menu

- Click the **Configuration** button in the QualiPHY main menu:



- Select a configuration from the pop-up menu:

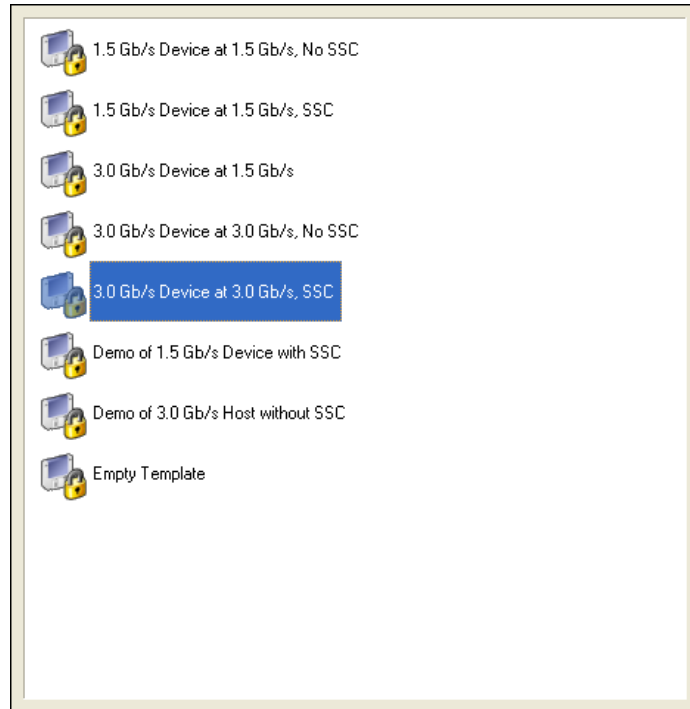


Figure 5. QualiPHY configuration selection menu

- Click **Start**.



- Follow the pop-up window prompts.

Customizing QualiPHY

The predefined configurations in the **Configuration** screen cannot be modified. However, you can create your own test configurations by copying one of the standard test configurations and making modifications. A description of the test is also shown in the description field when selected.

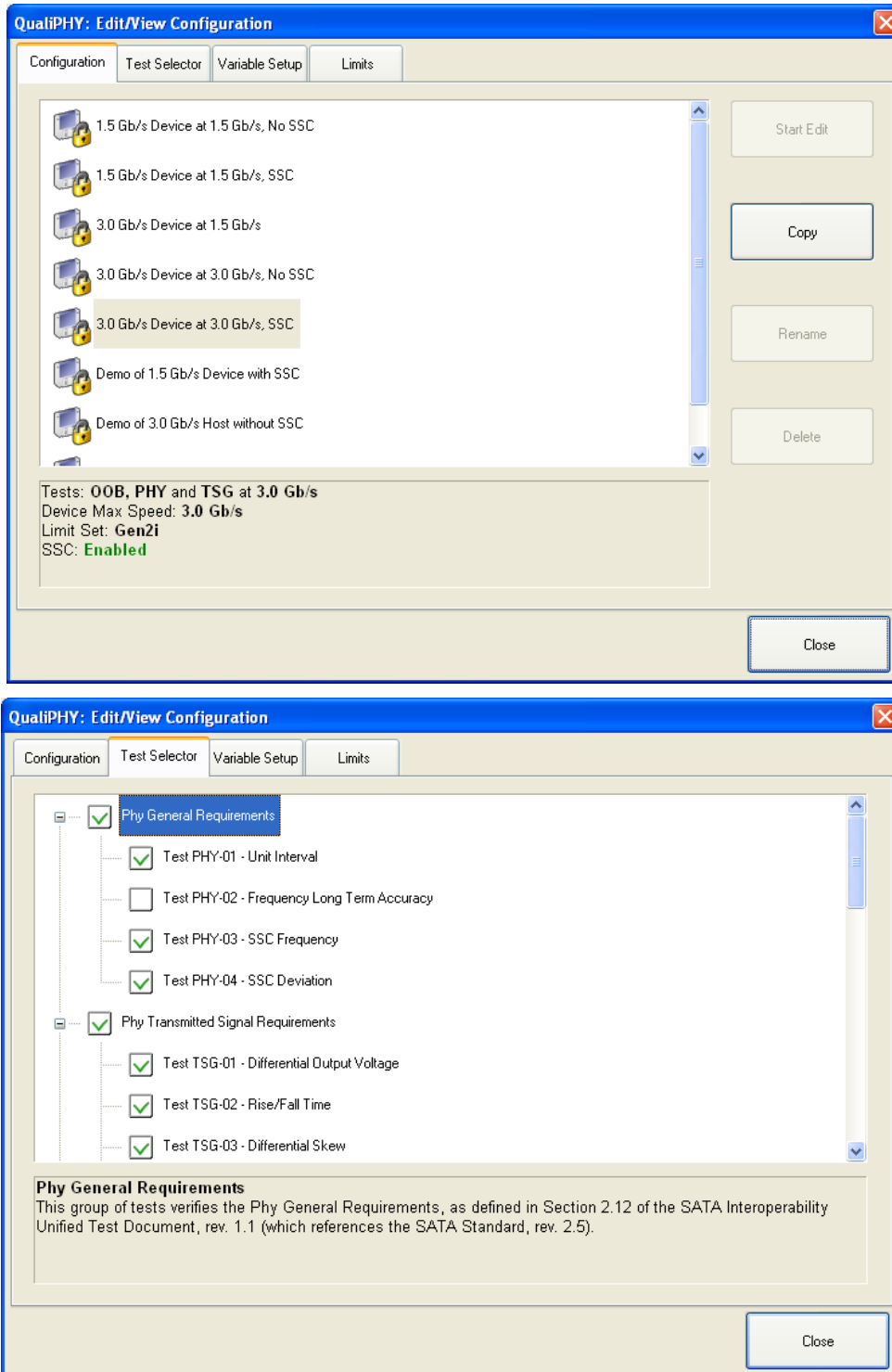


Figure 6. QualiPHY test item selection menu

Once a custom configuration is defined, script variables and the test limits can be changed by using the **Variable Setup** and **Limits Manager** from the **Edit/View Configuration** window.

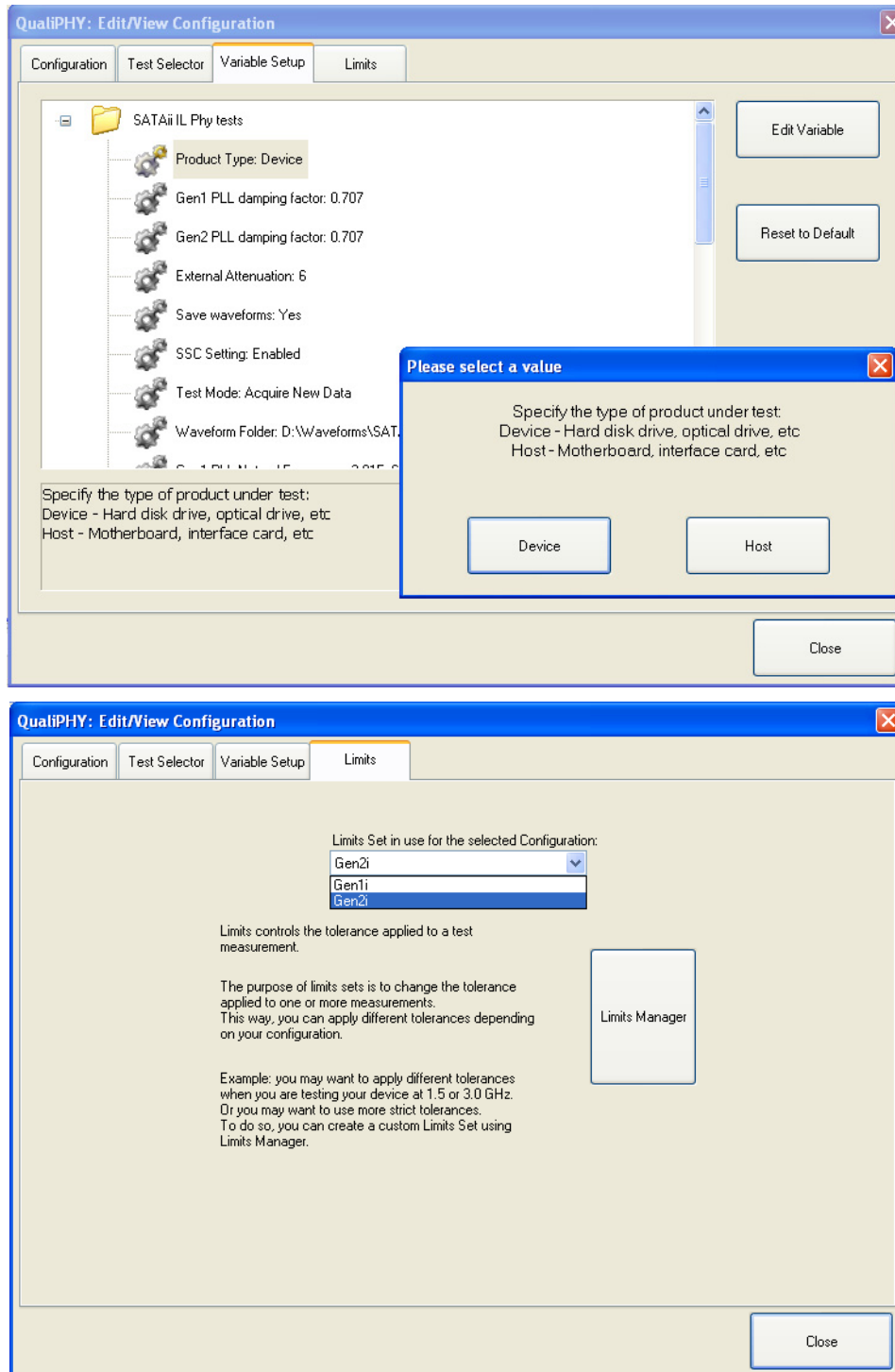


Figure 7. Variable Setup and Limits Manager windows

QPHY-SATA Operation

After pressing **Start** in the QualiPHY menu, the software instructs how to set up the test using pop-up connection diagrams and dialog boxes. QualiPHY also instructs how to properly configure the Product Under Test (PUT) to change test signal modes (when necessary).



Figure 8. Start button

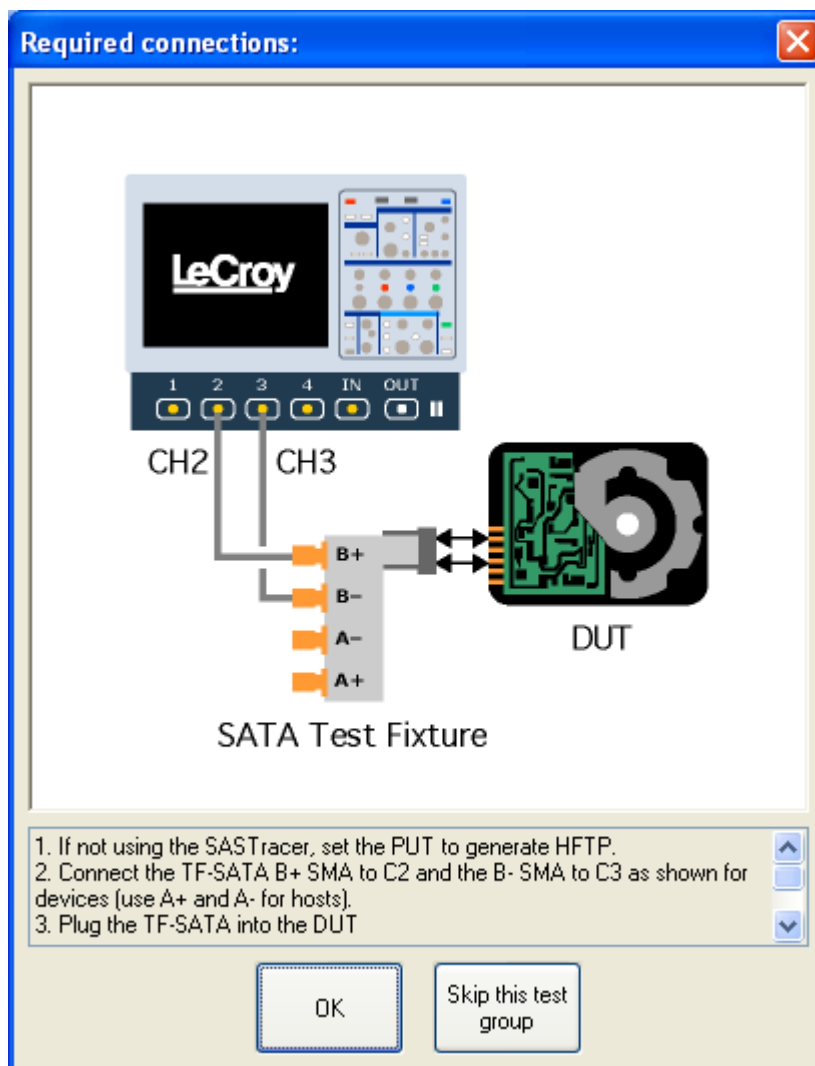


Figure 9. Example of pop-up connection diagram and dialog box

Test Pattern Generation Using LeCroy -SAS Tracer/Trainer

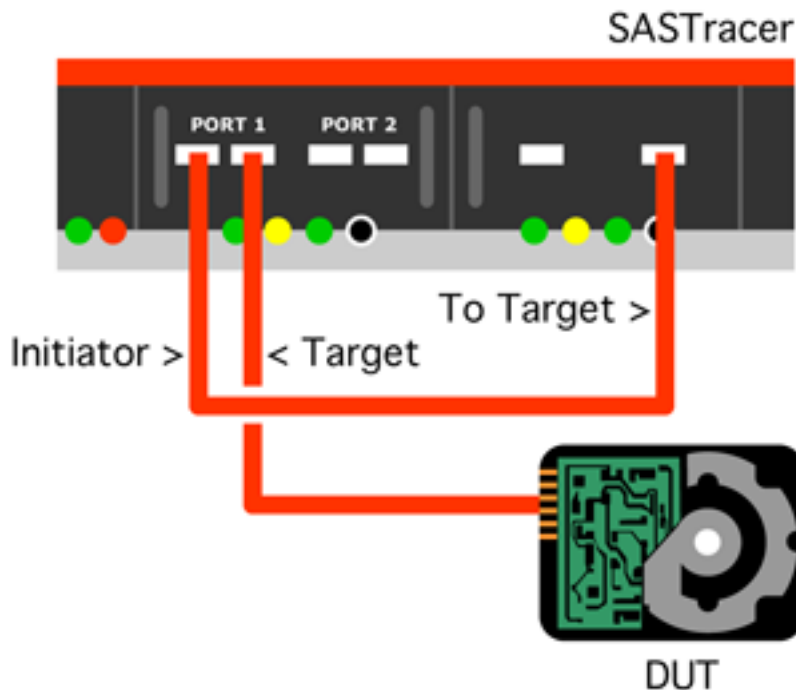
Note: All the scripts described in this section can be edited to generate other results. Any modifications to the scripts are made at the exclusive risk of the user. LeCroy is not responsible for changes made by users that modify the expected behavior or produce software or equipment malfunctions.

Testing a SATA product requires the generation of test patterns to determine compliance to SATA specifications. The following five test patterns are used by QPHY-SATA:

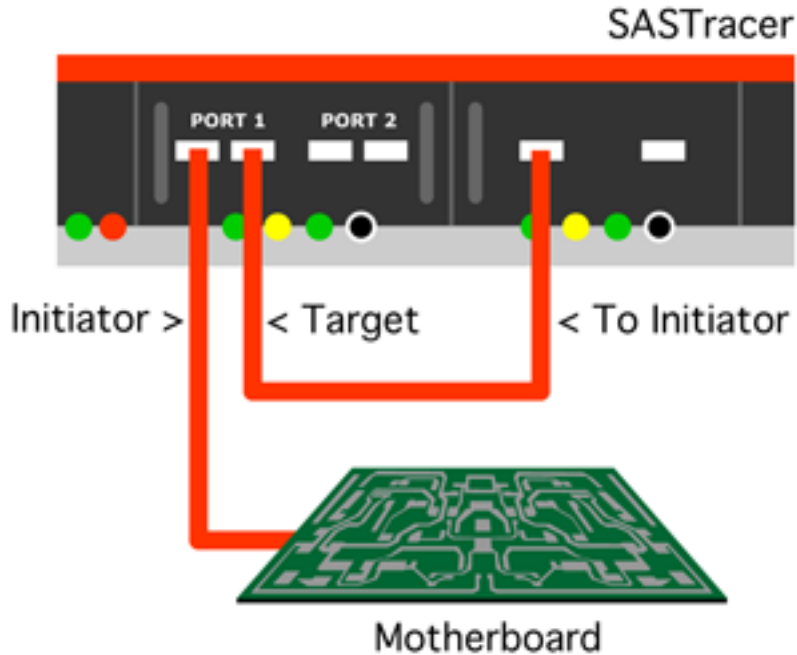
1. HFTP = High Frequency Test Pattern
2. MFTP = Medium Frequency Test Pattern
3. LFTP = Low Frequency Test Pattern
4. LBP = Lone Bit Pattern
5. SSOP = Simultaneous Switching Outputs Pattern

Any method that causes the Product Under Test (PUT) to produce the required patterns is acceptable. LeCroy uses a protocol exerciser to communicate with the PUT and instruct it to enter the built-in self-test (BIST) mode to generate the test patterns. LeCroy's SASTracer software allows you to load individual scripts to cause the exerciser to initiate SATA traffic. These scripts use BIST Activate FIS; the PUT must be able to respond to BIST Activate. The following section describes the specific actions required to successfully generate test patterns from a PUT connected to the LeCroy SAS Tracer/Trainer. It is assumed that you have started the SASTracer/Trainer software on the host computer and established communication with the Tracer/Trainer instrument via USB. When you are prompted to generate a specific test pattern during the execution of a SATA script, the requested pattern can be created by using the following steps:

1. Connect the SASTracer/Trainer to the PUT:
 - To test a SATA device, connect a SATA cable between the LeCroy Protocol Exerciser "To Target" port and the Protocol Analyzer "Initiator" port. Then connect a second SATA cable between the Protocol Analyzer "Target" port and the device, as shown in the following figure:

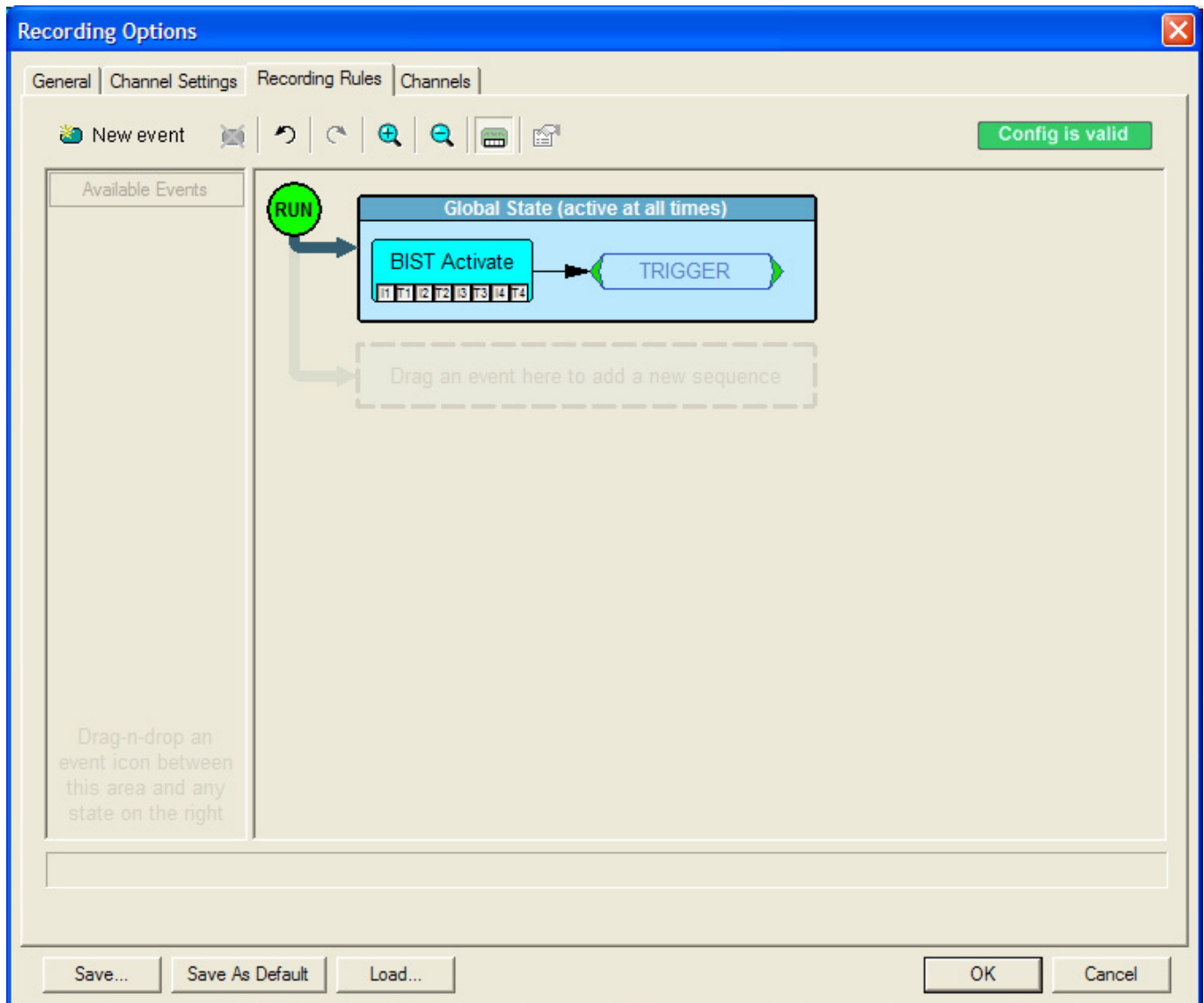


- To test a SATA host, connect a SATA cable between the LeCroy Protocol Exerciser “To Initiator” port and the Protocol Analyzer “Target” port. Then connect a second SATA cable between the Protocol Analyzer “Initiator” port and the host port under test, as shown in the following figure:



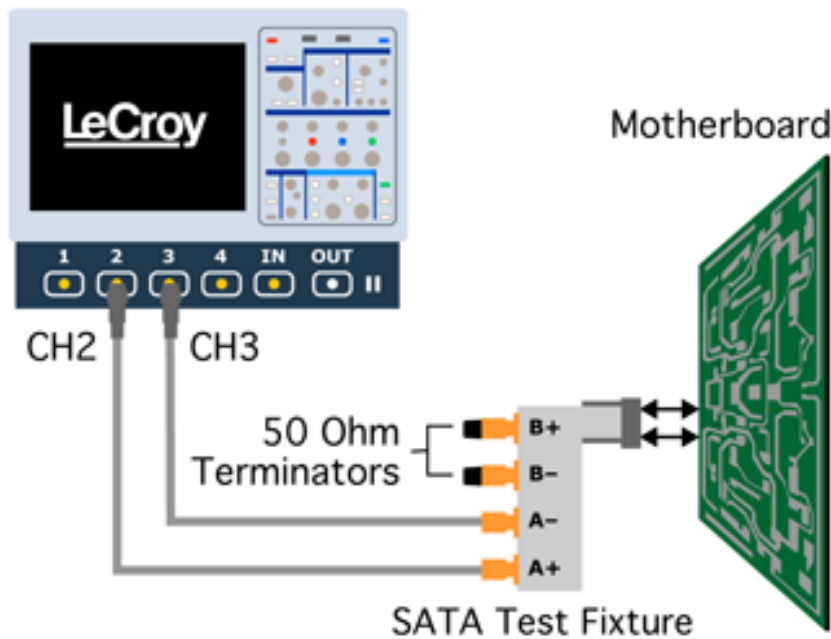
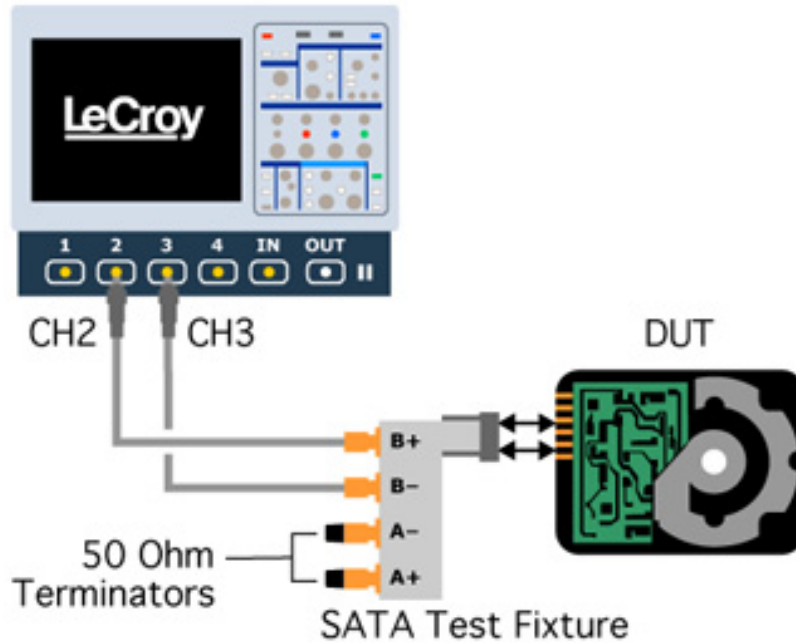
2. On the host PC, load the generation file for the desired test pattern in the SASTracer/Trainer software. The QPHY-SATA installation places these files in **C:\Program Files\LeCroy\XReplay\SATA\SASTracer**. There are multiple GenFiles (*.ssg) available, each corresponding to a SATA test pattern on a host or device, their names reflect the speed, the pattern, and whether they are for a host or device:
 - LeCroy1_5G Device BIST HFTP.ssg – Places a device in BIST-T with HFTP pattern at 1.5Gb/s
 - LeCroy3G Host BIST LBP.ssg – Places a host in BIST-T with LBP pattern at 3.0Gb/s

- In the SASTracer software, click **Record** → **Recording Options**. Click the **Recording Rules** tab and **Configure Bus Analyzer** to start acquisition/trigger on event: SATA FIS → BIST Activate, as follows:



- Close the Recording Options window and click **Record** → **Start**. Then, click **Generate** → **Start Generation**. When the recording triggers, the SASTracer has sent the BIST Activate FIS. At this point, the PUT should be generating the test pattern specified in the traffic generation file.

5. Disconnect the SATA cable from PUT and connect the SATA test fixture to the oscilloscope (via SMA cables) and directly into the PUT as follows – both for a device (DUT) and a Host (Motherboard):



Note: If the PUT is still not generating the test pattern it may not support BIST-T or it may not stay in the BIST mode after it is disconnected from the SASTracer. If the PUT drops out of BIST after being disconnected from the SASTracer, it will be necessary to use two SATA test fixtures connected via SMA cables to connect the SASTracer to the PUT in place of the SATA cable. After sending the BIST Activate FIS remove the transmit pair from the PUT (one SMA cable at a time) and connect them to the oscilloscope.

QPHY-SATA Test Configurations

Configurations include variable settings and limit sets as well, not just test selections. See the **QPHY-SATA Variables** section for a description of each variable value and its default value. The limit sets are either Gen1i or Gen2i.

1.5 Gb/s Device at 1.5 Gb/s, No SSC

This configuration performs all of the necessary compliance tests for a Gen1 device without SSC. The limit set in use is Gen1i. All of the variables are set to their default settings. The tests that are performed are:

- PHY-01 – Unit Interval
- PHY-02 – Frequency Long-Term Accuracy
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-03 – Differential Skew
- TSG-09 – TF at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- TSG-10 – DJ at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- OOB-01 – Signal Detection Threshold
- OOB-02 – UI During OOB (Bitrate)
- OOB-03 – COMINIT and COMWAKE Burst Length
- OOB-04 – COMINIT Gap Length
- OOB-05 – COMWAKE Gap Length
- OOB-06 – COMWAKE Gap Detection
- OOB-07 – COMINIT Gap Detection

1.5 Gb/s Device at 1.5 Gb/s, SSC

This configuration performs all of the necessary compliance tests for a Gen1 device with SSC. The limit set in use is Gen1i. All of the variables are set to their default settings except SSC is Enabled. The tests that are performed are:

- PHY-01 – Unit Interval
- PHY-03 – SSC Frequency
- PHY-04 – SSC Deviation
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-03 – Differential Skew
- TSG-09 – TF at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- TSG-10 – DJ at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- OOB-01 – Signal Detection Threshold
- OOB-02 – UI During OOB (Bitrate)
- OOB-03 – COMINIT and COMWAKE Burst Length
- OOB-04 – COMINIT Gap Length
- OOB-05 – COMWAKE Gap Length



- OOB-06 – COMWAKE Gap Detection
- OOB-07 – COMINIT Gap Detection

3.0 Gb/s Device at 1.5 Gb/s

This configuration performs all of the necessary compliance tests that must be verified for a Gen2 device while transmitting at the 1.5Gb/s data rate. The limit set in use is Gen1i. All of the variables are set to their default settings. The tests that are performed are:

- PHY-01 – Unit Interval
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-09 – TF at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- TSG-10 – DJ at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- OOB-01 – Signal Detection Threshold

3.0 Gb/s Device at 3.0 Gb/s, No SSC

This configuration performs all of the necessary compliance tests for a Gen2 device without SSC while transmitting at the 3.0Gb/s data rate. The limit set in use is Gen2i. All of the variables are set to their default settings. The tests that are performed are:

- PHY-01 – Unit Interval
- PHY-02 – Frequency Long-Term Accuracy
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-03 – Differential Skew
- TSG-04 – AC Common Mode Voltage
- TSG-05 – Rise/Fall Imbalance
- TSG-06 – Amplitude Imbalance
- TSG-11 –TF at Connector, 500UI (Edge-Ref) (3.0Gb/s)
- TSG-12 –DJ at Connector, 500UI (Edge-Ref) (3.0Gb/s)
- OOB-01 – Signal Detection Threshold
- OOB-02 – UI During OOB (Bitrate)
- OOB-03 – COMINIT and COMWAKE Burst Length
- OOB-04 – COMINIT Gap Length
- OOB-05 – COMWAKE Gap Length
- OOB-06 – COMWAKE Gap Detection
- OOB-07 – COMINIT Gap Detection

3.0 Gb/s Device at 3.0 Gb/s, SSC

This configuration performs all of the necessary compliance tests for a Gen2 device with SSC while transmitting at the 3.0Gb/s data rate. The limit set in use is Gen2i. All of the variables are set to their default settings except SSC is enabled. The tests that are performed are:

- PHY-01 – Unit Interval
- PHY-03 – SSC Frequency
- PHY-04 – SSC Deviation
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-03 – Differential Skew
- TSG-04 – AC Common Mode Voltage
- TSG-05 – Rise/Fall Imbalance
- TSG-06 – Amplitude Imbalance
- TSG-11 –TF at Connector, 500UI (Edge-Ref) (3.0Gb/s)
- TSG-12 –DJ at Connector, 500UI (Edge-Ref) (3.0Gb/s)
- OOB-01 – Signal Detection Threshold
- OOB-02 – UI During OOB (Bitrate)
- OOB-03 – COMINIT and COMWAKE Burst Length
- OOB-04 – COMINIT Gap Length
- OOB-05 – COMWAKE Gap Length
- OOB-06 – COMWAKE Gap Detection
- OOB-07 – COMINIT Gap Detection

Demo of 1.5 Gb/s Device with SSC

This configuration uses waveforms stored on the oscilloscope in **D:\Waveforms\SATA\Demo** to demonstrate a Gen1 device with SSC. The word "Demo" must be entered as **Device Under Test** in order to run this demonstration. The limit set in use is Gen1i. All of the variables are set to their default settings except External Attenuation is set to 0 (which is not relevant when running stored waveforms), SSC is enabled, TestMode is set to Use Saved Data and Filenames point to 1.5Gb/s data files. The tests that are demonstrated are:

- PHY-01 – Unit Interval
- PHY-03 – SSC Frequency
- PHY-04 – SSC Deviation
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-03 – Differential Skew
- TSG-09 – TF at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- TSG-10 – DJ at Connector, Edge-Ref fbaud/500 (1.5Gb/s)
- OOB-01 – Signal Detection Threshold
- OOB-02 – UI During OOB (Bitrate)
- OOB-03 – COMINIT and COMWAKE Burst Length



- OOB-04 – COMINIT Gap Length
- OOB-05 – COMWAKE Gap Length
- OOB-06 – COMWAKE Gap Detection
- OOB-07 – COMINIT Gap Detection

Demo of 3.0 Gb/s Host without SSC

This configuration uses waveforms stored on the oscilloscope in **D:\Waveforms\SATA\Demo** to demonstrate a Gen2 device without SSC. The word "Demo" must be entered as **Device Under Test** in order to run this demo. The limit set in use is Gen2i. All of the variables are set to their default settings except Product Type is set to Device, External Attenuation is set to 0, TestMode is set to Use Saved Data and Filenames point to 3.0Gb/s data files. The tests that are demonstrated are:

- PHY-01 – Unit Interval
- PHY-02 – Frequency Long-Term Accuracy
- TSG-01 – Differential Output Voltage
- TSG-02 – Rise/Fall Times
- TSG-03 – Differential Skew
- TSG-04 – AC Common Mode Voltage
- TSG-05 – Rise/Fall Imbalance
- TSG-06 – Amplitude Imbalance
- TSG-11 –TF at Connector, 500UI (Edge-Ref) (3.0Gb/s)
- TSG-12 –DJ at Connector, 500UI (Edge-Ref) (3.0Gb/s)
- OOB-01 – Signal Detection Threshold
- OOB-02 – UI During OOB (Bitrate)
- OOB-03 – COMINIT and COMWAKE Burst Length
- OOB-04 – COMINIT Gap Length
- OOB-05 – COMWAKE Gap Length
- OOB-06 – COMWAKE Gap Detection
- OOB-07 – COMINIT Gap Detection

Note: The waveforms for the demonstration are available from LeCroy as a compacted file **SATA Demo Waveforms.zip**.

Empty Template

This configuration is intentionally left blank so it can easily be copied and configured to the user's custom configuration. The limit set in use is Gen1i. All of the variables are set to their default settings.

QPHY-SATA Variables

Product Type

Used to select whether the Product Under Test is a Serial ATA **Host** or **Device**. Hosts and devices require different connections. If this value is set incorrectly, it will result in the wrong connection diagrams being displayed. The default value is **Device**.

Gen1 PLL damping factor

Gen2 PLL damping factor

These variables control the damping factor of the PLL used to recover the clock for jitter measurements at Gen1 and Gen2 data rates. Setting this value incorrectly results in more or less peaking in the PLL response and will affect the jitter results. To tune the clock recovery to the precise response dictated by the Jitter Transfer Function in the SATA specification, follow the calibration procedure for jitter measurement devices. The default value is **0.707**.

External Attenuation

Used to set the value (in dB) of any external attenuators attached to the channel. External attenuators are used to improve the return loss of the channel in order to meet the lab load requirements in the SATA specification. Setting this value incorrectly will result in incorrect measurement results. The default value is **6**.

Save Waveforms

Used to select whether or not acquired waveforms should be saved as trace (*.trc) files. The path for storing the waveforms is specified separately. The default value is **Yes**.

SSC Setting

Used to select whether the Product Under Test has Spread Spectrum Clocking (SSC) **Enabled** or **Disabled**. If this value is set incorrectly, some tests that are specific to products with or without SSC will not run. The default value is **Disabled**.

Test Fixture

Used to select which test fixture is being used. The options are TF-SATA (the LeCroy test fixture) and ICT (the ICTsols test fixture). The connection diagrams shown during testing use the test fixture selected. The default value is **ICT**.

Test Mode

Used to select whether to run the tests with newly acquired data or use previously saved data. If set to **Acquire New Data**, QualiPHY will prompt the user to connect the product and produce the necessary test patterns. If set to **Use Saved Data**, QualiPHY will load the waveforms specified in the **Waveform Folder** and **Filenames** variables. The default value is **Acquire New Data**.

Waveform Folder

Used to specify the path on the oscilloscope to save/recall waveforms. All waveforms will be saved/recalled to a subfolder in this folder based on the value entered for **Device Under Test**. When the **Test Mode** is set to **Acquire New Data** and **Save Waveforms** is enabled, the waveforms will be saved in this folder on the oscilloscope. When set to **Use Saved Data**, all the saved waveforms should be in this folder. The default value is **D:\Waveforms\SATA**.



Gen1 PLL Natural Frequency

Gen2 PLL Natural Frequency

These variables control the natural frequency of the PLL used to recover the clock for jitter measurements at Gen1 and Gen2 data rates. Setting this value incorrectly results in a different PLL bandwidth and will affect the jitter results. To tune the clock recovery to the precise response dictated by the Jitter Transfer Function in the SATA specification, follow the calibration procedure for jitter measurement devices. The default value is **4.2e6**.

Filenames

This group contains variables that allow the user to specify trace (.trc) files to be used to run tests on previously acquired data. If a parameter is left empty the tests requiring that pattern will be skipped. It is only necessary to set these filenames when **Test Mode** is set to **Use Saved Data**. The specified files must be available in a subfolder of the folder **Waveform Folder**; the subfolder name must match the **Device Under Test** name entered at the start of the session. The value does not include the ".trc" extension. When re-running a test using saved waveforms it is best to use the waveforms that were saved by QualiPHY so that the acquisition settings will be as expected.

QPHY-SATA Limit Sets

Gen1i

Contains the limits designated in the SATA specification for products running at 1.5Gb/s.

Gen2i

Contains the limits designated in the SATA specification for products running at 3.0Gb/s.

QPHY-SATA Test Descriptions

QualiPHY SATA covers the tests defined by the SATA-IO Interoperability Program appropriate for real-time oscilloscopes. The Interoperability Program defines the tests in the Unified Test Document (UTD) available at:

<http://www.sata-io.org/testing.asp>

The UTD includes electrical tests as well as digital and mechanical tests. The electrical test groups covered by QualiPHY are **Physical Layer general requirements (PHY)**, **PHY Transmitted Signal requirements (TSG)**, and **PHY Out Of Band requirements (OOB)**. In the following sections each of the tests is described followed by an example output from a QualiPHY report.




Note: For more details about any of the tests please consult the LeCroy PHY, TSG, OOB Method of Implementation (MOI) document, as well as the SATA-IO Unified Test Document and the SATA specification.

Physical Layer General Requirements (PHY)

The PHY group of tests includes parameters from Table 27 – General Specifications in the SATA specification Rev 2.6. There are four tests in this group. The High Frequency Test Pattern (HFTP) is used for all four PHY tests. The data is demodulated and a low-pass filter is then applied to create an SSCTrack which displays how the data rate varies over time. The carrier frequency of the SSC Track is set to the nominal frequency if there is no SSC. If SSC is enabled the carrier is set to the center frequency of the SSC waveform, assuming max deviation. The SSC Track has a low pass filter (LPF) with a cutoff frequency of 1.98 MHz. The output of the SSC Track is multiplied by 2 and offset by the mean frequency so that it becomes a track of the bitrate centered at the mean frequency.

PHY-01 – Unit Interval

This test measures the mean unit interval. It is measured by taking the mean of the SSC Track. This test applies whether SSC is enabled or not. The minimum and maximum unit intervals are also reported.

Pass	Test	Measurement	Current Value	Test Criteria
	PHY-01	Unit Interval Min	333.2823 ps	Informational Only
	PHY-01	Unit Interval Max	333.3931 ps	Informational Only
	PHY-01	Unit Interval Mean	333.3183 ps	333.2167 ps <= n <= 335.1167 ps

PHY-02 – Frequency Long Term Accuracy


This test measures “ftol”, the deviation of the mean data rate from the nominal data rate. It is calculated as: (mean data rate – nominal data rate) / nominal data rate * 1 million ppm

This test only applies to products that do not have SSC enabled.

	PHY-02	ftol	45.15 ppm	-350.00 ppm <= n <= 350.00 ppm
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PHY-03 – Spread Spectrum Modulation Frequency

This test measures the frequency of the spread spectrum modulation. It only applies to products that have SSC enabled.

	PHY-03	fSSC	31.150 kHz	30.000 kHz <= n <= 33.000 kHz
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TSG-01 – Differential Output Voltage

This test measures the differential output voltage of the transmitter. The minimum and maximum are tested differently. A persistence map is built from the differential waveform for both measurements. For VDiffMin, the HFTP, MFTP, and LBP patterns are used. Persistence histograms are accumulated over the center of the UI using a slice width of 1/10 of the UI for the high and low levels. Then the mean of histograms are used to compute the differential output voltage. The screenshot below shows the VDiffMin measurement using LBP. P1 is the mean of the histogram for the upper level. P2 is the mean of the histogram for the lower level. P3 is the difference between the two voltages.

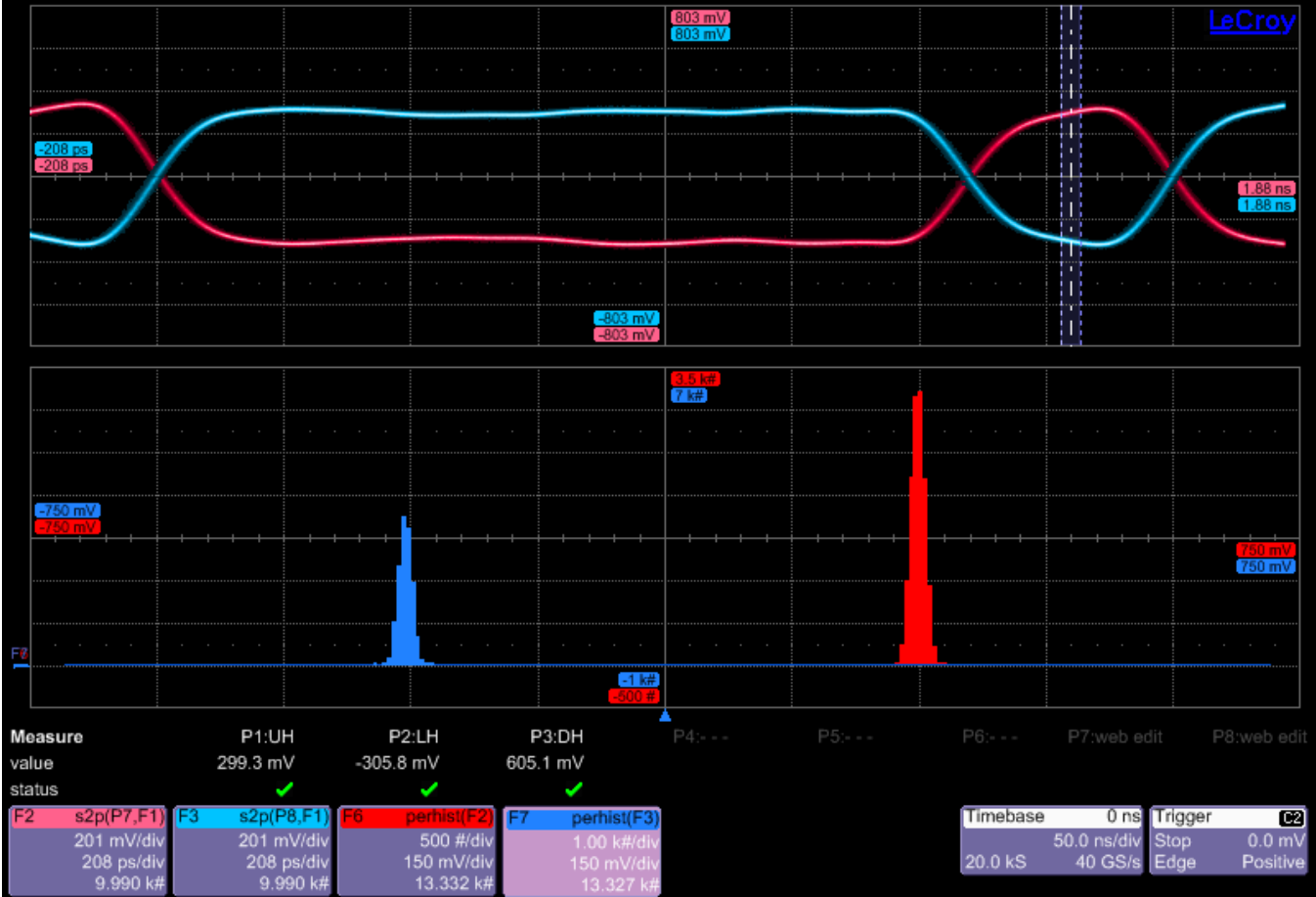


Figure 11. Screenshot of the VDiffMin measurement using LBP

The maximum differential output voltage is measured as a percentage of points exceeding half of the maximum allowed voltage in the positive (pu) or negative (pl) directions. It is tested on MFTP and LFTP. The results are reported for informational purposes only.

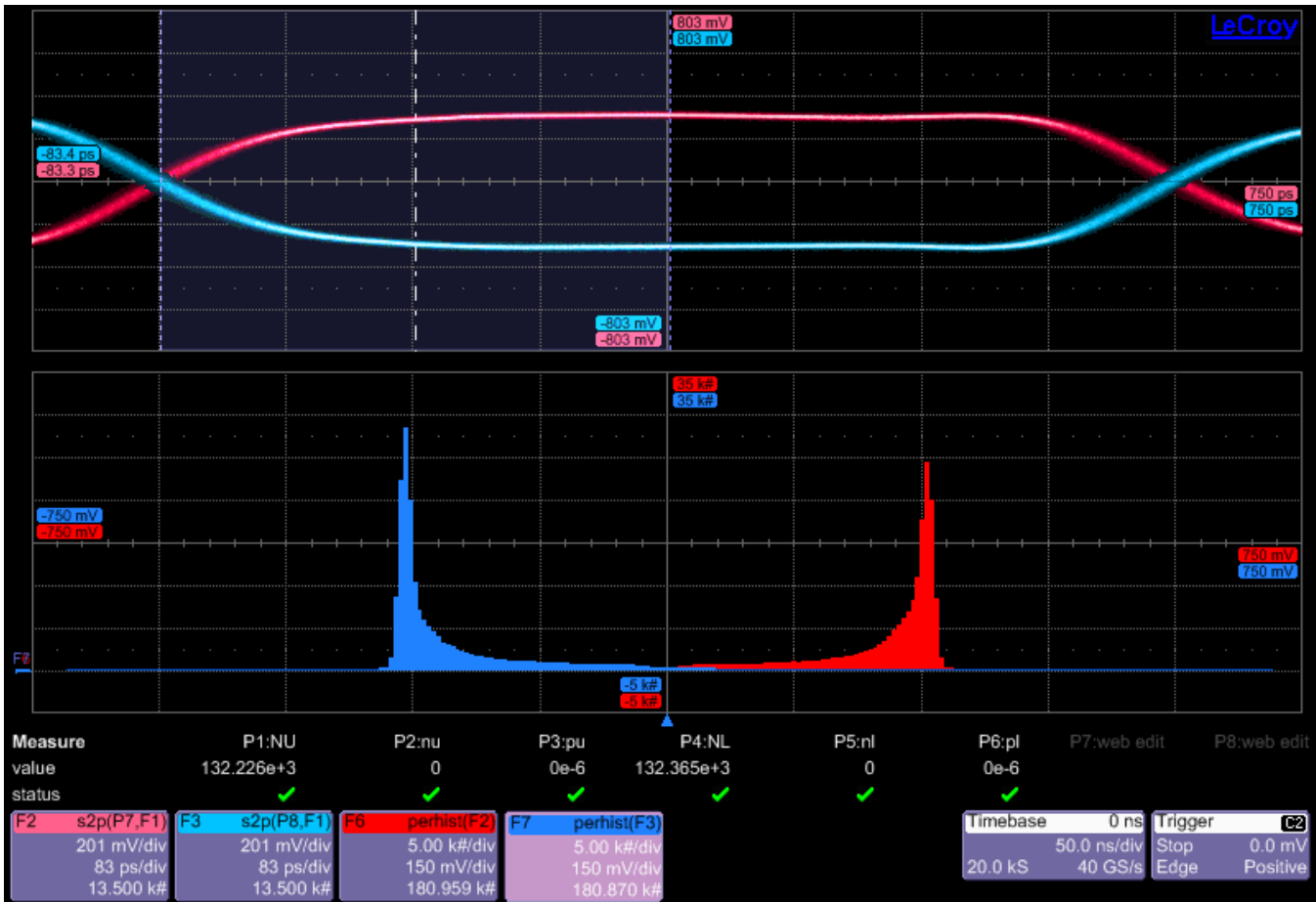








Figure 12. Screenshot of the VDiffMax measurement for an MFTP pattern

	TSG-01	UH HFTP	327.6 mV	Informational Only
	TSG-01	LH HFTP	-334.7 mV	Informational Only
	TSG-01	DH HFTP	662.3 mV	>= 400.0 mV
	TSG-01	UM MFTP	281.6 mV	Informational Only
	TSG-01	LM MFTP	-286.7 mV	Informational Only
	TSG-01	DM MFTP	568.2 mV	>= 400.0 mV
	TSG-01	A LBP	327.1 mV	Informational Only
	TSG-01	B LBP	-324.6 mV	Informational Only
	TSG-01	VTestLBP	651.8 mV	>= 400.0 mV
	TSG-01	VTest	568.2 mV	>= 400.0 mV
	TSG-01	pu MFTP	6.5 m	Informational Only
	TSG-01	pl MFTP	10.1 m	Informational Only
	TSG-01	pu LFTP	0.0 m	Informational Only
	TSG-01	pl LFTP	0.0 m	Informational Only

TSG-02 – Rise/Fall Times

This test measures the differential rise and fall times for the transmitted signal. The 20% and 80% levels are used. This test is only tested against the limits for the HFTP pattern. Results for LFTP and LBP are also reported for informational purposes.

	TSG-02	TX Rise HFTP	98.594 ps	<= 136.000 ps
	TSG-02	TX Fall HFTP	99.827 ps	<= 136.000 ps
	TSG-02	TX Rise LFTP	101.756 ps	Informational Only
	TSG-02	TX Fall LFTP	102.539 ps	Informational Only
	TSG-02	TX Rise LBP	98.642 ps	Informational Only
	TSG-02	TX Fall LBP	101.123 ps	Informational Only

TSG-03 – Differential Skew

This test measures the skew between TX+ and TX-. This measurement is made by finding the mean skew (at the 50% level) from the TX+ rising edge to the TX- falling edge and mean skew of the TX- falling edge to the TX+ rising edge. The absolute values of the two means are then averaged together. This test is measured on the HFTP and MFTP patterns.

	TSG-03	TskewTX HFTP	1.7 ps	<= 20.0 ps
	TSG-03	TskewTX MFTP	7.2 ps	<= 20.0 ps

TSG-04 – AC Common Mode Voltage

This test measure the AC Common Mode Voltage. A low-pass filter at half the bitrate is applied to the (TX+ - TX-) / 2. Then the peak to peak voltage is measured. This measurement is made using the MFTP pattern and only for products running at 3.0Gb/s.













	TSG-04	Vcm.acTX	24.6 mV	<= 50.0 mV
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TSG-05 – Rise/Fall Imbalance

This test measures the imbalance of rise to fall times for the differential pair. It is measured for HFTP and MFTP patterns and only for products running at 3.0Gb/s. The single-ended rise and fall times are reported for informational purposes. The rise/fall imbalance is computed as follows:

$$\text{Abs}(\text{Mean TX+ rise} - \text{Mean TX- fall}) / \text{average}(\text{MeanTX} + \text{rise}, \text{Mean TX- fall}) * 100\%$$

$$\text{Abs}(\text{Mean TX+ fall} - \text{Mean TX- rise}) / \text{average}(\text{MeanTX} + \text{fall}, \text{Mean TX- rise}) * 100\%$$



	TSG-05	TX+ Rise HFTP	95.344 ps	Informational Only
	TSG-05	TX+ Fall HFTP	102.837 ps	Informational Only
	TSG-05	TX- Rise HFTP	95.099 ps	Informational Only
	TSG-05	TX- Fall HFTP	101.509 ps	Informational Only
	TSG-05	RFBal TX+ Rise TX- Fall HFTP	6.27 %	<= 20.00 %
	TSG-05	RFBal TX+ Fall TX- Rise HFTP	7.81 %	<= 20.00 %
	TSG-05	TX+ Rise MFTP	98.033 ps	Informational Only
	TSG-05	TX+ Fall MFTP	115.598 ps	Informational Only
	TSG-05	TX- Rise MFTP	99.010 ps	Informational Only
	TSG-05	TX- Fall MFTP	116.591 ps	Informational Only
	TSG-05	RFBal TX+ Rise TX- Fall MFTP	17.27 %	<= 20.00 %
	TSG-05	RFBal TX+ Fall TX- Rise MFTP	15.44 %	<= 20.00 %

TSG-06 – Amplitude Imbalance

This test measures the amplitude imbalance of the differential pair. It is measured on HFTP and MFTP patterns and only for products running at 3.0Gb/s. It is calculated as follows:

$$\text{Abs}(\text{TX+ amplitude} - \text{TX- amplitude}) / \text{Average}(\text{TX+ amplitude}, \text{TX- amplitude})$$

Where TX+ and TX- amplitudes are determined from the mode of a persistence histogram of the high bit minus the mode of a persistence histogram of the low bit. The persistence histograms use a 10% UI slice width at the center of the UI (second UI for MFTP).

	TSG-06	AmpBal HFTP	4.33 %	<= 10.00 %
	TSG-06	AmpBal MFTP	930 m%	<= 10.00 %

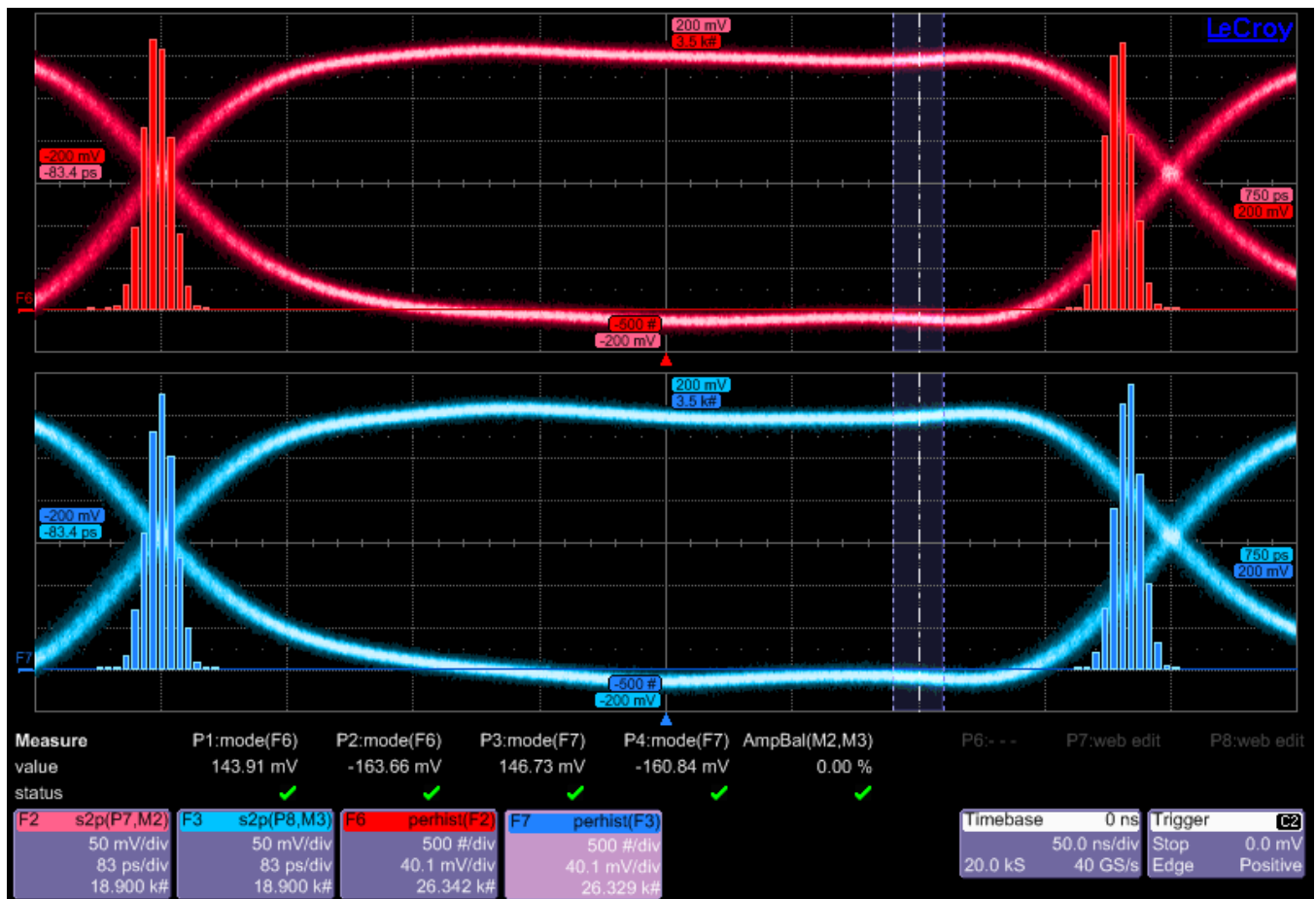


Figure 13. Amplitude Imbalance measurement on an MFTP pattern

The following tests measure the jitter, Total (Tj) and Deterministic (Dj), of the transmitter running at Gen1 speed. They have been rendered obsolete by the SATA-IO Interoperability Program and are left here for historical purposes.

TSG-07 – Gen1 (1.5Gb/s) TJ at Connector, Clock to Data fBAUD/10 (Obsolete)

TSG-08 – Gen1 (1.5Gb/s) DJ at Connector, Clock to Data fBAUD/10 (Obsolete)

The following tests measure the jitter, Total (Tj) and Deterministic (Dj), of the transmitter.

TSG-09 – Gen1 (1.5Gb/s) TJ at Connector, Clock to Data fBAUD/500

TSG-10 – Gen1 (1.5Gb/s) DJ at Connector, Clock to Data fBAUD/500

TSG-11 – Gen2 (3.0Gb/s) TJ at Connector, Clock to Data fBAUD/500

TSG-12 – Gen2 (3.0 GB/s) DJ at Connector, Clock to Data fBAUD/500

In the past, these tests had different implementations for products running at 1.5Gb/s and 3.0Gb/s. Currently, the implementation is the same, but the test names have been left as is. The jitter is measured using a phase-locked loop (PLL) to recover the clock. To tune the clock recovery to the precise response dictated by the Jitter Transfer Function in the SATA specification, follow the calibration procedure for jitter measurement devices. Jitter is measured on HFTP, MFTP and SSOP. The SSOP pattern is optional.

✓	TSG-09	Tj fBAUD/500 HFTP	111 mUI	<= 370 mUI
✓	TSG-09	Tj fBAUD/500 LBP	122 mUI	<= 370 mUI
i	TSG-09	Tj fBAUD/500 SSOP	124 mUI	Informational Only
✓	TSG-10	Dj fBAUD/500 HFTP	16 mUI	<= 190 mUI
✓	TSG-10	Dj fBAUD/500 LBP	19 mUI	<= 190 mUI
i	TSG-10	Dj fBAUD/500 SSOP	14 mUI	Informational Only
✓	TSG-11	Tj fBAUD/500 HFTP	206 mUI	<= 370 mUI
✓	TSG-11	Tj fBAUD/500 LBP	247 mUI	<= 370 mUI
i	TSG-11	Tj fBAUD/500 SSOP	216 mUI	Informational Only
✓	TSG-12	Dj fBAUD/500 HFTP	28 mUI	<= 190 mUI
✓	TSG-12	Dj fBAUD/500 LBP	17 mUI	<= 190 mUI
i	TSG-12	Dj fBAUD/500 SSOP	34 mUI	Informational Only

PHY OOB Requirements

The PHY OOB Requirements (OOB) group of tests includes parameters from Table 32 in the SATA specification, revision 2.6. There are a total of 7 tests defined in this group. There are two types of Out of Band (OOB) patterns: COMRESET/COMINIT and COMWAKE. Both consist of 6 bursts of data.

See the *SATA_PHY_MOI_LeCroy_PHY_TSG_OOB Method of Implementation* for detailed test procedures.

OOB-01 – Signal Detection Threshold

This test verifies the product responds to OOB signals above the minimum detection threshold and does not respond to OOB signals below the level at which it should not detect OOB. The test is conducted by sending an OOB waveform from a signal generator to the product under test and checking if it responds using the oscilloscope.

The following graphic illustrates the setup for a device:

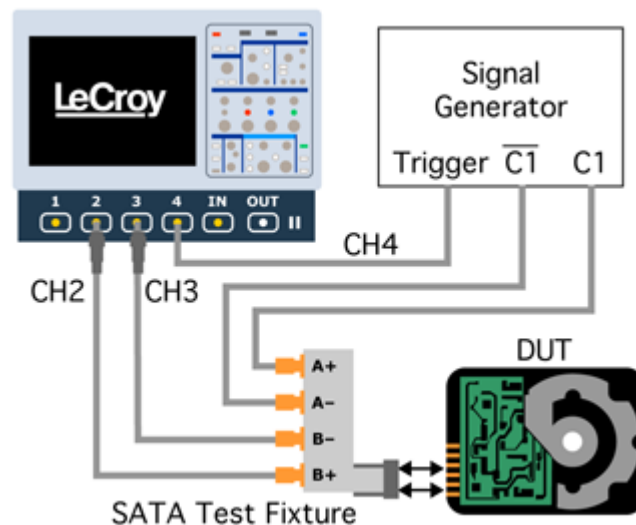


Figure 14. Signal Detection Threshold device setup

The signal generator is set to output a COMRESET at regular intervals. The trigger output is used to indicate when a COMRESET has been sent. When the device responds to COMRESET it sends COMINIT as follows:



Figure 15. Example of a Device detecting COMRESET

When the device does not detect COMRESET it will not respond. However, some devices implement Asynchronous Signal Recovery (ASR) and send out COMINIT every 10ms. In that case, one COMINIT may be seen from the device, but it will be clear that the product is not responding to the COMRESET. The device must respond to every COMRESET above the minimum threshold voltage.

A similar setup is used to test a host:

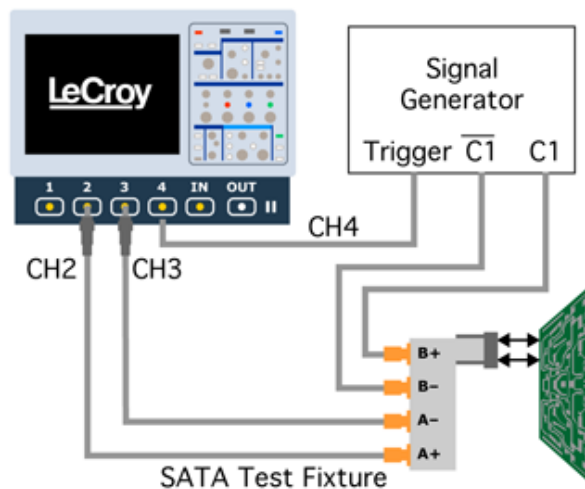


Figure 16. Signal Detection Threshold host setup



In this case, COMINIT is sent from the signal generator and the host must respond with COMRESET or COMWAKE.

QualiPHY prompts the user to look at the oscilloscope and see if the product is responding to the OOB signal. If the product responds click **Detect**, otherwise, click **No Detect**.

✓	OOB-01	OOB Signal Detection High Threshold	Detect	Detect
✓	OOB-01	OOB Signal Detection Low Threshold	No Detect	No Detect

OOB-02 – UI During OOB

This test measures the unit interval during the bursts of the COMRESET/COMINIT and COMWAKE signals. Devices that implement Asynchronous Signal Recovery (ASR) automatically send out COMINIT signals when powered on. For devices that do not support ASR, a signal generator is used to send a COMRESET to the device. Hosts send out a COMRESET when powered on and may continue to send out COMRESET periodically if they support ASR.

✓	OOB-02	UI during OOB	666.501 ps	646.670 ps <= n <= 686.670 ps
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OOB-03 – COMINIT/COMRESET and COMWAKE Burst Length

This test measures the width of the COMINIT/COMRESET and COMWAKE bursts. It reports the mean of the 6 COMINIT/COMRESET burst widths and the mean of the COMWAKE burst widths as informational. Then, it reports the mean, min and max of all 12 bursts.

i	OOB-03	COMINIT/COMRESET Burst Length	106.986818 ns	Informational Only
i	OOB-03	COMWAKE Burst Length	106.994378 ns	Informational Only
✓	OOB-03	Mean OOB Burst Length	106.991 ns	103.467 ns <= n <= 109.867 ns
✓	OOB-03	Min OOB Burst Length	106.958 ns	103.467 ns <= n <= 109.867 ns
✓	OOB-03	Max OOB Burst Length	107.016 ns	103.467 ns <= n <= 109.867 ns

OOB-04 – COMINIT/COMRESET Gap Length

This test measures the mean width of the 5 COMINIT/COMRESET gaps between the bursts.

✓	OOB-04	COMINIT/COMRESET Gap Length	319.666 ns	310.402 ns <= n <= 329.602 ns
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OOB-05 – COMWAKE Gap Length

This test measures the mean width of the 5 COMWAKE gaps between the bursts.

✓	OOB-05	COMWAKE Gap Length	106.329 ns	103.467 ns <= n <= 109.867 ns
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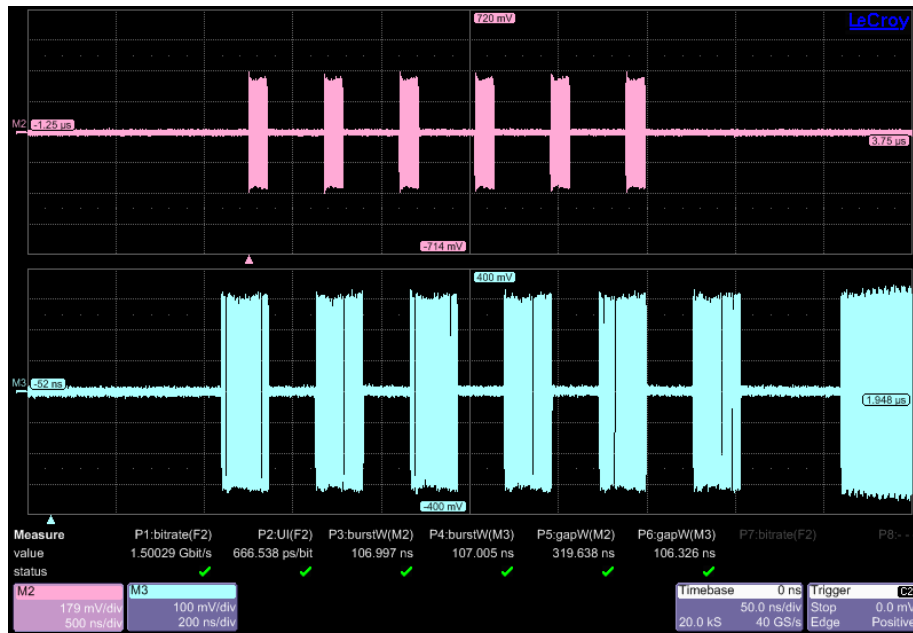


Figure 17. COMINIT and COMWAKE Timing Measurements

OOB-06 – COMWAKE Gap Detection

This test measures the response of the product to COMWAKE with different gap widths. A signal generator is used to send COMWAKE to the product. A device should respond to COMWAKE by sending COMWAKE followed by ALIGN primitives. A host should respond to COMWAKE by sending ALIGN primitives. The setup is the same as OOB-01.

The trigger output of the signal generator is used to indicate when a COMWAKE has been sent. When the product responds to COMWAKE it should look similar to the following:



Figure 18. Example of a Device Detecting COMWAKE



QualiPHY prompts the user to look at the oscilloscope and see if the product is responding to the OOB signal. If the product responds click **Detect**, otherwise click **No Detect**.

✓	OOB-06	COMWAKE Gap Detect 30 ns	No Detect	No Detect
✓	OOB-06	COMWAKE Gap Detect 103 ns	Detect	Detect
✓	OOB-06	COMWAKE Gap Detect 110 ns	Detect	Detect
✓	OOB-06	COMWAKE Gap Detect 177 ns	No Detect	No Detect

OOB-07 – COMINIT/COMRESET Gap Detection

This test measures the response of the product to COMINIT/COMRESET with different gap widths. A signal generator is used to send COMRESET to a device or COMINIT to a host. A device should respond to COMRESET by sending COMINIT. A host should respond to COMINIT by sending COMWAKE or COMRESET. The setup is the same as OOB-06. The setup and expected responses on the oscilloscope are the same as for OOB-01.

QualiPHY will prompt the user to look at the oscilloscope and see if the product is responding to the OOB signal. If the product responds click **Detect**, otherwise click **No Detect**.

✓	OOB-07	COMINIT Gap Detect 173 ns	No Detect	No Detect
✓	OOB-07	COMINIT Gap Detect 306 ns	Detect	Detect
✓	OOB-07	COMINIT Gap Detect 334 ns	Detect	Detect
✓	OOB-07	COMINIT Gap Detect 527 ns	No Detect	No Detect

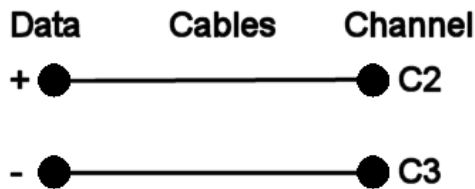
CALIBRATION PROCEDURES

Cable Deskewing

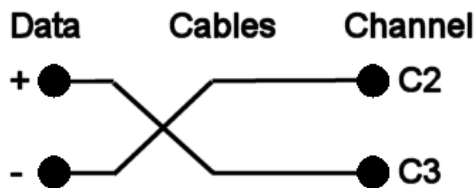
The following procedure demonstrates how to deskew two oscilloscope channels and cables using the differential data signal, with no need for any “T” connector or adapters.

This can be done once the temperature of the oscilloscope is stable. The oscilloscope must be warmed up 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 degree.

1. Connect a differential data signal to C2 and C3 using two approximately matching cables. Set up the oscilloscope to use the maximum sample rate (e.g. for WaveRunner 204Xi: two channel mode; on the Smart Memory menu set Fixed Sample Rate 10GS/s). Set the timebase for a few repetitions of the pattern (at least a few dozen edges).



2. On the C3 menu, check **Invert**. Now C2 and C3 should look the same.
3. Using the **Measure Setup**, set P1 to measure the Skew of C2, C3. 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).



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:

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

7. The above formula simplifies to:

$$[\text{cable skew} + \text{channel skew}]$$

8. Set the resulting value as the Deskew value in C2 menu.
9. 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.
10. On the C3 menu, un-check 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 C3 in order to make C2 and C3 both have positive edges at the same time.

Alternately, we clearly could have not inverted C3 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 (C3). However, it is somewhat agreed that the previous procedure looks much more aesthetically pleasing from the display as it shows C2 and C3 with the same polarity.

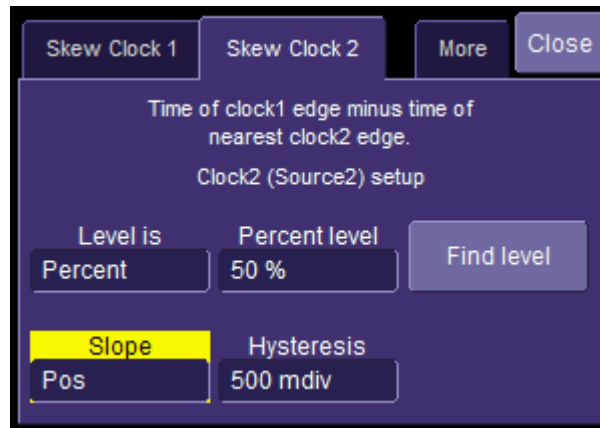


Figure 19. The Skew parameter right side dialog, Skew clock 2 tab, showing default setup

Jitter Transfer Function Calibration

The SATA specification requires that a reference clock is used for all jitter measurements. The reference clock is recovered from the data using a phase-locked loop (PLL). The PLL tracks small phase changes in the waveform. Therefore, the recovered clock will have less jitter at lower frequencies than the original data. This difference is called the Jitter Transfer Function (JTF). A change to the specification (SATA26_ECN008) defines the exact Jitter Transfer Function that the oscilloscope, or any jitter measurement device, must apply to a signal when recovering the clock. LeCroy oscilloscopes have two variables that control the PLL transfer function. Natural frequency controls the cutoff frequency of the PLL, and critical damping controls the peaking of transfer function. QualiPHY configurations include settings for both variables, as described in the QPHY-SATA Variables section. The SATA-IO has developed a procedure called the Jitter Measurement Device Calibration Procedure for verifying the jitter transfer function. Please consult the SATA_PHY_MOI_LeCroy_PHY_TSG_OOB Method Of Implementation for the procedure specific to LeCroy oscilloscopes.

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