Granite River Labs

USB 3.2 Receiver Test Method of Implementation (MOI) Using Anritsu MP1900A BERT, High Performance Real-Time Oscilloscope, and GRL-USB32-RXA Calibration and Test Automation Software

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1 Introduction

This MOI & User Guide contains the procedure for testing an electrical receiver for USB 3.2 certification using Anritsu MP1900A BERT, High Performance Real-Time Oscilloscope, and GRL-USB32-RXA Test Automation Software.

The main body of this MOI & User Guide describes how to perform automated Calibration and Testing of USB 3.2 Gen1/Gen2/Gen2x2 Hosts and Devices using the GRL-USB32-RXA software with an appendix describing the manual calibration process as a technical reference.

The tests in this MOI are the tests carried out by USB Independent Test Labs (ITL's). If performing the tests yourself, it is important for you to follow the MOI's as described in this document before submitting your Device Under Test (DUT) for Certification in order for you to be confident that your device will pass. ITL's also provide pre-compliance test services if your company does not have the equipment or resources to carry out the tests. Contact Granite River Labs for USB pre-compliance and compliance test services.

For Devices and Hosts with a USB Type-C® Connector, the USB-IF, VESA (DisplayPort over USB Type-C), and Thunderbolt™ Compliance programs all require USB 3.2 Gen1/Gen2/Gen2x2 receiver compliance testing.

The solution in this MOI can also be used for USB 3.2 receiver compliance for USB Type-A, USB Type-B and USB Type-B Micro Hosts and Devices.

In summary, this User Guide & MOI basically describes using the GRL-USB32-RXA software to:

1. Calibrate and Test a USB 3.2 Gen1/Gen2/Gen2x2 Receiver.
2. Generate Test Report for Compliance Reporting.

2 Reference Documents

[1] Universal Serial Bus 3.1 Specification Revision 1.0, July 26, 2013, and associated ECNs.

[2] Electrical Compliance Test Specification Enhanced SuperSpeed Universal Serial Bus Revision 1.0, February 14, 2017

3 Resource Requirements

3.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – SYSTEMS AND ACCESSORIES

Equipment	Qty.	Description	Key Specification Requirement
Keysight/Tektronix Oscilloscope	1	High Performance Real-time Oscilloscope [a]	≥ 16 GHz bandwidth with Windows 7+ OS [b]
Anritsu BERT	1	MP1900A Signal Quality Analyzer, with following modules: • MU181000A/B 12.5 GHz Synthesizer • MU181500B Jitter Modulation Source • MU195020A 21G/32G bit/s SI Pulse Pattern Generator • MU195040A 21G/32G bit/s SI Error Detector • MU195050A Noise Generator	
Computer	1	Laptop or desktop (Windows 7+ OS) for GRL automation control	

[a] Oscilloscope with scope software requirements as specified in vendor specific MOI's. For example, when using the Keysight Scope, scope software such as Keysight InfiniiSim / EZ-JIT / Serial Data Analysis / Serial Data Equalization that are required for testing and signal processing must be pre-installed on the Scope. Similarly, the Tektronix Scope shall be used with DPOJET (Jitter and Eye Analysis Tools) software for making measurements.

[b] Oscilloscope with scope bandwidth as specified in vendor specific MOI's.

TABLE 2. EQUIPMENT REQUIREMENTS – CABLES

Anritsu Cables [a]			
	Qty.	Description	Key Specification Requirement
BNC-SMA connector cable	2	J1508A	I, Q Connections from Synthesizer to Jitter module
SMA cables	4	J1349A or J1624A (0.3m)	Clock and gating connection between modules
Coaxial cables	1 pair [b] 2 pairs [c]	J1746A (3ft Phase Matched Pair)	Data connection between MU195020A and MU195050A
Phase matched K cables	2 pairs [b] 4 pairs [c]	J1551A (0.8m Phase Matched Pair)	Calibrated signal path and loopback connections
GND connection cable	1	J1627A	For DUT ground connection

[a] Based on the standard test configuration. May require more or less cables depending on the DUT type.

[b] Required for USB 3.2 Gen1/Gen2 based testing.

[c] Required for USB 3.2 Gen2x2 based testing.

3.2 USB-IF Fixture and Compliance Channel Requirements

TABLE 3. FIXTURE REQUIREMENTS

Fixture	Source
USB Type-C Connector Kit	USB 3.1 (10 GT/s) Type-C Electrical Test Fixture Kit *(orderable from USB-IF)*
USB Type-A and USB Type-B Micro Connector Kit	USB 3.2 Gen2x1 (10 GT/s) Type-A and Type-B Micro Electrical Test Fixture Kit *(orderable from USB-IF)*
USB 3.0 Connector Kit	USB 3.0 Electrical Test Fixture Kit (orderable from USB-IF)

3.3 Software Requirements

TABLE 4. SOFTWARE REQUIREMENTS

Software	Source
GRL-USB32-RXA	Granite River Labs USB 3.2 Receiver Calibration and Test Automation Software – www.graniteriverlabs.com Includes test setup and pattern files for USB 3.2 Rx testing Included with Node Locked License to single oscilloscope or PC OS
VISA (Virtual Instrument Software Architecture) API Software	VISA Software is required to be installed on the controller PC running GRL-USB32-RXA software. GRL's software framework has been tested to work with all three versions of VISA available on the Market: 1. NI-VISA: http://www.ni.com/download/ni-visa-17.0/6646/en/ 2. Keysight IO Libraries: www.keysight.com *(Search on IO Libraries)* 3. Tektronix TekVISA: www.tek.com *(Downloads > Software > TekVisa)*
SigTest	Standard Post Processing Analysis Software – www.intel.com/content/www/us/en/design/technology/high-speed-io/tools.html
MX190000A	Anritsu Mainframe SQA Control Software located on the BERT.
MX183000A	Anritsu High-Speed Serial Data Test Software – For loopback BER testing of the USB 3.2 Rx DUT. This software is located on the BERT.

4 Installing and Setting Up GRL-USB32-RXA Software

This section provides the procedures to start up and pre-configure the GRL-USB32-RXA automation software before running tests. It also helps users familiarize themselves with the basic operation of the software.

Note: The GRL software installer will automatically create shortcuts in the Desktop and Start Menu when installing the software.

To start using the GRL software, follow the procedures in the following sections.

4.1 Download GRL-USB32-RXA Software

Download and install the GRL software as follows:

1. If the GRL software is to be installed on a PC (where it is referred to as 'controller PC'), install VISA (Virtual Instrument Software Architecture) on to the PC where the GRL software is to be used (see Section 3.3).
2. Download the software ZIP file package from the Granite River Labs support site.
3. The ZIP file contains:
   - **USB3_2RxANPatternFilesInstallation00xxxxxxSetup.exe** – Run this on the Anritsu Signal Quality Analyzer to install the test pattern setup files.
   - **USB3_2RxANTestApplication00xxxxxxSetup.exe** – Run this on the controller PC or oscilloscope to install the GRL-USB32-RXA application.
   - **USB3_2RxANTestScopeSetupFilesInstallation00xxxxxxSetup.exe** – Run this on the oscilloscope to install the scope setup files.

4.2 Launch and Set Up GRL-USB32-RXA Software

1. Once the GRL-USB32-RXA software is installed, open the GRL folder from the Windows Start menu. Click on **GRL – Automated Test Solutions** within the GRL folder to launch the GRL software framework.

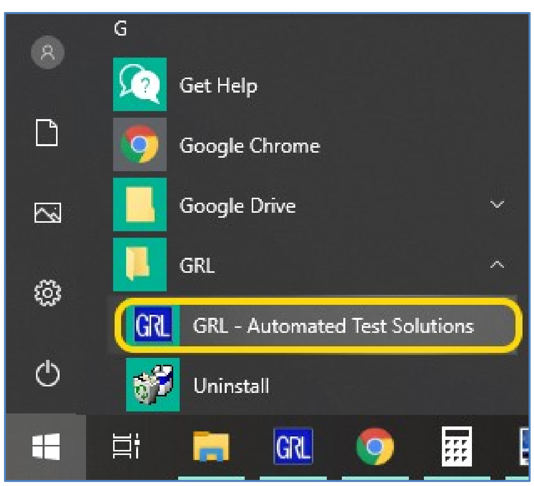


FIGURE 1. SELECT AND LAUNCH GRL FRAMEWORK

2. From the Application→Rx Test Solution drop-down menu, select 'Anritsu USB 3.2 Rx Test' to start the GRL-Anritsu USB 3.2 Rx Test Application. If the selection is grayed out, it means that your license has expired.

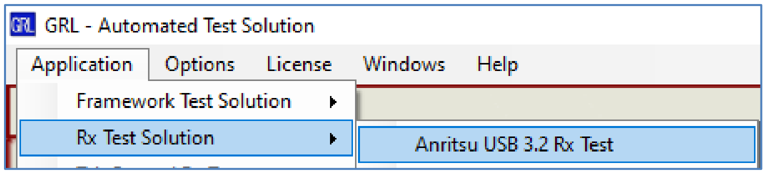


FIGURE 2. LAUNCHING GRL-ANRITSU USB 3.2 RX TEST APPLICATION

3. To enable license, go to License→License Details.

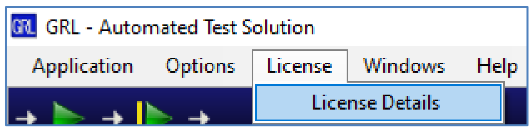


FIGURE 3. LICENSE DETAILS

a) Check the license status for the installed application.

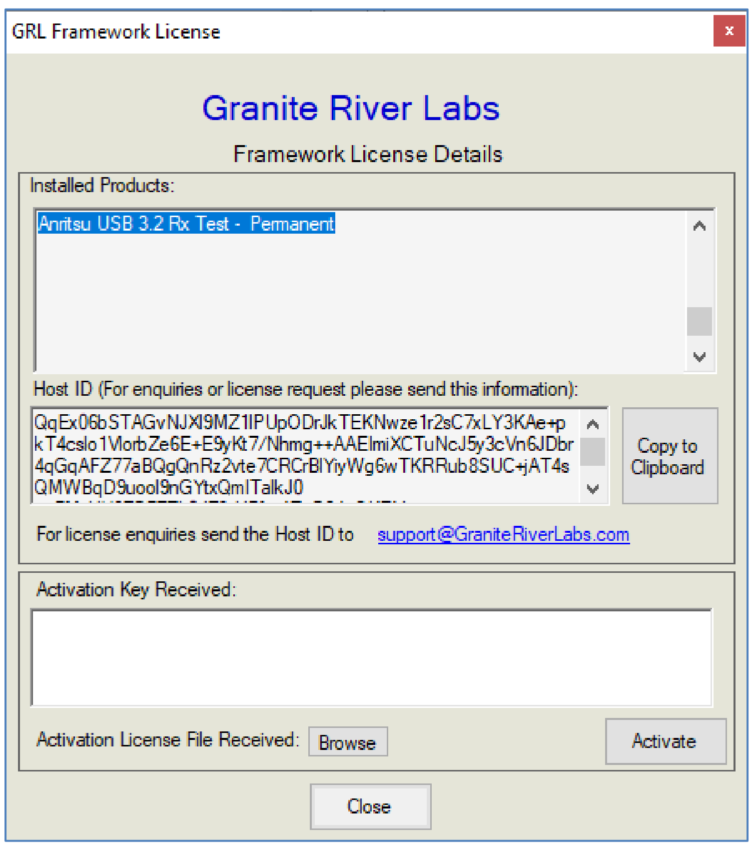


FIGURE 4. CHECK LICENSE FOR INSTALLED APPLICATIONS

b) Activate a License:

- If you have an Activation Key, enter it in the field provided and select "Activate".

- If you do not have an Activation Key, select “Close” to use a demo version of the software over a free 10-day trial period.

Note: *Once the 10-day trial period ends, you will need to request an Activation Key to continue using the software on the same computer or oscilloscope. The demo software is also limited in its capability, in that it will only calibrate the maximum frequency for each data rate. Thus, the demo version cannot be used to fully calibrate and test a device. For Demo and Beta Customer License Keys, please request an Activation Key by contacting support@graniteriverlabs.com.*

4.2.1 Connection Configuration on the Scope or Controller PC OS

4.2.1.1 Connecting Anritsu Signal Quality Analyzer BERT with Scope or PC

Connect the Anritsu BERT via LAN to the GRL automation control enabled Scope or PC. The BERT and MX183000A software can be connected using connection string formats similar to the following examples:

- BERT: “TCPIP0::192.168.0.14::5001::SOCKET” or “192.168.0.14:5001”
- MX183000A: “TCPIP0::192.168.0.14::5000::SOCKET” or “192.168.0.14:5000”

(Note the IP addresses listed above are only examples and should be changed according to the actual network connection being used.)

4.2.1.2 Connecting Oscilloscope with PC

Connect the oscilloscope with the GRL automation control enabled PC through either GPIB, USB or LAN.

(Note: Additional information for connecting the Keysight and Tektronix oscilloscopes to the PC is provided in the Appendix of this MOI.)

4.2.2 On the Scope or Controller PC

1. Select the Equipment Setup icon on the GRL-Anritsu USB 3.2 Rx Test Application menu.
2. On the Scope or PC, obtain the network addresses for all the connected instruments from the device settings. Note these addresses as they will be used to connect the instruments to the GRL automation software.
3. If instruments are connected using LAN, type in the IP Address of each instrument into “Address” field, or if using USB, type in the COM address, and click the “lightning” button ( ).

   The “lightning” button should turn green ( ) once the software has successfully established connection with each instrument.

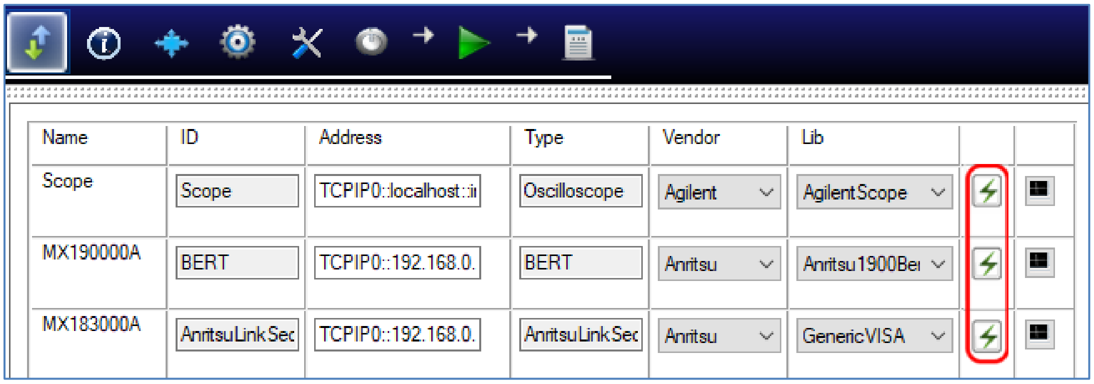


FIGURE 5. GRL RX TEST SOLUTION INSTRUMENT ADDRESSING

4. *(Note: If the GRL software is installed on the* ***Tektronix Scope****, ensure the Scope is connected via GPIB and type in the GPIB network address, for example "GPIB8::1::INSTR.)*

   If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example "TCPIP0::192.168.0.110::inst0::INSTR". Note to ***omit*** the Port number from the address.

   (Note: If the GRL software is installed on the ***Keysight Scope****, and if there is error in connection, type in the Scope IP address as "TCPIP0::192.168.0.4::5025::SOCKET".)*

5. The "lightning" button should turn green if successfully connected to the instrument.

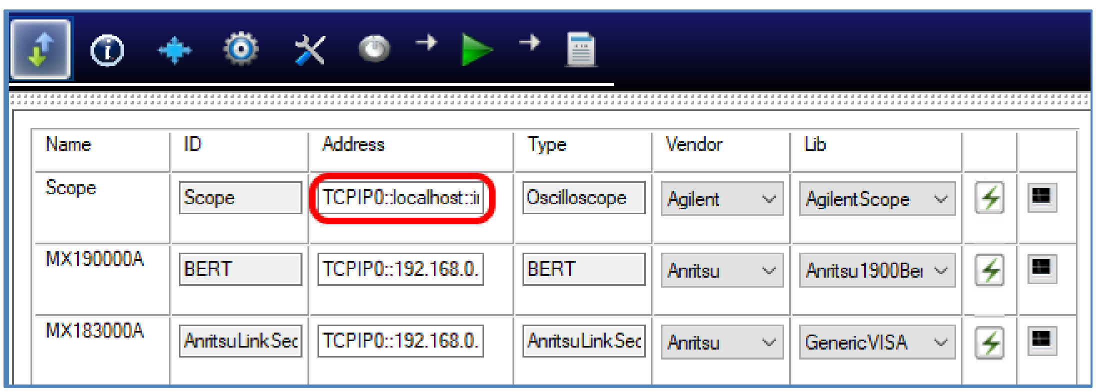


FIGURE 6. GRL RX TEST SOLUTION IP ADDRESSING ON SCOPE

5 Receiver Calibration Setups

The Electrical Compliance Test Specification for Enhanced SuperSpeed Universal Serial Bus describes the Receiver Calibration and Test Procedure in the following sections.

- TD.1.8 – Receiver Jitter Tolerance Test at 5GT/s (for USB Type-A and USB Type-B Micro)
- TD.1.9 – Receiver Jitter Tolerance Test at 5GT/s (for USB Type-C)
- TD.1.10 – Receiver Jitter Tolerance Test at 10GT/s

The following sections show the setup connection diagrams for the BERT Calibration. The fixtures and channels used for USB 3.2 Compliance testing are available from USB-IF.

Refer to Section 10 for details on which fixture and calibration channel to use for each topology. If the device supports USB 3.2 Gen1 (5GT/s), Gen2 (10GT/s) and Gen2x2 (20GT/s), all data rates need to be tested.

5.1 Connection Setup for BERT Generator Set

Figure 7 shows the connection setup between each module of the Anritsu MP1900A BERT Generator Set.

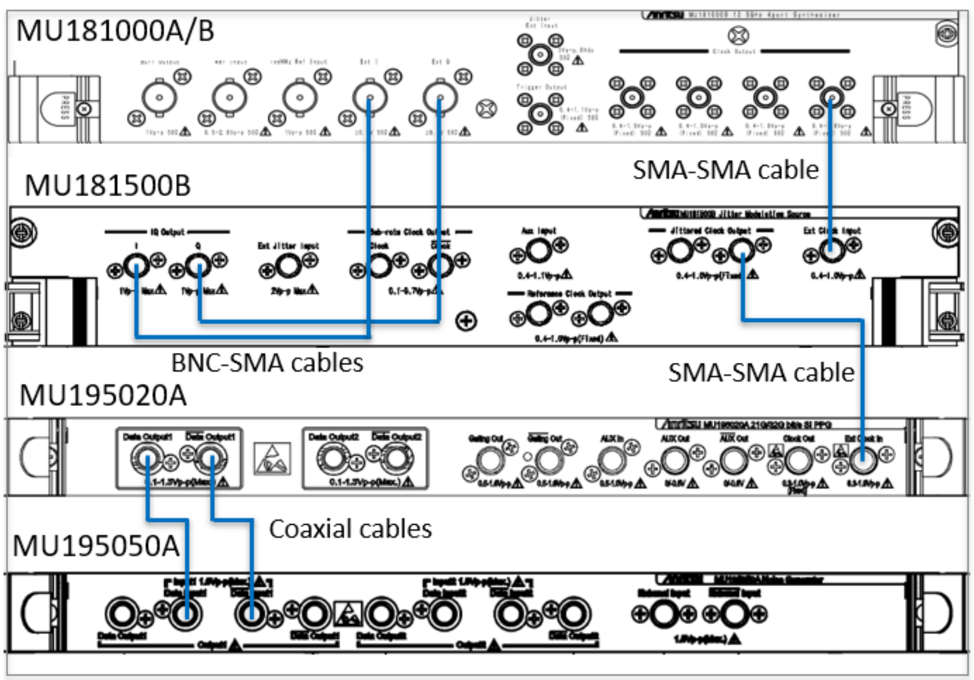


FIGURE 7. CONNECTION SETUP FOR MP1900A BERT GENERATOR SET MODULES

Connection Steps:

1. Using a SMA-SMA short cable, connect the MU181000A/B clock output to the MU181500B Ext clock input.

2. Using a SMA-SMA short cable, connect the MU181500B jittered clock output to the MU195020A Ext clock input.
3. Using BNC-SMA cables, connect the MU181000A/B Ext I_Ext Q to the MU181500B I_Q output.
4. Using coaxial cables, connect the MU195020A data outputs to the MU195050A data inputs.

5.2 Connection Setup for Swing and De-Emphasis Calibration

Figure 8 shows the Calibration setup diagram for calibrating swing and de-emphasis using the MP1900A BERT. The cables attached to the oscilloscope should remain attached to the scope after performing Deskew (Section 14) and Swing and De-Emphasis calibration in the following sections.

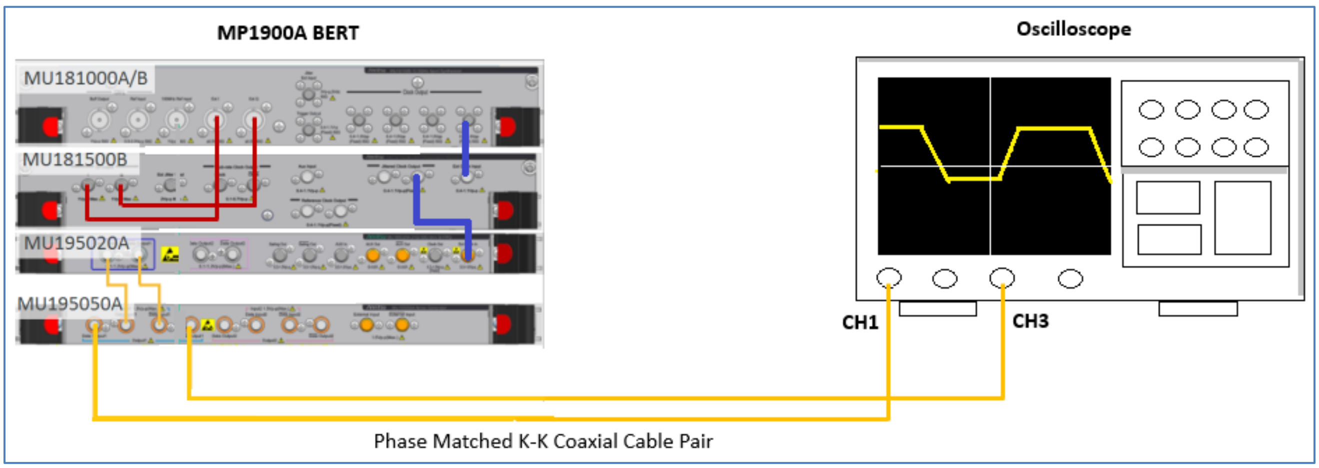


FIGURE 8. CALIBRATION SETUP FOR SWING AND DE-EMPHASIS

Connection Step:

Using phase matched K-K coaxial cables, connect the MU195050A data outputs to Channels 1 and 3 on the oscilloscope.

5.3 Calibration Setup for TD.1.8 Jitter Tolerance 5GT/s (USB Type-A, USB Type-B Micro)

Figure 9 shows the Calibration setup diagram for Hosts/Devices with USB Type-A or USB Type-B Micro connectors when testing at 5GT/s using the MP1900A BERT.

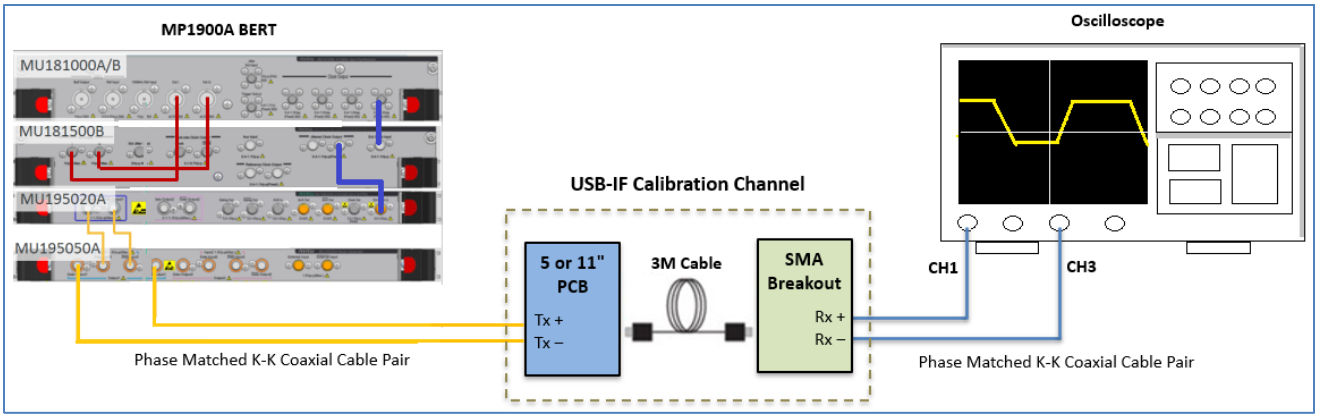


FIGURE 9. CALIBRATION SETUP FOR 5GT/S USB TYPE-A OR USB TYPE-B MICRO

Connection Steps:

1. Continue from Swing and De-Emphasis Calibration Setup.
2. Disconnect the phase matched K-K coaxial cables from the data outputs of the MU195050A, leaving the other side of the cable pair attached to Channels 1 and 3 of the Oscilloscope.
3. Using another phase matched K-K coaxial cable pair, connect the MU195050A data outputs to the Tx+/Tx- input of the appropriate USB-IF Calibration Channel.
4. Using the phase matched K-K coaxial cables, connect the Rx+/Rx- output of the USB-IF Calibration Channel to Channel 1/3 of the Oscilloscope.

5.4 Calibration Setup for TD.1.9 Jitter Tolerance 5GT/s (USB Type-C)

Figure 10 shows the Calibration setup diagram for Hosts/Devices with the USB Type-C connector using the MP1900A BERT.

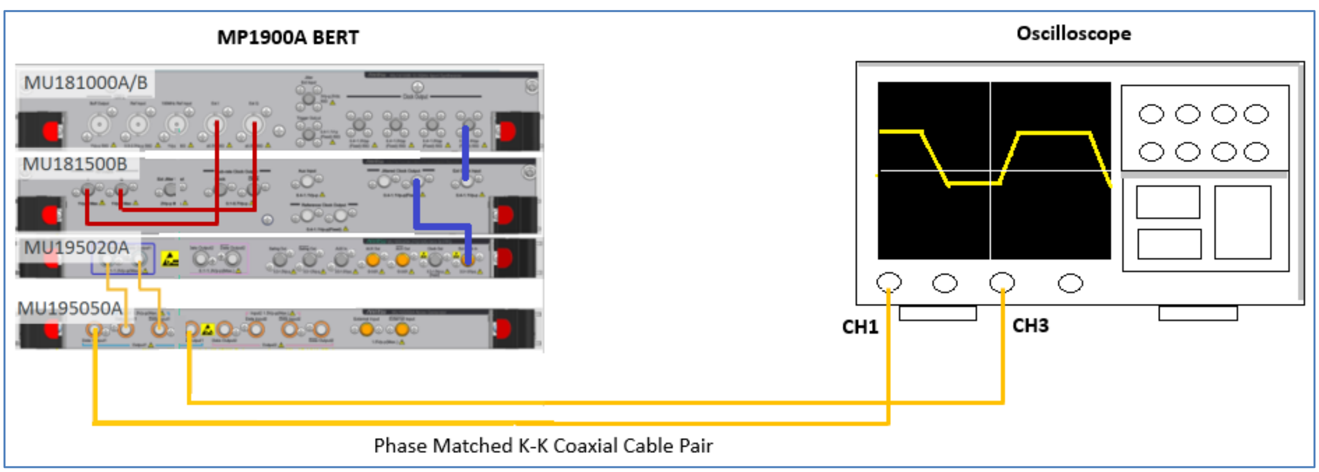


FIGURE 10. CALIBRATION SETUP FOR 5GT/S USB TYPE-C

Connection Step:

Continue from Swing and De-Emphasis Calibration Setup. No additional setup is needed.

5.5 Calibration Setup for TD.1.10 Jitter Tolerance 10GT/s (All Connector Types)

Figure 11 shows the Calibration setup diagram for Hosts/Devices with all connector types when calibrating to 10GT/s using the MP1900A BERT.

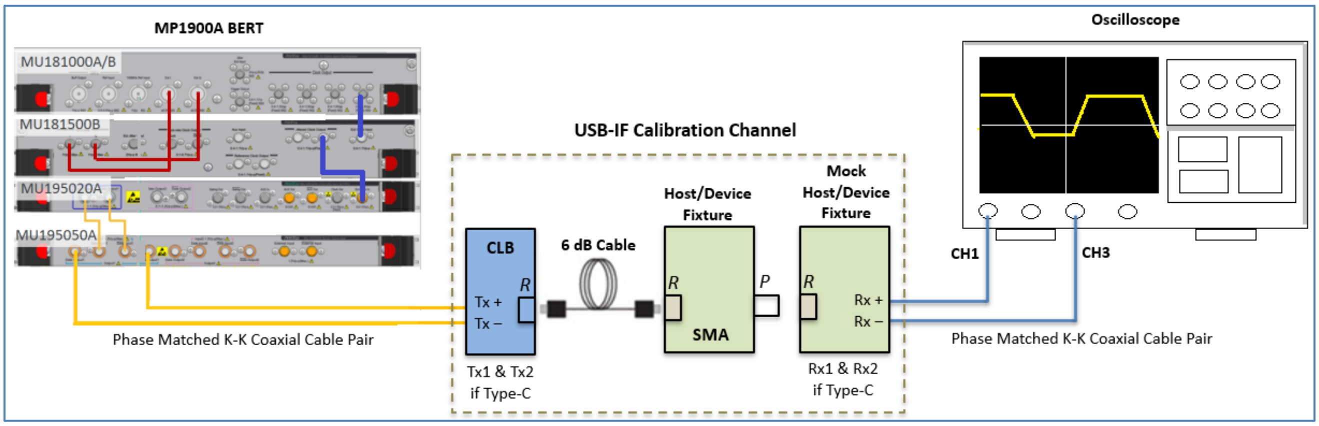


FIGURE 11. CALIBRATION SETUP FOR 10GT/S (ALL CONNECTOR TYPES) USING MP1900A BERT

Connection Steps:

1. Continue from Swing and De-Emphasis Calibration Setup.
2. Disconnect the phase matched K-K coaxial cables from the data outputs of the MU195050A, leaving the other side of the cable pair attached to Channels 1 and 3 of the Oscilloscope.
3. Using another phase matched K-K coaxial cable pair, connect the MU195050A data outputs to the Tx+/Tx- input of the appropriate USB-IF Calibration Channel.
4. Using the phase matched K-K coaxial cables, connect the Rx+/Rx- output of the USB-IF Calibration Channel to Channel 1/3 of the Oscilloscope.

Note: When testing a USB Type-C device, both Rx1 and Rx2 paths need to be tested. This can be done by either flipping the cable and testing through the Rx1 path twice, or calibrating both Rx1 and Rx2 paths separately.

6 Calibrating Using GRL-USB32-RXA Software

6.1 Enter Calibration/Test Session Information

Select the button in the main software menu to access the Session Info page. Enter the information as required for the test session that is currently being run. The information provided will be included in the test report generated by the software once tests are completed.

- The fields under **DUT Info** and **Test Info** are defined by the user.
- The **Software Info** field is automatically populated by the software.

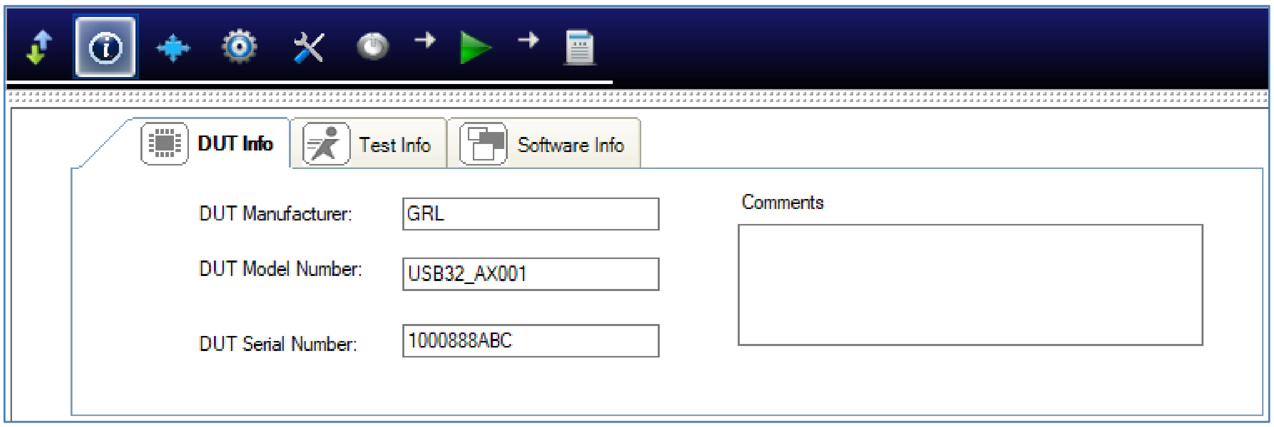


FIGURE 12. SESSION INFO PAGE

6.2 Set Up Conditions for Calibration/Testing

Select the button in the main software menu to access the Conditions page to set the conditions for calibration and testing. The GRL software will perform calibration and testing for selected data rates and defined SJ frequencies.

Recommended procedure:

- *Step 1*: When calibrating, select all conditions that may be used for testing, and perform the calibration.
- *Step 2*: Once calibration is completed and ready for testing, re-select the necessary test conditions. For example, if required to test for a single SJ frequency, then select only the required SJ frequency for testing.

1. Select the Data Rate.

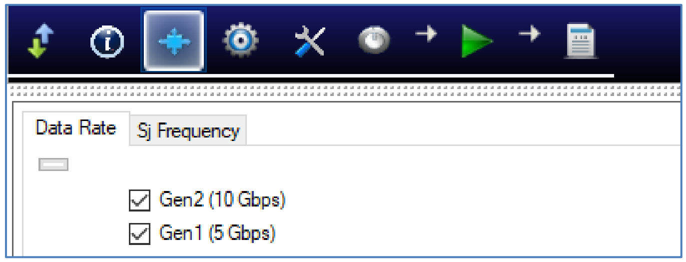


FIGURE 13. SELECT DATA RATE

2. Select the SJ frequency.

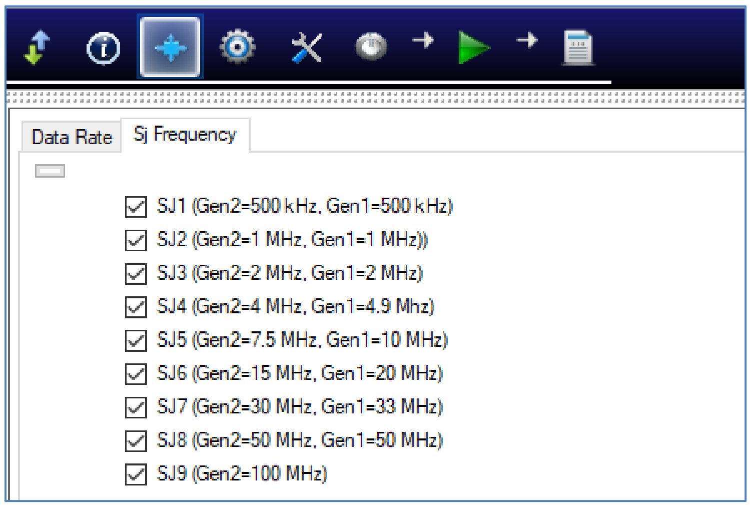


FIGURE 14. SELECT SJ FREQUENCY

6.3 Configure DUT Type

Select the button in the main software menu to access the Setup Configuration page.

6.3.1 Device Type Setup

Select either a Host or a Device to be used as DUT.

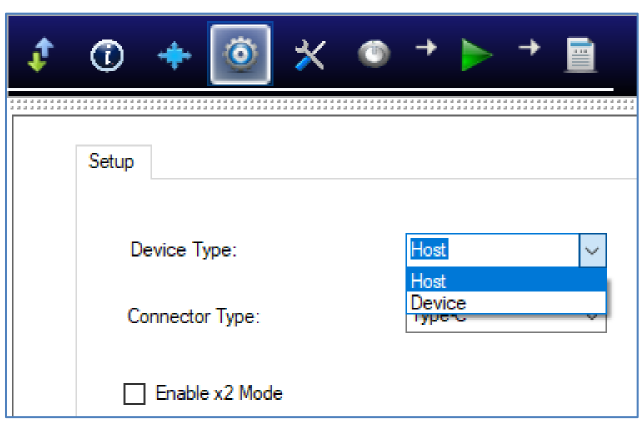


FIGURE 15. SELECT DUT TYPE

6.3.2 Connector Type Setup

Select the “Type-C” connector if supported by the DUT or “Other” if the DUT is non USB Type-C based.

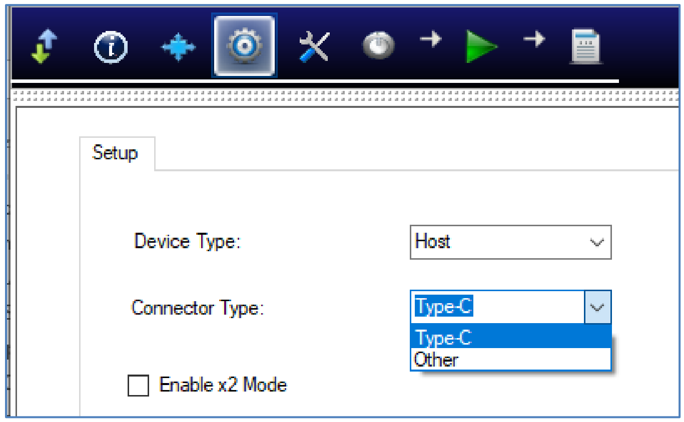


FIGURE 16. SELECT CONNECTOR TYPE

If the DUT is USB Type-C based and supports USB 3.2 Gen 2x2, select the “Enable x2 Mode” checkbox to enable calibration and tests at 20GT/s with dual channel PPG and ED for the DUT.

6.4 Select Calibration

The test selection page allows calibration/tests that need to be performed to be selected. Initially when starting for the first time or changing anything in the setup, it is suggested to run Calibration first. If the calibration is not completed, the Rx Tests will throw an error message.

The GRL-USB32-RXA software automatically runs the selected calibration when initiated. See Section 6.7 on running the calibration.

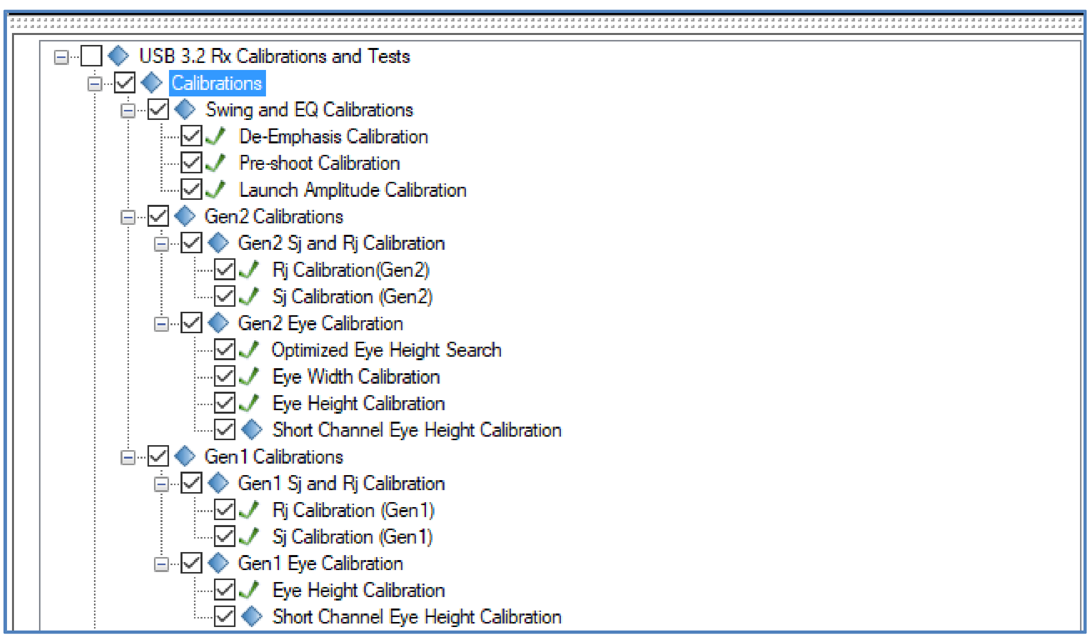


FIGURE 17. SELECT CALIBRATION

Note: The marking shown on the left of each test parameter indicates the status of the calibration/test result of the parameter. In the above example, ◆ *indicates that testing has not been run for the specific test parameter, while* ✓ *indicates that testing has been run and completed successfully for the specific test parameter with a Pass result.*

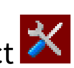
6.4.1 Calibrations Group

Select the main Calibrations checkbox to perform all USB 3.2 Rx calibration supported by the GRL software.

TABLE 5. SUPPORTED CALIBRATION

Calibration	Description
De-Emphasis	Calibrates the BERT De-emphasis and forms a linear curve fit.
Pre-shoot	Calibrates the BERT Pre-shoot and forms a linear curve fit.
Launch Amplitude	Calibrates the BERT Amplitude to 800mV.
Gen1/Gen2 Sj	Calibrates sinusoidal jitter (SJ) of all eight frequencies for USB 3.2 Gen1 and nine frequencies for USB 3.2 Gen2 as required by USB 3.2 Specs and forms a linear curve fit for each SJ frequency.
Gen1/Gen2 Rj	Calibrates random jitter (RJ) of the BERT.
Gen2 Optimized Eye Height Search	Determines the CLB fixture which gives an eye height closest to 70mV.
Gen2 Eye Height	Calibrates Eye Height to requirement by USB 3.2 Specs.
Gen2 Eye Width	Calibrates Eye Width to requirement by USB 3.2 Specs.
Gen1/Gen2 Short Channel Eye Height	Calibrates Eye Height for short channel compliance to requirement by USB 3.2 Specs.

6.5 Configure Calibration Parameters

After selecting the desired calibration, select  from the menu to access the Configurations page. Set the required parameters for calibration as described below.

To return all parameters to their default values, select the 'Set Default' button.

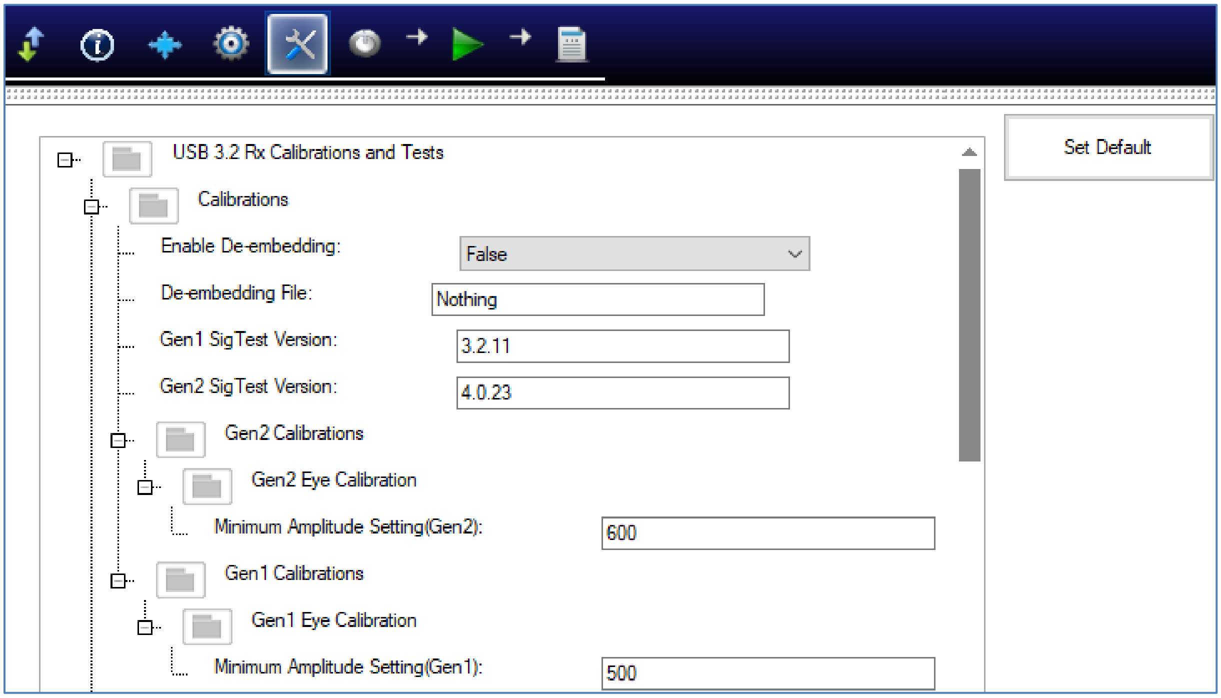


FIGURE 18. CONFIGURE CALIBRATION PARAMETERS

TABLE 6. CALIBRATION PARAMETERS DESCRIPTION

Parameter	**Description**
Enable De-embedding	Select ‘True’ to de-embed cable while calibrating.
De-embedding File	Define the cable transfer function file. *Applicable only when Enable De-embedding is set to ‘True’.*
Gen1 & 2 SigTest Version	Enter the version number of the SigTest software to be used for each USB 3.2 Gen 1 and Gen 2 calibration.
Gen1 & 2 Eye Calibration Minimum Amplitude Setting	Enter the minimum amplitude value to be applied for each USB 3.2 Gen 1 and Gen 2 eye calibration.

6.6 Configure Calibration Target Values

For debugging purposes ONLY, the default calibration target values can be changed for the RJ and SJ calibration. To do this, select  from the menu to access the Calibration page.

By default, the calibration target values are those defined in the specification. To change the values, un-select the ‘Use Default Value’ checkbox. In case the default values are required again, just select the checkbox to allow all existing values to be reset to default.

Note: The PID Control setting is used to adjust the step width for steps calculation if the target measurement cannot be met with the current step. To adjust, use a lower PID Control value to reduce the subsequent step or increase the control value to make the subsequent step bigger.

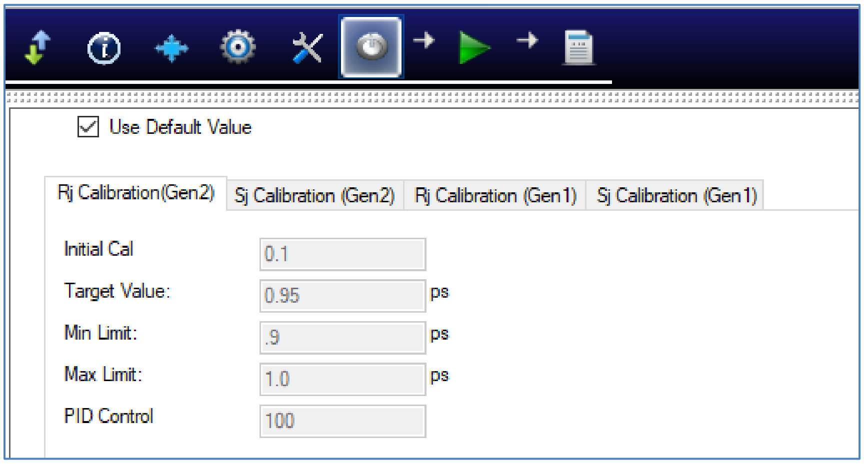
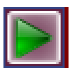


FIGURE 19. OVERWRITE EXISTING CALIBRATION TARGETS

6.7 Run Calibration

Select  in the main software menu to access the Run Tests page.

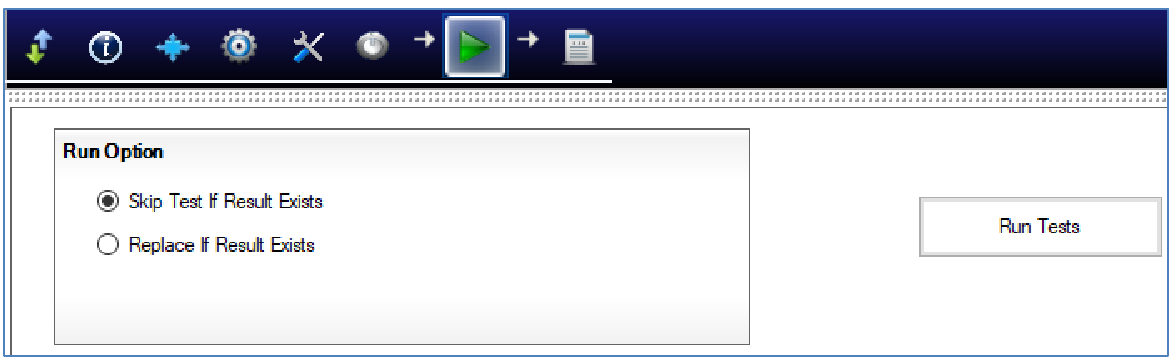


FIGURE 20. RUN CALIBRATION

Select the Run Option before clicking the Run Tests button to start running selected calibration:

- **Skip Test if Result Exists.** If previous calibration results exist, then the software will *skip* the calibration steps that have existing reports.
- **Replace if Result Exists.** If previous calibration results exist, then the software will *replace* each step in the calibration with new results.

When calibration is running, the connection setup diagram of the respective calibration will initially appear as a guide for the user to make sure all connections are proper before calibration is performed.

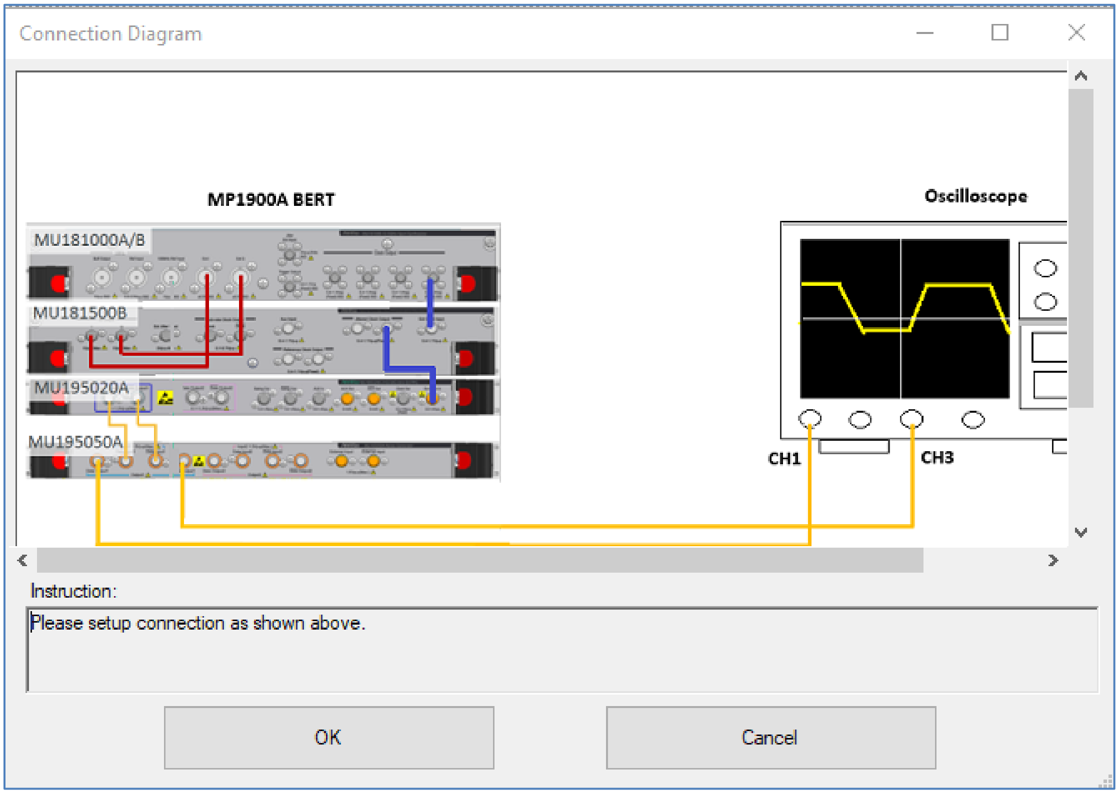


Figure 21. Connection Diagram Dialog Example

If you need to re-run only certain calibration on certain conditions, delete the calibration results from the Report tab and Run with **Skip Test if Result Exists.** The GRL software will keep track of the missing calibration results in the report and perform those calibration only.

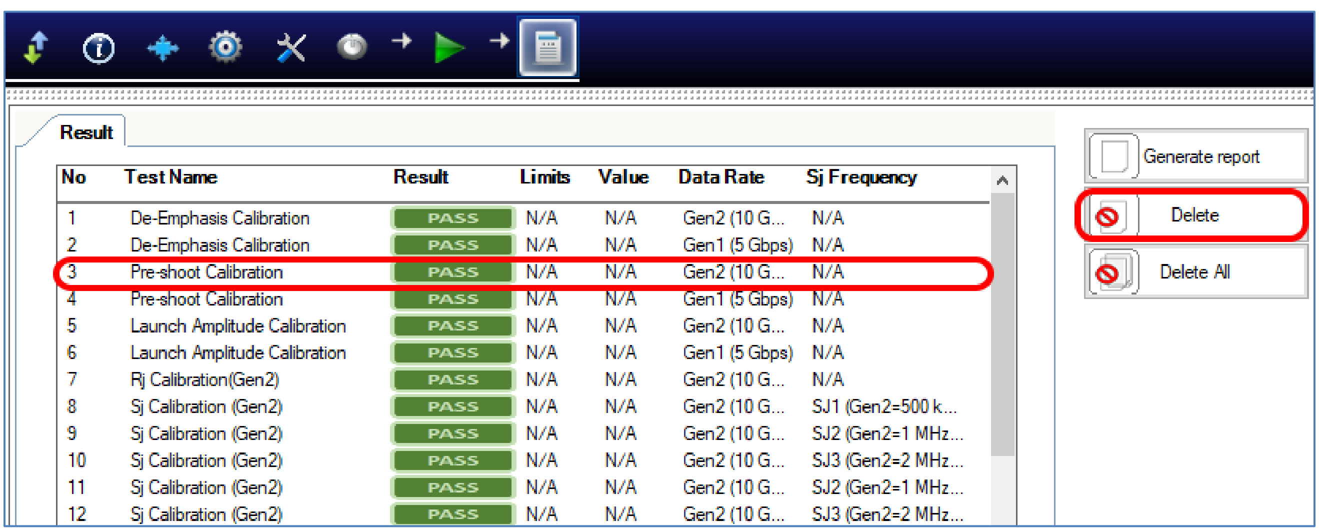


Figure 22. Delete Calibration Results

7 Compliance Testing Using GRL-USB32-RXA Software

After calibration has completed successfully, receiver channel compliance and optional margin testing can then be performed on the device under test (DUT). The GRL-USB32-RXA software automates USB 3.2 Gen1 & 2 receiver compliance testing for long and short channels, at the spec-defined or user-defined jitter frequency steps as well as USB 3.2 Gen2x2 Rx testing with dual channel PPG and ED for the USB Type-C DUT. The GRL software also supports nested loop testing of multiple parameters to facilitate testing across multiple test conditions. The DUT can be placed in the loopback mode to be tested for specified BER (Bit Error Rate) compliance with the calibration stressed signals.

If desired, optional receiver margin testing can be additionally performed via the GRL software to search for SJ margins and plot marginal eye diagrams.

When testing is completed, the results will be logged in an aggregated test report which can be generated into the PDF format.

7.1 Connection Setup for BERT Generator Set

Figure 23 shows the connection setup between each module of the Anritsu MP1900A BERT Generator Set for DUT compliance testing.

[Note: The red dotted lines represent the connection for the USB 3.2 Gen2x2 based USB Type-C DUT only. For non-USB 3.2 Gen2x2 based DUT's, this connection is not required in the test setup.]

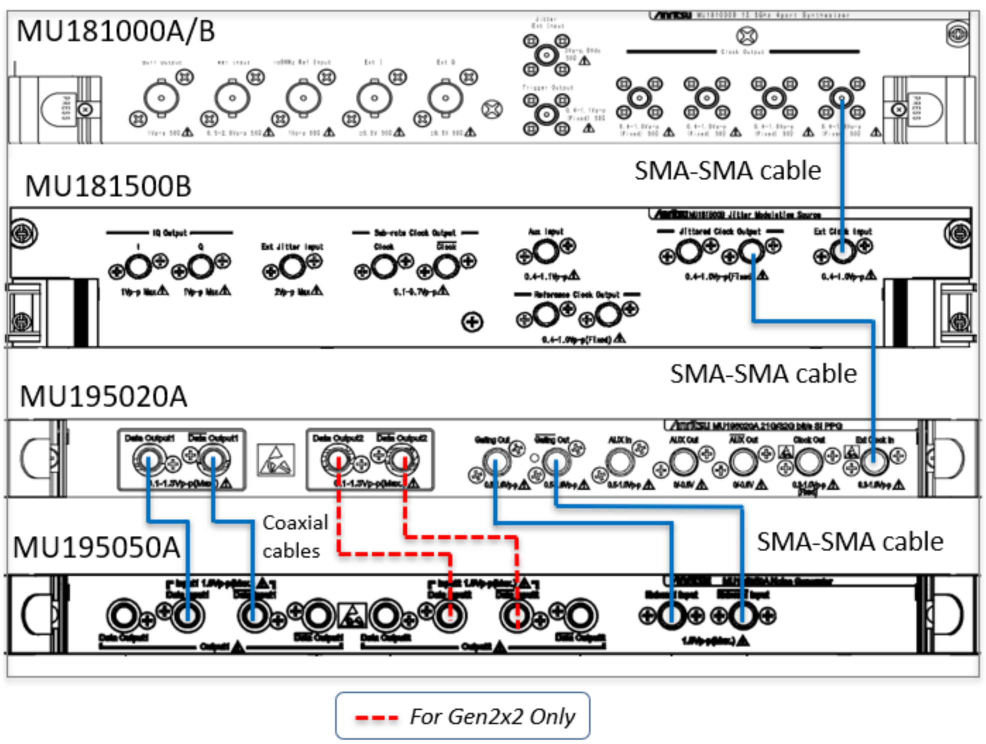


FIGURE 23. CONNECTION SETUP FOR MP1900A BERT GENERATOR SET MODULES FOR DUT TESTING

Connection Steps:

1. Using a SMA-SMA short cable, connect the MU181000A/B clock output to the MU181500B Ext clock input.
2. Using a SMA-SMA short cable, connect the MU181500B jittered clock output to the MU195020A Ext clock input.
3. Using SMA-SMA cables, connect the MU195020A Gating outputs to the MU195050A External inputs.
4. Using coaxial cables, connect the MU195020A data outputs (Data Output1) to the MU195050A data inputs (Data Input1). If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another pair of coaxial cables between the MU195020A data outputs (Data Output2) to the MU195050A data inputs (Data Input2).

7.2 Connection Setups for Testing

7.2.1 Test Setup for TD.1.8 Jitter Tolerance at 5GT/s (USB Type-A, USB Type-B Micro)

Figure 24 shows the Test setup diagram for Hosts/Devices with USB Type-A or USB Type-B Micro connectors when testing at 5GT/s using the MP1900A BERT.

[Note: The red dotted lines represent the connection for the USB 3.2 Gen2x2 based USB Type-C DUT only. For non-USB 3.2 Gen2x2 based DUT's, this connection is not required in the test setup.]

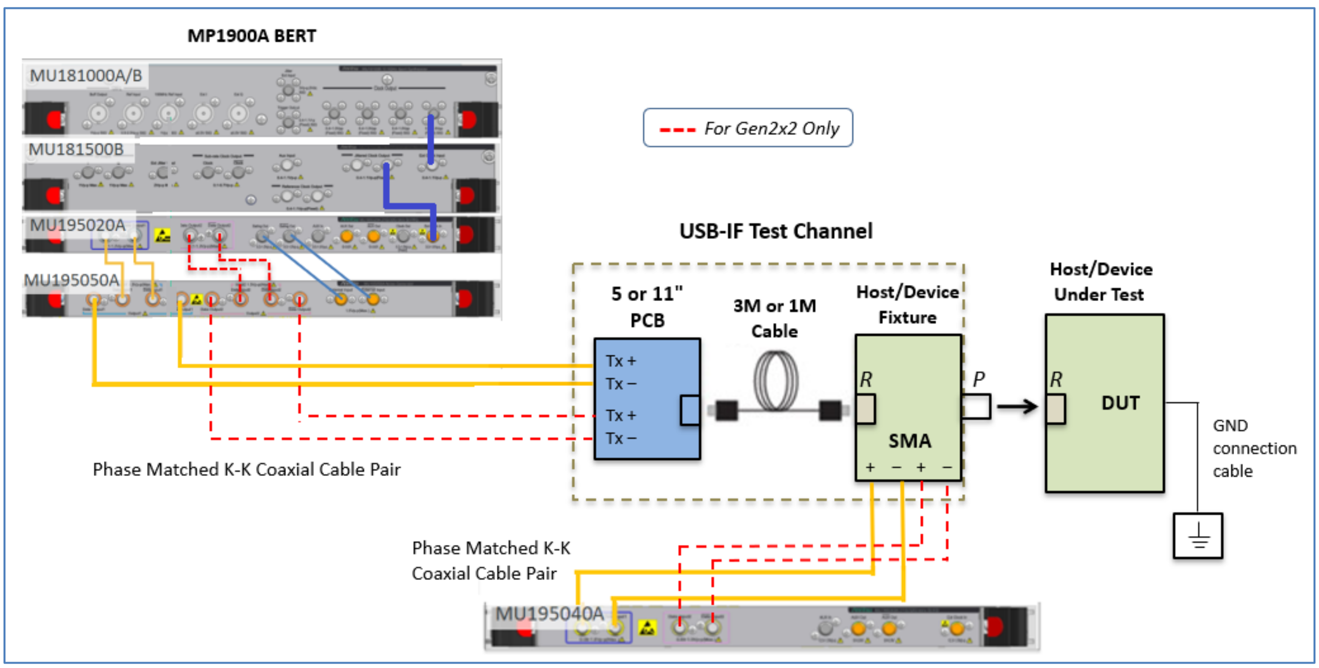


FIGURE 24. TEST SETUP FOR 5GT/S USB TYPE-A OR USB TYPE-B MICRO

Connection Steps:

1. Set up the BERT as shown in Figure 23.

2. If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another phase matched K-K coaxial cable pair from the MU195050A data outputs to the Tx+/Tx- input of the USB-IF Test Channel.
3. Disconnect the far end of the USB cable used in the test channel from the SMA breakout fixture used for calibration.
4. Connect the connector-specific Host/Device fixture to the far end of the USB cable. *(Note: If the DUT is a USB Micro Host/Device, then the 3M Cable used for calibration is to be replaced with a 1M Cable.)*
5. Using the phase matched K-K coaxial cables, connect the SMA connections from the Host/Device fixture '+' and '-' to the MU195040A data inputs respectively for loopback error detection. If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another phase matched K-K coaxial cable pair from the Host/Device fixture '+' and '-' SMA connections to the MU195040A data inputs respectively.
6. Connect the DUT to ground using a GND connection cable.
7. Launch the MX183000A "High-Speed Serial Data Test" Software on the BERT.
8. Connect the Host/Device fixture to the DUT when prompted to initiate loopback training sequence.

7.2.2 Test Setup for TD.1.9 Jitter Tolerance at 5GT/s (USB Type-C)

Figure 25 shows the Test setup diagram for Hosts/Devices with USB Type-C when testing at 5GT/s using the MP1900A BERT.

[Note: The red dotted lines represent the connection for the USB 3.2 Gen2x2 based USB Type-C DUT only. For non-USB 3.2 Gen2x2 based DUT's, this connection is not required in the test setup.]

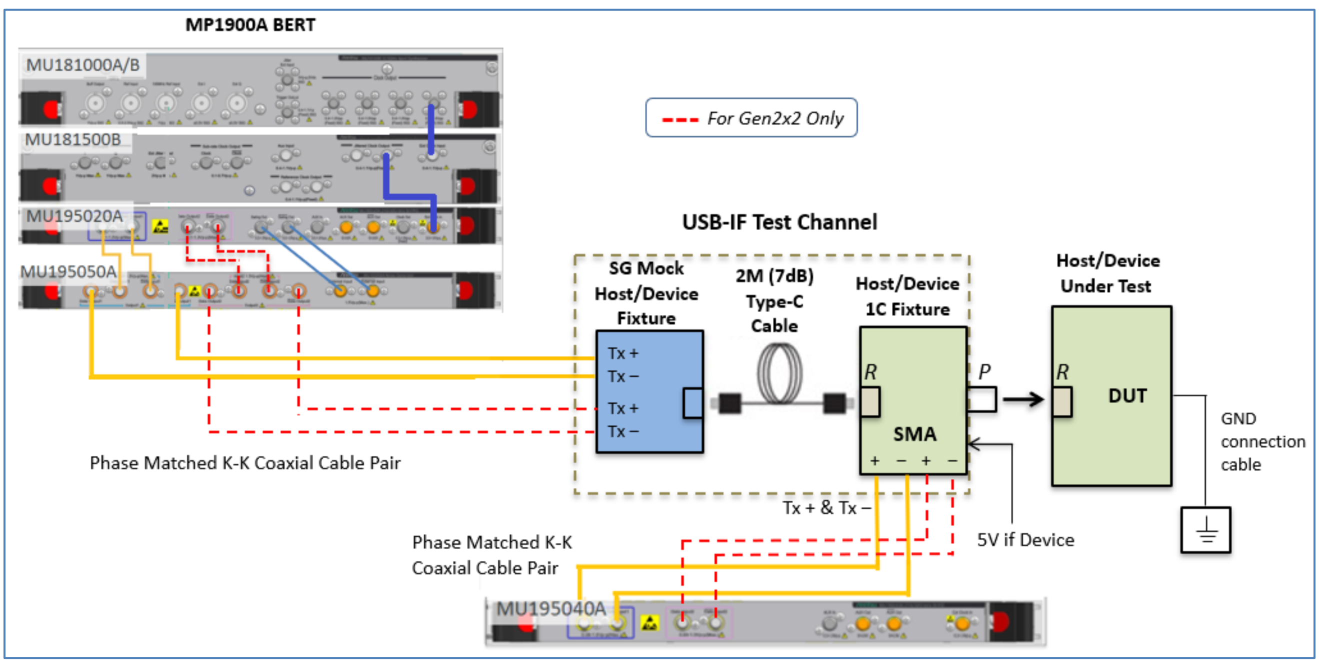


FIGURE 25. TEST SETUP FOR 5GT/S USB TYPE-C

Connection Steps:

1. Set up the BERT as shown in Figure 23.
2. Disconnect the phase matched K-K coaxial cables from Ch1 and Ch3 of the Oscilloscope used for calibration.
3. Without disconnecting the other end of the phase matched K-K coaxial cable pair from the data outputs of the MU195050A, connect the other end to the Tx+/Tx- input of the appropriate USB-IF Test Channel.
4. If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another phase matched K-K coaxial cable pair from the MU195050A data outputs to the Tx+/Tx- input of the USB-IF Test Channel.
5. Using the phase matched K-K coaxial cables, connect the SMA connections from the Host/Device 1C Fixture 'Tx+' and 'Tx-' to the MU195040A data inputs respectively for loopback error detection. If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another phase matched K-K coaxial cable pair from the Host/Device 1C Fixture 'Tx+' and 'Tx-' SMA connections to the MU195040A data inputs respectively.
6. Connect the DUT to ground using a GND connection cable.
7. Launch the MX183000A "High-Speed Serial Data Test" Software on the BERT.
8. Connect the Host/Device Test Fixture to the DUT when prompted to initiate loopback training sequence.

Note: When testing a USB Type-C device, both Rx1 and Rx2 paths need to be tested. This can be done by either flipping the cable and testing through the Rx1 path twice, or calibrating both Rx1 and Rx2 paths separately. Care must be taken to make sure the proper Tx1/Rx1 and Tx2/Rx2 signal paths are used for testing.

7.2.3 Test Setup for TD.1.10 Jitter Tolerance at 10GT/s (All Connector Types)

Figure 26 shows the Test setup diagram for Hosts/Devices with any connector type when testing at 10GT/s using the MP1900A BERT.

[Note: The red dotted lines represent the connection for the USB 3.2 Gen2x2 based USB Type-C DUT only. For non-USB 3.2 Gen2x2 based DUT's, this connection is not required in the test setup.]

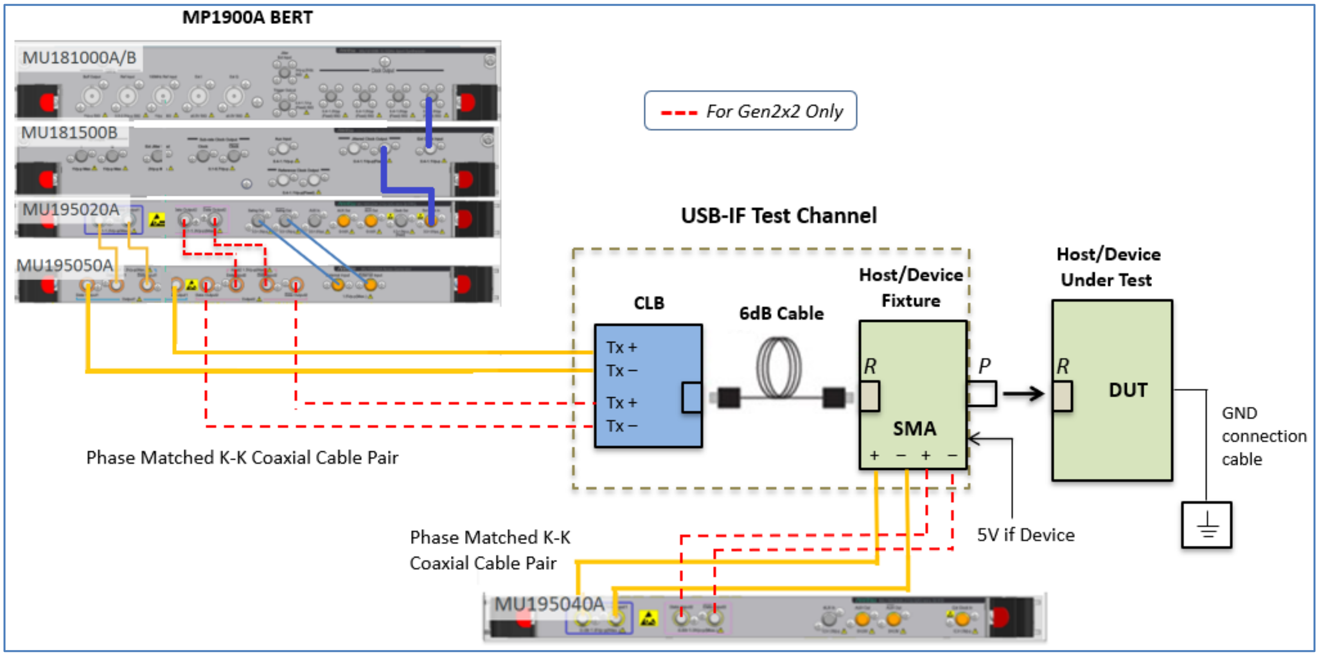


FIGURE 26. TEST SETUP FOR 10GT/S (ALL CONNECTOR TYPES)

Connection Steps:

1. Set up the BERT as shown in Figure 23.
2. If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another phase matched K-K coaxial cable pair from the MU195050A data outputs to the Tx+/Tx- input of the USB-IF Test Channel.
3. Disconnect the Host/Device Plug fixture from the Mock Host/Device Receptacle fixture used for calibration.
4. Using the phase matched K-K coaxial cables, connect the SMA connections from the Host/Device Fixture '+' and '-' to the MU195040A data inputs respectively for loopback error detection. If testing a USB 3.2 Gen2x2 based USB Type-C DUT, connect another phase matched K-K coaxial cable pair from the Host/Device fixture '+' and '-' SMA connections to the MU195040A data inputs respectively.
5. Connect the DUT to ground using a GND connection cable.
6. Launch the MX183000A "High-Speed Serial Data Test" Software on the BERT.
7. Connect the Host/Device Test Fixture to the DUT when prompted to initiate loopback training sequence.

Note: When testing a USB Type-C device, both Rx1 and Rx2 paths need to be tested. This can be done by either flipping the cable and testing through the Rx1 path twice, or calibrating both Rx1 and Rx2 paths separately. Care must be taken to make sure the proper Tx1/Rx1 and Tx2/Rx2 signal paths are used for testing.

7.3 Select DUT Rx Tests

On the test selection page, deselect all Calibration selections as they were completed in the previous section. Scroll down to access the Rx Test selections. Select the check boxes of the respective tests to be run.

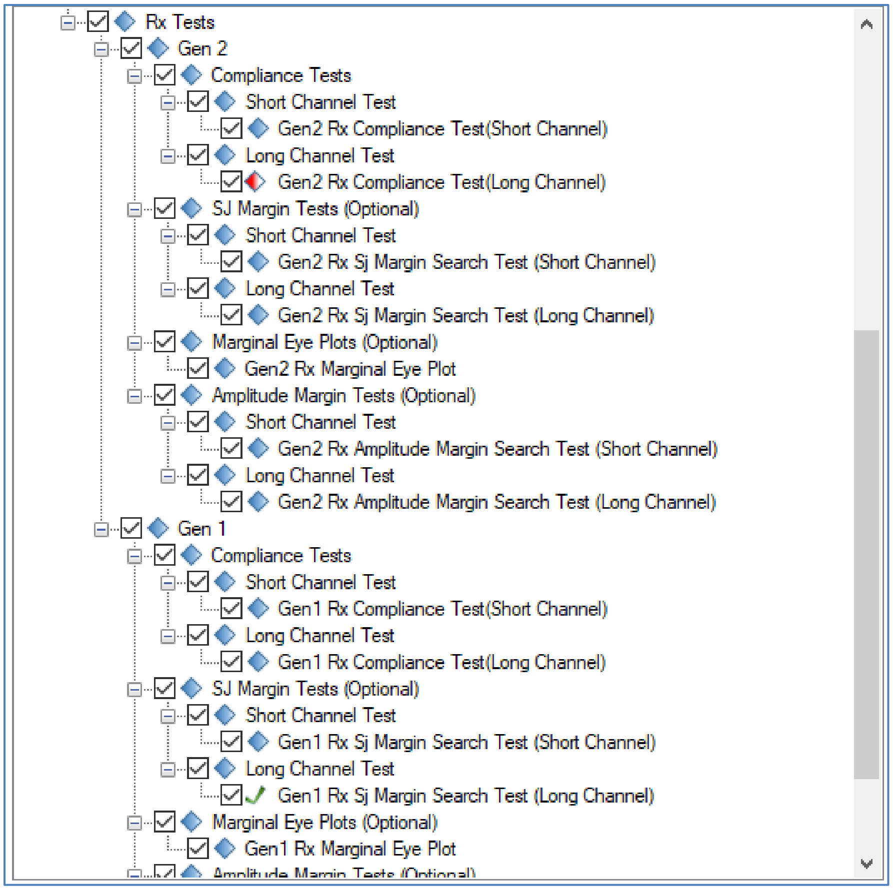


FIGURE 27. SELECT DUT RX TESTS TO BE RUN

7.3.1 Receiver Test Group

Select the main Rx Tests checkbox to perform all USB 3.2 Rx tests for the DUT as supported by the GRL software with parameters from the calibration steps.

TABLE 7. SUPPORTED RX TESTS

Rx Test	Description
Compliance Tests	Runs all Compliance Tests as required by the USB 3.2 Specs
SJ Margin Search Tests	Runs optional Tests to search for SJ Margins
Amplitude Margin Search Tests	Runs optional Tests to search for Amplitude Margins.
Marginal Eye Plots	Runs optional Tests to plot the eye diagrams and SSC profiles to determine

	the source of failures or results with minimal margin. *[Note: These tests are only available for selection when the "Show Eye Plot Test" parameter is set to "True" from the Configurations page. See Section 7.4 below.]*

7.4 Configure Receiver Test Parameters

After selecting the desired tests, select from the menu to access the Configurations page. Set the required parameters for DUT Rx testing as described below.

To return all parameters to their default values, select the 'Set Default' button.

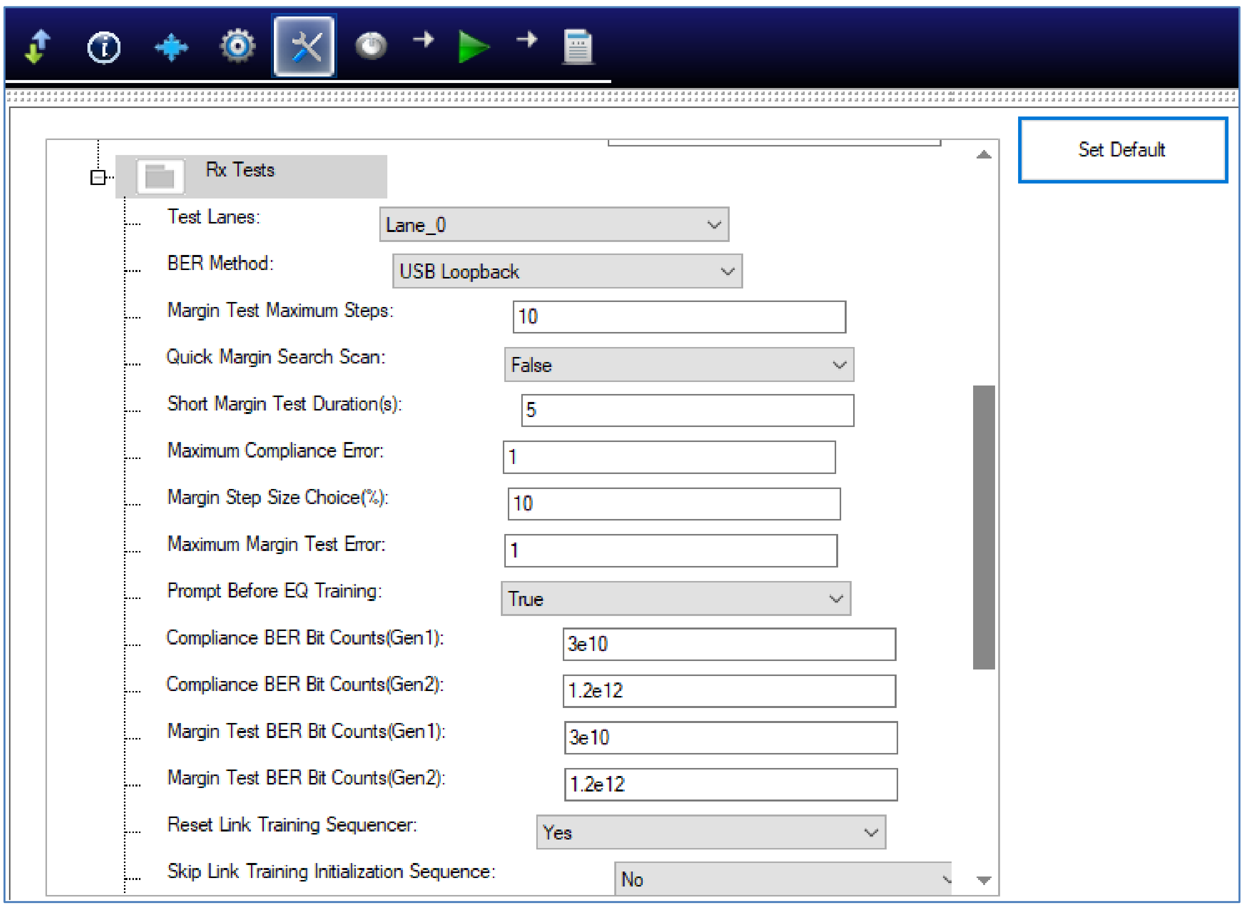


FIGURE 28. CONFIGURE TEST PARAMETERS

TABLE 8. TEST PARAMETERS DESCRIPTION

Parameter Name	Description
Test Lanes	Select test lane 0 or lane 1 if the DUT supports USB 3.2 Gen1/Gen2, or select both test lanes if the DUT is USB Type-C based and supports the USB 3.2 Gen2x2 mode.

BER Method	Select to run BER tests manually or using USB Link Sequencer software loopback.
Margin Test Maximum Steps	Define the maximum number of steps to step through margins.
Quick Margin Search Scan	Select 'True' to perform a quick scan for worst-case margins during margin search tests.
Short Margin Test Duration(s)	Set the duration in seconds to run a brief margin search test.
Maximum Compliance Error	Define the maximum error count for error checking in Rx compliance tests.
Margin Step Size Choice(%)	Set the step size for stepping through margins when running the optional margin search tests.
Maximum Margin Test Error	Define the maximum error count for error checking in margin search tests.
Prompt Before EQ Training	Select 'True' if you want to be prompted prior to start running equalization training.
Compliance BER Bit Counts (Gen1 & Gen2)	Set the total bit count for USB 3.2 Gen1 and Gen2 Rx compliance tests error detection.
Margin Test BER Bit Counts (Gen1 & Gen2)	Set the total bit count for USB 3.2 Gen1 and Gen2 margin tests error detection.
Reset Link Training Sequencer	Select 'Yes' to reset the MX183000A Link Training sequencer to the initial state and re-apply all stresses. Select 'No' for the MX183000A and BERT to remain in the current state and only SJ/amplitude are changed *[for Debug purposes only]*.
Skip Link Training Initialization Sequence	Select the option to skip the initial loopback training sequence.
Retrain When Sj Frequency Changed	Select 'True' to re-send link training sequence when this is a change in the Sj frequency.
Ignore Failed Link Training	Select 'True' to ignore failed tests when running link training sequence.
Save BERT Setup Only	Select 'True' to only save the BERT test setup configuration.
Margin Plot Upper & Lower Limit	Set the upper and lower limit values for the data plot generated from the margin tests results.
CTLE Setting & Gain	Select the CTLE method and set the CTLE gain of the error detector during Rx compliance testing.
Interval Time Divider	Increase the interval time divider value to reduce interval time in between the Anritsu MX183000A command flow.
Show Eye Plot Test	Select 'True' to display the Marginal Eye Plots test selection in the test list.

7.5 Set Up Loopback BER Testing

1. To set up the GRL software for loopback BER testing, define the VISA address that connects to the Anritsu MX183000A software.

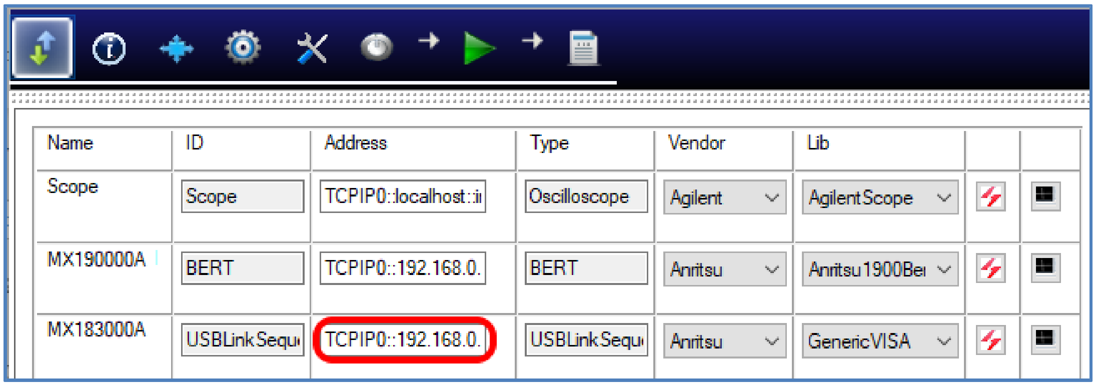


FIGURE 29. CONNECT TO MX183000A

2. Select the BER Method as "USB Loopback" in the Configurations page as below.

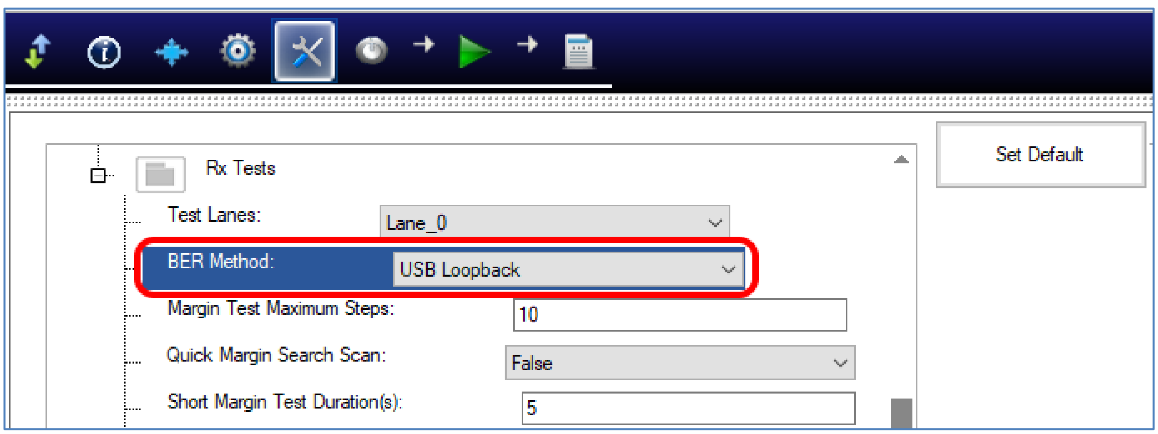
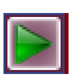


FIGURE 30. SELECT BER LOOPBACK METHOD

7.6 Run the DUT Rx Tests

Select  in the main software menu to access the Run Tests page. Select the Run Option as desired before clicking the Run Tests button to start testing the DUT. *(This is similar to Section 6.7; refer for more details.)*

8 Test Results and Reports Using GRL-USB32-RXA Software

The **Report** page has all the results from all the test runs displayed. If some of the results are not desired, they can be individually deleted by using the **Delete** button. Also for a PDF report, select the **Generate report** button. To have the calibration data plotted in the report, make sure the **Plot Calibration Data** box is checked.

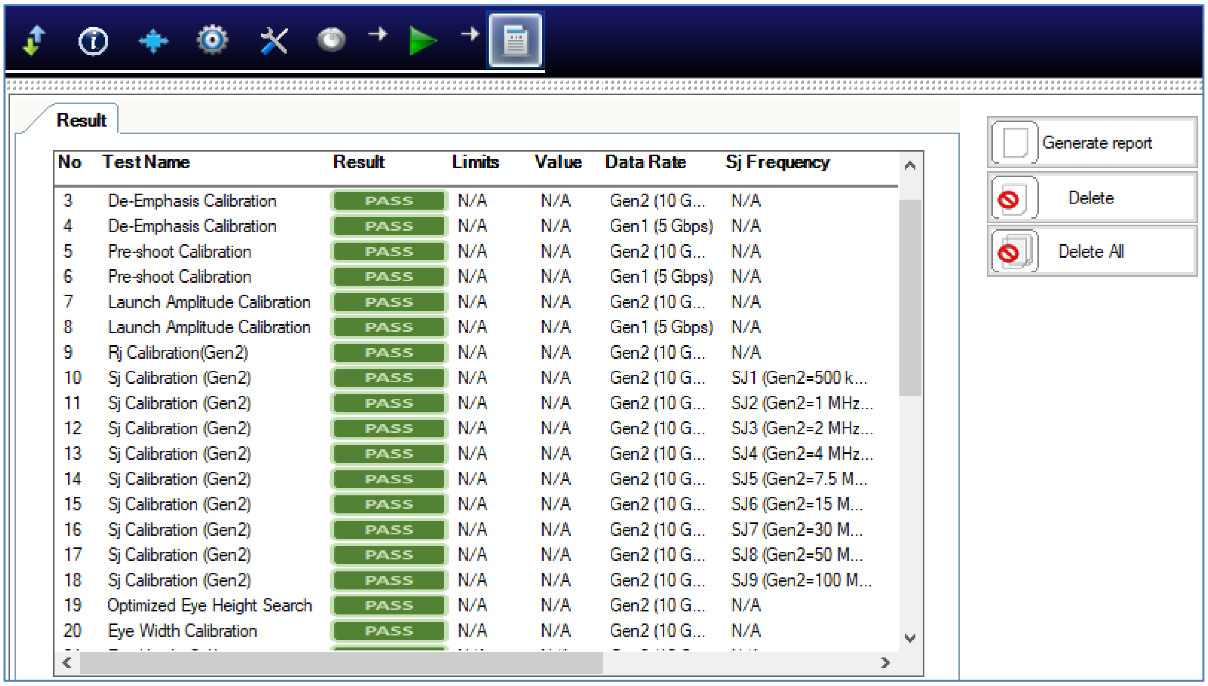
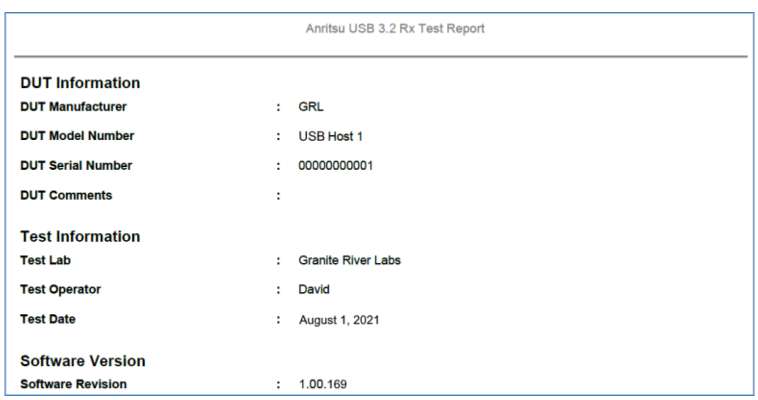


FIGURE 31. REPORT RESULTS PAGE

8.1.1 DUT Information

This portion is populated from the information in the DUT tab from the **Session Info** tab.



Anritsu USB 3.2 Rx Test Report

DUT Information

DUT Manufacturer	:	GRL
DUT Model Number	:	USB Host 1
DUT Serial Number	:	00000000001
DUT Comments	:	

Test Information

Test Lab	:	Granite River Labs
Test Operator	:	David
Test Date	:	August 1, 2021

Software Version

Software Revision	:	1.00.169

FIGURE 32. DUT INFORMATION

8.1.2 Summary Table

This portion is populated from the calibration and tests performed with their respective results. This gives an overall view of all the results and test conditions.

No	TestName	Limits	Value	Results	Data Rate	Sj Frequency
1	De-Emphasis Calibration	True/False	True	Pass	Gen2_10G	N/A
2	De-Emphasis Calibration	True/False	True	Pass	Gen1_5G	N/A
3	Pre-shoot Calibration	True/False	True	Pass	Gen2_10G	N/A
4	Pre-shoot Calibration	True/False	True	Pass	Gen1_5G	N/A
5	Launch Amplitude Calibration	True/False	True	Pass	Gen2_10G	N/A
6	Launch Amplitude Calibration	True/False	True	Pass	Gen1_5G	N/A
7	Rj Calibration(Gen2)	True/False	True	Pass	Gen2_10G	N/A
8	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ1
9	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ2
10	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ3
11	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ4
12	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ5
13	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ6
14	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ7
15	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ8
16	Sj Calibration (Gen2)	True/False	True	Pass	Gen2_10G	SJ9
17	Optimized Eye Height Search	True/False	True	Pass	Gen2_10G	N/A
18	Eye Width Calibration	True/False	True	Pass	Gen2_10G	N/A
19	Eye Height Calibration	True/False	True	Pass	Gen2_10G	N/A
20	Short Channel Eye Height Calibration	True/False	True	Pass	Gen2_10G	N/A
21	Rj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	N/A
22	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ1
23	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ2
24	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ3
25	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ4
26	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ5
27	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ6
28	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ7
29	Sj Calibration (Gen1)	True/False	True	Pass	Gen1_5G	SJ8
30	Short Channel Eye Height Calibration	True/False	True	Pass	Gen1_5G	N/A

FIGURE 33. SUMMARY TABLE

8.1.3 Compliance Test Results

This portion is populated from the results of all Rx compliance tests performed.

Gen2 Short Channel Compliance Test

Sj Frequency	SJ1	SJ2	SJ3	SJ4	SJ5	SJ6	SJ7	SJ8	SJ9
Gen2_10G	X	X	X	X	X	X	X	X	X

Gen2 Long Channel Compliance Test

Sj Frequency	SJ1	SJ2	SJ3	SJ4	SJ5	SJ6	SJ7	SJ8	SJ9
Gen2_10G	X	X	X	X	X	X	X	X	X

FIGURE 34. COMPLIANCE TEST RESULTS

8.1.4 Calibration & Test Result Details

This portion is populated with results from each of the calibration and test runs. Here the results are explained in depth with supporting data points and screenshots. If the Plot Calibration Data checkbox is selected, then the plots are also displayed.

30. Short Channel Eye Height Calibration [Gen1_5G]

Pass/Fail Stats	:	Pass
Test Limits	:	True/False
Result	:	True
Cal Parameter	:	Short Channel Vpp_Gen1_5G
Settings	:	828.0000 mV
Measured Value	:	1.1936 V
Test completed time	:	05 March 2021 19:28:58 PM

Gen1ShortChannelEyeHeightCalibration(Gen1_5G) Plot

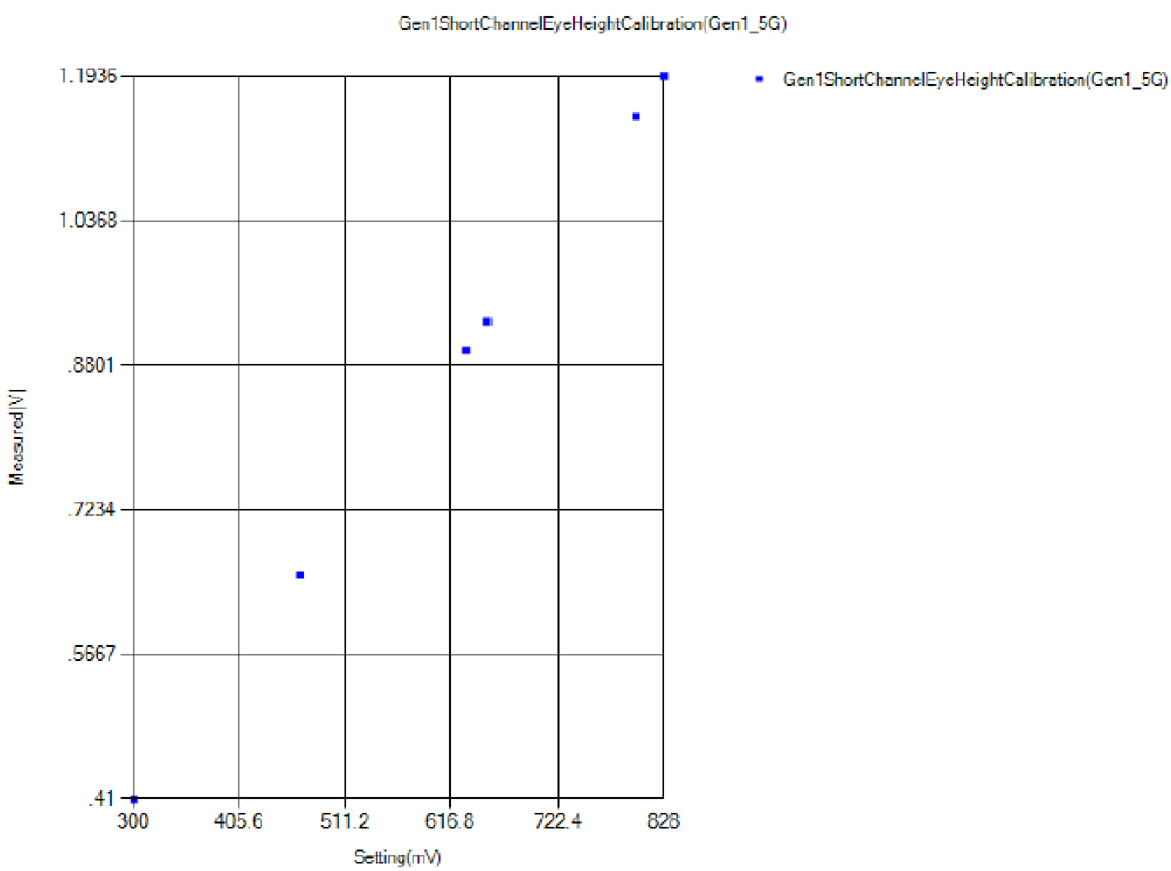


FIGURE 35. CALIBRATION/TEST RESULT DETAILS EXAMPLE

8.1.5 Margin Test Results

This portion is populated from the optional Margin Search Tests if performed.

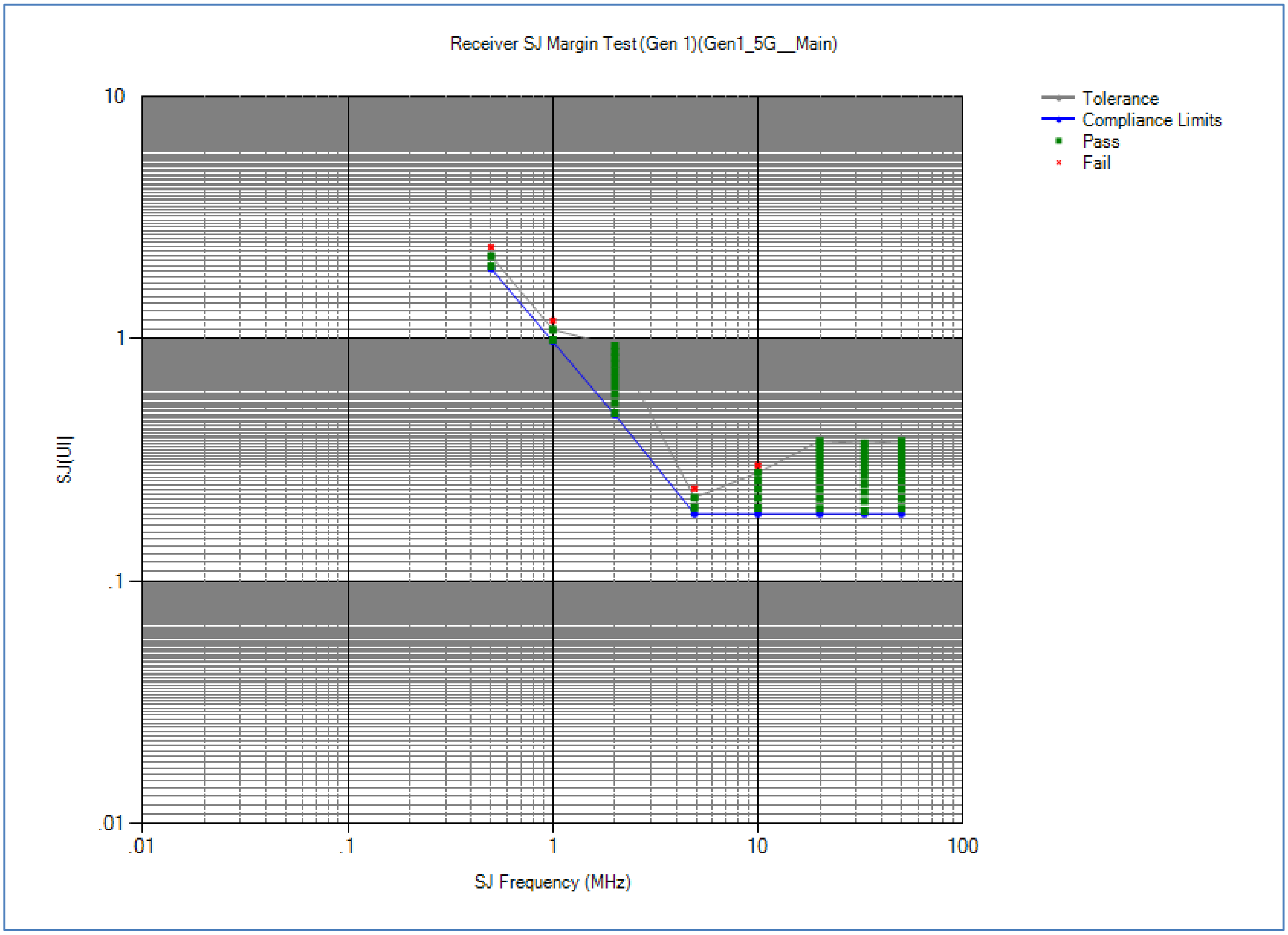


FIGURE 36. MARGIN TEST RESULTS EXAMPLE

8.2 Delete Reports

If some of the results are not desired, they can be individually deleted by selecting the **Delete** button.

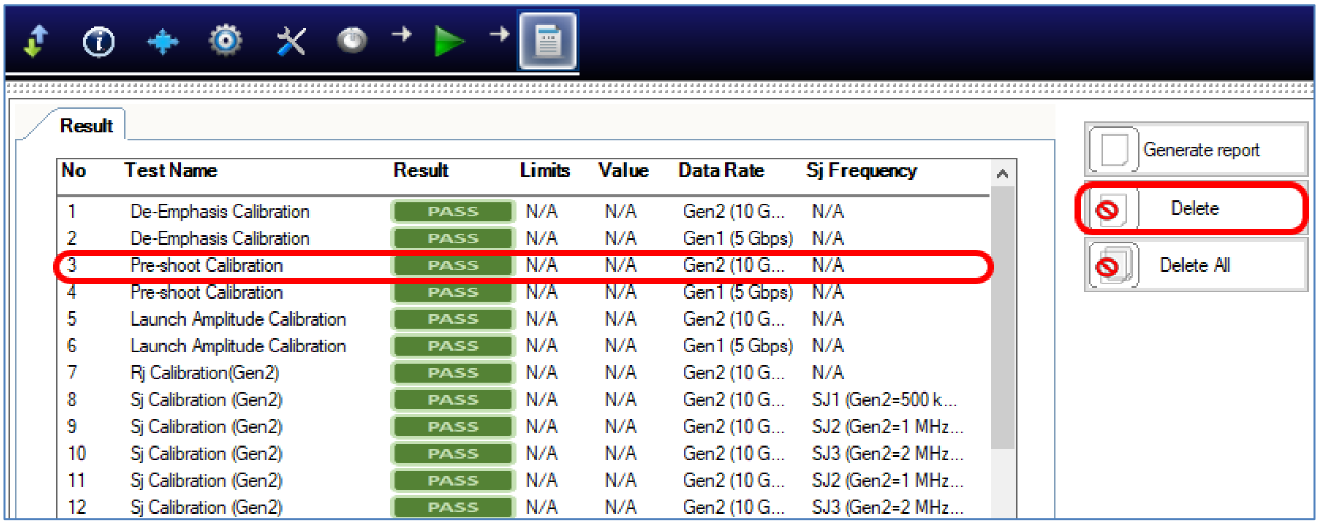


FIGURE 37. DELETE INDIVIDUAL CALIBRATION/TEST RESULTS EXAMPLE

To remove all results, select the **Delete All** button.

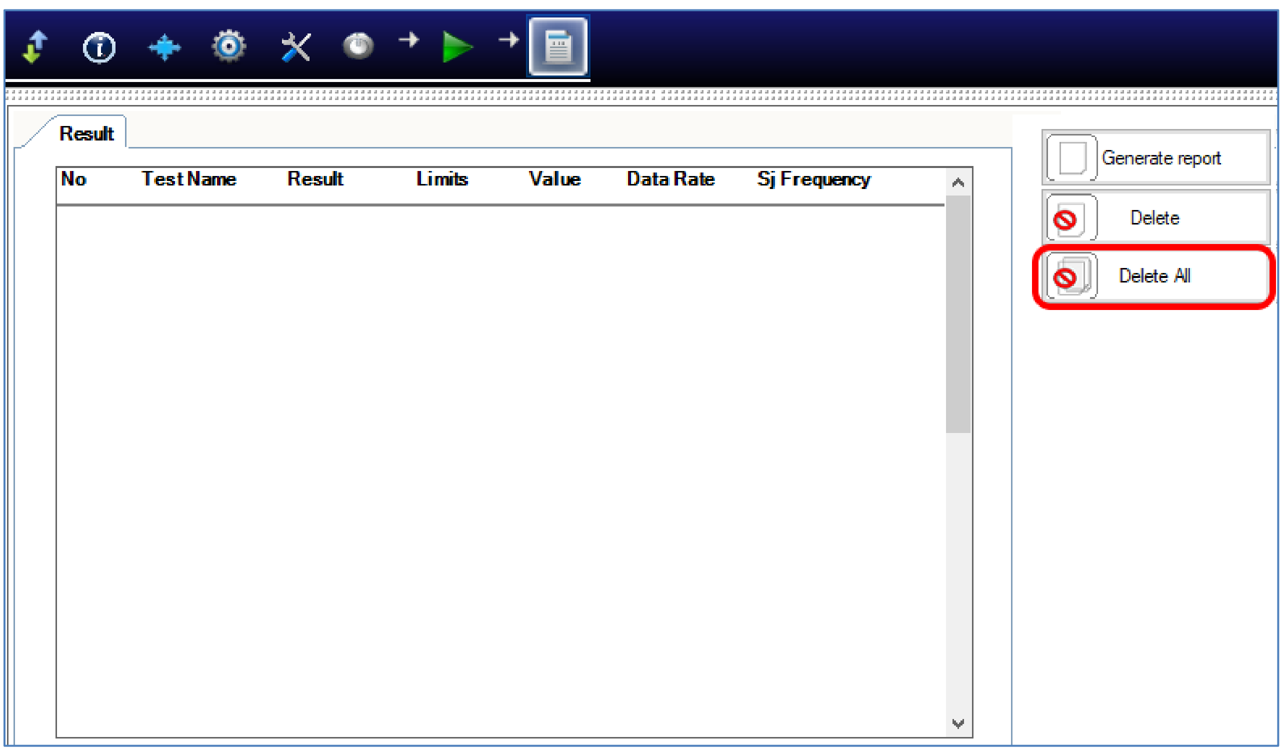


FIGURE 38. DELETE ALL RESULTS

9 Saving and Loading Test Sessions

The GRL-USB32-RXA software enables Calibration and Test Results to be created and maintained as a 'Live Session' in the application. This allows you to quit the application and return later to continue where you left off.

Save and Load Sessions are used to Save a Test Session that you may want to recall later. You can 'switch' between different sessions by Saving and Loading them when needed.

To save a session, with all of the parameter information, the test results, and any waveforms, use the "Options" command on the menu bar, then the "Save Session" command.

To load a session back into the software, including the saved parameter settings, use the "Options" command on the menu bar, then the "Load Session" command.

To create a New session and return the application back to a default configuration, use "Options" command on the menu bar, then the "New Session" command.

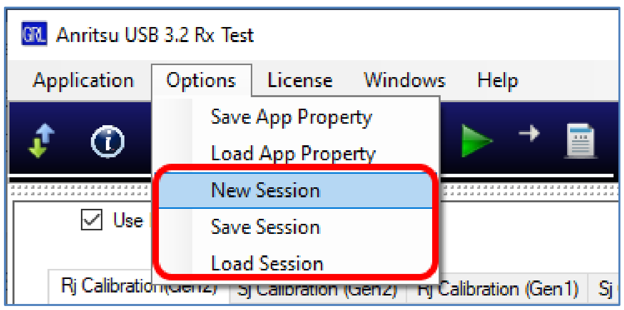


FIGURE 39. SAVING AND LOADING CALIBRATION AND TEST SESSIONS

The configuration and session results are saved in a file with the extension '.ses', which is a compressed zip-style file, containing a variety of information.

10 Appendix A: Manual CTS Calibration and Test Procedure

The Electrical Compliance Test Specification for Enhanced SuperSpeed Universal Serial Bus describes the Receiver Calibration and Test Procedure in the following sections.

- TD.1.8 – Receiver Jitter Tolerance Test at 5GT/s (for USB Type-A and USB Type-B Micro)
- TD.1.9 – Receiver Jitter Tolerance Test at 5GT/s (for USB Type-C)
- TD.1.10 – Receiver Jitter Tolerance Test at 10GT/s

The following sections describe the manual procedure to calibrate the stressed signal with the Anritsu BERT and Keysight Oscilloscope. After calibration is complete, then Loopback negotiation and BER testing per the CTS is performed.

If the device supports USB 3.2 Gen1 (5GT/s), Gen2 (10GT/s) and Gen2x2 (20GT/s), all data rates need to be tested.

10.1 TD.1.8 Receiver Jitter Tolerance Test at 5 GT/s (USB Type-A, USB Type-B Micro)

This test verifies that the receiver properly functions in the presence of deterministic and random jitter at multiple frequencies. The jitter characteristics are defined by the USB 3.2 specification. To reduce test time, the receiver is tested to a bit error ratio (BER) of 10^{-10}. To comprehend noise effects, such as crosstalk, it is up to the component manufacturer to make sure that any other links are active for the DUT.

The receiver test is performed with asynchronous SSC clocks in the test system and the DUT. The test system SSC shall be triangular at the maximum specified SSC frequency (33 kHz) and down spread of 5000 ppm. The test system SSC shall meet the specification limits on slew rate.

Note*: When the DUT is in loopback for this test, it shall not exit loopback unless it receives a warm reset or an LFPS Exit Handshake.*

Note*: The test procedures for channels involving a 1 meter, USB Type-A Micro to USB Type-B Micro cable assume that the cable is selected to have a well-controlled nominal loss of 3.5 dB at 2.5 GHz.*

TABLE 9. CHANNELS FOR TESTING DEVICE TYPES

Connector Type	Calibration Channel (Using breakout fixture to measure at end of channel)	Test Channel
USB Type-A	3m Cable + 5” PCB	3m Cable + 5” PCB
USB Type-B	3m Cable + 11” PCB	3m Cable + 11” PCB
USB Type-B Micro	3m Cable + 11” PCB	1m Cable + 11” PCB

Connector Type	Calibration Channel (Using breakout fixture to measure at end of channel)	Test Channel
USB Type-AB Micro (Host Only)	3m Cable + 5" PCB	1m Cable + 5" PCB + USB Type-A Micro to USB Type-A Receptacle adapter
USB Type-AB Micro (DRD)	3m Cable + 11" PCB	1m Cable + 11" PCB (device mode) 1m Cable + 5" PCB + USB Type-A Micro to USB Type-A Receptacle adapter (host mode) Both tests are required
Tethered (USB Type-A Plug)	3m Cable + 11" PCB	8" (short) USB Type-A to USB Type-B cable + 11" PCB
All Connector Types Must Also Perform Short Channel Test	Same as above (Either 3m Cable + 5" PCB or 3m Cable + 11" PCB) depending on connector type	Breakout Fixture Only

Note: Refer to http://www.usb.org/developers/estoreinfo/SuperSpeedTestTopologies.pdf

10.1.1 Calibration for TD.1.8 Receiver Jitter Tolerance at USB 3.2 Gen1 5 GT/s (USB Type-A, USB Type-B Micro)

Let equipment warm up for 30 minutes before starting the test, and follow the manufacturers' recommendations for user calibration before making any measurements.

Follow procedure in Section 14 to de-skew Ch1 and Ch3 of Oscilloscope.

The test runs in the Polling.Loopback substate. Perform the following steps.

Calibration Steps:

1. Calibrate swing and de-emphasis:
   a) Connect the end of the cables that will connect to the SMAs on the test fixture (as in Figure 8, and as directly as possible) to a real-time oscilloscope and the other end to the test equipment generator.

      Using the oscilloscope measurement procedure in Section 11 and the BERT adjustment procedure in Section 12, calibrate the signal stressors. Transmit a pattern with 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern at 5GT/s.
   b) Calibrate the differential amplitude of the measured signal to 800mV peak to peak.
   c) Calibrate the measured de-emphasis to 3.0 + 0.3/-0 dB fixed de-emphasis.

Note: The signal source must support full bit de-emphasis.

2. Connect the calibration channel to the signal source as in Figure 9.

Using the BERT calibration procedure in Section 12 and the Scope measurement procedure in Section 11, calibrate RJ, SJ and Eye Height.

Calibrate RJ (2.42 +/- 10% ps RMS/30.8 +/- 10% ps peak to peak at a BER of 10^{-10}) with clock pattern (CP1). Calibrate at the end of the channel applying the CTLE and JTF. SSC and all other noise sources are turned off for this step.

Calibrate SJ (40.0 ps +0/-10% at 50 MHz) with CP0. Calibrate at the end of the channel applying only CTLE. SSC is turned off for this step. (Calibration is done by testing the measured maximum peak to peak jitter without extrapolation [measured TJ] without SJ and then adding SJ until the measured maximum peak to peak jitter without extrapolation [measured TJ] increases by 40 picoseconds). All other noise sources are turned off during this calibration. A 49 kHz critically damped high pass filter with 40 dB/decade roll-off is used during SJ calibration instead of the standard JTF.

Measure eye height with CP0 at a BER of 10^{-6} at the end of the channel with the host fixtures with all jitter sources and SSC turned on applying the JTF and the Long channel reference CTLE. Adjust the signal source amplitude to provide:

180 mV +5/-0 mV of eye height with host test fixtures for testing a host.

145 mV +5/-0 mV of eye height with device test fixtures for testing a device.

Note: Amplitude should be calibrated to be as close to the minimum value as possible without going under the minimum.

Note: De-emphasis at the instrument output must be adjusted to remain at 3.0 + 0.3/- 0 dB after the eye height calibration process is complete.

After calibration is complete, the TJ at a BER of 10^{-12} with CP0 and all jitter sources turned on must be between 90 and 95 picoseconds. This measurement is performed only with the SJ frequency of 50 MHz and is performed by checking the average TJ over three iterations of 1 million unit interval oscilloscope captures. Due to degradation in connections in the test channel or other test channel issues, it may be necessary to switch to a new test channel to achieve a calibrated TJ value in the expected range.

10.1.2 Testing for TD.1.8 Receiver Jitter Tolerance at USB 3.2 Gen1 5 GT/s (USB Type-A, USB Type-B Micro)

Use the BERT test procedure in Section 13 to perform the following:

1. Connect the DUT to the appropriate test channel as in Figure 24.
2. Power on the DUT.
3. Transmit 400 Polling.LFPS (4 ms).

Note that all jitter sources are added during all transmissions to the DUT. If the DUT does not go into loopback, then it fails the test.

4. Transmit 65536 TSEQ.
5. Transmit 256 to 65536 TS1.
6. Transmit 256 to 65536 TS2 with loopback bit set.
7. Start transmitting the BDAT test pattern.
8. Transmit BDAT for 2 ms before starting error calculations.
9. Transmit the BDAT sequence from the signal source for a total of $3x10^9$ symbols ($3x10^{10}$ bits). A single SKP ordered set is inserted in the sequence every 354 symbols.
10. The DUT fails if more than one error is encountered.

    Note: The channel to the test equipment receiver should be kept as short and clean as possible.

11. Repeat steps 1-9 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 33 MHz frequency with -3 dB of equalization.
12. Repeat steps 1-9 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 20 MHz frequency with -3 dB of equalization.
13. Repeat steps 1-9 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 10 MHz frequency with -3 dB of equalization.
14. Repeat steps 1-9 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 4.9 MHz frequency with -3 dB of equalization.
15. Repeat steps 1-9 with 100 +0/-5% ps of periodic (sinusoidal) at a 2 MHz frequency with -3 dB of equalization.
16. Repeat steps 1-9 with 200 +0/-5% ps of periodic (sinusoidal) at a 1 MHz frequency with -3 dB of equalization.
17. Repeat steps 1-9 with 400 +0/-5% ps of periodic (sinusoidal) at a 500 kHz frequency with -3 dB of equalization.

    Note: Connect the oscilloscope directly to the signal source with the signal source keeping all settings the same as the calibrated settings with the calibration channel.

18. Measure the maximum peak-to-peak differential voltage with a pattern with 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern at 5 GT/s with all jitter sources, Tx equalization and SSC turned off. Adjust the amplitude to provide a maximum peak-to-peak differential voltage of 1200 mV +0/-20 mV using the clock portion of the pattern for the measurement.
19. Turn on all jitter sources, Tx equalization and SSC to the same settings as the long channel calibration, and complete the short channel test with the DUT connected directly to the breakout fixture.
20. Repeat steps 1-17.

Note: Amplitude should be calibrated to be as close to the maximum value as possible without going over the maximum.

Note: De-emphasis at the instrument output must be adjusted to remain at 3.0 + 0.3/- 0 dB.

10.2 TD.1.9 Receiver Jitter Tolerance Test at USB 3.2 Gen1 5 GT/s (USB Type-C)

This test verifies that the receiver properly functions in the presence of deterministic and random jitter at multiple frequencies. The jitter characteristics are defined by the USB 3.2 specification. To reduce test time, the receiver is tested to a bit error ratio (BER) of 10^{-10}. To comprehend noise effects, such as crosstalk, it is up to the component manufacturer to make sure that any other links are active for the DUT.

The receiver test is performed with asynchronous SSC clocks in the test system and the DUT. The test system SSC shall be triangular at the maximum specified SSC frequency (33 kHz) and down spread of 5000 ppm. The test system SSC shall meet the specification limits on slew rate.

Note: When the DUT is in loopback for this test, it shall not exit loopback unless it receives a warm reset or an LFPS Exit Handshake.

TABLE 10. CHANNELS FOR TESTING DEVICE TYPES

Connector Type	Calibration Channel	Test Channel
USB Type-C (Host)	All calibration at BERT output	BERT -> 5G Host/Device Fixture 2 (14.4”) -> 7dB cable -> Host Fixture 1C -> DUT
USB Type-C (Device)	All calibration at BERT output	BERT -> 5G Host/Device Fixture 2 (14.4”) -> 7dB cable -> Device Fixture 1C -> DUT
All Connector Types Must Also Perform Short Channel Test	All calibration at BERT output	BERT-> USB 3.2 Full USB Type-C Breakout -> DUT

Note: Refer to http://www.usb.org/developers/estoreinfo/USB3p1_Fixture_Topologies.pdf

10.2.1 Calibration for TD.1.9 Receiver Jitter Tolerance at USB 3.2 Gen1 5 GT/s (USB Type-C)

Let equipment warm up for 30 minutes before starting the test and follow the manufacturers’ recommendations for user calibration before making any measurements.

Follow procedure in Section 14 to de-skew Ch1 and Ch3 of the oscilloscope.

The test runs in the Polling.Loopback substate. Perform the following steps.

Calibration Steps:

1. Calibrate swing and de-emphasis:
    a) Connect the end of the cables that will connect to the SMA’s on the test fixture (as in Figure 8, and as directly as possible) to a real-time oscilloscope and the other end to the test equipment generator.

Using the oscilloscope measurement procedure in Section 11 and the BERT adjustment procedure in Section 12, calibrate the signal stressors. Transmit a pattern with 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern at 5 GT/s.

b) Calibrate the differential amplitude of the measured signal to 800 mV peak to peak.
c) Calibrate the measured de-emphasis to 3.0 + 0.3/-0 dB fixed de-emphasis.

Note: The signal source must support full bit de-emphasis.

2. Calibrate RJ and SJ.

Calibrate RJ (2.42 +/- 10% ps RMS/30.8 +/- 10% ps peak to peak at a BER of 10^{-10}) with clock pattern (CP1). Calibrate after applying only the JTF. SSC and all other noise sources are turned off for this step.

Calibrate SJ (40.0 ps +0/-10% at 50 MHz) with CP0. Calibrate applying only a 49 kHz critically damped high pass filter with 40 dB/decade roll-off instead of the standard JTF. SSC is turned off for this step. (Calibration is performed by testing the measured maximum peak-to-peak jitter without extrapolation [measured TJ] without SJ and then adding SJ until the measured maximum peak-to-peak jitter without extrapolation [measured TJ] increases by 40 ps). All other noise sources are turned off during this calibration.

10.2.2 Testing for TD.1.9 Receiver Jitter Tolerance at USB 3.2 Gen1 5 GT/s (USB Type-C)

Continue the steps in Section 10.2.1 as follows:

3. Connect the calibration channel to the signal source as in Figure 25.
4. Connect the DUT to the appropriate test channel.
5. Power on the DUT if the power is turned off.
6. Transmit 400 Polling.LFPS (4 milliseconds).

   Note that all jitter sources are added during all transmissions to the DUT. If the DUT does not go into loopback, then it fails the test.

7. Transmit 65536 TSEQ.
8. Transmit 256 to 65536 TS1.
9. Transmit 256 to 65536 TS2 with loopback bit set.
10. Start transmitting the BDAT test pattern.
11. Transmit BDAT for 2 milliseconds before starting error calculations.
12. Transmit the BDAT sequence from the signal source for a total of $3x10^{9}$ symbols ($3x10^{10}$ bits). A single SKP ordered set is inserted in the sequence every 354 symbols.
13. The DUT fails if more than one error is encountered.

Note: The channel to the test equipment receiver should be kept as short and clean as possible.

14. Repeat steps 3-13 with 40.0 +0/-10% picoseconds of periodic (sinusoidal) at a 33 MHz frequency with -3 dB of equalization.
15. Repeat steps 3-13 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 20 MHz frequency with -3 dB of equalization.

16. Repeat steps 3-13 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 10 MHz frequency with -3 dB of equalization.
17. Repeat steps 3-13 with 40.0 +0/-10% ps of periodic (sinusoidal) at a 4.9 MHz frequency with -3 dB of equalization.
18. Repeat steps 3-13 with 100 +0/-5% ps of periodic (sinusoidal) at a 2 MHz frequency with -3 dB of equalization.
19. Repeat steps 3-13 with 200 +0/-5% ps of periodic (sinusoidal) at a 1 MHz frequency with -3 dB of equalization.
20. Repeat steps 3-13 with 400 +0/-5% ps of periodic (sinusoidal) at a 500 kHz frequency with -3 dB of equalization.

    Connect the oscilloscope directly to the signal source with the signal source keeping all settings the same as the calibrated settings with the calibration channel.

21. Measure the maximum peak-to-peak differential voltage using a pattern with 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern at 5 GT/s with all jitter sources, Tx equalization and SSC turned off. Adjust the amplitude to provide a maximum peak-to-peak differential voltage of 1200 mV +0/-20 mV using the clock portion of the pattern for the measurement.
22. Turn on all jitter sources, Tx equalization and SSC to the same settings as the long channel calibration, and complete the short channel test with the DUT connected directly to the breakout fixture.
23. Repeat steps 3-20.
24. If the DUT is USB Type-C, repeat all testing with the alternate Rx path by changing the CC state or by flipping the fixture.

Note: Amplitude should be calibrated to be as close to the maximum value as possible without going over the maximum.

Note: De-emphasis at the instrument output must be adjusted to remain at 3.0 + 0.3/- 0 dB.

10.3 TD.1.10 Receiver Jitter Tolerance Test at USB 3.2 Gen2 10 GT/s (All Connector Types)

This test verifies that the receiver properly functions in the presence of deterministic and random jitter at multiple frequencies. The jitter characteristics are defined by the USB 3.2 specification. To comprehend noise effects, such as crosstalk, it is up to the component manufacturer to make sure that any other links are active for the DUT.

The receiver test is performed with asynchronous SSC clocks in the test system and the DUT. The test system SSC shall be triangular at the maximum specified SSC frequency (33 kHz) and down spread of 5000 ppm. The test system SSC shall meet the specification limits on slew rate.

Note: When the DUT is in loopback for this test, it shall not exit loopback unless it receives a warm reset or an LFPS Exit Handshake.

Note: The test procedures for channels involving a USB cable will assume the cable is selected to have a well-controlled nominal loss of 6.0 dB at 5.0 GHz.

TABLE 11. CHANNELS FOR TESTING DEVICE TYPES

Connector Type	Calibration Channel (Using breakout fixture to measure at end of channel)	Test Channel
USB Type-A	BERT >> USB 3.3 Compliance Load Board >> 6 dB Cable >> USB 3.2 Host Fixture 1A >> USB 3.2 Mock Host 7.2" >> Scope	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Host Fixture 1A >> Host Under Test
USB Type-B Micro	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> USB 3.2 Mock Device 7.2" >> Scope	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> DUT
USB Type-AB Micro (Host Only)	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> USB 3.2 Mock Device 7.2" >> Scope	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> DUT
USB Type-AB Micro (DRD)	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> USB 3.2 Mock Device 7.2" >> Scope	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> DUT

Connector Type	Calibration Channel (Using breakout fixture to measure at end of channel)	Test Channel
Captive (USB Type-A Plug)	BERT >> USB 3.2 Compliance Load Board >> 6 dB Cable >> USB 3.2 Device Fixture 1A >> USB 3.2 Mock Device 7.2" >> Scope	BERT >> USB 3.2 Captive Cable Device Fixture USB Type-A >> DUT
USB Type-C Host	BERT >> USB 3.2 Compliance Load Board USB Type-C >> 6 dB Cable >> USB 3.2 Host Fixture 1C >> USB 3.2 Mock Host/Device USB Type-C 7.2" >> Scope	BERT >> USB 3.2 Compliance Load Board USB Type–C >> 6 dB Cable >> USB 3.2 Host Fixture 1C >> DUT
USB Type-C Device	BERT >> USB 3.2 Compliance Load Board USB Type-C >> 6 dB Cable >> USB 3.2 Device Fixture 1C >> USB 3.2 Mock Host/Device USB Type-C 7.2" >> Scope	BERT >> USB 3.2 Compliance Load Board USB Type-C >> 6 dB Cable >> USB 3.2 Device Fixture 1C >> DUT
Captive (USB Type-C Plug)	BERT >> USB 3.2 Compliance Load Board USB Type-C >> 6 dB Cable >> USB 3.2 Device Fixture 1C >> USB 3.2 Mock Host/Device USB Type-C 7.2" >> Scope	BERT >> USB 3.2 Captive Device Fixture USB Type-C >> DUT
All Connector Types Must Also Perform Short Channel Test	See procedure for short channel calibration details	For USB Type-C BERT >> USB 3.2 Full USB Type-C Breakout >> DUT For USB Type-A – Use the breakout fixture from a test vendor used for 5 GT/s testing

Note: All cable losses in dB are at 5 GHz.

Note: Refer to http://www.usb.org/developers/estoreinfo/USB3p1_Fixture_Topologies.pdf.

10.3.1 Calibration for TD.1.10 Receiver Jitter Tolerance at USB 3.2 Gen2 10 GT/s (All Connector Types)

The test runs in the Polling.Loopback substate. Perform the following steps.

1. Calibrate swing and de-emphasis without the test channel.
   a) Connect the end of the SMA cables that will connect to the SMA's on the test fixture (as in Figure 8, and as directly as possible) to a real-time oscilloscope and the other end to the test equipment generator.

Using the oscilloscope measurement procedure in Section 11 and the BERT adjustment procedure in Section 12, calibrate the signal stressors. Transmit a pattern with 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern at 10 GT/s.

b) Measure the transmitted signal on the oscilloscope and adjust the post cursor de-emphasis and swing of the generator until the low frequency and high frequency portions of the signal have an equal differential amplitude of 800mV peak to peak.
c) Calibrate the measured Tx EQ to 2.2 +/- .1 dB fixed pre-shoot.
d) Calibrate the Tx EQ de-emphasis settings for -1.0 +/- .1 dB, -3.1 +/- 1 dB and -5.0 +/- .1 dB.

Note: The signal source must support full bit de-emphasis.

2. Calibrate RJ (1.0 +0/-.1 ps RMS) with clock pattern (CP10). Calibrate after applying the JTF. The reference equalizer is not used for this RJ calibration. SSC is turned off and all other jitter sources are turned on but set to zero.
3. Calibrate SJ (17.0 ps +0/-10% at 100 MHz) with CP9. Calibrate without reference receiver equalization. SSC is turned off and all other jitter sources are turned on but set to zero. (Calibration is performed by testing the measured maximum peak-to-peak jitter without extrapolation [measured TJ] without SJ and then adding SJ until the measured maximum peak-to-peak jitter without extrapolation [measured TJ] increases by 17 ps. A 75 kHz critically damped high pass filter with 40 dB/decade roll-off is used during SJ calibration instead of the standard JTF.
4. Connect the calibration channel to the signal source using the shortest compliance load board (5.6") as in Figure 11.
5. Measure the eye height with CP9 at a BER of 1E-6 using the calibrated SJ and RJ values with SSC enabled. The eye height is measured after applying the JTF, the reference CTLE curve fixed to a DC gain of -5 dB, and DFE.
6. Change the compliance load board to the mid-length (7.1") and repeat the eye height measurement.
7. Change the compliance load board to the longest (8.1") and repeat the eye height measurement.
8. Select the compliance load board that yields the eye height measurement closest to 70 mV and use this compliance load board for the remaining calibration and testing.
9. Adjust the de-emphasis from 1 dB to 5 dB to adjust the eye width with a target of 48 +2/-0 ps. The width is measured after applying the JTF, the reference equalizer CTLE curve fixed to a DC gain of -5 dB, and DFE. *SSC is still enabled for this step*.
10. If the width target was not met in step 10, then perform the following:

    a) If the width is too big, add a second SJ tone at 87 MHz, and adjust until the width target is met.
    b) If the width is too small, reduce the 100 MHz SJ tone until the width target is met.

    Note: If the adjustment in step 10a or 10b is bigger than 5 ps, it may indicate a problem with the fixtures or setup.

11. Adjust the signal source amplitude to provide 70 mV +5/-0 mV of eye height with the calibration channel.

Note: Amplitude should be calibrated to be as close to the minimum value as possible without going under the minimum.

10.3.2 Testing for TD.1.10 Receiver Jitter Tolerance at USB 3.2 Gen2 10 GT/s (All Connector Types)

1. Connect the DUT to the appropriate test channel as shown in Figure 26.
2. Power on the DUT.

Note: If the BERT is protocol aware, it is allowed to just follow the protocol rules in the base specification.

3. Configure the BERT to send the following sequences:
   a) 2-32 SCD1
   b) 2-32 SCD2
   c) 4-32 LBPM (with PHY capability)
   d) 4-32 LBPM (with PHY ready)

Note that all jitter sources are added during all transmissions to the DUT. If the DUT does not go into loopback, then it fails the test.

4. Transmit 524288 to 577288 TSEQ. It is preferred for the BERT to transmit as close to 524288 TSEQ as possible. If the DUT requires a number of TSEQ outside this range to pass the test then it will be considered as failed.
5. Transmit 31 to 65536 TS1. *(SYNC, 31 TS1, SKP – repeat up to 65536 total TS1)*
6. Transmit 31 to 65536 TS2 with loopback bit set.
7. Start transmitting the CP9 test pattern.
8. Transmit CP9 for 2 milliseconds before starting error calculations.
9. Transmit a "modified" CP9 sequence from the signal source for a total of 2 minutes. The modified CP9 pattern starts with a SYNC ordered set. Then data blocks are added and scrambled with the USB10G specific PRBS-23 scrambler polynomial. A single SKP ordered set with 20SKP symbols (192 bits) must be inserted in the sequence every 40 blocks. At least 65536 data blocks must be sent before the pattern is repeated.
10. The DUT fails if more than one error is encountered.

Note: The channel to the test equipment receiver should be kept as short and clean as possible.

Note: If adjustments were made in step 10, they should be kept for each additional SJ frequency. If an 87 MHz tone was used, it should be kept at the same magnitude for each SJ frequency. If the 100 MHz SJ tone was reduced, the SJ targets at each other frequency should be reduced by the same amount in ps.

11. Repeat steps 3-10 with 17.0 +0/-10% ps of periodic (sinusoidal) at a 50 MHz frequency.
12. Repeat steps 3-10 with 17.0 +0/-10% ps of periodic (sinusoidal) at a 30 MHz frequency.

13. Repeat steps 3-10 with 17.0 +0/-10% ps of periodic (sinusoidal) at a 15 MHz frequency.
14. Repeat steps 3-10 with 17.0 +0/-10% ps of periodic (sinusoidal) at a 7.5 MHz frequency.
15. Repeat steps 3-10 with 37.0 +0/-5% ps of periodic (sinusoidal) at a 4 MHz frequency.
16. Repeat steps 3-10 with 87.0 +0/-5% ps of periodic (sinusoidal) at a 2 MHz frequency.
17. Repeat steps 3-10 with 203.0 +0/-5% ps of periodic (sinusoidal) at a 1 MHz frequency.
18. Repeat steps 3-10 with 476.0 +0/-5% ps of periodic (sinusoidal) at a 500 kHz frequency.

Connect the oscilloscope directly to the signal source with the signal source keeping all settings the same as the calibrated settings with the calibration channel.

19. Measure the maximum peak-to-peak differential voltage with a pattern with 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern at 10 GT/s with all jitter sources, Tx equalization and SSC turned off. Adjust the amplitude to provide a maximum peak-to-peak differential voltage of 1200 mV +0/-20 mV using the clock portion of the pattern for the measurement.
20. Turn on all jitter sources, Tx equalization and SSC to the same settings as the long channel calibration, and complete the short channel test with the DUT connected directly to the breakout fixture.

Note: Amplitude should be calibrated to be as close to the maximum value as possible without going over the maximum. Tx equalization must not change during this calibration.

21. Repeat steps 1-18.
22. If the DUT is USB Type-C, repeat all testing with the alternate Rx path by changing the CC state or by flipping the fixture. If the CC state is changed, repeat the eye calibration for the new fixture path.

11 Appendix B: Manual Scope Procedures for Calibration

11.1 Oscilloscope Setups for BERT Calibration

Note: This section describes setups using the Keysight oscilloscope.

11.1.1 Oscilloscope Setup for Amplitude and De-Emphasis Calibration

For Calibration of Amplitude and De-Emphasis, use the following oscilloscope setup.

TABLE 12. OSCILLOSCOPE SETUP FOR AMPLITUDE AND DE-EMPHASIS

Setting	Setup
Vertical	Ch1-Ch3 (using the full range of the Scope's D/A)
Record Length	4 kpts (enough to capture >1 sequences of 64 zeros followed by 128 bits of a 1010 clock pattern)
Sample Rate	80 GSs
Averaging	OFF
Sample Mode	Real Time
Bandwidth	16 GHz (enough to capture Nyquist rate at 10 GT/s)
Vertical Scale	Set to full screen without clipping
Sin x/x	OFF

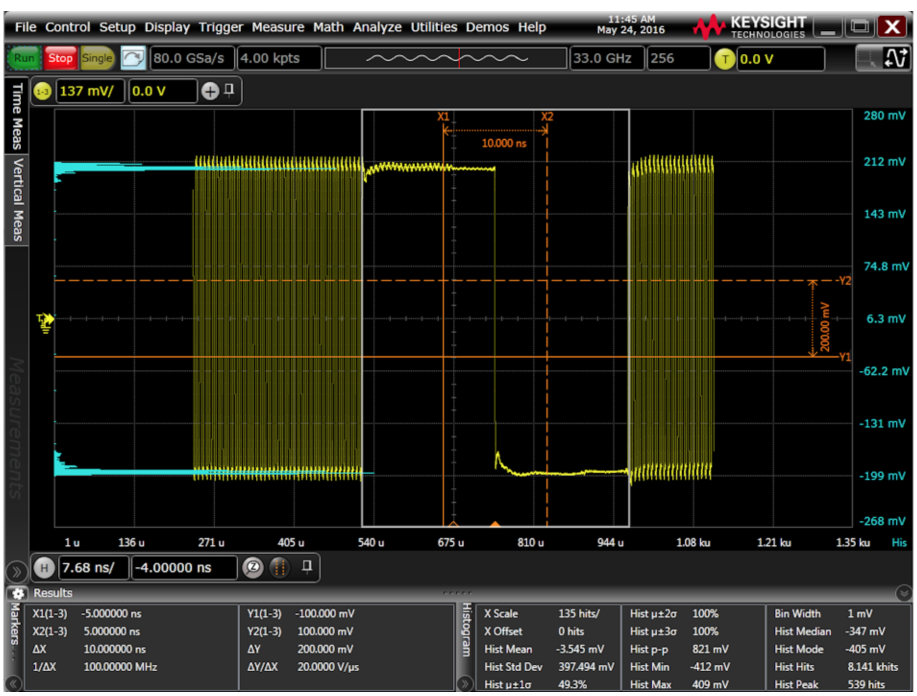


FIGURE 40. OSCILLOSCOPE SETUP FOR AMPLITUDE AND DE-EMPHASIS

11.1.2 Oscilloscope Setup for SigTest Measurements (RJ, SJ, and Eye Height)

Oscilloscope Setup for jitter and eye diagram measurements.

TABLE 13. OSCILLOSCOPE SETUP FOR SIGTEST MEASUREMENTS

Setting	Setup
Vertical	Ch1-Ch3 (using the full range of the Scope's D/A)
Record Length	20 Meg (enough to capture 2 Million UI) Record Length calculation is as follows: For Gen 1 5 GT/s: 1 UI = [1/5 GT/s] = 200 ps (200 ps/UI) x (2M UI) = 400 µs 400 µs x 40 GS/s = 16 Meg. Thus, use 20 Meg. For USB 3.2 Gen2 10 GT/s: 1 UI = [1/10 GT/s] = 100 ps (100 ps/UI) x (2M UI) = 200 µs 200 µs x 80 GS/s = 16 Meg. Thus, use 20 Meg.
Sample Rate	For USB 3.2 Gen1 5 GT/s: 40 GS/s For USB 3.2 Gen2 10 GT/s: 80 GS/s
Averaging	OFF
Sample Mode	Real Time
Bandwidth	16 GHz (enough to capture Nyquist rate at 10 GT/s)
Vertical Scale	Set to full screen without clipping
Sin x/x	OFF

FIGURE 41. OSCILLOSCOPE SETUP FOR SIGTEST MEASUREMENTS (RJ, SJ AND EYE HEIGHT)

11.2 Running SigTest Software On Scope Captures

11.2.1 Measuring RJ Using SigTest

RJ measurements are made using SigTest Software Version 4.0.19 or higher (for USB 3.2 Gen2) and SigTest Software Version 3.2.11 (for USB 3.2 Gen1). To make RJ measurements with SigTest, do the following.

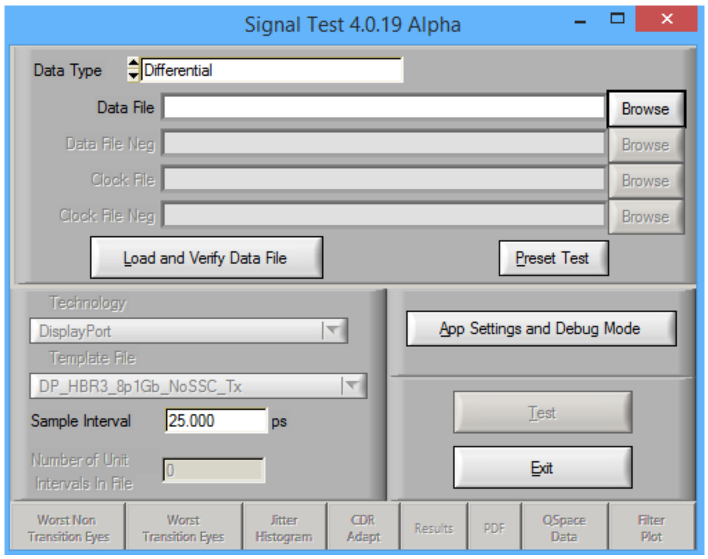
1. Select the right BERT pattern:
   a) For USB 3.2 Gen1 5 GT/s, make sure the BERT is transmitting CP1 (5 GT/s 10101… Clock Pattern).
   b) For USB 3.2 Gen2 10 GT/s, make sure the BERT is transmitting CP10 (10 GT/s 10101… Clock Pattern).

   Note: For USB 3.2 Gen1 5 GT/s, RJ is measured with the Calibration channel attached. For USB 3.2 Gen2 10 GT/s, RJ is measured before attaching the Calibration channel. This inconsistency *in methodology is acknowledged by the USB-IF Electrical Working group. It was kept the same as USB 3.2 Gen1 for legacy reasons.*

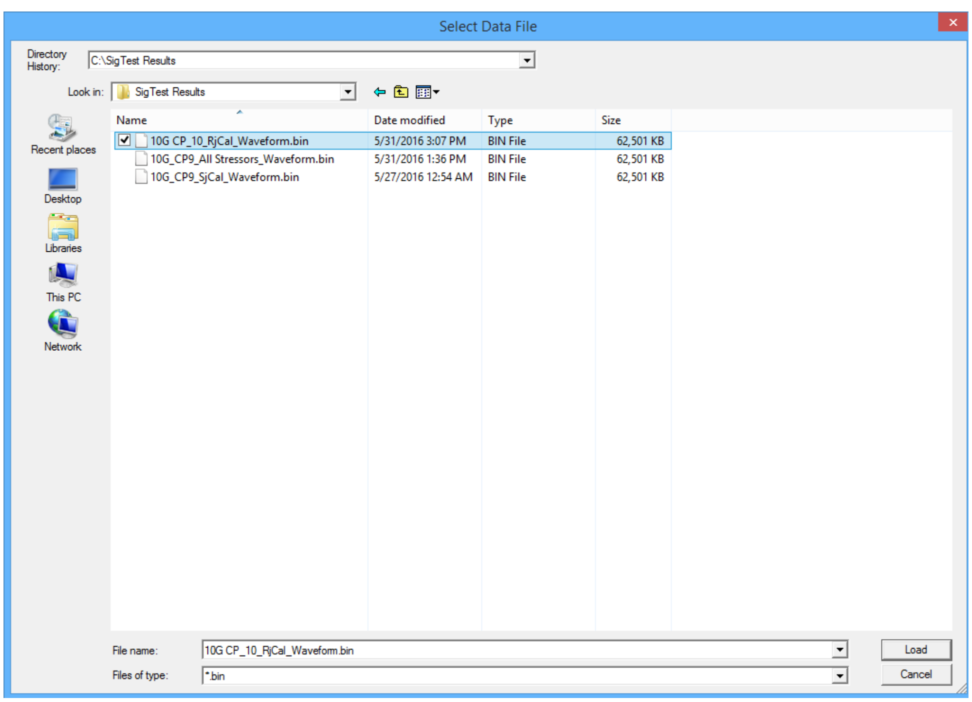
2. Capture the Signal with the oscilloscope setup described above.
3. Save the .bin file to a file on the oscilloscope's hard drive.
4. Run SigTest using the following procedure

   a) Run the SigTest Software. Refer to Section 14 for SigTest Installation.

   b) Load the captured CP1 or CP10 signal into the SigTest SW.



   c) Select 'Browse'.



d) Select *.bin as the File type, and select the appropriate data rate CP1 or CP10 waveform. *'Gen2 CP10' is selected in this example.*
e) Click 'Load' from the Browser.
f) Select the 'Load and Verify Data File' button in SigTest.
g) Once the waveform is verified, the Technology portion of the GUI becomes active.
h) For RJ, select the following SigTest Templates:

- For USB 3.2 Gen1 5 GT/s:

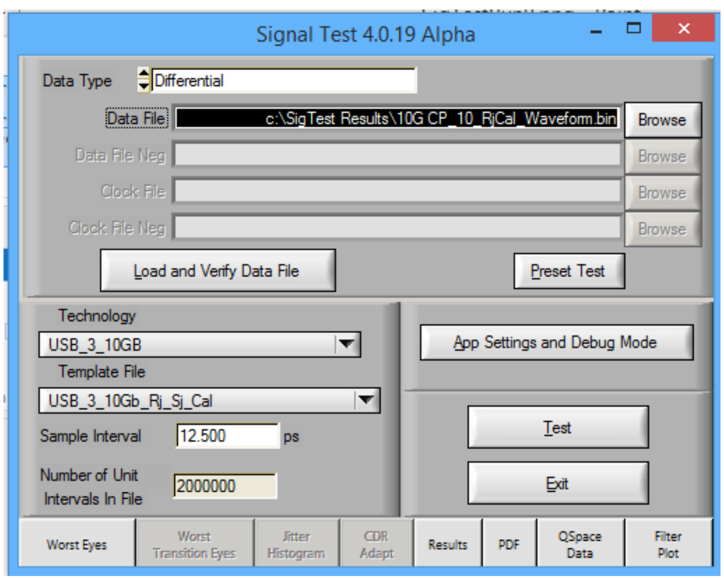
  Technology > USB_3_5GB

  Template File > USB_3_5Gb_CP1.dat (non-USB Type-C), or
  USB_3_5Gb_CP1_SHORT.dat (USB Type-C)

- For USB 3.2 Gen2 10 GT/s:

  Technology > USB_3_10GB

  Template File > USB_3_10Gb_Rj_Sj_Cal



i) Select the 'Test' button.

Note: The Test Result will appear on-screen, and a HTML test report will be written to the folder of the waveform.

5. Use the RJ measurement reported from SigTest to obtain the RJ test result.

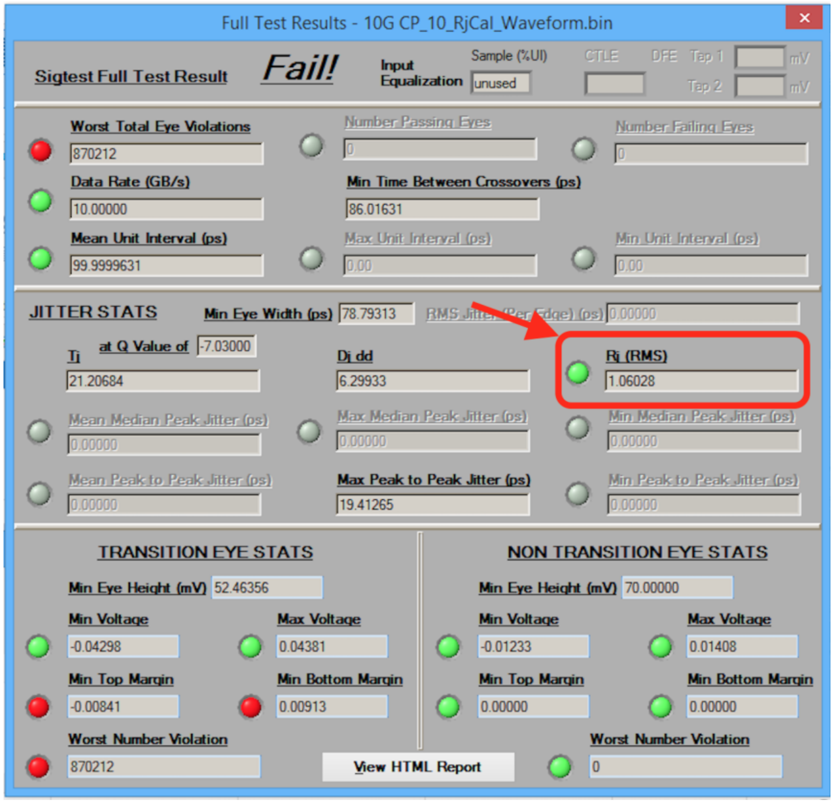


FIGURE 42. SIGTEST RJ TEST RESULT

11.2.2 Measuring SJ Using SigTest

SJ measurements are made using SigTest Software Version 4.0.19 or higher (for USB 3.2 Gen2) and SigTest Software Version 3.2.11 (for USB 3.2 Gen1). To make SJ measurements with SigTest, perform the following procedure.

1. Select the right BERT pattern:
   a) For USB 3.2 Gen1 5 GT/s, make sure the BERT is transmitting CP0 (5 GT/s Compliance Pattern).
   b) For USB 3.2 Gen2 10 GT/s, make sure the BERT is transmitting CP9 (10 GT/s Compliance Pattern).
2. Capture the Signal with the oscilloscope setup described above.
3. Save the *.wfm file to a file on the oscilloscope's hard drive.
4. After completing RJ measurements in the above section, run SigTest for SJ measurements as follows:
   a) Select 'Browse' to access the saved waveform folder.
   b) Select *.bin as the File type, and select the CP0 or CP9 Waveform for the data rate being tested. *For this case, 'Gen2 CP9' is selected.*
   c) Click 'Load' on the file browser.
   d) Select the 'Load and Verify Data File' button in SigTest.

e) Once the waveform is verified, the Technology portion of the GUI becomes active.
f) For RJ, select the following SigTest Templates:

- For USB 3.2 Gen1 5 GT/s:

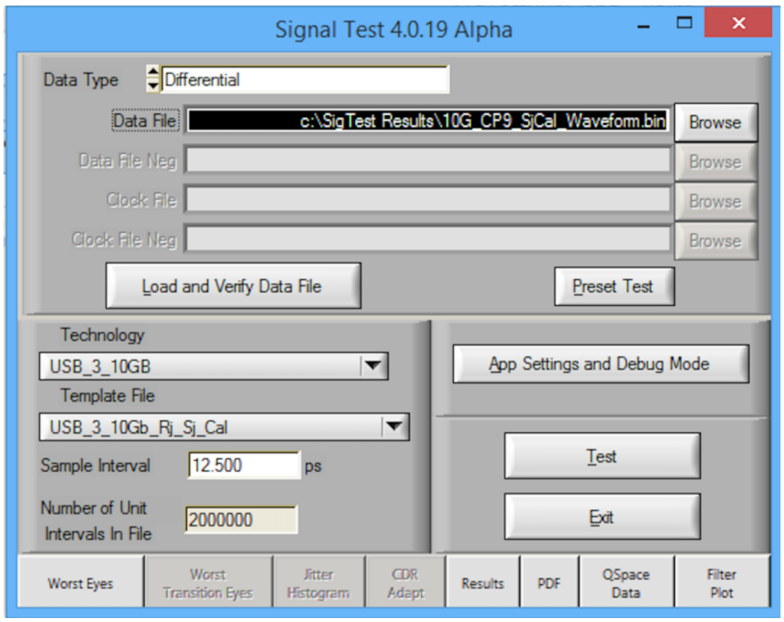
  Technology > USB_3_5GB

  Template File > USB_3_5Gb_CP0_RjIN_SjCal_SHORT (for USB Type-C), and USB_3_5Gb_CP0_RjIN_SjCal.dat (for non-USB Type-C)

- For USB 3.2 Gen2 10 GT/s:

  Technology > USB_3_10GB

  Template File > USB_3_10Gb_Rj_Sj_Cal



g) Select the 'Test' button.

Note: The Test Result will appear on-screen, and a HTML test report will be written to the folder of the waveform.

5. Use the DJ measurement reported from SigTest to obtain the SJ test result.

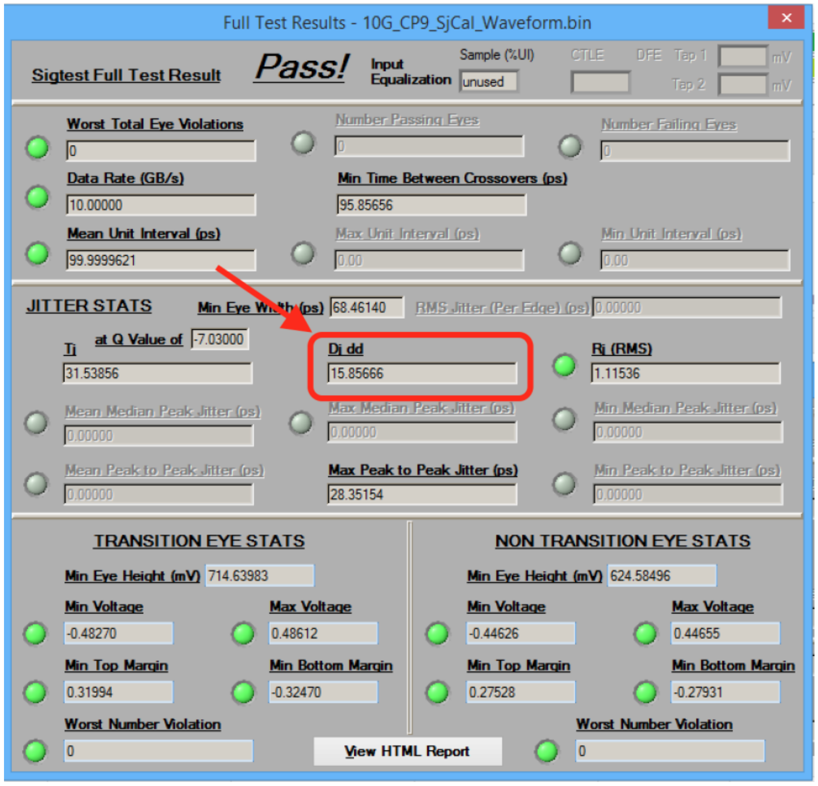


FIGURE 43. SIGTEST SJ TEST RESULT

11.2.3 Calibrating Eye Height and Eye Width Using SigTest

Eye Height measurements are made using SigTest Software Version 4.0.19 or higher (for USB 3.2 Gen2) and SigTest Software Version 3.2.11 (for USB 3.2 Gen1). To make Eye Height measurements with SigTest, perform the following steps.

1. Select the right BERT pattern:
   a) For USB 3.2 Gen1 5 GT/s, make sure the BERT is transmitting CP0 (5 GT/s Compliance Pattern).
   b) For USB 3.2 Gen2 10 GT/s, make sure the BERT is transmitting CP9 (10 GT/s Compliance Pattern).
2. Capture the Signal with the oscilloscope setup described above.
3. Save the *.wfm file to a file on the oscilloscope's hard drive.
4. After completing SJ measurements in the above section, run SigTest for Eye Height and Eye Width measurements as follows:
   a) Select 'Browse' to access the saved waveform folder.
   b) Select *.bin as the File type, and select the CP0 or CP9 Waveform for the data rate being tested. *For this case, 'Gen2 CP9' is selected.*
   c) Click 'Load' on the file browser.
   d) Select the 'Load and Verify Data File' button in SigTest.

e) Once the waveform is verified, the Technology portion of the GUI becomes active.
f) For RJ, select the following SigTest Templates:

- For USB 3.2 Gen1 5 GT/s:

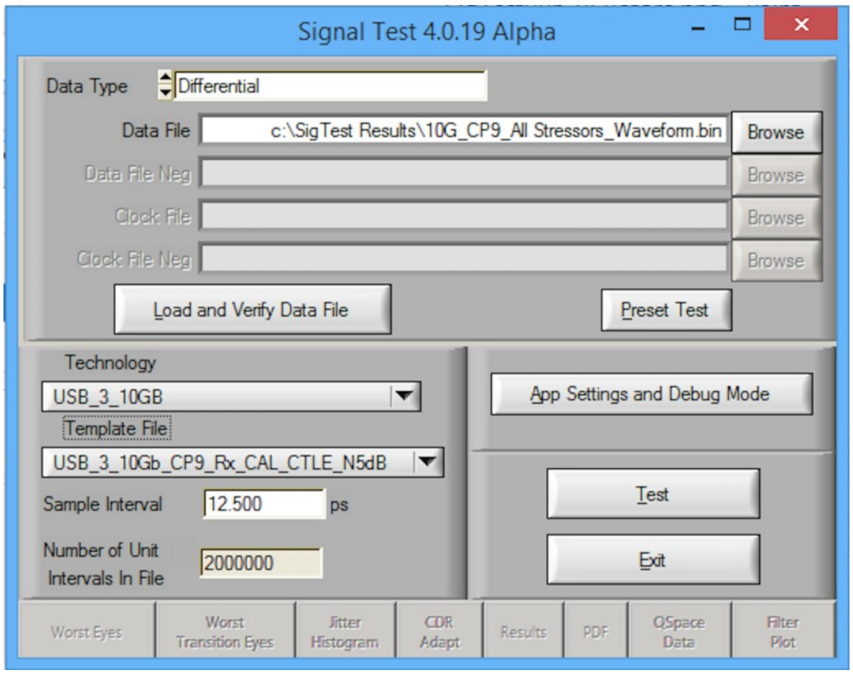
  Technology > USB_3_5GB

  Template File > USB_3_5gb_CP0_RjIN.dat

- For USB 3.2 Gen2 10 GT/s:

  Technology > USB_3_10GB

  Template File > USB_3_10Gb_CP9_Rx_CAL_CTLE_N5dB



g) Select the 'Test' button.

Note: The Test Result will appear on-screen, and a HTML test report will be written to the folder of the waveform.

5. Use the Eye Height and Eye Width measurements reported from SigTest for calibration.

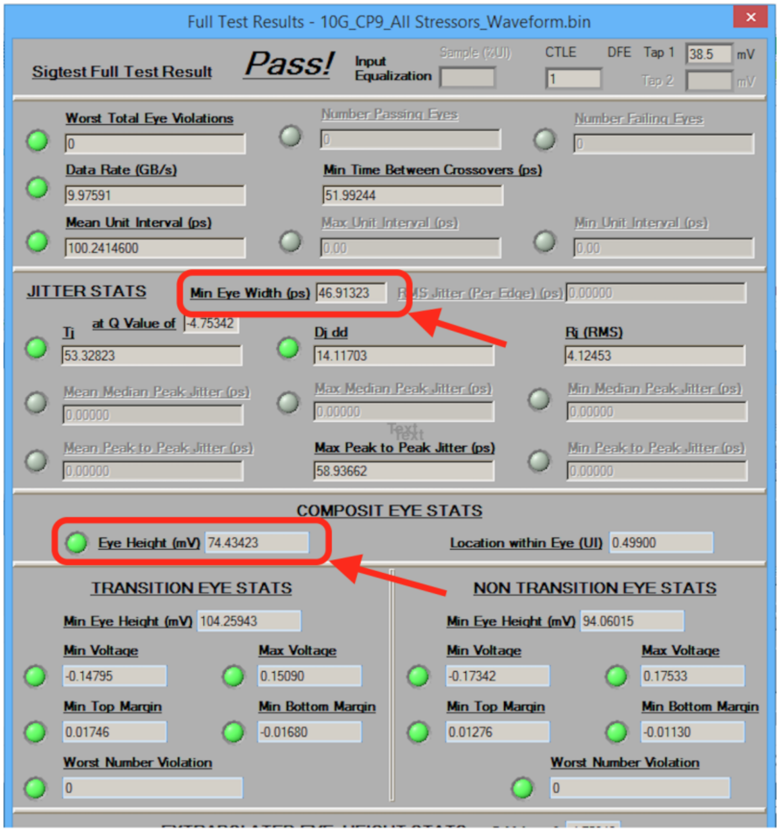


FIGURE 44. SIGTEST EYE HEIGHT AND EYE WIDTH TEST RESULT

12 Appendix C: Manual BERT Procedure for Calibration

Note: This section describes procedure using the Anritsu MP1900A Series BERT model.

12.1 BERT Setup and Adjustments for Calibration

The following table shows the BERT settings needed for calibration.

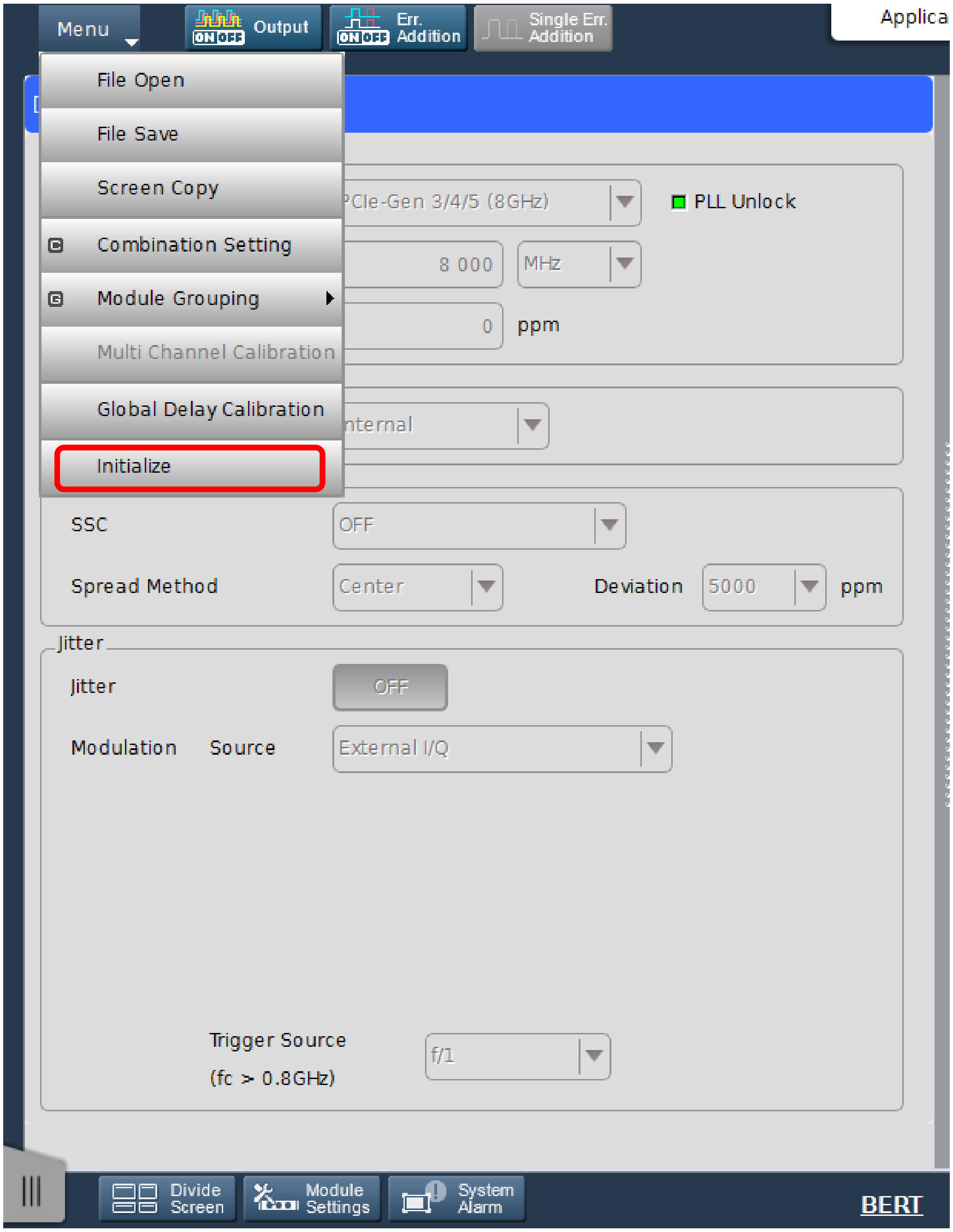
TABLE 14. INITIAL BERT SETUP

Setting	Setup
Bit Rate	For USB 3.2 Gen1 5GT/s: 5Gb/s For USB 3.2 Gen2 10GT/s: 10Gb/s
Clock Rate	Full Rate
Pattern	For Swing and De-Emphasis at USB 3.2 Gen1 5GT/s and Gen2 10GT/s: 64 ones followed by 64 zeros followed by 128 bits of a 1010 clock pattern For USB 3.2 Gen1 5GT/s RJ: USB3.1 CP1 For USB 3.2 Gen1 5GT/s SJ: USB3.1 CP0 For USB 3.2 Gen1 5GT/s Eye Height: USB3.1 CP0 For USB 3.2 Gen2 10GT/s RJ: USB3.1 CP10 For USB 3.2 Gen2 10GT/s DJ: USB3.1 CP9 For USB 3.2 Gen2 10GT/s Eye Height: USB3.1 CP9
Emphasis Box Data Input	Unit1:Slot3:MU183020A
Emphasis Box Data/Clock Adjustment	Manual
SSC Setting	33KHz with -0.5% Triangle Down spread

12.1.1 Initial BERT Setup

Use the following procedure to set up the MX190000A.

1. Start the MX190000A and click **Initialize** from the MX190000A Menu drop-down.



2. Link the MU181000B and MU181500B Clock Source.
3. Link the MU183020A and MU181500B Clock Source.
4. Set the MU183020A Output Clock Rate to Fullrate.

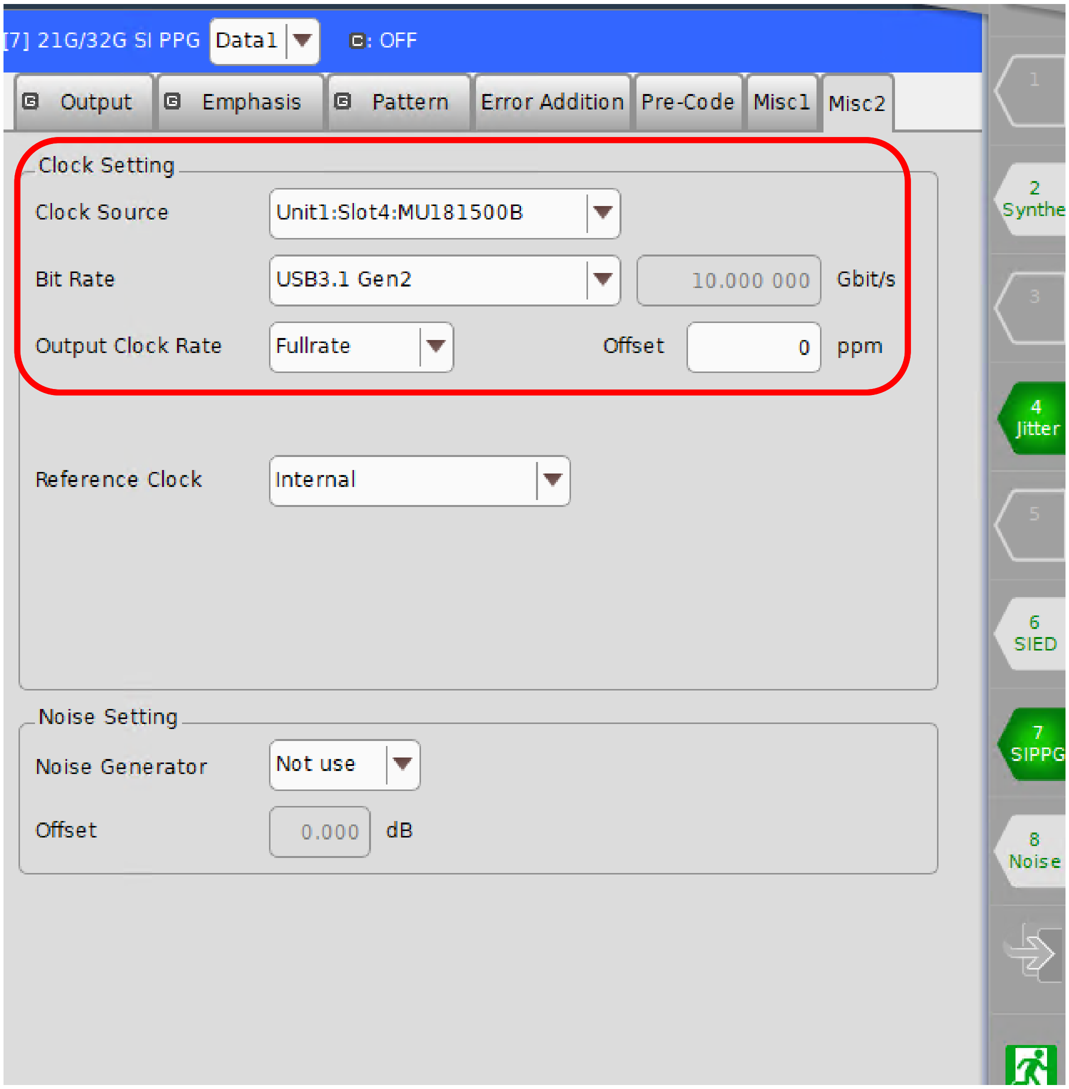


FIGURE 45. CLOCK SETTING

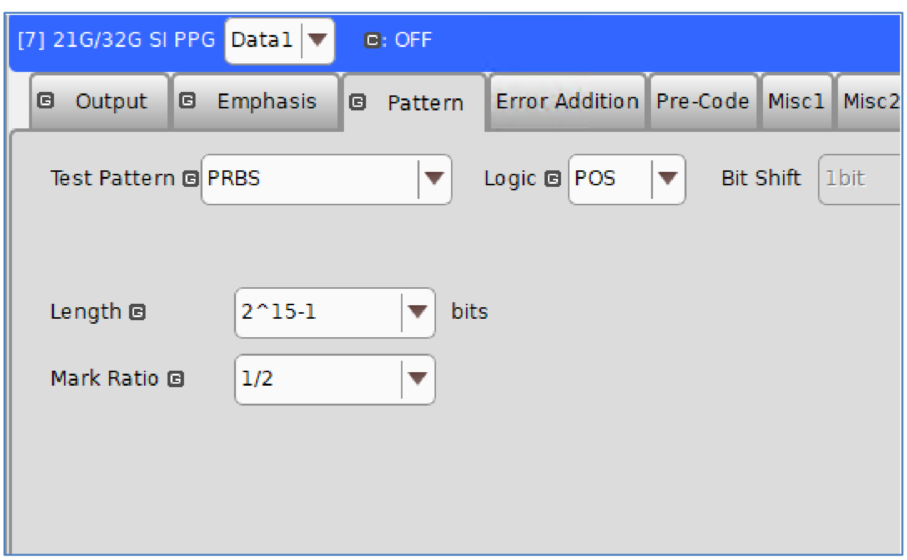


FIGURE 46. PATTERN SETTING

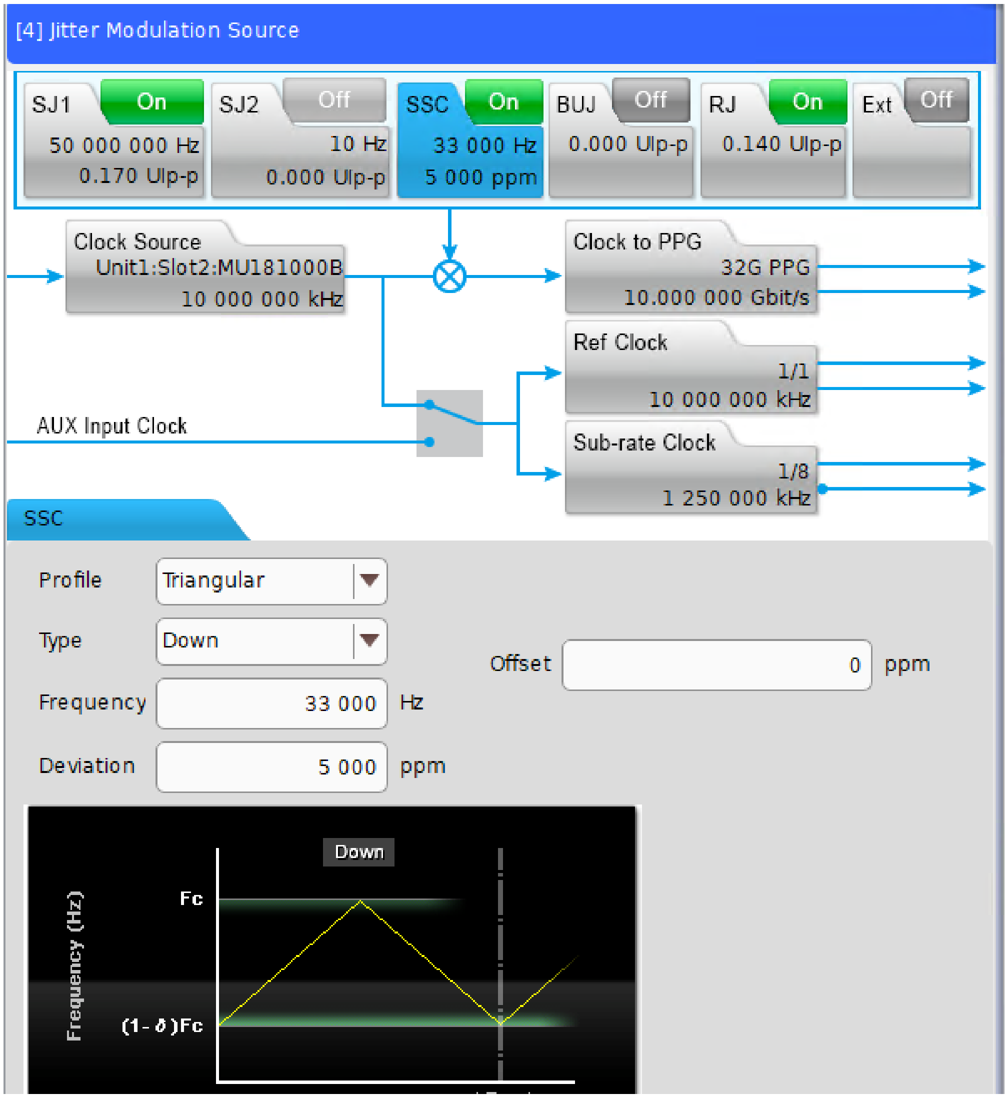


FIGURE 47. SSC SETUP

12.1.2 BERT Adjustment for Swing and De-Emphasis Calibration

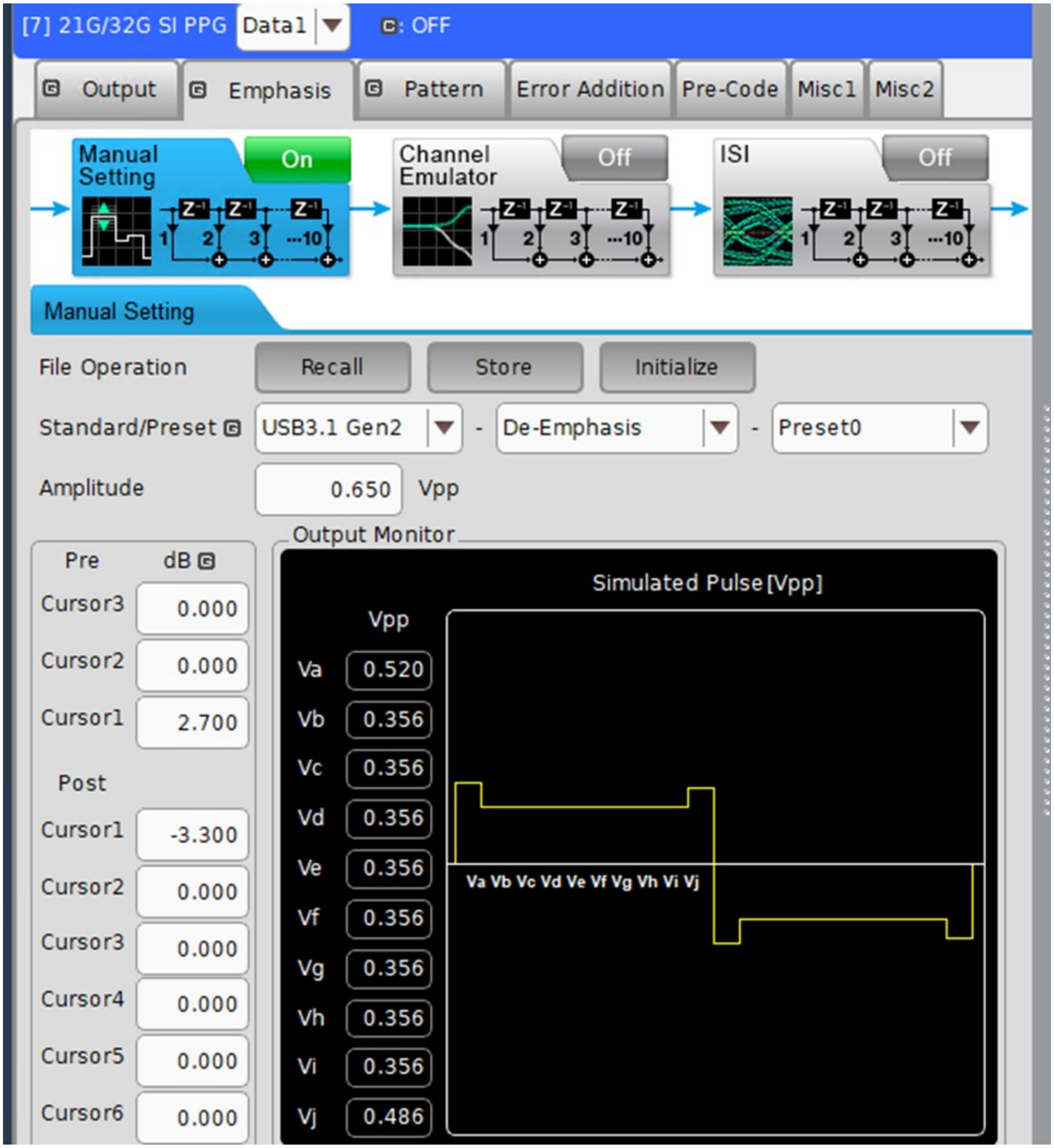
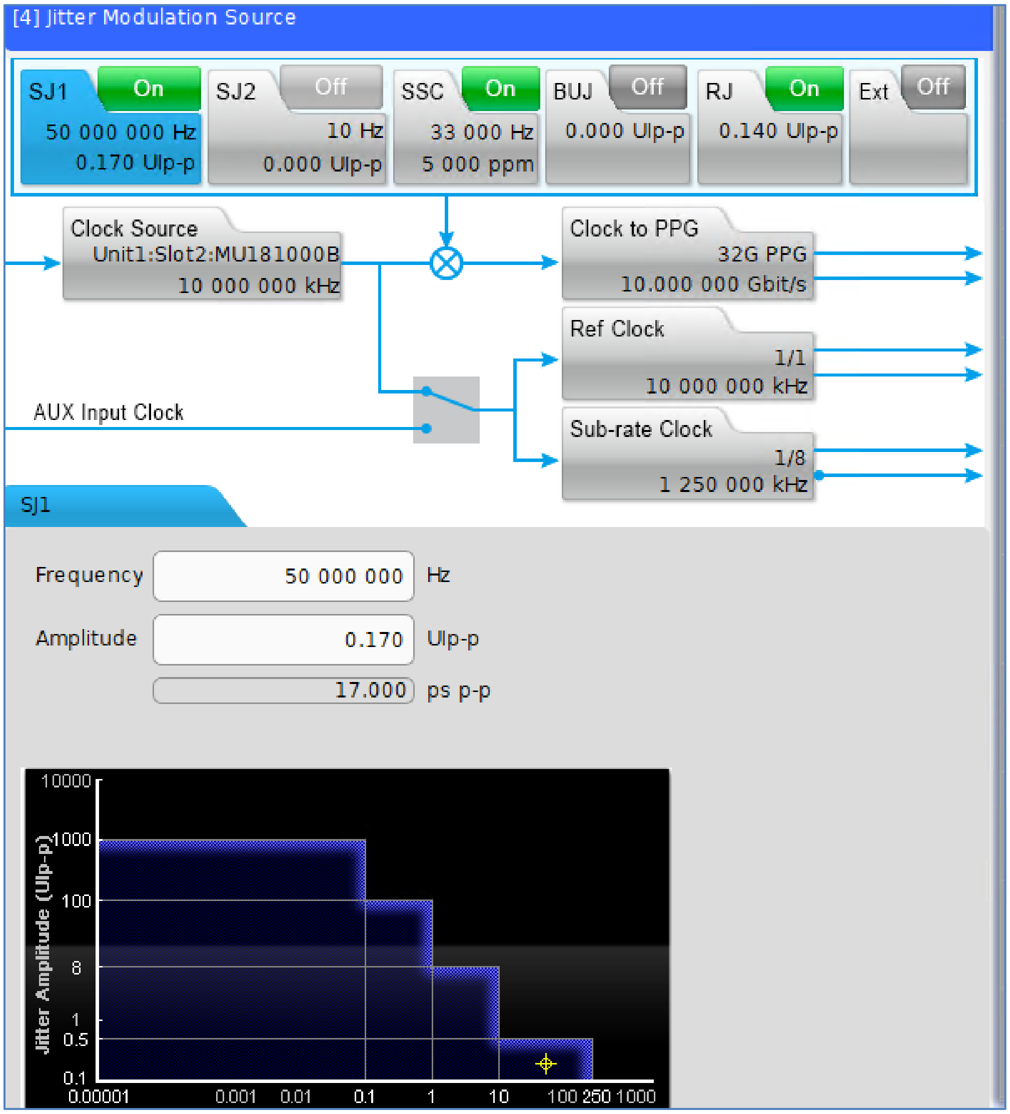


FIGURE 48. AMPLITUDE, EMPHASIS AND PRESHOOT SETUP EXAMPLE

12.1.3 BERT Adjustment for RJ and SJ Calibration



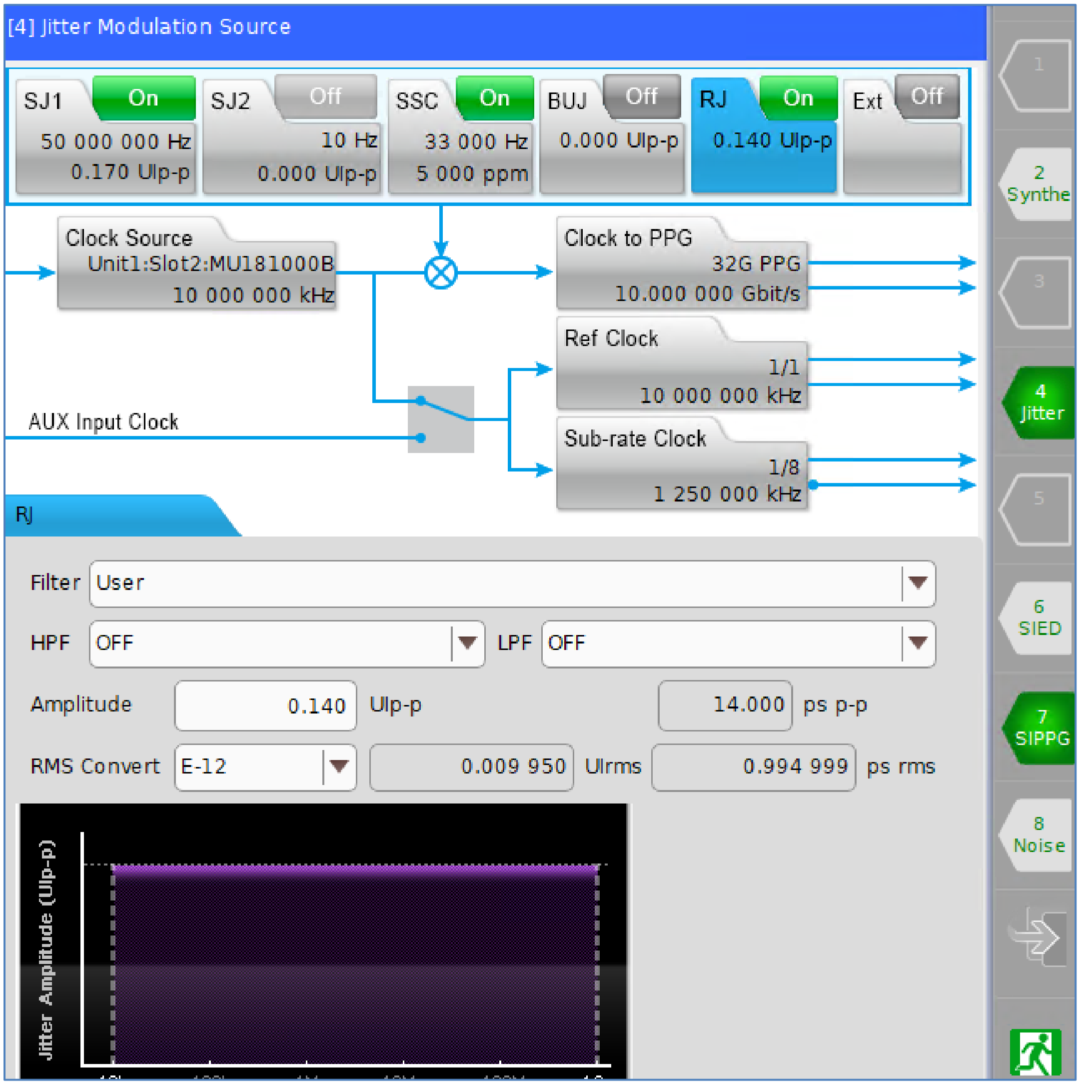


Figure 49. Jitter Amplitudes Example

12.1.4 BERT Adjustment for Eye Height Calibration

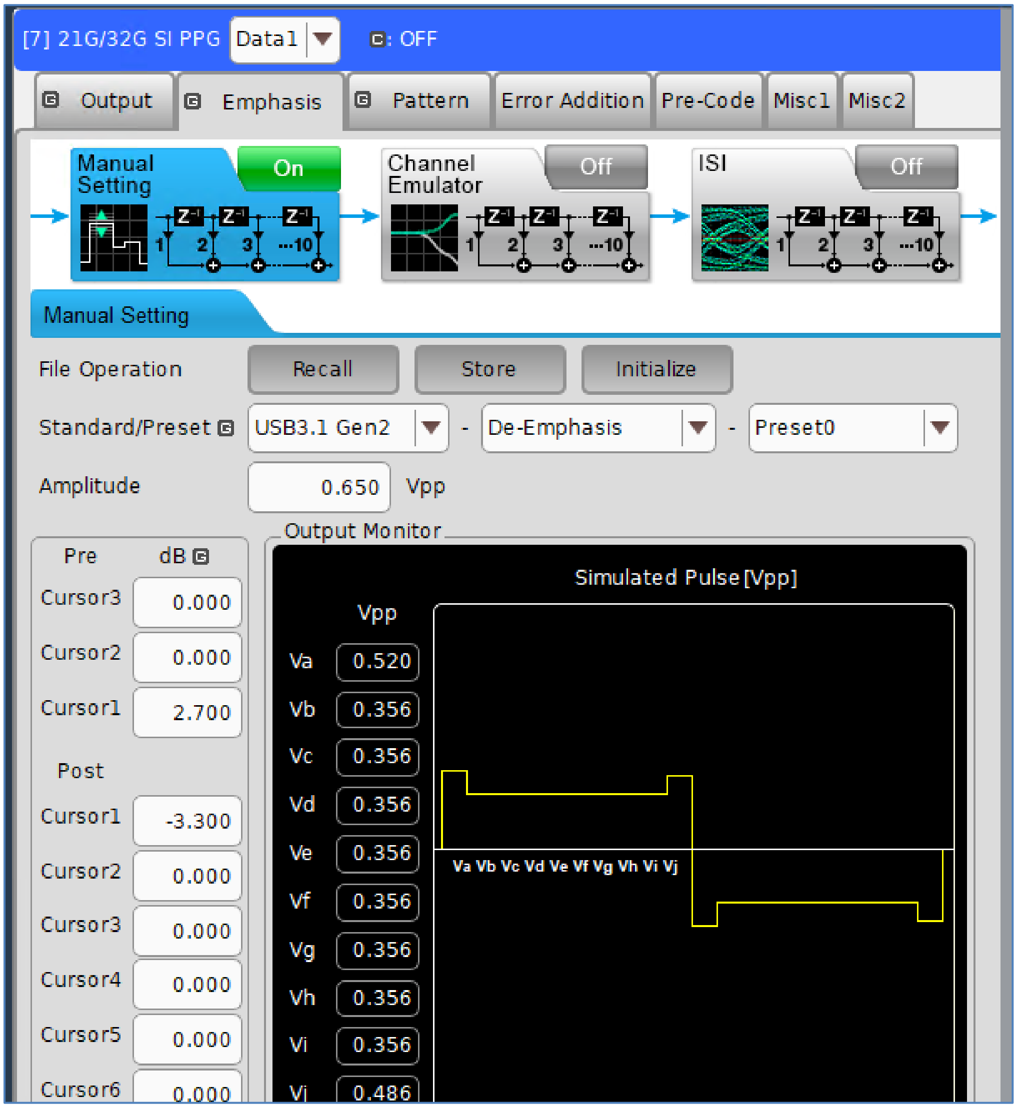


FIGURE 50. EYE AMPLITUDES EXAMPLE

13 Appendix D: Manual BERT Procedure for Testing

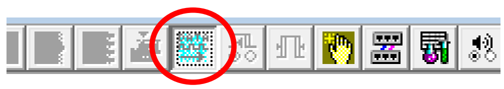
Note: This section describes procedure using the Anritsu MP1900A Series BERT model.

13.1 Connecting the Equipment for Loopback and Testing

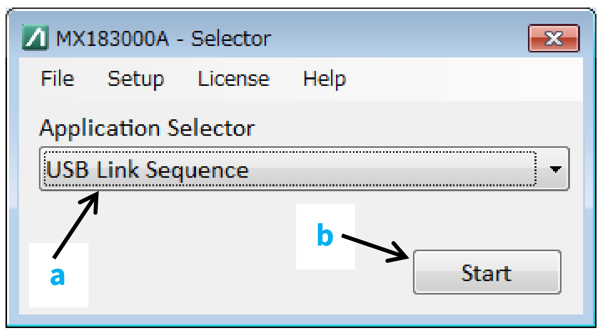
Make a loopback connection between the equipment using the cable connections as described in Section 7.2.

13.2 Loopback Training

1. Click the Data Output button as shown.

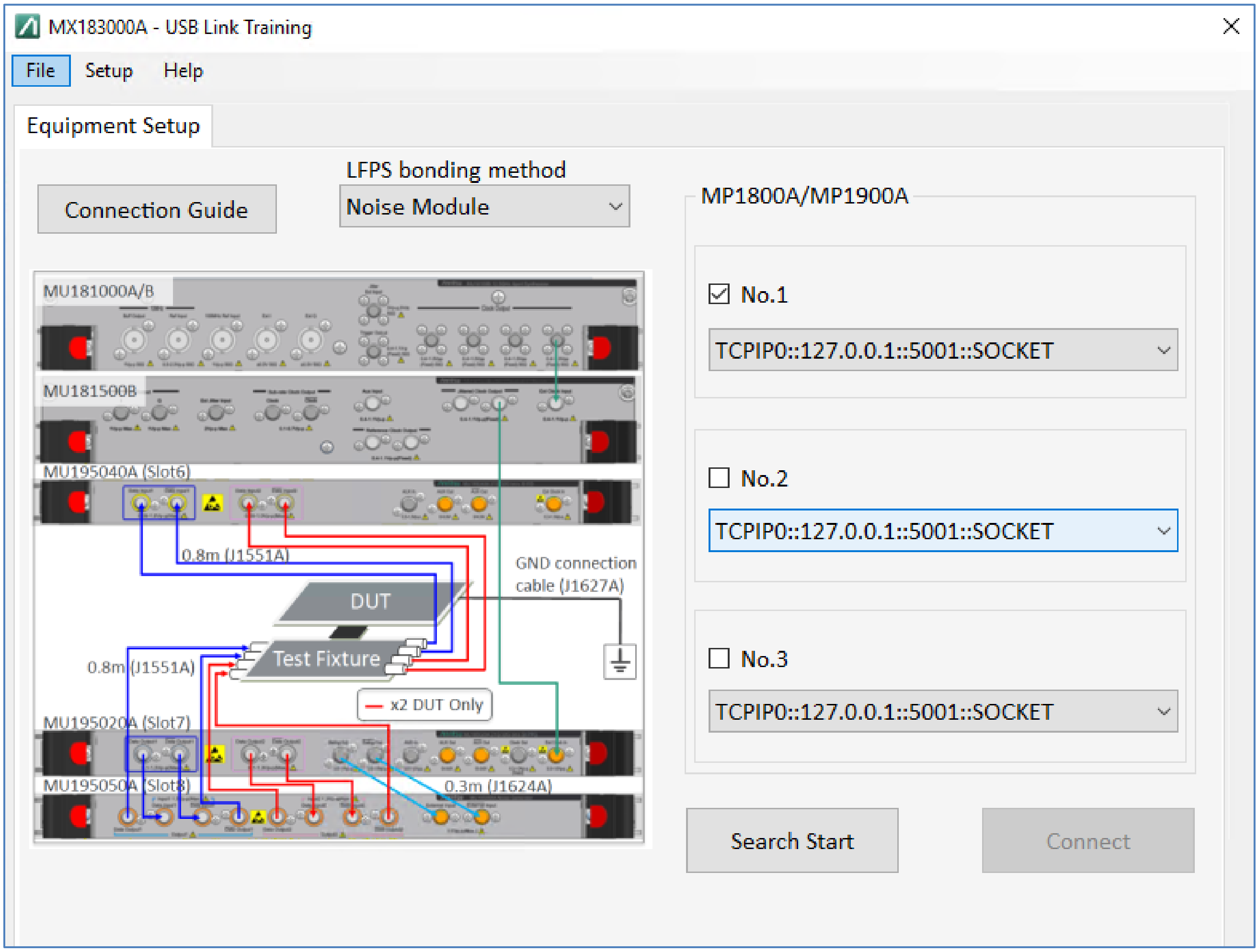


2. Initialize the MX183000A.
3. Start the USB Link Sequence application:



   a) Select 'USB Link Sequence' at Application Selector.
   b) Click Start.

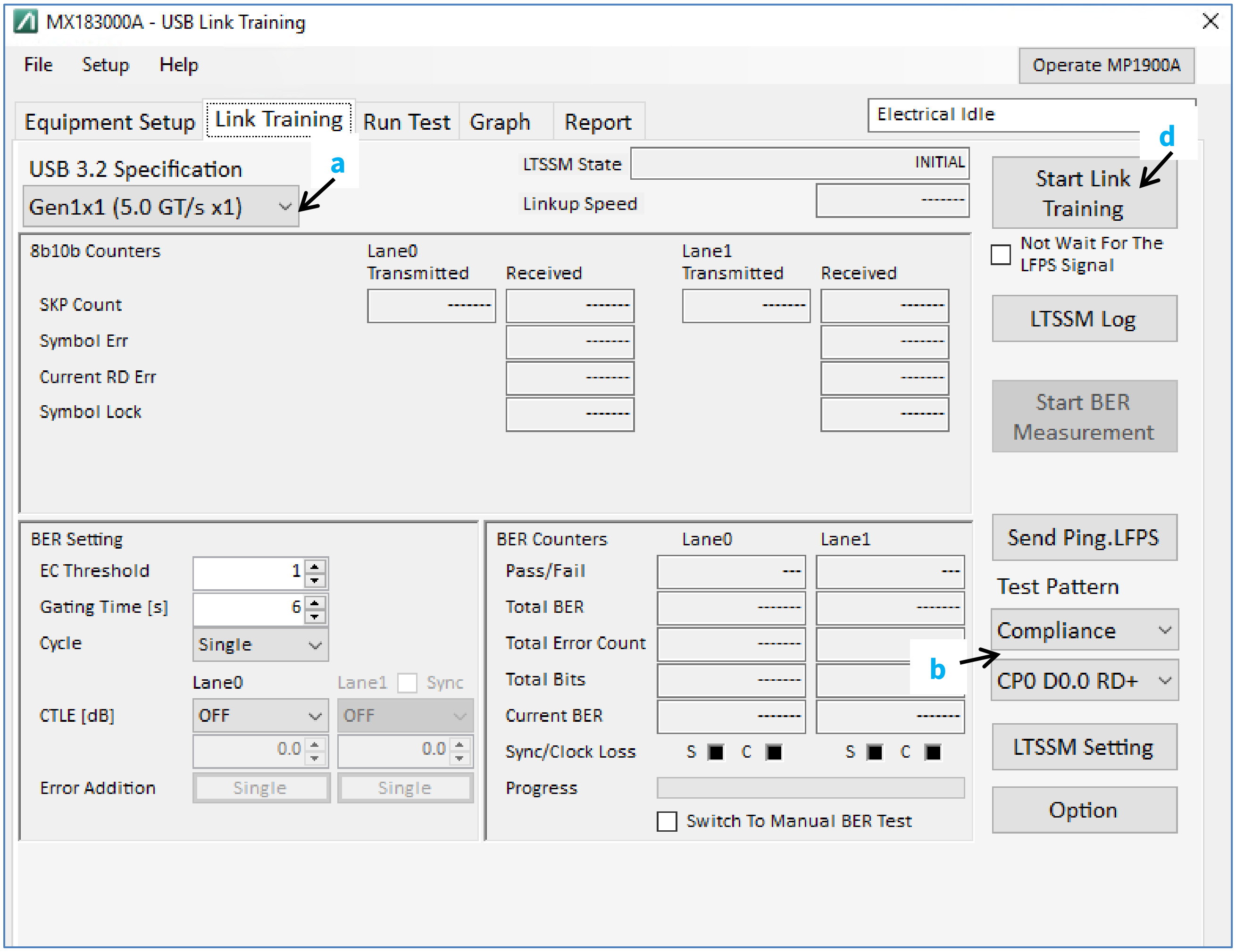
4. Set the Network Device (Equipment Setup):



a) Select the network device created in Section 12, *Appendix C: Manual BERT Procedure for Calibration*.

b) Click 'Search Start' and then click 'Connect'.

5. Run the following procedure at the Link Training tab.



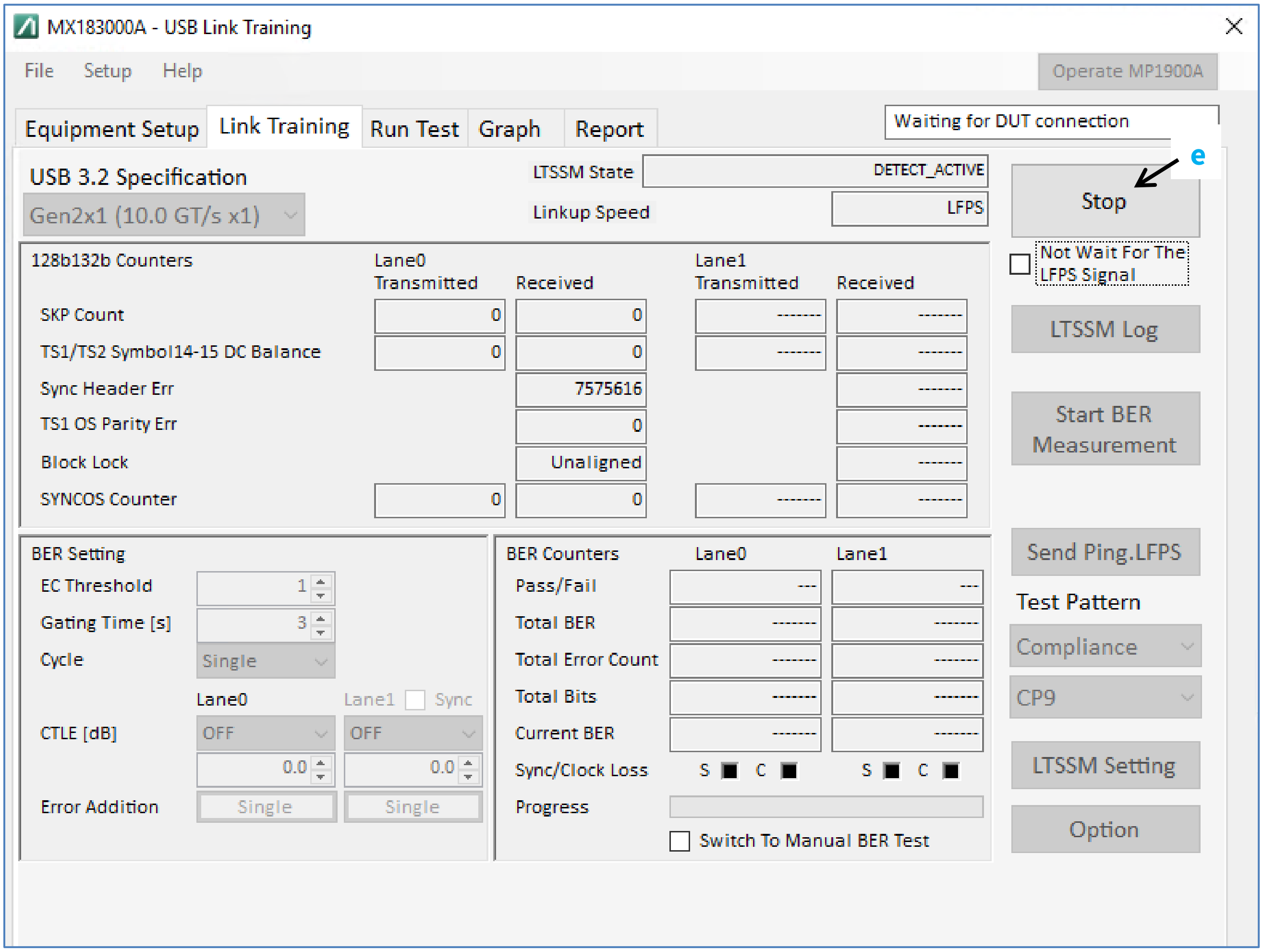
a) Select the test target specification.
b) Set the test pattern to the following:

- USB 3.2 Gen1 – 'Compliance CP0'
- USB 3.2 Gen2 – 'Compliance CP9'

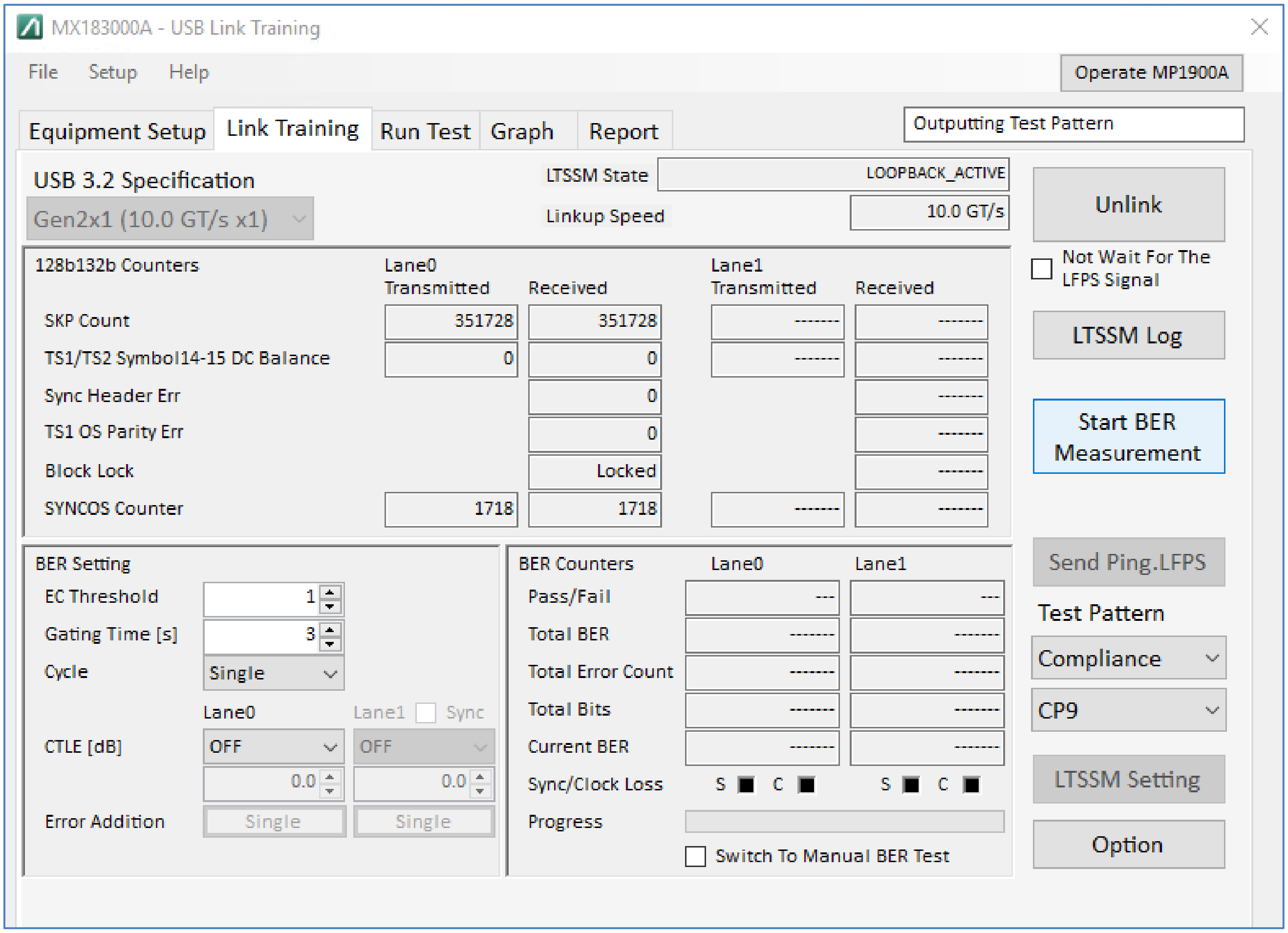
c) Disconnect the USB Test Fixture from the DUT.
d) Click 'Start Link Training'.
e) When 'Start Link Training' is clicked, the 'Start Link Training' button changes to 'Stop'.

While in this condition, connect the USB Test Fixture to the DUT.

When the DUT is connected, the LFPS signal output from the DUT is detected by the MU183020A and the sending of the training sequence starts.

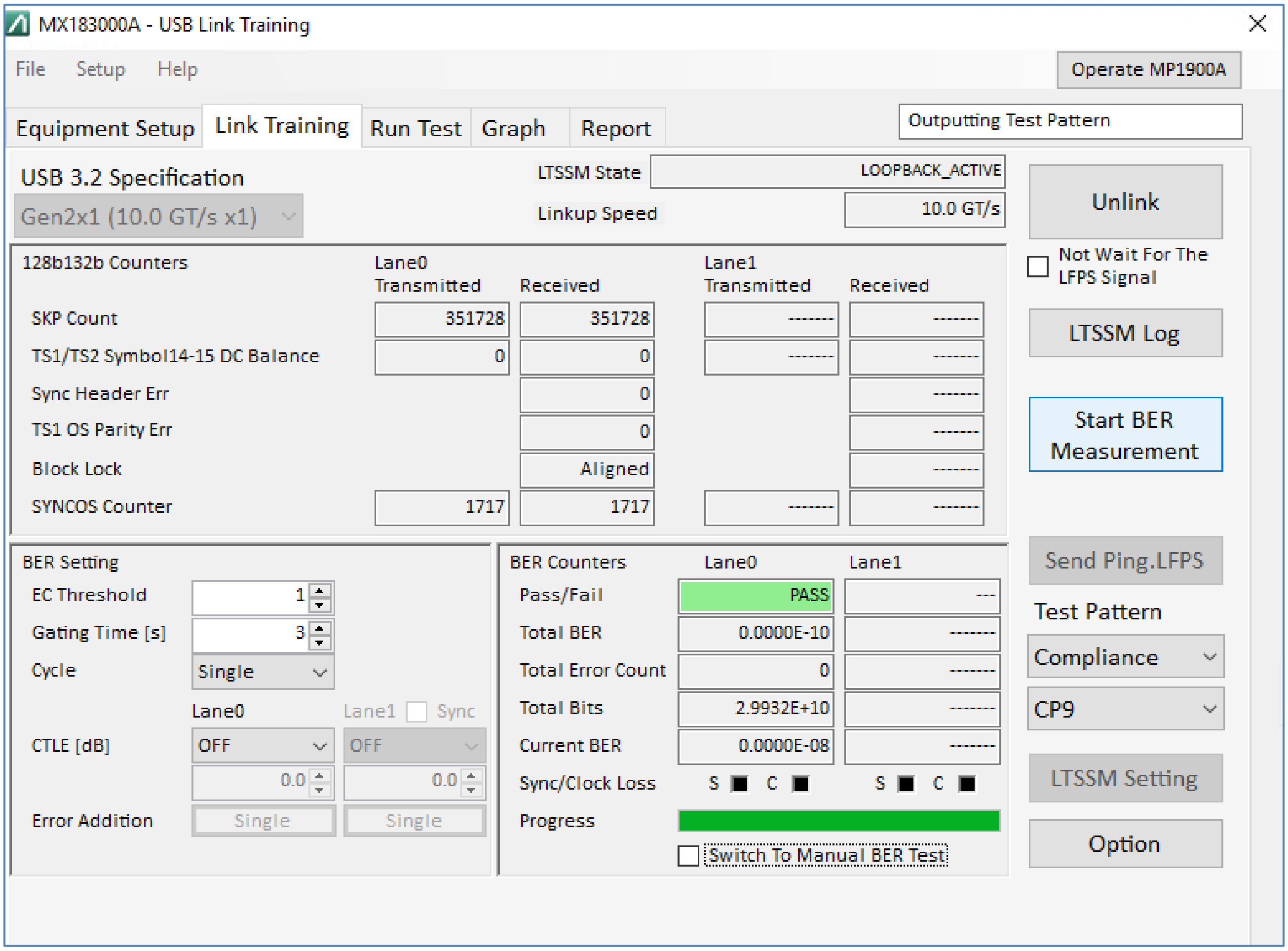


f) When the training sequence has completed, proceed to configure the BER measurement.

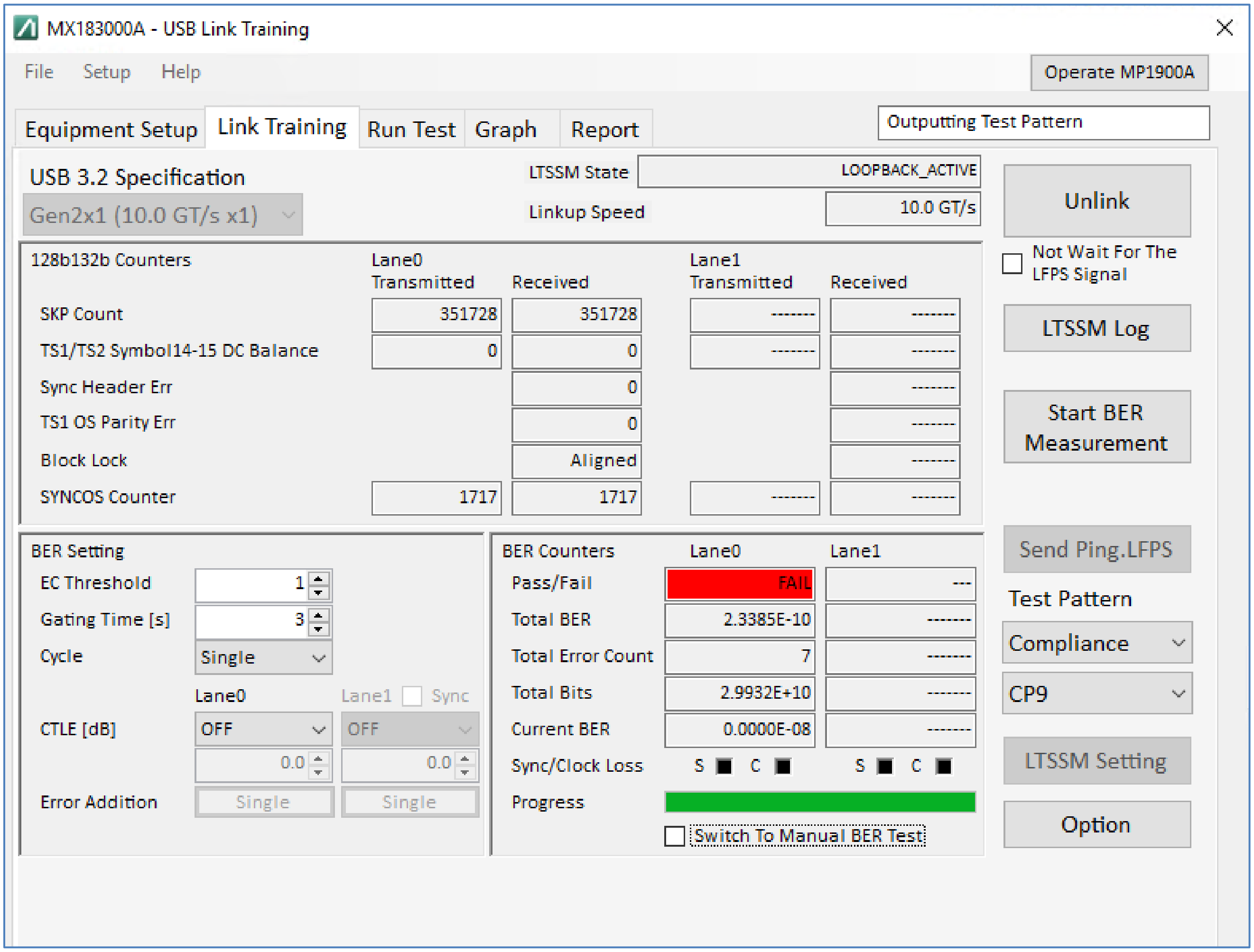


13.3 BER Testing

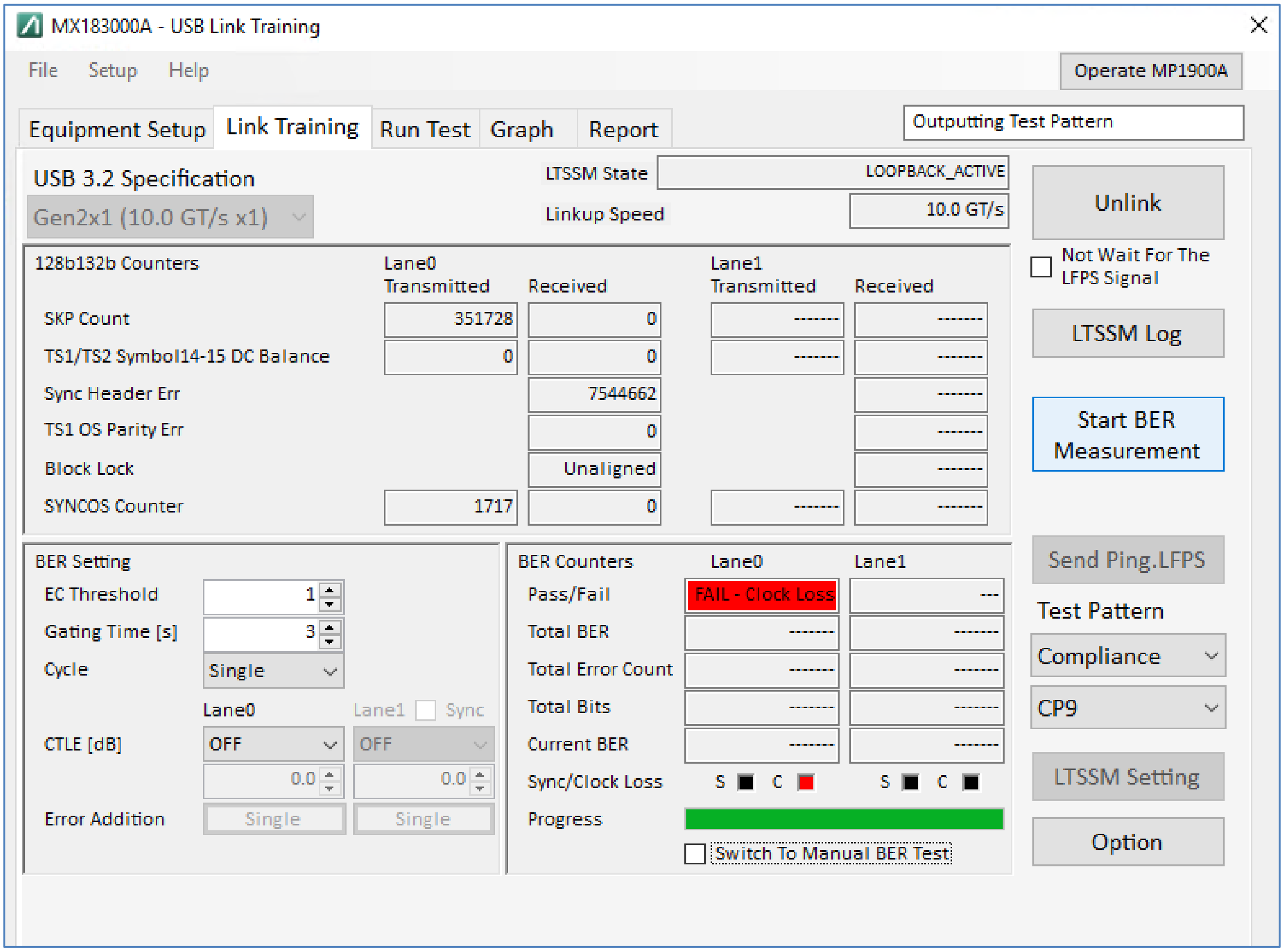
1. Click the 'Start BER Measurement' button to start the BER measurement.
2. The BER measurement result will be shown.
3. When the Total Error Count is less than the EC Threshold, "PASS" will be displayed.



4. When the Total Error Count is more than the EC Threshold, “Fail” will be displayed.



5. When the ‘Sync/Clock Loss’ indicator turns red, “FAIL” may be caused by the following:
   a) The DUT is not looped back.
   b) The PPG data output is disabled.


MX183000A - USB Link Training
File
Setup
Help
Operate MP1900A
Equipment Setup
Link Training
Run Test
Graph
Report
Outputting Test Pattern
USB 3.2 Specification
Gen2x1 (10.0 GT/s x1)
LTSSM State
LOOPBACK_ACTIVE
Linkup Speed
10.0 GT/s
Unlink
Not Wait For The LFPS Signal
128b132b Counters
Lane0
Lane1
Transmitted
Received
SKP Count
351728
0
TS1/TS2 Symbol14-15 DC Balance
Sync Header Err
7544662
TS1 OS Parity Err
Block Lock
Unaligned
SYNCOS Counter
1717
LTSSM Log
Start BER Measurement
BER Setting
EC Threshold
Gating Time [s]
Cycle
Single
CTLE [dB]
OFF
0.0
Sync
Error Addition
BER Counters
Pass/Fail
FAIL - Clock Loss
Total BER
Total Error Count
Total Bits
Current BER
Sync/Clock Loss
S
C
Progress
Switch To Manual BER Test
Send Ping.LFPS
Test Pattern
Compliance
CP9
LTSSM Setting
Option

14 Appendix E: Scope and Cable De-skew

Before beginning any test or data acquisition, the oscilloscope must be warmed, calibrated, and cables de-skewed. This section describes the procedure for calibrating the Oscilloscope, and de-skewing the cables, if using the Keysight Scope.

The DSO/DSA90000A and DSAX/DSOX 90000A series Oscilloscopes must be calibrated manually, and this is recommended after a 30- to 60-minute warm-up period.

FIGURE 51. SCOPE DESKEW SETUP

Perform the following steps, with reference to Figure 51.

1. Select the **File → Open → Setup…** menu to open the **Open Setup File** window.
2. Navigate to the directory location that contains the **INF_SMA_Deskew.set** setup file. If the setup file is not available, it can be created by following the instructions in Section 14.1.
3. Select the **INF_SMA_Deskew.set** setup file by clicking on it.
4. Click the **Open** button to configure the oscilloscope from this setup file.

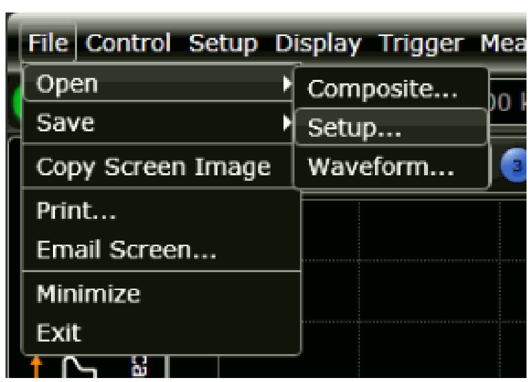


FIGURE 52. OPEN SCOPE DE-SKEW SETUP FILE WINDOW

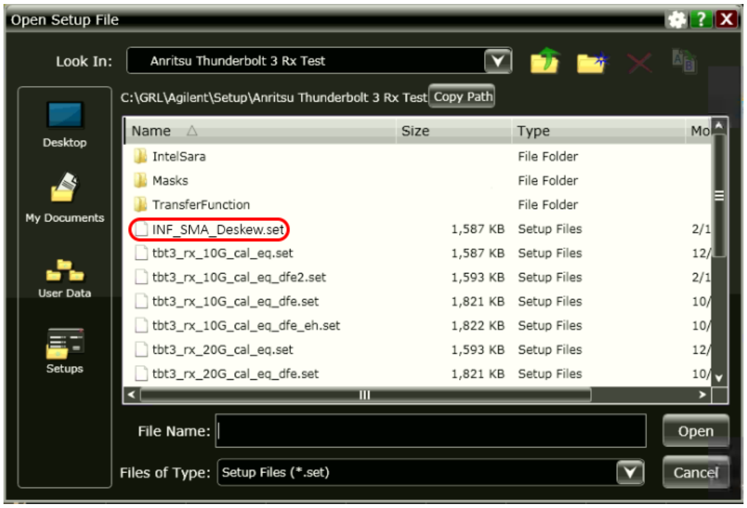


FIGURE 53. SCOPE DE-SKEW SETUP FILE

The oscilloscope display should look similar to Figure 54. A rising edge of the square wave is shown in a 100ps/div horizontal scale. The upper portion of the screen shows channel 1 (yellow trace) and channel 3 (blue trace) superimposed on one another. The lower portion of the screen is the differential signal (white trace) of channel 1 minus channel 3. The top two traces provide for visual inspection of relative time skew between the two channels. The bottom trace provides for visual presentation of unwanted differential mode signal resulted from relative channel skew (and to a much lesser extent from other inevitable channel mismatch parameters like gain and non-linearity). Figure below is an example of exaggerated skew between channel 1 and channel 3.

FIGURE 54. SCOPE DE-SKEW OSCILLOSCOPE DISPLAY

Figure 55 shows the desired effect of no skew between the cables. Note that the channel 1 (yellow trace) and channel 3 (blue trace) traces overlap, and the differential signal (white trace) is flat. If this is not the case, then perform the following steps to reduce the skew between channels 1 and 3.

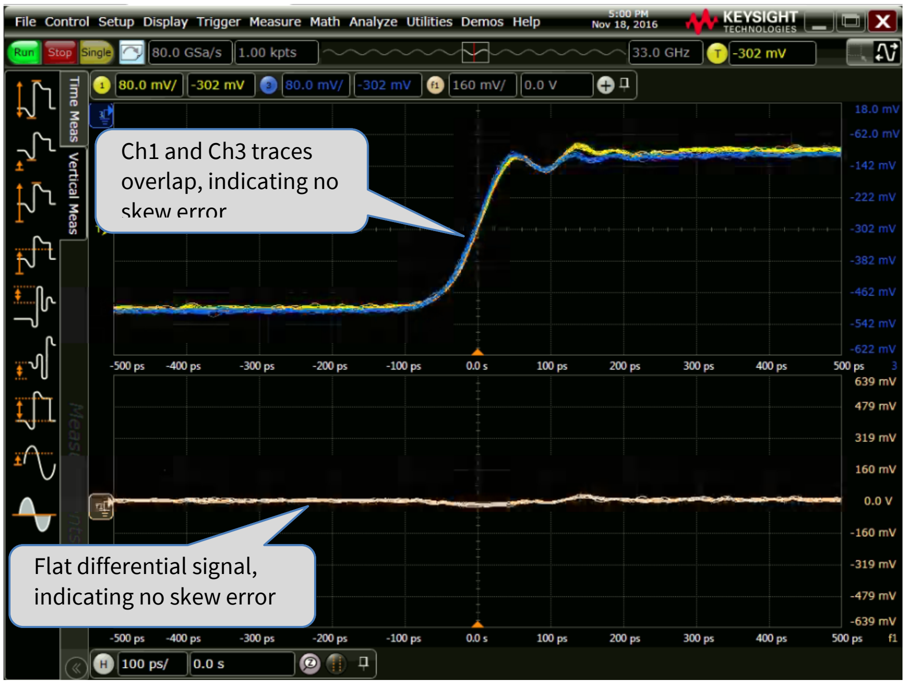


FIGURE 55. SCOPE DE-SKEW OSCILLOSCOPE DISPLAY DE-SKEWED

Referring to Figure 56 and Figure 57, perform the following steps to de-skew the channels:

1. Click on the **Setup → Channel 1…** menu to open the **Channel** window.
2. Move the **Channel** window to the left so you can see the traces.
3. Adjust the **Skew** by clicking on the ← or → arrows, to achieve the flattest response on the differential signal (white trace).
4. Close the Channel window.
5. The de-skew operation is now complete.
6. Disconnect the cables from the Tee on the Aux Out BNC. Leave the cables connected to the Channel 1 and Channel 3 inputs.

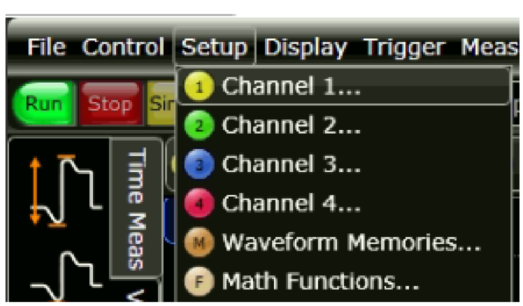


FIGURE 56. SCOPE DE-SKEW PROCESS – OPEN CHANNEL WINDOW

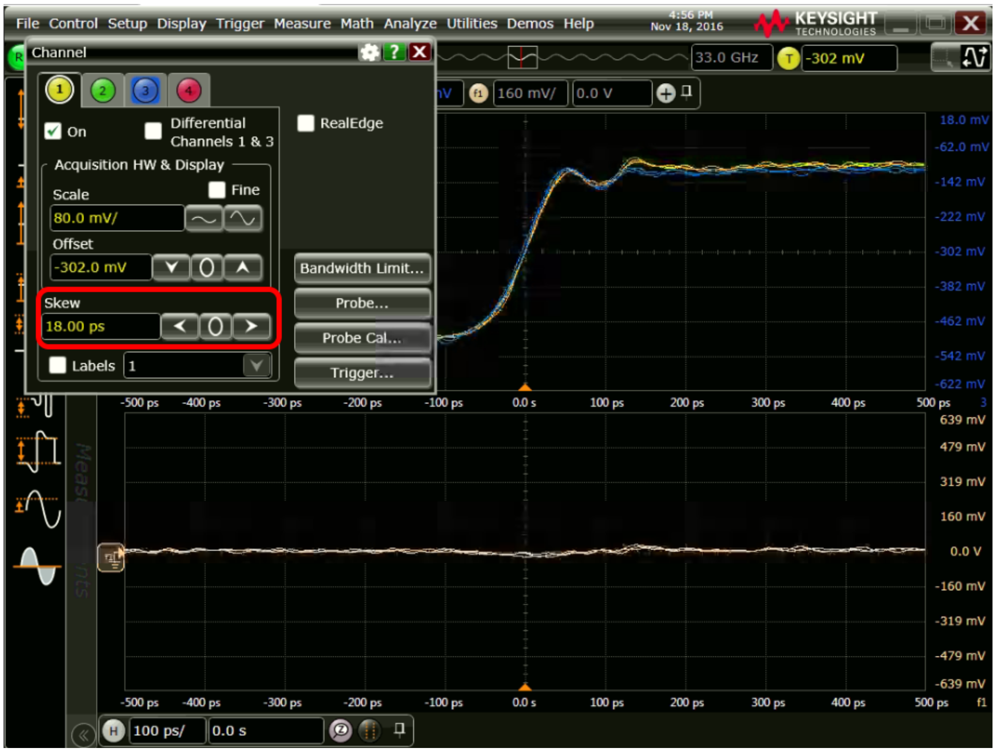


FIGURE 57. SCOPE DE-SKEW PROCESS – ADJUST SKEW

14.1 De-Skew Setup File Detail

This setup information is for Channel 1 and Channel 3 on the DSO91304A Scope.

Working from the details in the file INF_SMA_Deskew.set, one begins from a default setup by pressing the Default Setup key on the Scope's front panel. Continue to configure the settings as listed in Table 15.

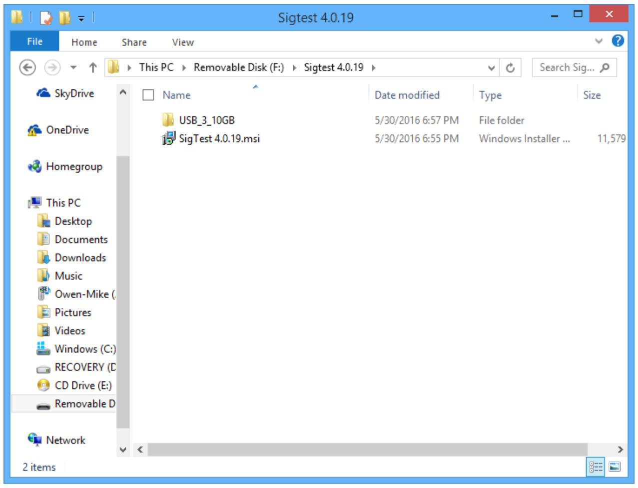
TABLE 15. SCOPE / CABLE DE-SKEW SETUP

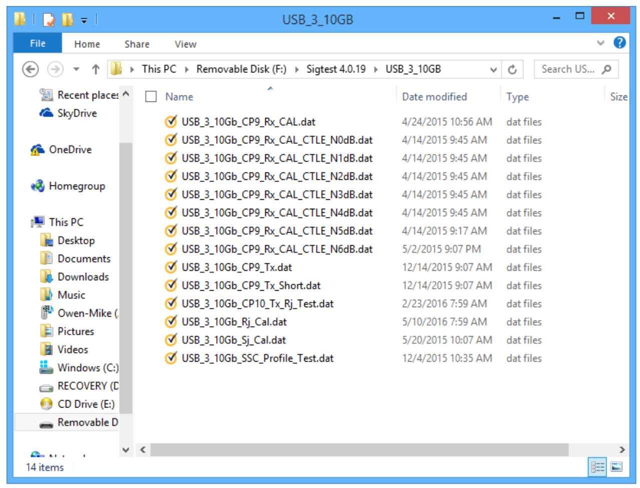
Setting	Setup	
Acquisition Averaging	ON	
Number of Averages	16	
Interpolation	ON	
Time Base Scale	200 ps/sec	
Trigger Level	-173 mV	
Trigger Slope	Falling	
Function 2	ON, and configure for "Channel 1 subtract Channel 3"	
Vertical Scale	50 mV	
Vertical Offset	100.000 mV	
	Channel 1	**Channel 3**
Scale	100.0 mV	100 mV
Offset	-350 mV	-350 mV
Coupling DC Impedance	50 Ohms	50 Ohms

15 Appendix F: Installing SigTest for Manual Testing

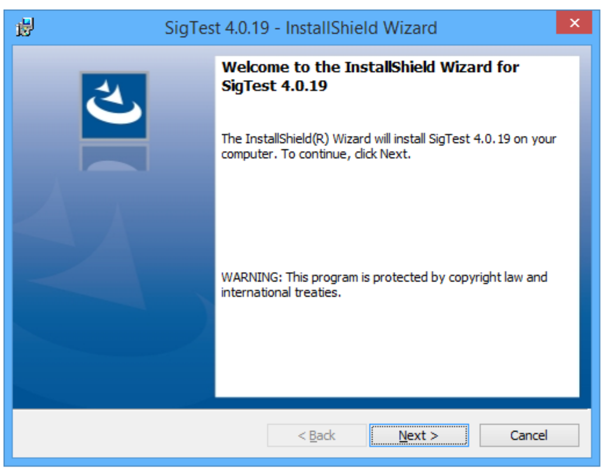
This section shows how to install the SigTest application using SigTest version 4.0.19 as example.

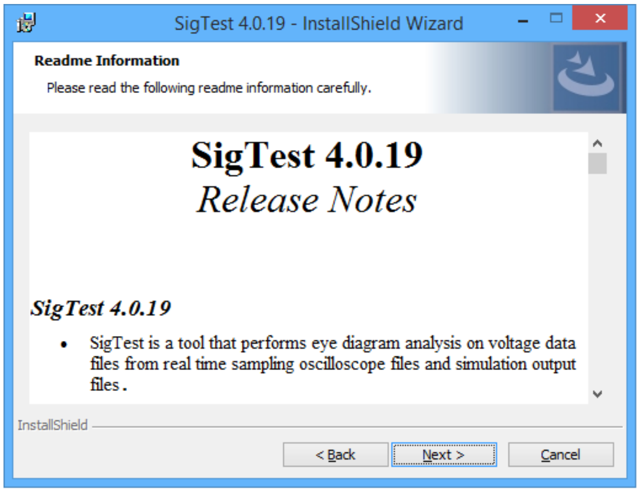
The contents of the SigTest version 4.0.19 and the included folder with the USB 3.2 template files are shown below. To install SigTest for USB 3.2 Calibration testing, install SigTest and copy the template files into the appropriate folder. Below shows the procedure.

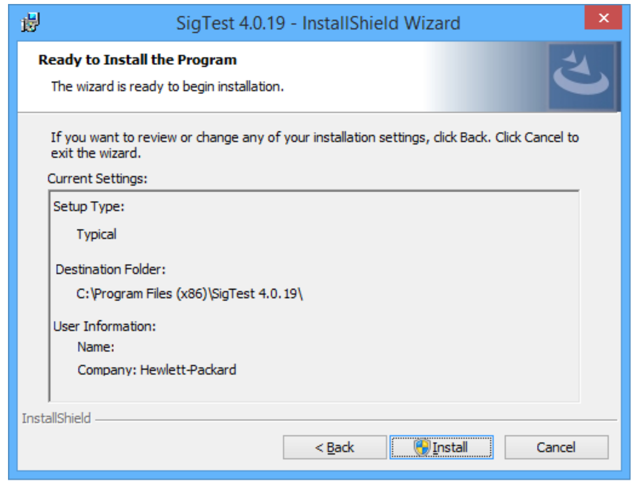


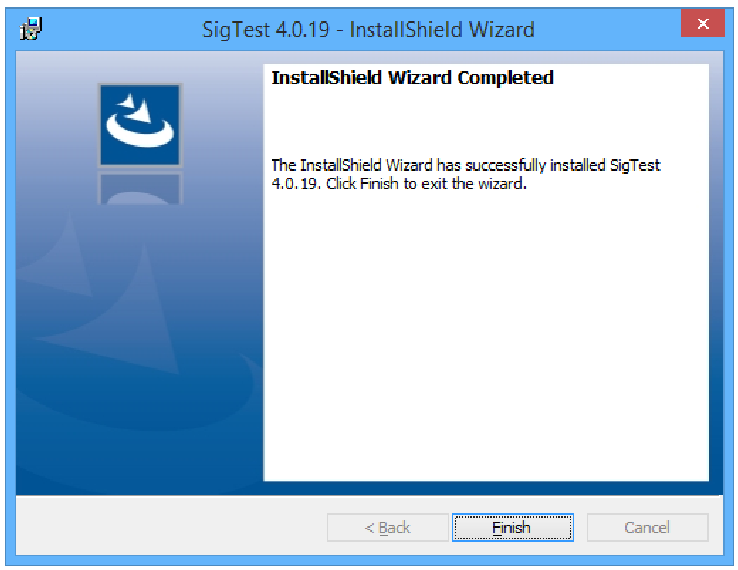


1. Click on the SigTest 4.0.19.exe icon to install the SigTest software. You will see the following prompts appear.









2. Copy the contents of the USB_3_10G folder to an appropriate folder.
3. Once SigTest is installed, the Icon appears on the Desktop.

4. Click on the SigTest Icon to run SigTest.

16 Appendix G: Connecting Keysight Oscilloscope to PC

If using a Keysight oscilloscope, refer to the following procedure on how to connect the Scope to be used with a PC. The Keysight Scope can be connected to the PC through GPIB, USB, or LAN.

1. Download the latest version of the Keysight IO Libraries Suite software from the Keysight website and install on the PC.
2. When installed successfully, the IO icon ( ) will appear in the taskbar notification area of the PC.
3. Select the IO icon to launch the **Keysight Connection Expert**.
4. Click Rescan.

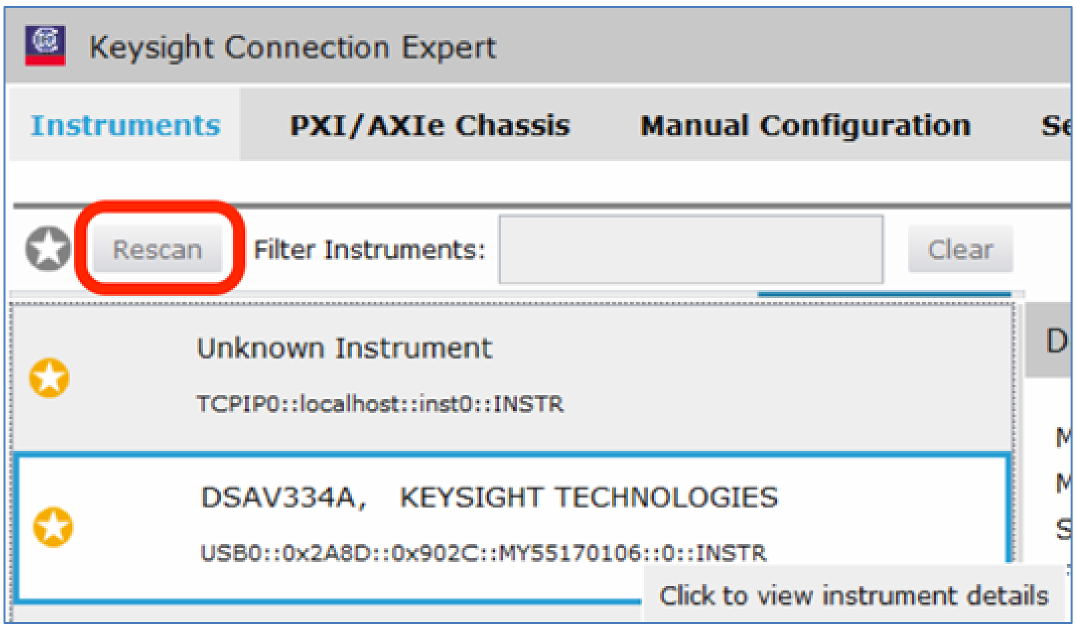


FIGURE 58. KEYSIGHT CONNECTION EXPERT

5. Refresh the system. The Keysight Scope is shown on the left pane and the VISA address is shown on the right pane.

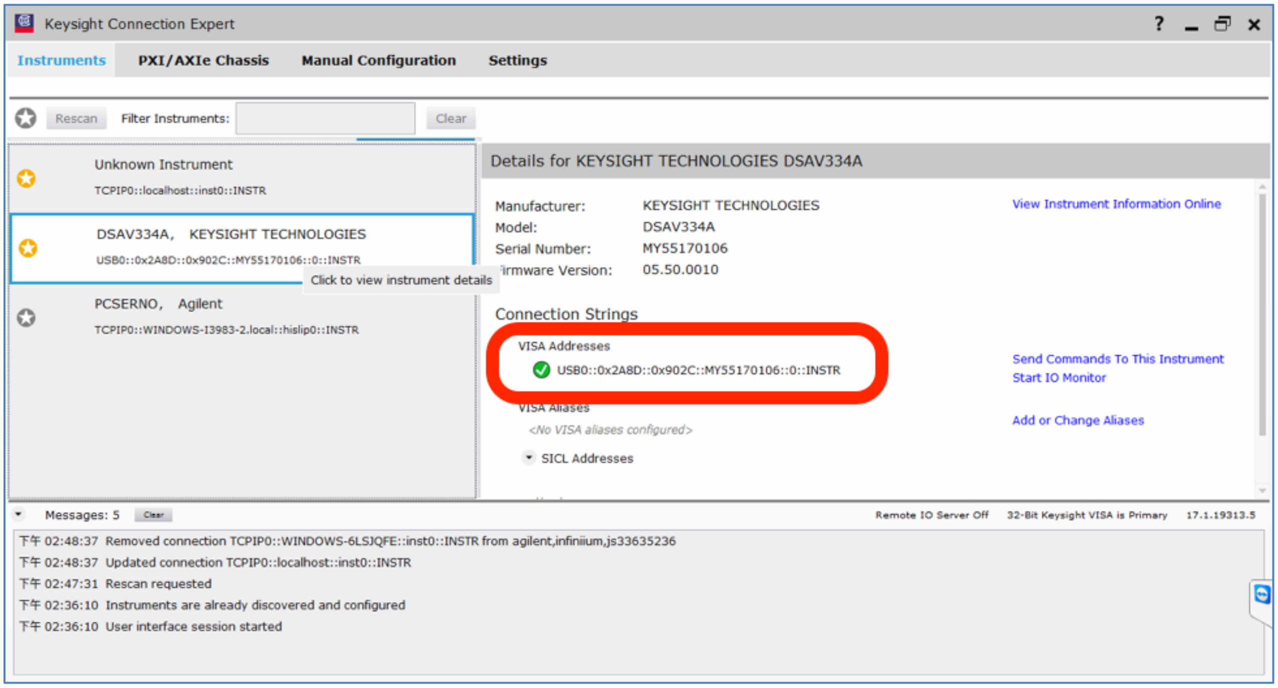


FIGURE 59. OSCILLOSCOPE'S VISA ADDRESS

6. When connecting the Keysight Scope to the PC through GPIB/USB, type in the VISA address into the 'Address' field on the Equipment Setup page of the GRL USB 3.1 Rx Test Application. If connected via LAN, type in the Scope IP address, for example "TCPIP0::192.168.0.110::inst0::INSTR". Note to ***omit*** the Port number from the address.

   If there is error in connection, type in the Scope IP address as "TCPIP0::192.168.0.4::5025::SOCKET".

17 Appendix H: Connecting Tektronix Oscilloscope to PC

If using a Tektronix DPOJET Series oscilloscope, refer to the following procedure on how to connect the Scope to be used with a PC. The Tektronix Scope can be connected to the PC through GPIB, USB, or LAN.

1. Download the latest version of the Tektronix TekVISA software from the Tektronix website and install on the PC.
2. When installed successfully, open the OpenChoice Instrument Manager application.

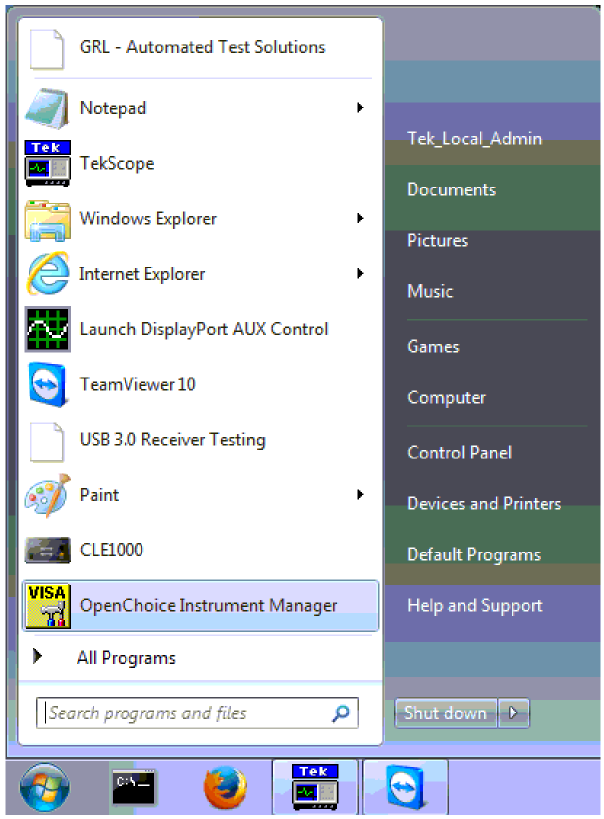


FIGURE 60. OPENCHOICE INSTRUMENT MANAGER IN START MENU

3. The left “Instruments” panel on the OpenChoice Instrument Manager will display all connected instruments. The functional buttons below the “Instruments” panel – “Instrument List Update”, “Search Criteria”, “Instrument Identify” and “Properties” can be used to detect the Scope in case it does not initially appear under “Instruments”.
   a) “Instrument List Update”: Select to refresh the instrument list and locate new instruments connected to the PC.
   b) “Search Criteria”: Select to configure the instrument search function.
   c) “Instrument Identify”: Select to use a supported programming language to send a query to identify the selected instrument.
   d) “Properties”: Select to display and view the selected instrument properties.

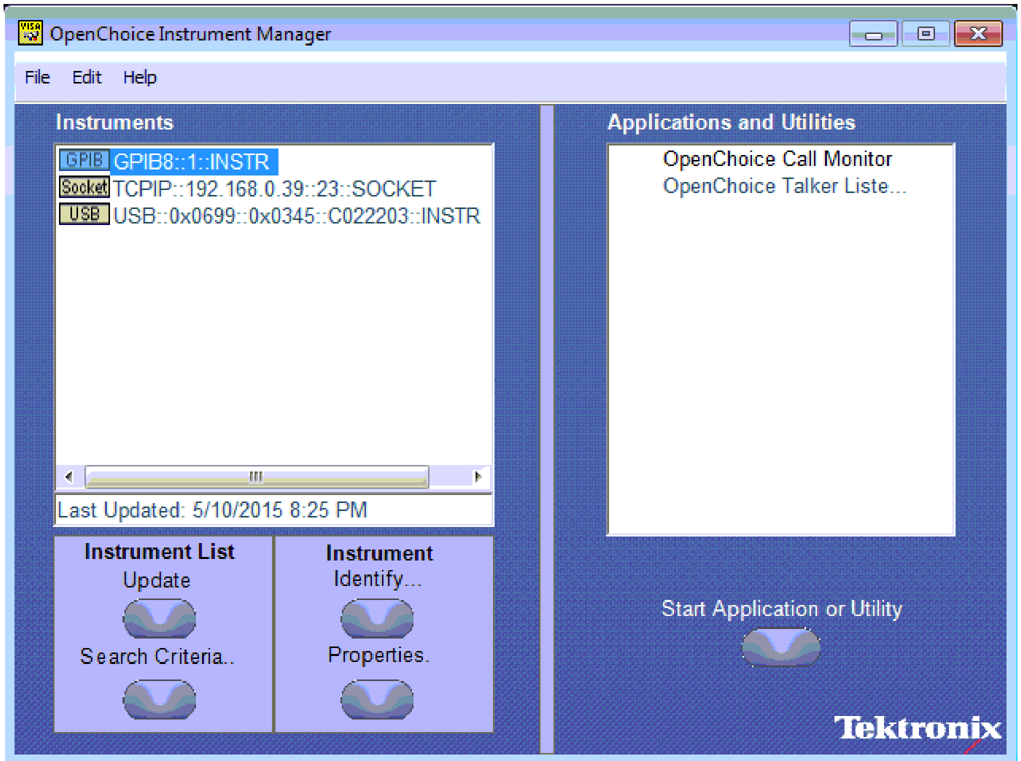


FIGURE 61. OPENCHOICE INSTRUMENT MANAGER MENU

4. If connecting the Tektronix Scope to the PC via USB, select the “Search Criteria” function to ensure that USB connection is enabled, and then select the “Instrument List Update” function. When the Scope appears on the “Instruments” panel, select it and then go to the “Instrument Identify” function. This will display the model and serial number of the Scope once detected. Select the “Properties” function to view the Scope address.
5. If connecting the Tektronix Scope to the PC via LAN, the Scope IP address must be pre-determined beforehand. Then select the “Search Criteria” function to ensure that LAN connection is enabled and type in the Scope IP address. When the Scope shows up in the list, select it followed by “Search”. The Scope should then appear on the “Instruments” panel. Select it and access the “Instrument Identify” function to view the Scope model and serial number as well as the “Properties” function to view the Scope address.
6. On the Equipment Setup page of the GRL USB 3.1 Rx Test Application, type in the Scope address into the ‘Address’ field. If the GRL USB 3.1 Rx Test Application is installed on the Tektronix Scope, ensure the Scope is connected via GPIB and type in the GPIB network address, for example “GPIB8::1::INSTR”. If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example “TCPIP0::192.168.0.110::inst0::INSTR”. Note to ***omit*** the Port number from the address.

END_OF_DOCUMENT