Granite River Labs

USB4® Receiver Test Method of Implementation (MOI)
Using Keysight M8040A BERT,
High Performance Real-time Oscilloscope,
and GRL-USB4-RX-KS Calibration and Test Automation Software

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1 Introduction

This MOI & User Guide contains the procedure for testing an electrical receiver for USB4® certification using the Keysight M8040A BERT, High Performance Real-Time Oscilloscope, and GRL-USB4-RX-KS Test Automation Software as per USB-IF standards.

The main body of this MOI & User Guide describes how to perform automated Calibration and Testing of USB4 Gen2/Gen3 Hosts and Devices using the GRL-USB4-RX-KS 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 @ support@graniteriverlabs.com 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 USB4 Gen2/Gen3 receiver compliance testing.

The solution in this MOI can also be used for USB4 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-USB4-RX-KS software to:

1. Calibrate and Test a USB4 Gen2/Gen3 Receiver.
2. Generate Test Report for Compliance Reporting.

2 Resource Requirements

2.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – SYSTEMS AND ACCESSORIES

System	Qty.	Description	Key Specification Requirement
Oscilloscope	1	High Performance Real-time Oscilloscope[a]	• ≥ 21 GHz bandwidth[b] • 16 GB and above memory RAM
BERT	1	Keysight M8040A 64 Gbaud High-Performance BERT, with following modules: • M8045A Pattern Generator with M8057A/B remote head • M8195A Arbitrary Waveform Generator (AWG) • M8046A Error Analyzer	• 64.8 GBd max sampling rate • 0.9 Vpp @ 58 GBd amplitude • With built-in clock data recovery
Accessory	**Qty.**	**Description**	**Key Specification Requirement**
TP3' Test Fixture	1	USB4 Test Point 3' (Case 1) Test Fixture	
TP3 Test Fixture	1	USB4 Test Point 3 (Case 2) Calibration Test Fixture	
TP3 ISI	1	USB4 Test Point 3 (Case 2) ISI Tolerance Fixture	
TP3' Low Speed Fixture	1	USB4 Test Point 3' (Case 1) Low Speed Fixture	For connecting USB Type-C Passive and Active Cables to USB4 Microcontroller
TP3 Test Cables	1	2m USB Type-C Passive Cable	Insertion Loss -18dB at 5GHz
	1	0.8m / 1m USB Type-C Passive Cable [c]	Insertion Loss -16.5dB at 10GHz
USB4 Controller	1	Wilder-Tech USB4 Microcontroller	CG3-TPA-TR, with USB Cable [d] • *Optional for some test configurations, see Appendix F.*
Cable Deskew Fixture	1	Splitter	
DC Block	2	Keysight N9398F DC Block	Bandwidth of at least 33GHz
Adapter	2	Keysight 11904C Adapter	2.4 mm (m) to 2.92 mm (f), DC to 40 GHz
Adapter	2	Keysight 11904D Adapter	2.4 mm (f) to 2.92 mm (m), DC to 40 GHz

Pick-off Tee	2	HYPERLABS HL9465M Broadband Z-matched Pick-off Tee	DC to 50 GHz
Computer	1	Laptop or Desktop PC	Windows 7+ OS For automation control (running GRL-USB4-RX-KS software)

[a] Oscilloscope with scope software requirements as specified in vendor specific MOI's. For example, when using the Keysight Scope, scope software such as the 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 the Tektronix DPOJET (Jitter and Eye Analysis Tools) software while the Teledyne LeCroy oscilloscope requires scope software such as the SDAIII analysis tool for making measurements.

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

[c] The 0.8m USB Type-C passive cable shall be used with the older version USB4 test fixture, while the 1m USB Type-C passive cable shall be used the newer version USB4 test fixture.

[d] Intel TenLira test scripts loaded on the PC/oscilloscope running GRL-USB4-RX-KS software. Provides sideband SBU control of the DUT for reading BER values from the DUT Rx registers.

***Note**: Cable connector type and length requirements may vary according to the lab setup and the dimensions of the DUT board. Table below is a recommended list. Please also refer to the respective manufacturer for detailed cabling recommendations related to USB4.*

TABLE 2. EQUIPMENT REQUIREMENTS – CONNECTION CABLES

Connection Cable	Qty.	Key Specification Requirement
M8195A Arbitrary Waveform Generator (AWG) M8045A Pattern Generator	1	2.92 mm (0.5 m) cable
Matched Cable Pairs	3	Phase Matched ±5° at 40GHz Insertion Loss 1dB maximum in 10GHz
RPC-2.92 Jack to SMP Jack	4	Rosenberger 02K119-K00E3
USB Type-C Passive and Active Cables	2	For connecting the control PC to the DUT
2.4mm Cable	2	For connecting between the HL9465M pick-off tees and 11904D adapters
USB Type-A to Type-B Cable	1	For connecting the USB4 Microcontroller to the control PC
Ethernet Cable	1	For connecting the control PC to the M8040A BERT

2.2 Software Requirements

Software	Source
GRL-USB4-RX-KS	Granite River Labs USB4 Receiver Calibration and Test Automation Software for the Keysight M8040A BERT– www.graniteriverlabs.com (Resources → Download Center) Includes test setup and pattern files for USB4 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 control PC running GRL-USB4-RX-KS 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)*
Keysight M8000 System Software	Keysight M8040A BERT pre-requisite software is required to be installed on the control PC or scope running GRL-USB4-RX-KS software.
SigTest Application	Downloadable from USB-IF's website. *(Note: Approval and NDA as a USB-IF Adopter is required to gain access to USB-IF products.)*
USB4 Electrical Test Tool (ETT)	Downloadable from USB-IF's website. *See Section 3.1.1 for more details.*
Intel TenLira Test Scripts (For Thunderbolt 3 DUT's)	Downloadable from Intel Corporation IBL's website.
ActiveTcl (For Thunderbolt 3 DUT's)	Version 8.5.18.0 or above (downloadable from ActiveState's website: http://www.activestate.com/activetcl/downloads). Refer to ActiveState's website for specific system requirements and other information for installing the Tcl installation package. Also see the documentation available on the website for installation instructions.

3 Installing and Setting Up GRL-USB4-RX-KS Software

This section provides the procedure for installing, configuring and verifying the operation of the GRL-USB4-RX-KS software. It also helps you familiarize yourself with the basic operation of the software.

The software installer automatically creates shortcuts in the Desktop and Start Menu.

To open the software application, follow the procedure in the following section.

3.1 Download and Set Up GRL-USB4-RX-KS Software

Install, launch and set up the GRL-USB4-RX-KS software on a PC or an oscilloscope (where GRL-USB4-RX-KS is referred to as 'Control PC' or 'Scope' respectively in this MOI & User Guide):

1. Install VISA (Virtual Instrument Software Architecture) on to the PC/Scope where GRL-USB4-RX-KS is to be used (see Section 2.2).
2. Download the GRL-USB4-RX-KS ZIP file package from the Granite River Labs support site.
3. The ZIP file contains:
   a) **USB4RxKSTestApplication00xxxxxxSetup.exe** – Run this on the control PC or scope to install the GRL-USB4-RX-KS application.
   b) **USB4RxKSTestScopeSetupFilesInstallation00xxxxxxSetup.exe** – Run this on the scope to install the scope setup files.
4. Launch and set up the software as follows:
   a) From the Windows Start Menu, click on **GRL – Automated Test Solutions** to launch the GRL software framework.

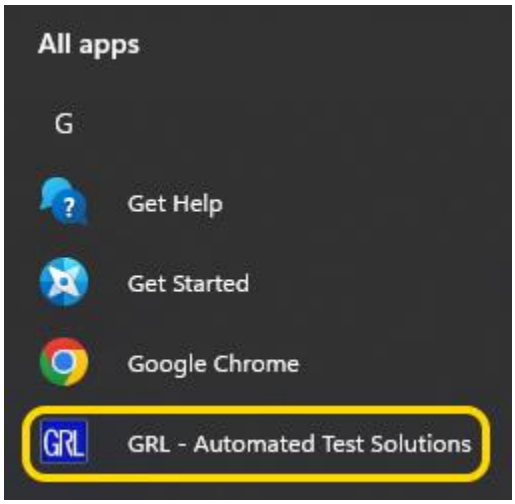


FIGURE 1. LAUNCHING GRL SOFTWARE FRAMEWORK

   b) From the **Application → Rx Test Solution** drop-down menu, select **GRL USB4 Rx Test**. If the selection is grayed out, it means that your license has expired.

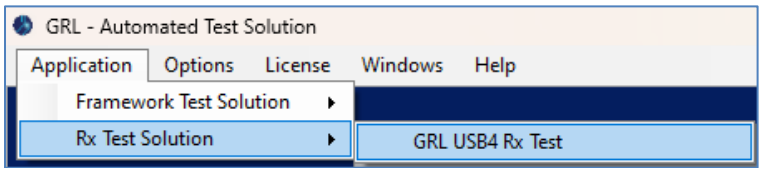


FIGURE 2. LAUNCHING KEYSIGHT USB4 RX TEST APPLICATION

i) To enable license, go to **License → License Details**.

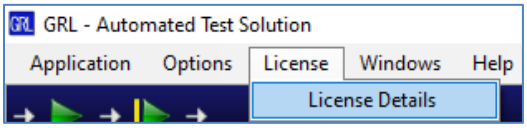


FIGURE 3. LICENSE DETAILS

ii) Review the installed application.

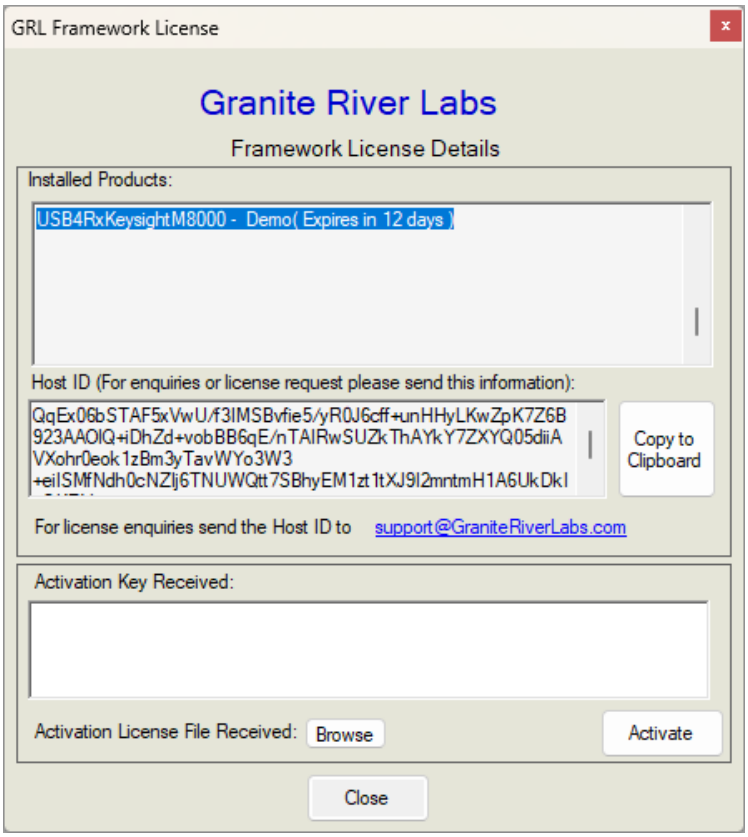


FIGURE 4. INSTALLED APPLICATION

iii) Activate a License:

[1] If you have an Activation Key, enter it in the box provided, and select **Activate**.
[2] If you do not have an Activation Key, select **Close** to use the software for 10 days free of charge.

Note: *Once the 10-day trial times out, you will need to request an Activation Key for future usage 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 full calibrate and test a device.*

For Demo and Beta Customer License Keys, please request an Activation Key by contacting support@graniteriverlabs.com.

3.1.1 Download and Install USB4 Electrical Test Tools (ETT)

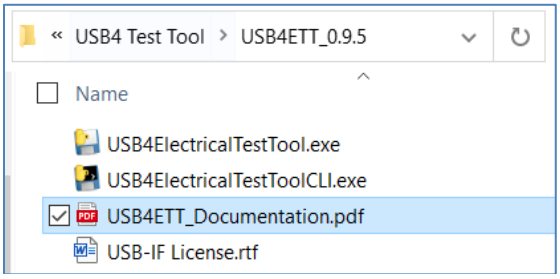
For USB4 Rx measurements, the Host/Device's CIO PHY must be in an active state during testing. Its transmitters shall be transmitting PRBS31 into the analyzer measurement channel during testing and its receivers shall have their terminations enabled during testing. Thus, a PHY microcontroller must be used to put the DUT into the right state for USB4 Rx testing.

Download ETT:

Visit the USB-IF official website and download "USB4 Electrical Test Tool" (ETT) at https://www.usb.org/usb4tools.

Install ETT:

Before running ETT, configure the Control PC's environment using the instructions in **USB4ETT_Documentation.pdf** from the ETT package downloaded from USB-IF.



For USB4 Host Testing:

- The ETT can be loaded on the Control PC with the GRL-USB4-RX-KS software. In this case, the Wilder-Tech µController is required. The DUT is controlled using a 0.8m / 1m USB Type-C passive cable from the Wilder-Tech µController to the USB4 Test Fixture.

For USB4 Device Testing:

- **Upstream Facing Port (UFP):** The ETT can be loaded on the Control PC with the GRL-USB4-RX-KS software. In this case, the Wilder-Tech µController is required. The DUT is controlled using a 0.8m / 1m USB Type-C passive cable from the Wilder-Tech µController to the USB4 Test Fixture.
- **Downstream Facing Port (DFP):** Connect the DUT's UFP to any USB4 Host via the USB4 Type-C cable. The ETT tools can be loaded on the Control PC with the GRL-USB4-RX-KS software. In this case, the Wilder-Tech µController is required. The DUT is controlled using a 0.8m / 1m USB Type-C passive cable from the Wilder-Tech µController to the USB4 Test Fixture. *Take note for the device DUT, if the port under test is a Downstream Facing Port (DFP), a USB4 Host will be required to connect to the DUT's Upwards Facing Port (UFP).*

3.1.2 Launch and Set Up GRL-USB4-RX-KS Software

3.1.2.1 On the Scope or Control PC

1. Launch GRL Host Application from **Start Menu** → **GRL** → **GRL – Automated Test Solutions**.
2. Select **Application** → **Rx Test Solution** → **GRL USB4 Rx Test**.
3. Select the Equipment Setup icon  on the GRL USB4 Rx Test Application menu.
4. Connect the Keysight M8040A BERT via LAN to the GRL automation control enabled Scope or PC.
5. On the Scope or control 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.
6. On the Equipment Setup page of the GRL USB4 Rx Test Application, type in the address of each connected instrument into the 'Address' field.
7. *(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".)*

   *(Note: If the GRL software is installed on the **Keysight Scope**, type in the Scope IP address, for example "TCPIP0::127.0.0.1::inst0::INSTR".)*

   If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example "TCPIP0::192.168.0.35::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::192.168.0.35::5025::SOCKET".)*
8. If the GRL software is installed on the PC to control the Scope, set up the Remote File Server as described in Section 3.1.3.
9. Then select the "lightning" button () for each connected instrument.

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

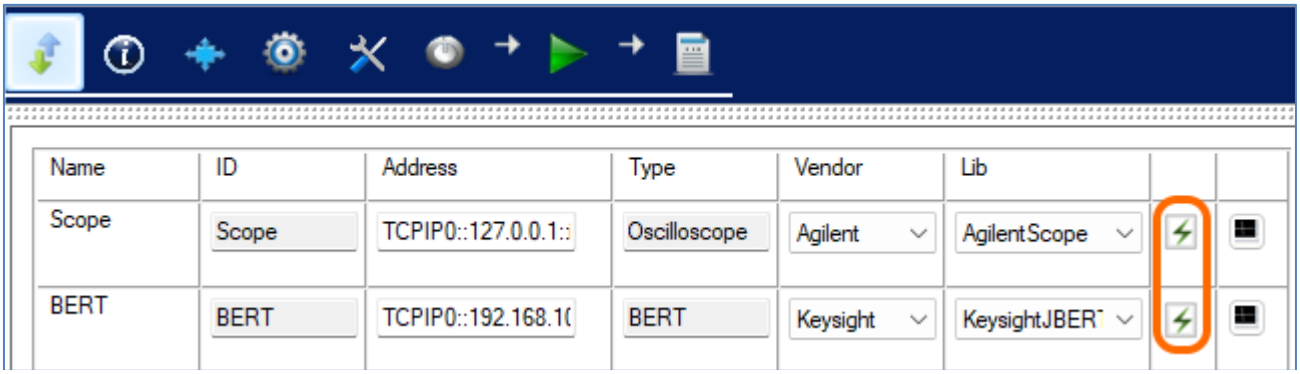


FIGURE 5. GRL SOFTWARE INSTRUMENT CONNECTION SETUP

Note: Additional information for connecting supported vendor oscilloscopes (Keysight, Tektronix and Teledyne LeCroy) to the control PC is provided in the Appendix of this document.

3.1.3 Set Up Remote File Server

1. The **GRLRemoteProxyServer.exe** will also be installed along with the **USB4RxKSTestScopeSetupFilesInstallation0xxxxxxxxxSetup.exe** on the Scope. The GRLRemoteProxyServer.exe is installed under the *"C:\GRL\GRLRemoteProxyServer"* directory.

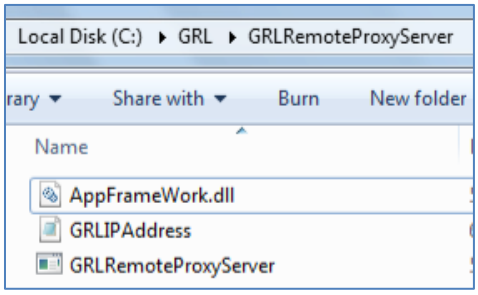


FIGURE 6. INSTALLED GRLREMOTEPROXYSERVER.EXE FILE DIRECTORY

2. If the GRL software is installed on the PC to control the Scope and SigTest is selected as the test method to be used (refer Section 5.4), the GRLRemoteProxyServer.exe must be run on the Scope to move large waveform files back to the control PC. The GRL software will then perform post-processing and analysis of these waveforms using SigTest.
3. When running the GRLRemoteProxyServer.exe, make sure that the control PC and Scope are connected to the same network, using IP addresses as in following example:
    - Control PC IP address: 192.168.100.8
    - Scope IP address: 192.168.100.35

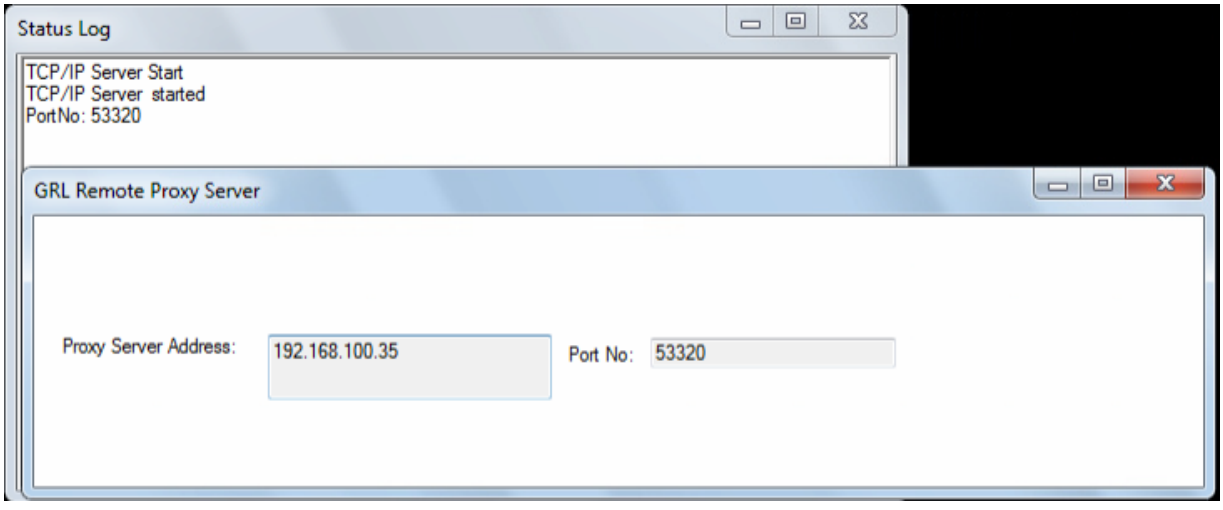


FIGURE 7. VERIFY PROXY SERVER CONNECTION FOR CONTROL PC AND SCOPE

4. On the GRL USB4 Rx Test Application, configure the “Remote File Server IP Address” and “Remote File Server Port Number” parameters on the Configurations page to match the network settings of the GRL Remote Proxy Server as shown in the example below:

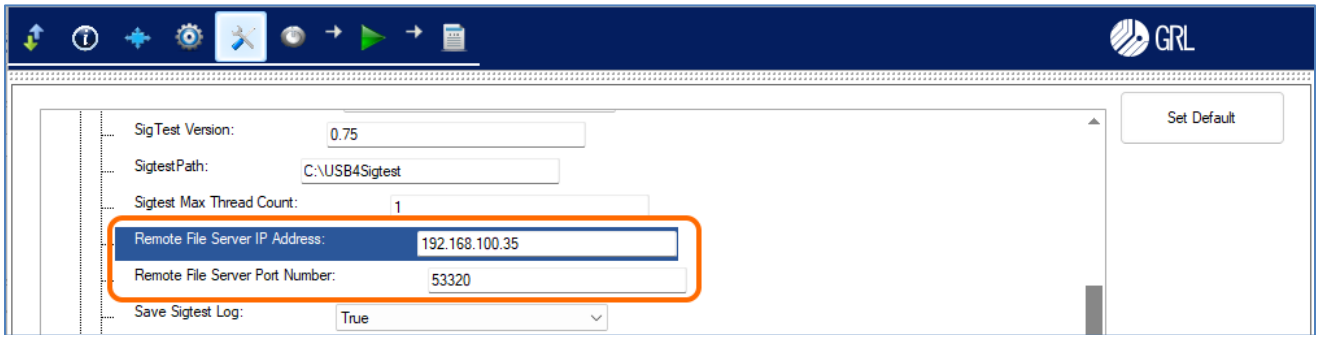


FIGURE 8. CONFIGURE GRL REMOTE PROXY SERVER NETWORK SETTINGS ON GRL SOFTWARE

Refer Section 5.4 for more details on parameters available on the Configurations page.

4 Receiver Calibration Setups

The following sections show the setup connection diagrams for the Keysight M8040A BERT calibration. The fixtures and channels used for USB4 Compliance testing are available from the USB-IF.

4.1 Connection Setup for Keysight M8040A BERT

Figure 9 shows the connection setup between each module of the Keysight M8040A BERT and the M8057B remote head.

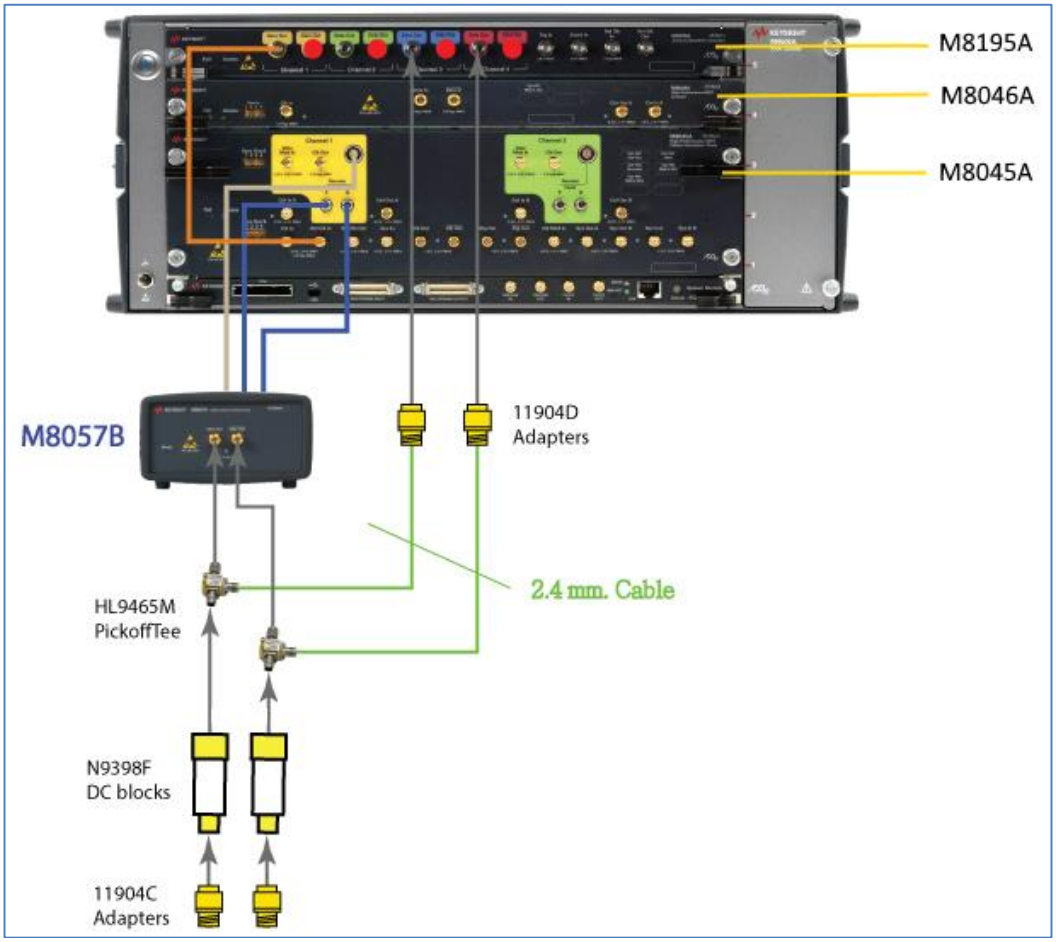


FIGURE 9. CONNECTION SETUP FOR M8040A BERT

Connection Steps:

1. Using a 2.92 mm (0.5 m) cable, connect the Channel 1 Data Out port of the M8195A Arbitrary Waveform Generator (AWG) to the Ref Clk In port of the M8045A Pattern Generator.
2. Connect a 2.92 mm cable from the M8057B remote head to the Channel 1 Remote Head connector of the M8045A Pattern Generator.
3. Connect a second 2.92 mm cable from the M8057B remote head to the Channel 1 Remote Head “P” connector of the M8045A Pattern Generator.

4. Connect a third 2.92 mm cable from the M8057B remote head to the Channel 1 Remote Head "N" connector of the M8045A Pattern Generator.
5. Connect the Channel 3 and 4 Data Out ports of the M8195A AWG directly to the 11904D adapters.
6. Using 2.4 mm cables, connect the 11904D adapters to the Pick-off jacks of the HL9465M pick-off tees.
7. Connect the Thru 2 plugs of the HL9465M pick-off tees directly to the Data Out ports of the M8057B remote head.
8. Connect the N9398F DC blocks in between the Thru 1 jacks of the HL9465M pick-off tees and the 11904C adapters.

4.2 Connection Setup for TP3' (Case 1) Calibration

Figure 10 shows the calibration setup diagram for TP3' (Test Point 3') using the Keysight M8040A BERT. TP3' (Case 1) is a physical test point for calibration without the effect of a channel.

Note: Cables connecting the signal to the Scope should be < 1m.

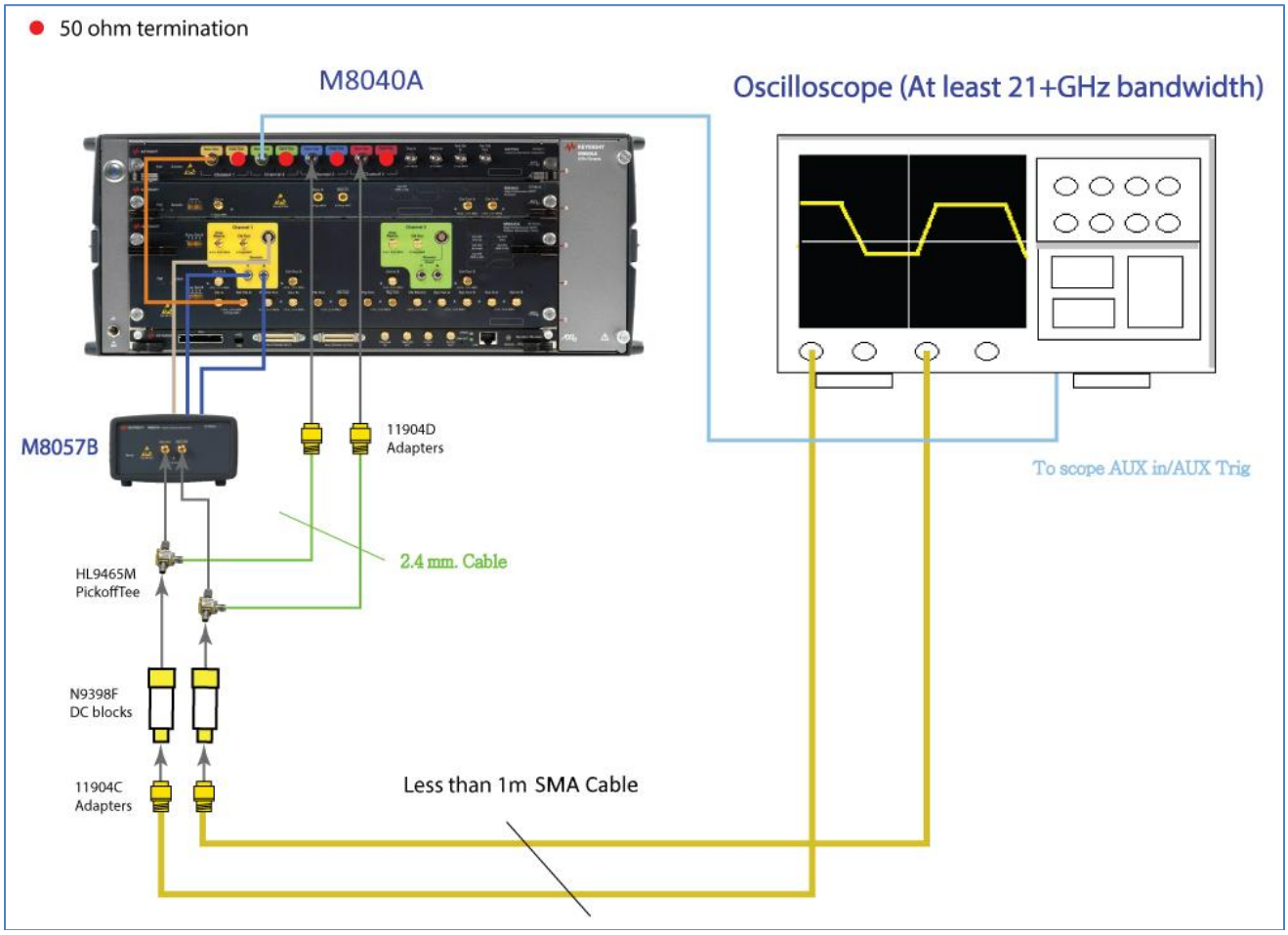


FIGURE 10. SETUP FOR TP3' (CASE 1) CALIBRATION

Connection Step:

Using the MP1900A BERT setup connections (Section 4.1), connect the 11904C adapters to Channels 1 and 3 on the scope using phase matched K-K coaxial cables. Connect the Channel 2 Data Out port of the M8195A AWG to the scope AUX IN / AUX TRIG port.

Note: Make sure to terminate all unused Data Out ports of the M8195A AWG with 50 Ω termination.

4.3 Connection Setup for TP3 (Case 2) Calibration

Figure 11 and Figure 12 show the calibration setup diagrams for TP3 (Test Point 3) using the Keysight M8040A BERT. TP3 (Case 2) is a physical test point that will affect the eye opening due to the sum of a fixed channel length (representing the fixed ISI on the transmitter side of a host or device) and a physical USB Type-C Passive Cable.

For USB4 Gen2 speed (10Gb/s) or Thunderbolt 3 compatible Gen2 speed (10.3125Gb/s), the total Insertion Loss is -17.5 ~ -18.5dB at 5GHz, which uses a 2M USB Type-C passive cable.

For USB4 Gen3 speed (20Gb/s) or Thunderbolt 3 compatible Gen3 speed (20.625Gb/s), the total Insertion Loss is -16 ~ -17dB at 10GHz, which uses a 0.8M / 1M USB Type-C passive cable.

The cable's downstream plug connector is connected to a calibration fixture to measure the signal with the scope. The scope uses software equalization to open the eye for calibration.

Note: Cables connecting the signal to the Scope should be de-embedded and ≤ 1m.

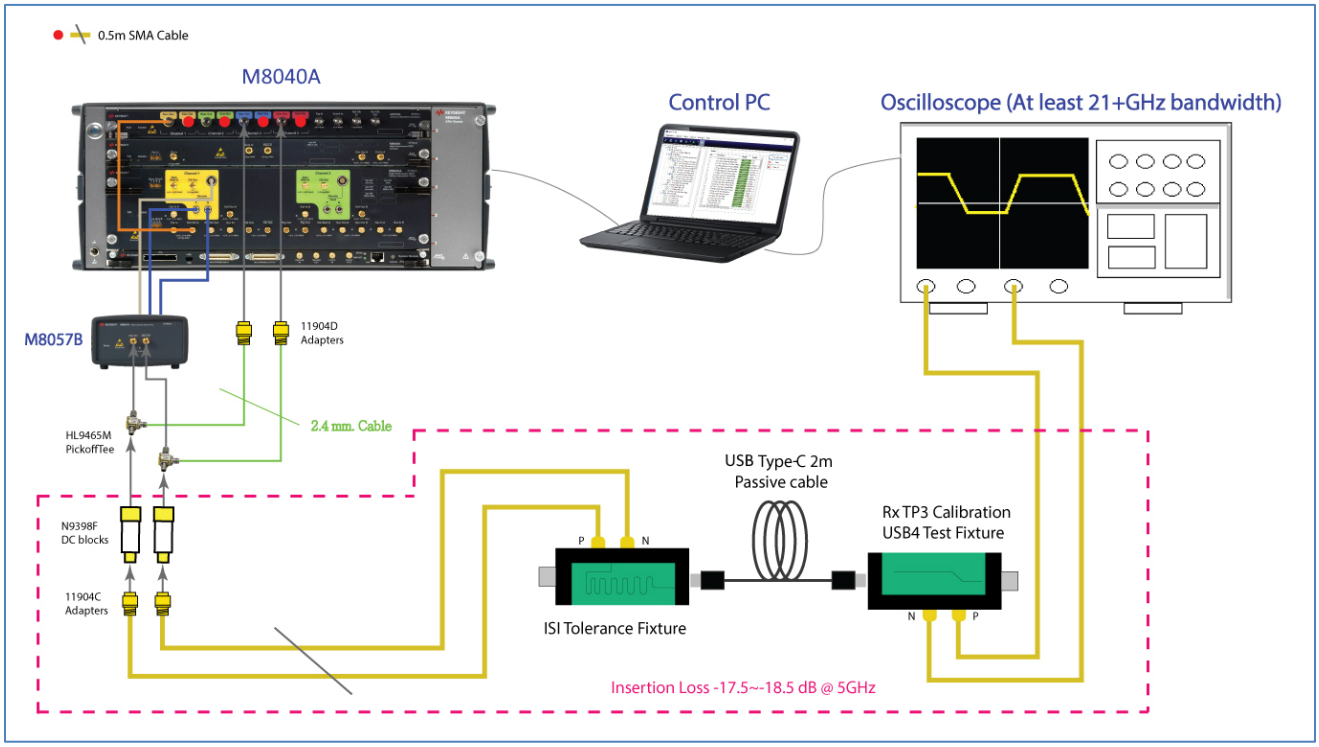


FIGURE 11. SETUP FOR TP3 (CASE 2) CALIBRATION AT 10G OR 10.3125G

Connection Steps:

1. Continuing from the M8040A BERT TP3' (Case 1) calibration setup (Section 4.1), disconnect the 11904C adapters from the scope channels.
2. Connect the 11904C adapters to the ISI tolerance fixture (for 10Gb/s or 10.3125Gb/s) and then to the calibration fixture with a 2M USB Type-C passive cable, and then to Channels 1 and 3 on the scope.

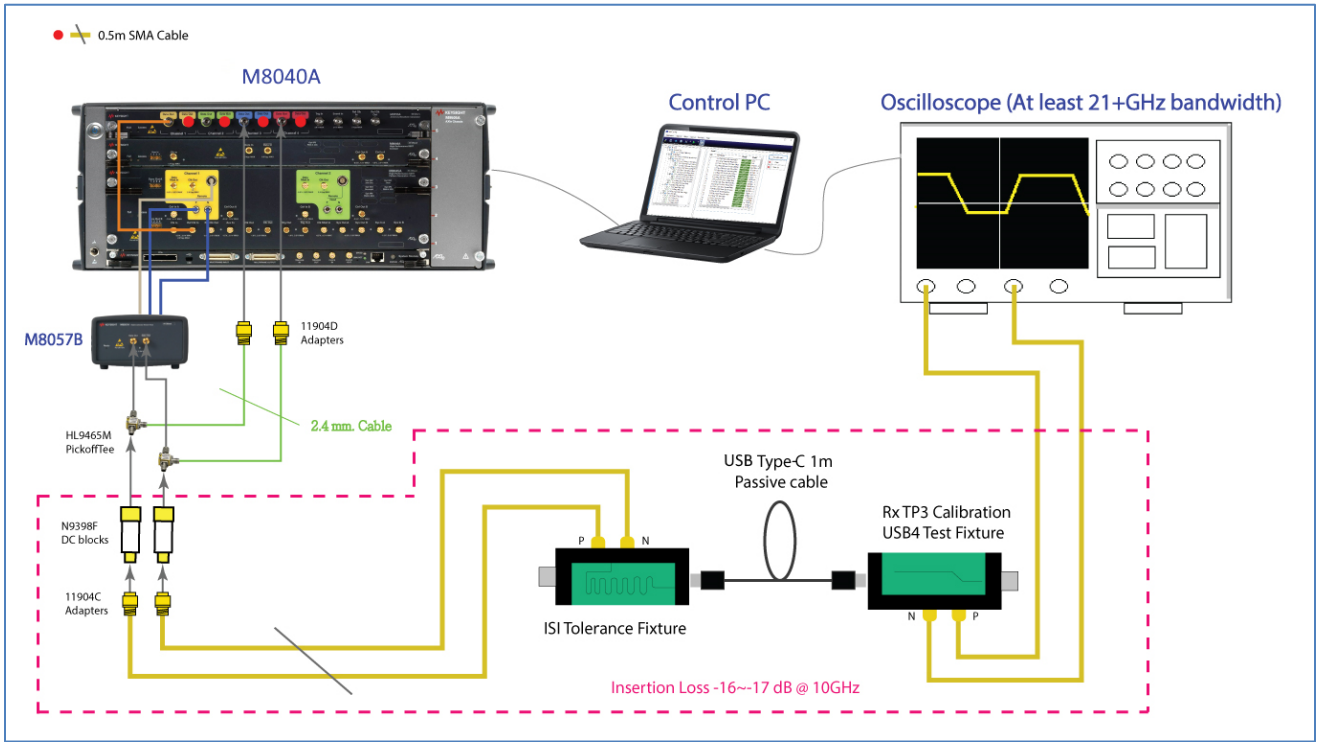


FIGURE 12. SETUP FOR TP3 (CASE 2) CALIBRATION AT 20G OR 20.625G

Connection Steps:

1. Continuing from the M8040A BERT TP3' (Case 1) calibration setup (Section 4.1), disconnect the 11904C adapters from the scope channels.
2. Connect the 11904C adapters to the ISI tolerance fixture (for 20Gb/s or 20.625Gb/s) and then to the calibration fixture with a 1M USB Type-C passive cable, and then to Channels 1 and 3 on the scope.

5 Calibrating Using GRL-USB4-RX-KS Software

5.1 Enter Calibration/Test Session Information

Select  from the software menu to access the **Session Info** page. Enter the information as required for the calibration/test session that is currently being run. The information provided will be included in the test report generated by the software once calibration/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.

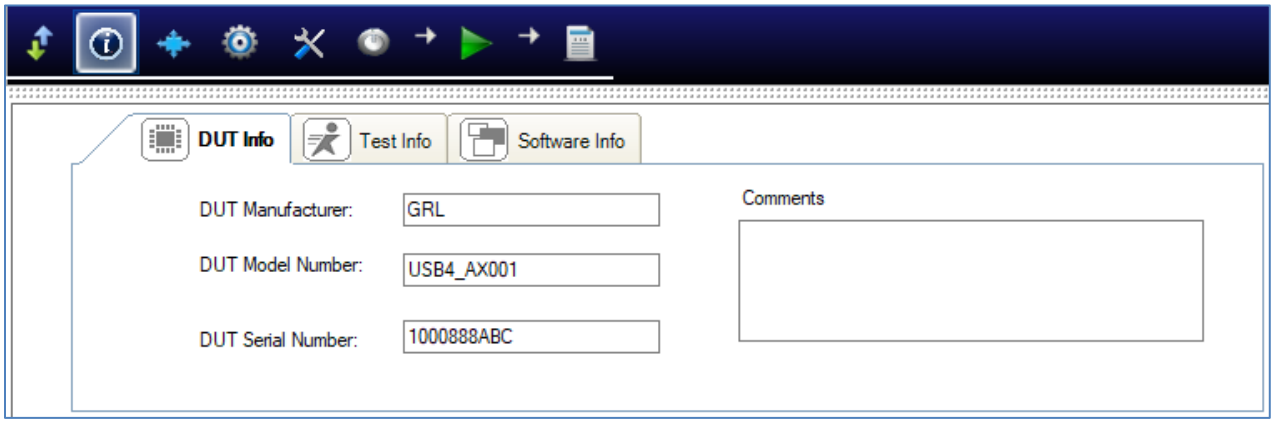


FIGURE 13. ENTER CALIBRATION/TEST SESSION INFORMATION

5.2 Set Up Conditions for Calibration/Testing

Select  from the software menu to access the Conditions page. In this section, conditions for Testing and Calibration will need to be set.

1. Select the Test Point(s). *[Note: Case 1 calibration (Total Jitter & Eye Height @ TP3') must be performed first prior to Case 2 calibration (Optimized EQ Lookup, Eye Height & Eye Width @ TP3).]*

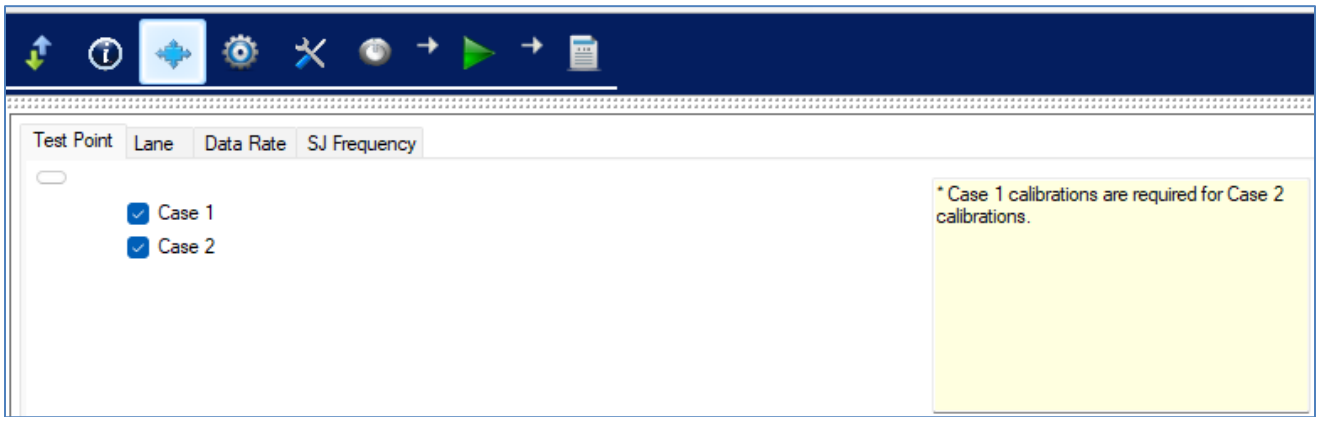


FIGURE 14. SELECT TEST POINT

2. Select the test Port(s) and Lane(s) for the DUT. *(Note: This is only applicable for DUT compliance test and NOT for calibration.)*

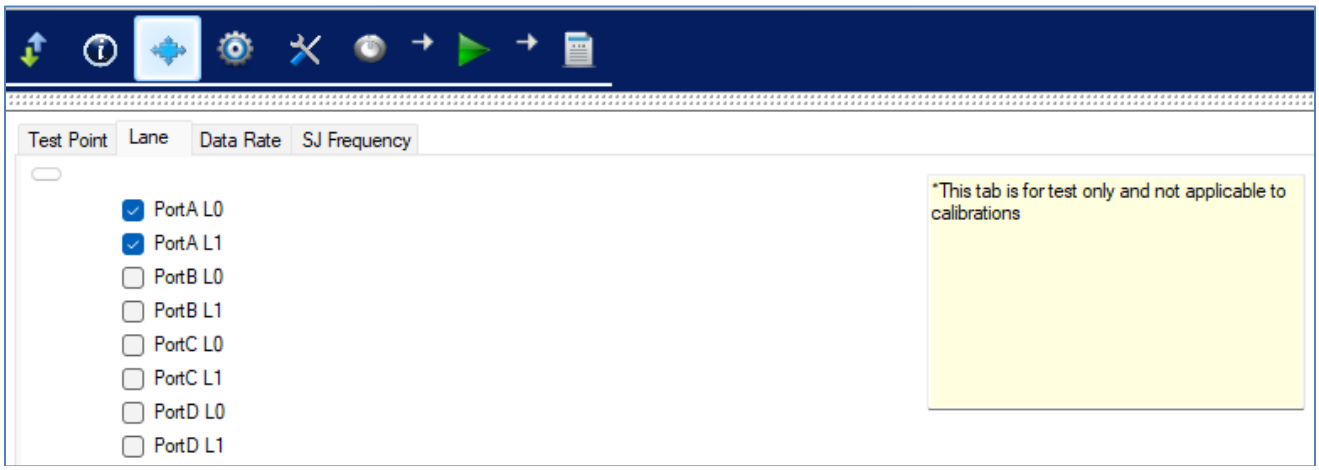


FIGURE 15. SELECT DUT PORT AND LANE UNDER TEST

3. Select the Data Rate(s) of USB4 Gen2 speed (10Gb/s), USB4 Gen3 speed (20Gb/s), Thunderbolt 3 compatible Gen2 speed (10.3125Gbps) and Thunderbolt 3 compatible Gen3 speed (20.625Gbps).

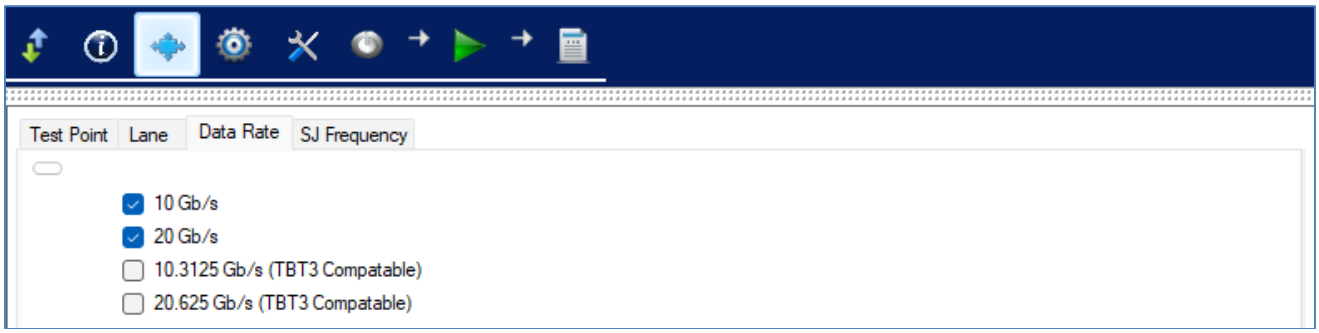


FIGURE 16. SELECT DATA RATE

4. Select the SJ Frequency.

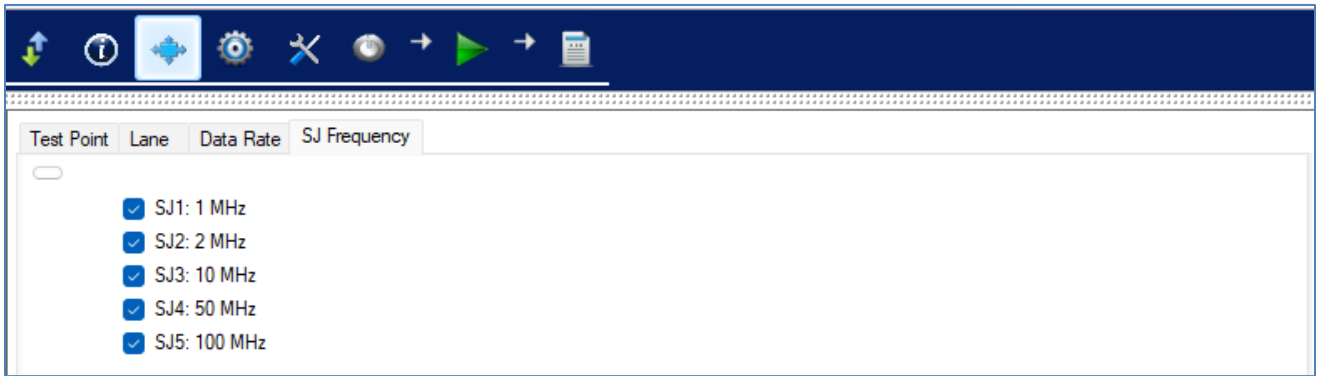


FIGURE 17. SELECT SJ FREQUENCY

5.3 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-USB4-RX-KS software automatically runs the selected calibration when initiated. See Section 5.6 on running the calibration.

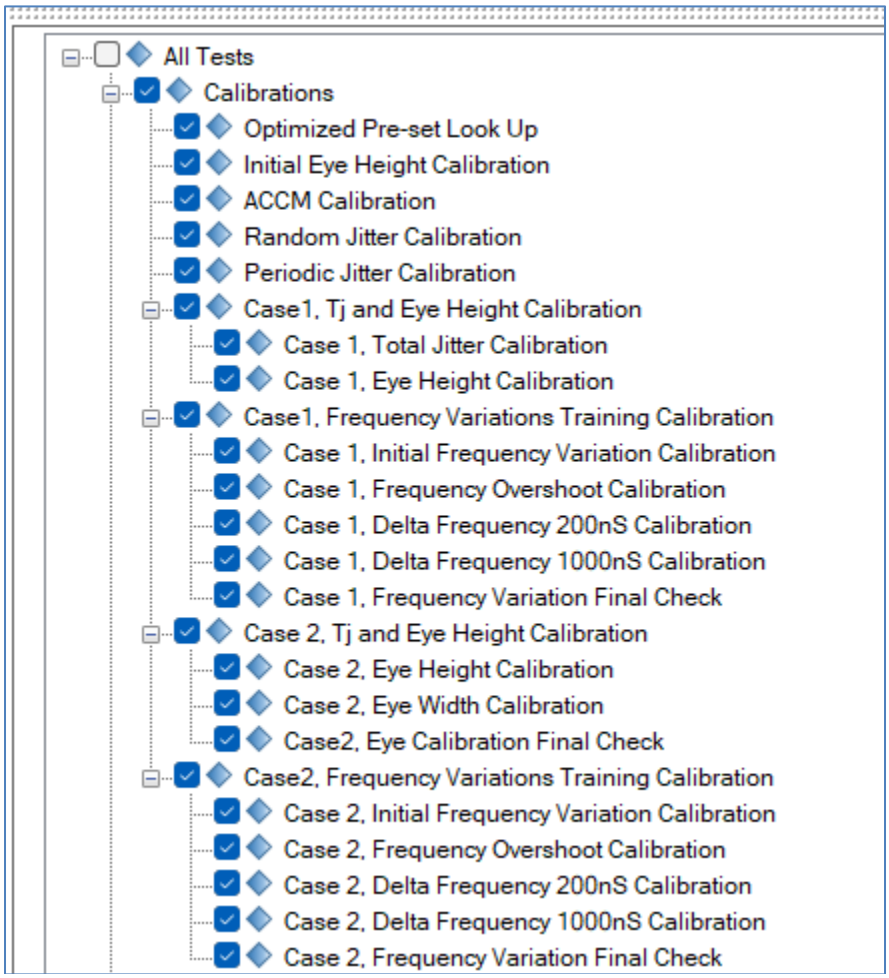


FIGURE 18. SELECT CALIBRATION

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 calibration/testing has not been run for the specific calibration/test parameter. When calibration/testing has been run and completed successfully for the specific calibration/test parameter with a Pass result, this will be indicated with ✓.

5.3.1 Calibrations Group

Select the main Calibrations checkbox to perform all USB4 Rx calibration supported by the GRL-USB4-RX-KS software.

TABLE 3. SUPPORTED CALIBRATION

Calibration	Description
Optimized Pre-set Look Up	Searches for the optimized preset out of 15 possible presets defined in the USB4 Specs. Optimized preset is defined as the preset which yields the lowest number of DDJ.
Initial Eye Height	Calibrates the initial eye height to requirement by USB4 Specs.
ACCM	Calibrates the ACCM as required by USB4 Specs.
Random Jitter	Calibrates random jitter of the BERT using the PRBS15 pattern.
Periodic Jitter	Calibrates sinusoidal jitter of all five of the frequencies as required by the USB4 Specs, and forms a linear curve fit for each SJ frequency.
Case 1, Total Jitter and Eye Height	Calibrates all total jitter and eye height for Case 1 setup at TP3'.
Case 1 & Case 2, Frequency Variations Training	Applies transmitter frequency variation and verifies that the DUT does not lose lock and record errors for Case 1 setup at TP3' and Case 2 setup at TP3 respectively.
Optimized EQ Look Up	Searches for the optimized equalization for the TP3_EQ test point. *Note: This option will only be enabled if "Other" is selected as the Calibration method from the Configurations page.*
Case 2, Eye Height and Eye Width	Calibrates eye height and eye width for Case 2 setup at TP3.

5.4 Configure Calibration/Test Parameters

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

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

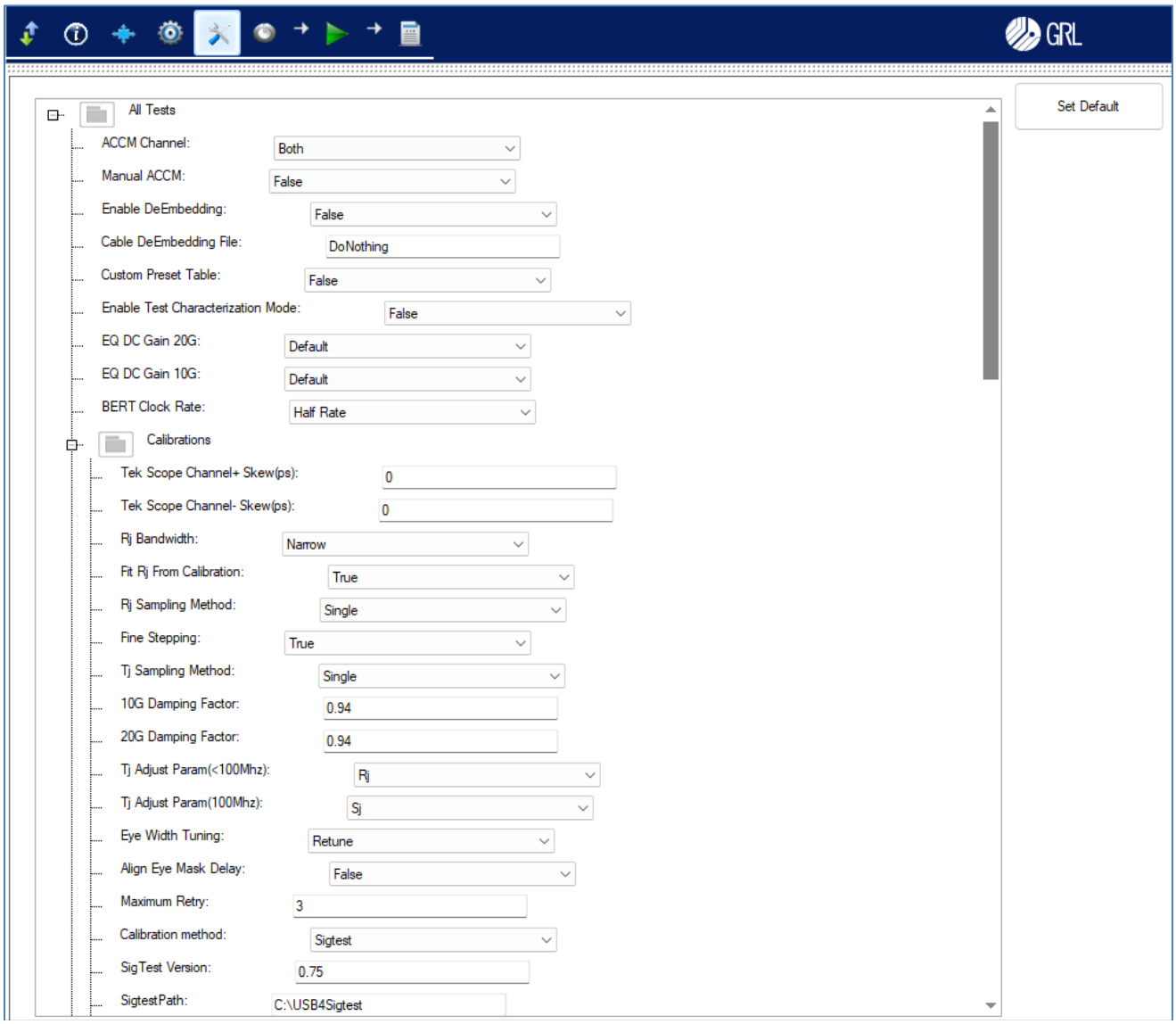


FIGURE 19. CONFIGURE CALIBRATION/TEST PARAMETERS

TABLE 4. CALIBRATION/TEST PARAMETERS DESCRIPTION

Parameter	Description
ACCM Channel	Select “Both” or single channel (splitter required) as the AC Common Mode (ACCM) source if used.
Manual ACCM	Set to “True” to manually set the ACCM source or “False” to apply calibrated values from ACCM calibration.
Enable DeEmbedding	Set to “True” to de-embed cable while calibrating.
Cable DeEmbedding File	Define the cable transfer function file. Applicable only when the “Enable DeEmbedding” field is set to “True”.

Custom Preset Table	Set to “True” to use the list of user-defined measurement preset values for calibration.
Enable Test Characterization Mode	Set to “True” to run eye diagram tests to determine worst-case margins.
EQ DC Gain (20G & 10G)	Select the DC Gain setting index for the 10G and 20G TP3_EQ systems.
BERT Clock Rate	Select the BERT clock to operate at full bit-rate or at half bit-rate for testing forward clocked devices.
Tek Scope Channel+ & Channel- Skew	If the Tektronix ATI based Scope is to be used for measurements, enter the channel skew or timing to perform alignment of the Scope channels.
Rj Bandwidth	Select to use “Narrow” or “Wide” band for jitter decomposition algorithm to separate random jitter.
Fit Rj From Calibration	Set to “True” to fit random jitter value from calibration when running total jitter calibration.
Rj Sampling Method	Select the method to be used to perform random jitter sampling.
Fine Stepping	Set to “True” to enable fine stepping for the eye mask.
Tj Sampling Method	Select the method to be used to perform total jitter sampling.
10G & 20G Damping Factor	Define the 10G and 20G damping factor rates to use for calibration.
Tj Adjust Param	Select whether to use “Rj” or “Sj” for total jitter calibration for both <100 MHz and 100 MHz cases.
Eye Width Tuning	Select “Retune” to repeat the tuning cycle or “Retry” the current tuning procedure when measuring eye width.
Align Eye Mask Delay	Set to “True” to perform alignment for the delay in between validating the eye mask.
Maximum Retry	Enter the number of times to repeat calibration for pass/fail condition.
Calibration Method	Select the method to be used to perform post processing waveform analysis for Rx stressed eye calibration. The SigTest signal quality test method will be used by default or select “Other” to use other supported vendor specific method (Keysight, Tektronix or Teledyne LeCroy Scope measurement tools). *Note: The vendor specific method option will eventually be obsolete and replaced with SigTest instead.* *Note: Selecting “Other” will enable the “Optimized EQ Look Up” calibration option under the Case 2, TJ and Eye Height Calibration group. See Table 3. Supported Calibration.* SigTest allows waveforms captured with the oscilloscope to be analyzed and checked against the specified pass/fail criteria. *Refer to Appendix of this document for additional information on SigTest requirements.*

SigTest Version	Enter the Version number of the SigTest signal quality test to be run during calibration to ensure waveform compliance. Make sure that the SigTest application is already installed in the test controller system.
SigTest Path	Enter the full path of the SigTest location in the test controller system.
SigTest Max Thread Count	Set the maximum process threads to generate for checking the Rx device functionality when running SigTest.
Remote File Server IP Address	Enter the IP address for the GRL Remote Proxy Server. See Section 3.1.3 on how to set up the remote file server.
Remote File Server Port Number	Enter the Port number for the GRL Remote Proxy Server. See Section 3.1.3 on how to set up the remote file server.
Save SigTest Log	"True" is usually the case. Set to "False" if you do not want to save the SigTest results to a file.
Prompt if Final Eye Result Not Match	"True" is usually the case. Set to "False" if you do not want to be notified by the GRL software if the final eye does not meet compliance for the TJ and Eye Height calibration.
Perform Link Training	Select the option to always run, run for one time only or disable link training for Rx test.
BER Automation	Select the method to be used to run Rx BER tests.
Save BERT Setup Only	"False" is usually the case. Set to "True" if you are sure that you only want to save the BERT test setup in the Rx test.
Prompt Before Link Training	"False" is usually the case. Set to "True" if you want to be prompted prior to start running link training. Ensure that the "Always" or "Once" run option is selected in the "Perform Link Training" field.
Link Training Prompt/Reset Frequency	Select the option to allow prompt for link training or frequency reset to occur all the time or just once.
Skip DUT Reset	"False" is usually the case. Set to "True" if you want to reset the DUT when performing tests.
Script Version	Select the version of the TenLira test script ("ver 0.8.3" or above) or the ETT test script ["ETT(v0.9.4)", "ETT(v0.9.5)" or "ETT(v1.1.2)"] to be used.
DUT Platform	Select the platform/processor as supported by the DUT for running test scripts.
DUT with Re-timer	If the **ETT** test script is selected in the "Script Version" field, set to "True" if the DUT has additional re-timer.
ETT Test Port Mapping	If the **ETT** test script is selected in the "Script Version" field, specify the test connector lanes to validate the port mapping of the DUT connectors.
TxFFE Swap Detection	If re-timers are present, select the option to detect or force swap during USB4 Link TxFFE handshake.

Set Swap Lane with ETT	If the **ETT** test script is selected in the "Script Version" field, select the router and/or re-timer setup to perform lane switching for the DUT.
Test Lane 1 as Lane0	"False" is usually the case. Set to "True" to enable Lane 1 to be tested as Lane 0.
Preset Negotiation Interval(s)	Set the time interval in seconds between preset negotiations.
Ridge	If the **Tenlira** test script is selected in the "Script Version" field, select the number of ports to be tested for the ridge DUT.
DUT Chipset (When Using Tenlira Only)	If the **Tenlira** test script is selected in the "Script Version" field, select the Titan Ridge "TR" or Alpine Ridge "AR" processor as supported by the DUT.
Remote/Local Working Directory	Set the working directory to the path where the test script is installed in the host PC.
Remote IP Address	Enter the IP address of the remote host of the test script.
Remote Port Number	Enter the port number of the remote host of the test script.
Remote Script	Enter the name of the remote test script.
Remote Script Arguments	Set the arguments for executing the remote test script.
Run Post Test Script	Select the option to run the remote test script in the post-test stage.
Post Test Remote Script	Enter the name of the remote test script for post-test.
Post Test Remote Script Directory	Set the working directory to the path where the post-test script is installed in the host PC.
Short Test Link Training Cycle	Define the number of times to perform link training for short BER loopback.
Maximum Error	Define the maximum error count for error checking during Rx test.
Prompt When BER Overflow	"False" is usually the case. Set to "True" if you want to be prompted if there is buffer overflow during BER testing.
Case 1 Preset Mapping	Select "Active" or "Passive" mapping for presets for Case 1 setup at TP3'.
Load User Calibration Data	"False" is usually the case. Set to "True" if you want to recall and use a saved calibrated setup in the Rx test.
Run ETT with Semaphore	"True" is usually the case. Set to "False" if you do not want to use a semaphore file to run the USB4 ETT.
10G & 20G Compliance Test Duration	Set how long it would take (in seconds) to test the DUT for 10G or 20G compliance.
Check Test Lane Before Test	"True" is usually the case. Set to "False" if you do not want to check if the test lane is proper prior to running tests.
Skip Second Trial BER Test	"False" is usually the case. Set to "True" if you want to bypass the second

	trial attempt for BER testing.
Frequency Variation Test Trials	Set the number of times to run the Rx signal frequency variations training test for each DUT lane.
Frequency Variation Test with SSC Profile	"True" is usually the case. Set to "False" if SSC is not supported by the DUT when running the Rx signal frequency variations training test.
Use Calibrated SSC Profile	"True" is usually the case. Set to "False" if you do not want to use a saved calibrated SSC profile setup when running the Rx signal frequency variations training test.
Margin Step Size (%)	Set the step size for stepping through SJ or amplitude margins when running the optional margin search tests.
Maximum Margin Test Error	Define the maximum error count for error checking during margin search tests.
Maximum Steps	Define the maximum number of steps to step through margins.
10G & 20G Margin Test Duration(s)	Set how long it would take (in seconds) to run full margin search tests for the 10G and 20G data rates.
Short Margin Test Duration	Set the duration in seconds to run a brief margin search test.
Quick Margin Search Scan	Set to "True" to perform a quick scan for worst-case margins during margin search tests.
Margin Limit Line	Select the option to use a limit based on calibrated or specification values for margin search tests.
Final Eye Preset	Select the option to use a preset from calibration or link training for final eye measurements.
CTLE DC Gain	Select the DC Gain value to be used based on the CTLE model to measure eye heights for TP3_EQ tests.
10G & 20G User Defined CTLE Gain	If "User Defined" is selected in the "TP3 CTLE DC Gain" field, select the optimized CTLE Gain setting index for the 10G and 20G TP3_EQ systems.
Enable LRD Cable Test	"False" is usually the case. Set to "True" if you want to enable testing for the Linear Re-Driver Active Cable (LRD).
Test Flow	Select the post-processing method for the LRD cable test either to capture and process live waveforms, capture live waveforms only or process captured waveforms in offline mode.

5.5 Configure Calibration Target Values

Select  in the main software menu to access the Calibration Target page. User may change the calibration target value for any of the calibration items. By default, the target values are those defined in the specification. Change the values only when debugging.

To change the values, un-select the Use Default Value checkbox. Also at any point in time if the default values are required, just select the checkbox and the default values will replace all the current values.

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.

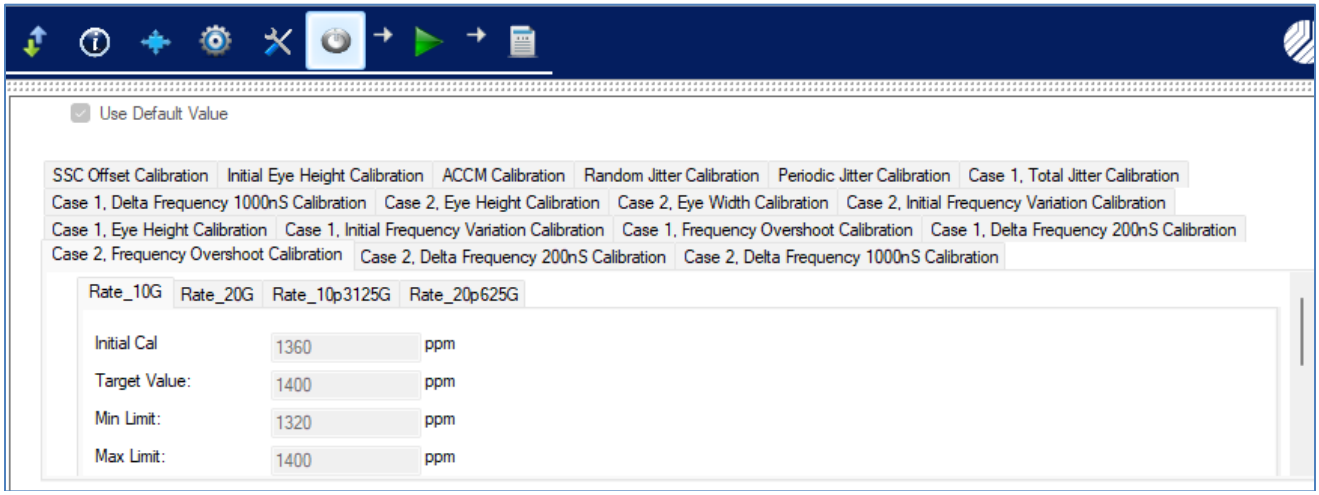


FIGURE 20. OVERWRITE EXISTING CALIBRATION TARGETS

5.6 Run Calibration

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

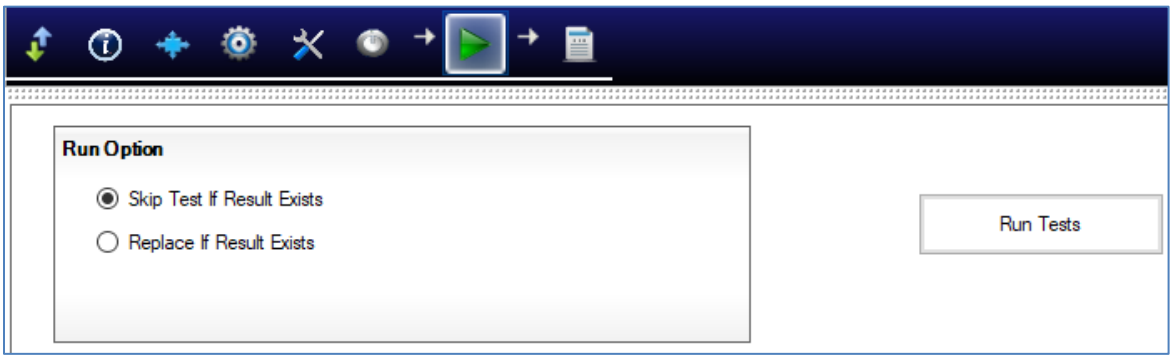


FIGURE 21. RUN CALIBRATION

Select the Run Option before clicking the “Run Tests” button to start 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.

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. See Section 7.2, Delete Test Results for details.

6 Compliance Testing Using GRL-USB4-RX-KS Software

After calibration has completed successfully, receiver BER (Bit Error Rate) compliance and optional margin testing can then be performed on the device under test (DUT). The GRL-USB4-RX-KS software automates the Gen2 & 3 receiver compliance testing for BER tolerance, at the spec-defined or user-defined jitter frequency steps. The receiver will also undergo signal frequency variations during Link training for the Case 2 setup, before obtaining steady state.

If desired, optional receiver margin testing can be additionally performed via the GRL-USB4-RX-KS software to search for SJ and amplitude margins.

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

6.1 Connection Setups for BER Testing

This section describes the test setups for the host/device DUT using the USB4 microcontroller and M8040A BERT. Test scripts as listed in Section 2.2 are required to run the automation tests. Also refer to Section 3.1.1 or Appendix F for options on how to configure the test setup.

6.1.1 BER Test Setup for TP3' (Using USB4 Microcontroller Method)

Figure 22 shows the USB4 host/device DUT test setup diagram for TP3' (Test Point 3', Case 1) using the USB4 microcontroller method and the M8040A BERT. The calibrated stressed signal is attached to the test fixture and crosstalk is added to the fixture from the DUT which generates crosstalk signals. The microcontroller is used to directly control the DUT by executing microcontroller test scripts.

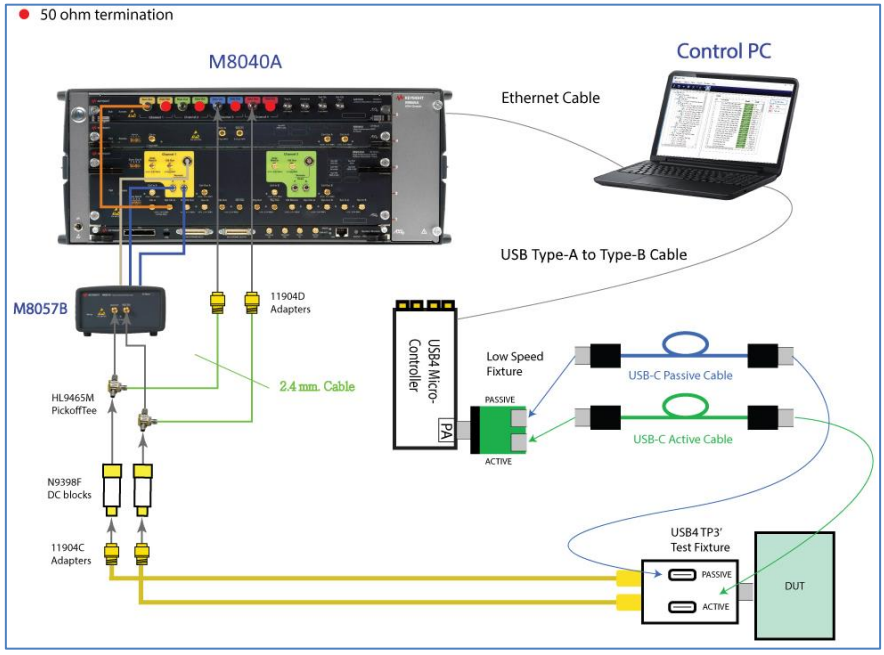


FIGURE 22. RX BER TEST SETUP AT TP3' (USING USB4 MICROCONTROLLER)

Connection Steps:

1. Attach the USB Type-C connector of the test fixture to the DUT receptacle.
2. Using the M8040A BERT TP3' (Case 1) calibration setup (Section 4.2), disconnect the 11904C adapters from the scope channels.
3. Connect the 11904C adapters to the test fixture.
4. Connect the control PC to the M8040A BERT using an Ethernet cable.
5. Connect the USB4 microcontroller to power supply and to the control PC.
6. Attach a low speed fixture to the microcontroller and then connect the USB Type-C passive and active cables between the low speed fixture and test fixture.
7. Run the microcontroller test scripts to control the DUT.

6.1.2 BER Test Setup for TP3 (Using USB4 Microcontroller Method)

Figure 23 shows the USB4 host/device DUT test setup diagram for TP3 (Test Point 3, Case 2) at 10G using the USB4 microcontroller method and the M8040A BERT. The USB Type-C cable is disconnected from the calibration fixture and connected to the host/device DUT's USB Type-C receptacle connector. The microcontroller is used to directly control the host/device DUT by executing microcontroller test scripts.

For USB4 Gen2 speed (10Gb/s) or Thunderbolt 3 compatible Gen2 speed (10.3125Gb/s), the setup uses a 2M USB Type-C passive cable.

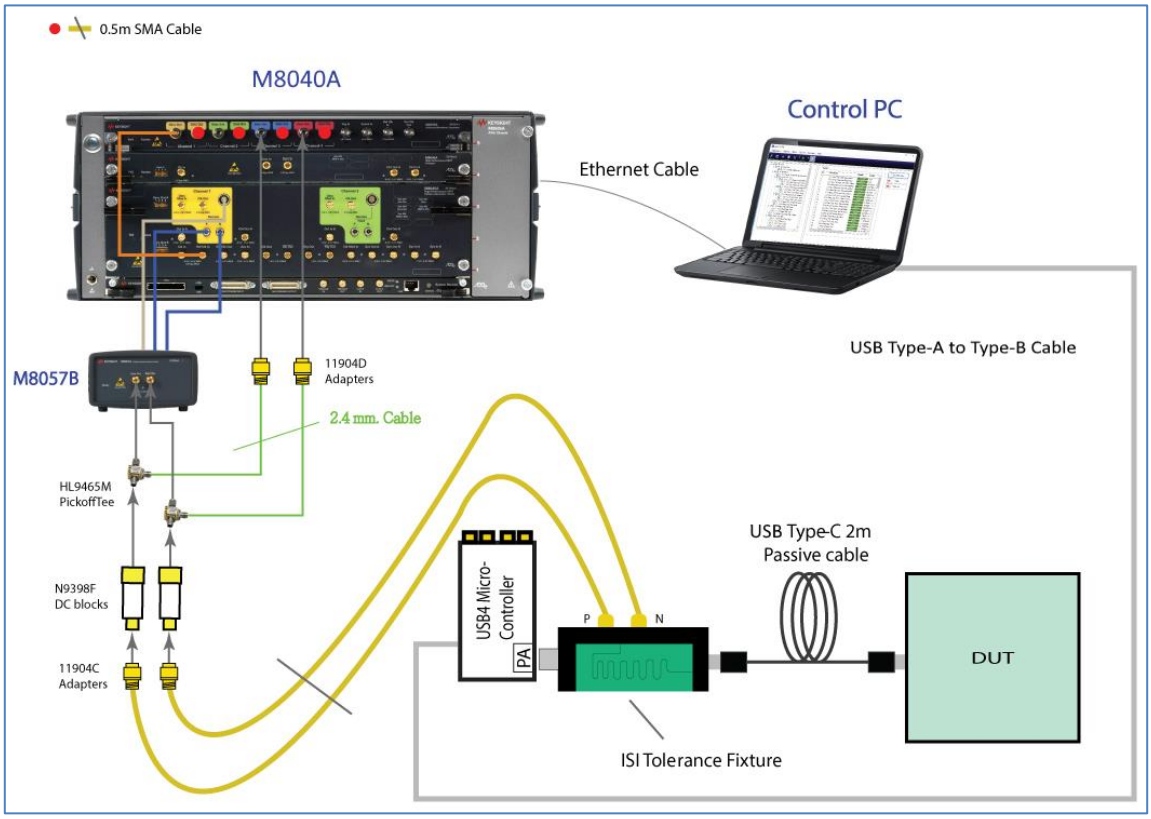


FIGURE 23. SETUP FOR TP3 RX BER TEST AT 10G OR 10.3125G (USING USB4 MICROCONTROLLER)

Connection Steps:

1. Using the M8040A BERT TP3 (Case 2) calibration setup (Section 4.3), disconnect the calibration fixture that connects to the scope.
2. Attach the 2M USB Type-C passive cable to the DUT receptacle.
3. Connect the USB4 microcontroller to power supply and to the control PC.
4. Attach the microcontroller to the ISI tolerance fixture.
5. Run the microcontroller test scripts to control the DUT.

Figure 24 shows the USB4 host/device DUT test setup diagram for TP3 (Test Point 3, Case 2) at 20G using the USB4 microcontroller method and the M8040A BERT. The USB Type-C cable is disconnected from the calibration fixture and connected to the host/device DUT's USB Type-C receptacle connector. The microcontroller is used to directly control the host/device DUT by executing microcontroller test scripts.

For USB4 Gen3 speed (20Gb/s) or Thunderbolt 3 compatible Gen3 speed (20.625Gb/s), the setup uses a 1M USB Type-C passive cable.

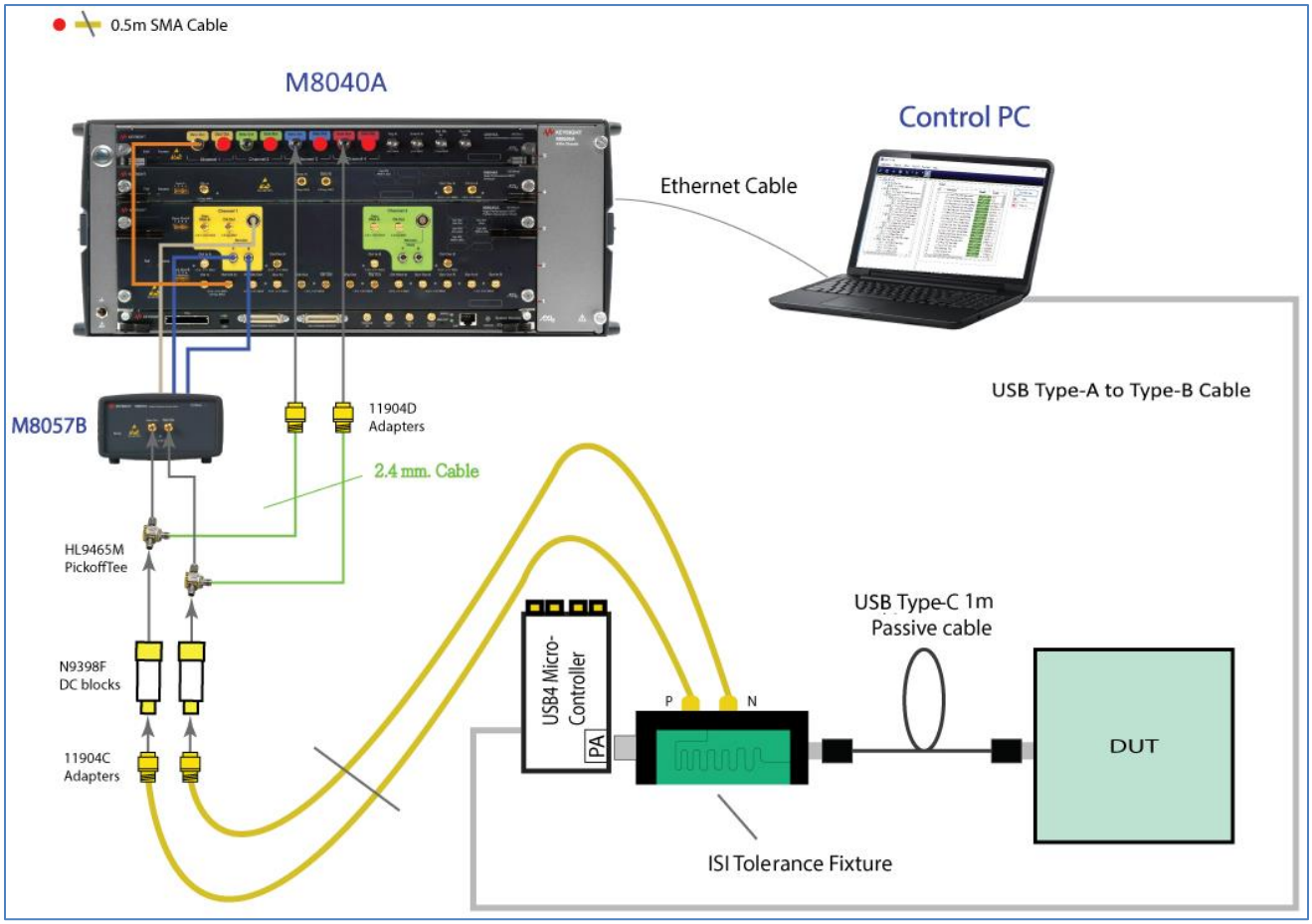


FIGURE 24. SETUP FOR TP3 RX BER TEST AT 20G OR 20.625G (USING USB4 MICROCONTROLLER)

Connection Steps:

1. Using the MP8040A BERT TP3 (Case 2) calibration setup (Section 4.3), disconnect the calibration fixture that connects to the scope.
2. Attach the 1M USB Type-C passive cable to the DUT receptacle.
3. Connect the USB4 microcontroller to power supply and to the control PC.
4. Attach the microcontroller to the ISI tolerance fixture.
5. Run the microcontroller test scripts to control the DUT.

6.2 Select Test Mode

Select  from the software menu to access the Setup Configuration page.

Select the checkbox to run tests in compliance mode for the DUT in order to meet USB4 CTS compliance.

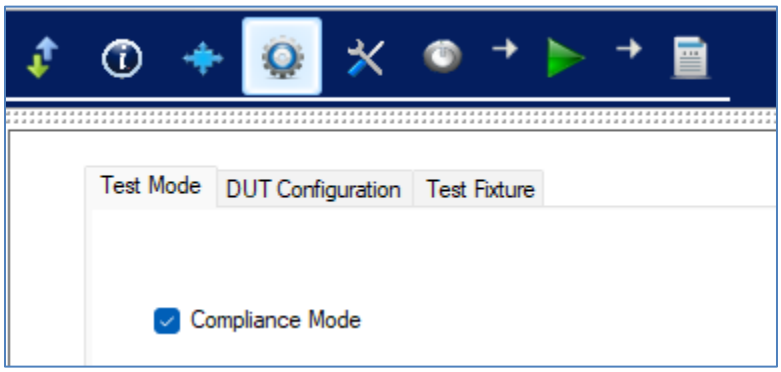


FIGURE 25. SELECT TEST MODE

6.3 Select DUT Type

Select  from the software menu to access the Setup Configuration page.

Select either a USB4 Host or Device to be tested.

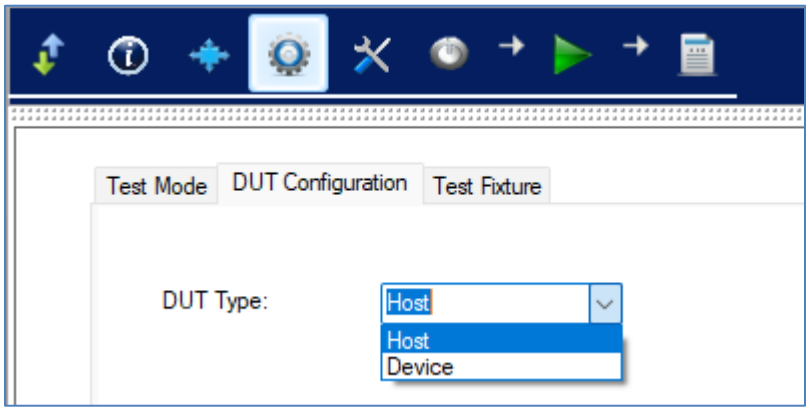


FIGURE 26. SELECT DUT TYPE

6.4 Select Test Fixture Type

Select  from the software menu to access the Setup Configuration page.

Select either a SMP or SMA test fixture to be used for testing.

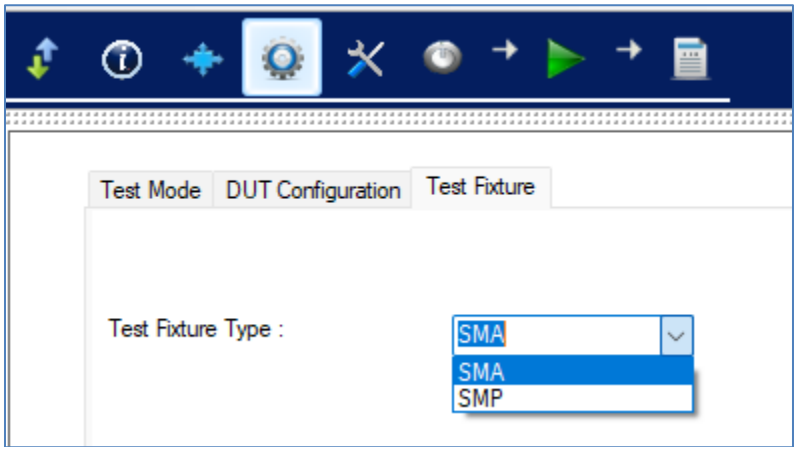


FIGURE 27. SELECT TEST FIXTURE TYPE

6.5 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.

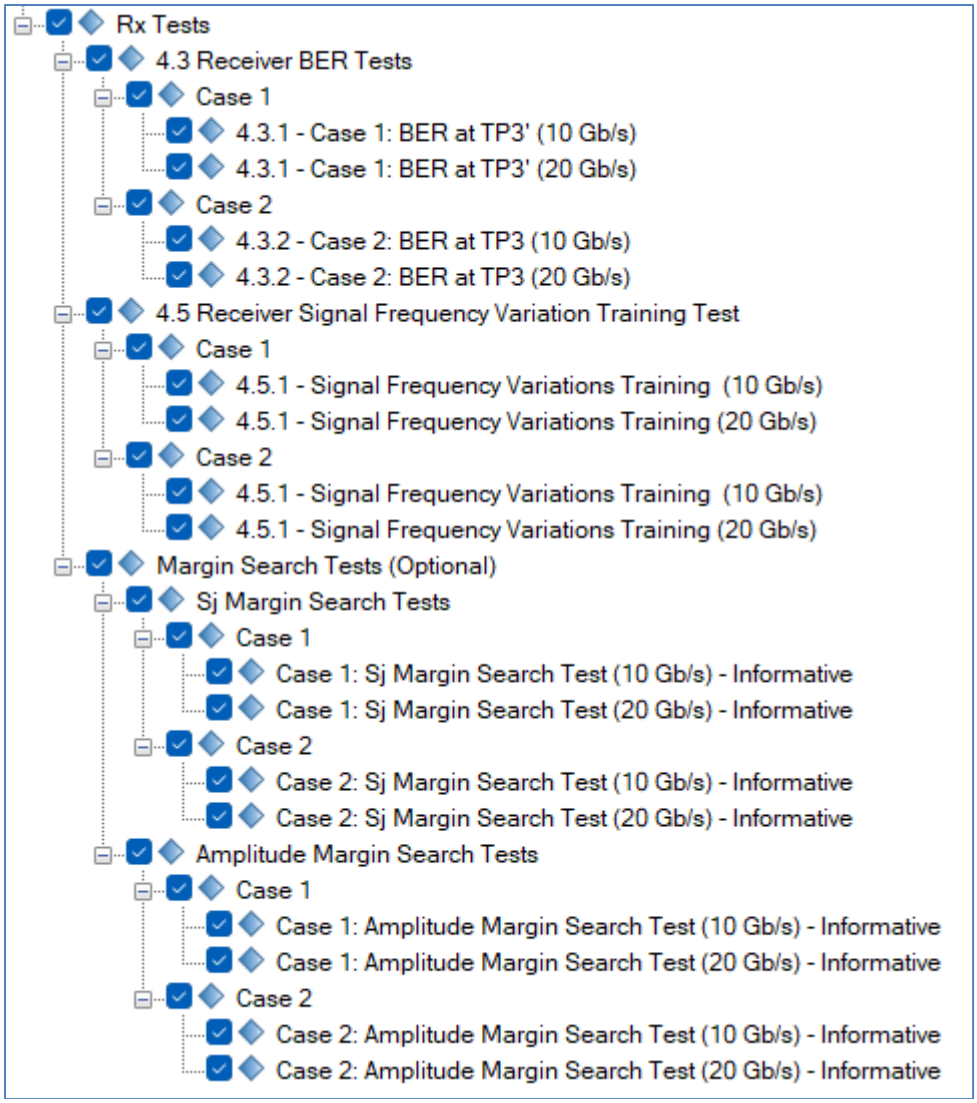


FIGURE 28. SELECT DUT RX TESTS TO BE RUN

6.5.1 Receiver Test Group

Select the main Rx Tests checkbox to perform all USB4 Rx tests for the DUT supported by the GRL software with parameters from the calibration steps.

TABLE 5. SUPPORTED RX TESTS

Rx Test	Description

Receiver BER Tests	Runs all BER compliance tests as required by the USB4 Specs.
Receiver Signal Frequency Variation Training Tests	Applies transmitter frequency variations during link training before obtaining steady state.
Sj Margin Search Tests	Runs Optional tests to search for SJ Margin (for information purpose only)
Amplitude Margin Search Tests	Runs Optional tests to search for Amplitude Margin (for information purpose only)

6.6 Set Up USB4 Microcontroller Environment

Select  from the software menu to access the Configurations page.

The fields for setting up the USB4 microcontroller environment are as shown below:

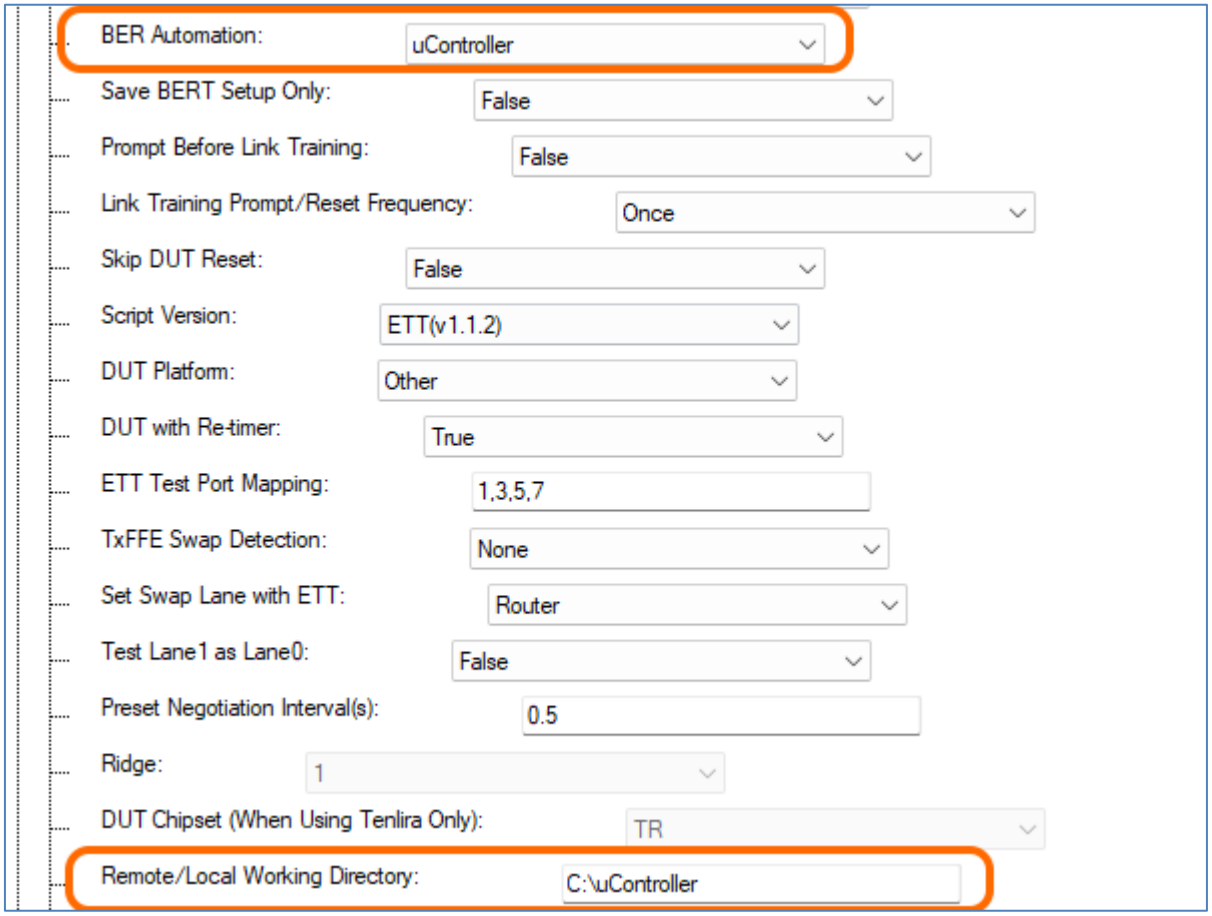


FIGURE 29. SETUP FOR USB4 MICROCONTROLLER ENVIRONMENT

To set up the software to call the microcontroller script from a control PC:

1. Set the **BER Automation** field to “uController”.

2. Set the **Remote/Local Working Directory** field to the path where the microcontroller script is installed in the control PC.

6.7 Set Up Intel's TenLira Environment

Select  from the software menu to access the Configurations page.

The fields for setting up the TenLira environment are as shown below:

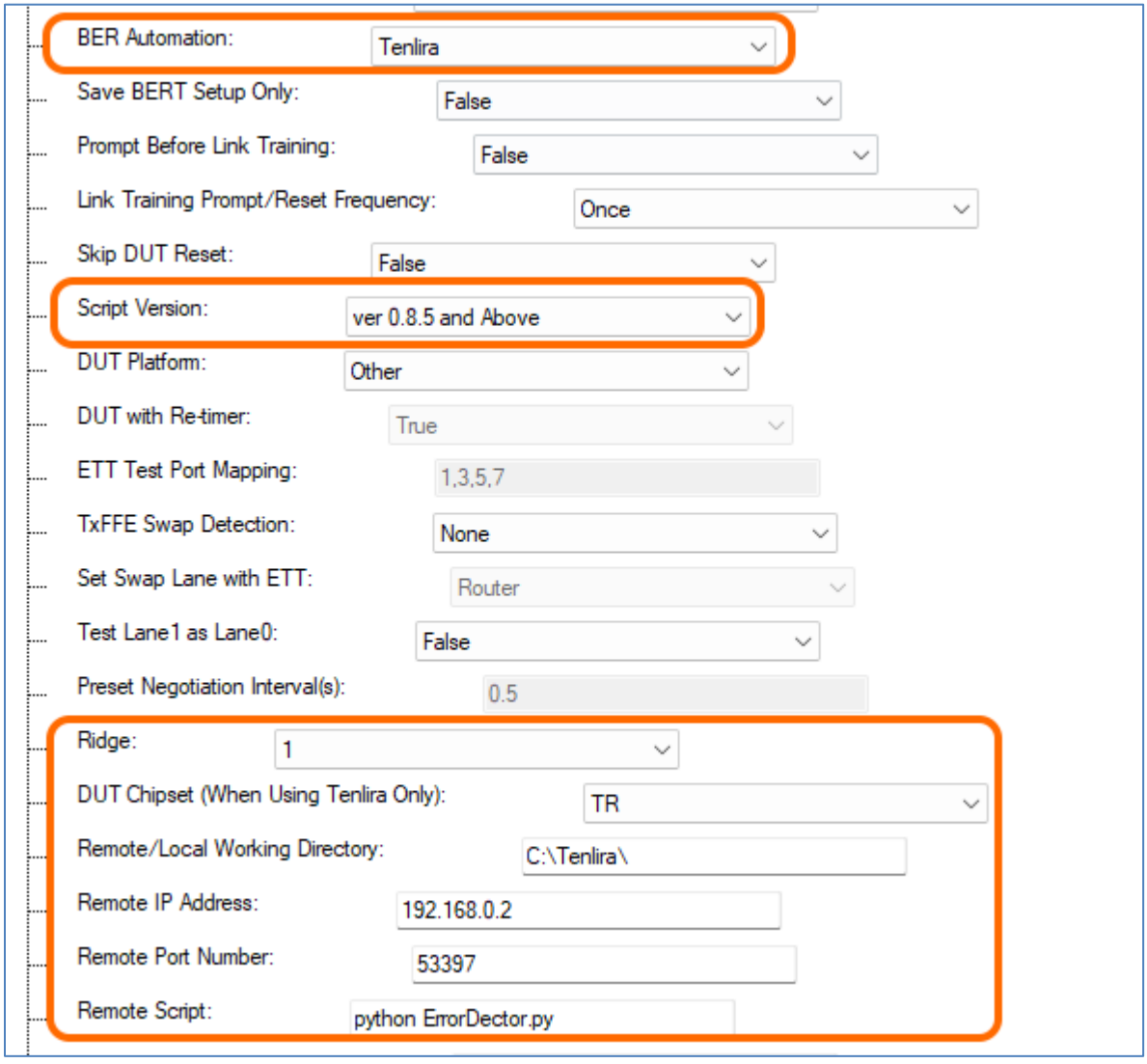


FIGURE 30. SETUP FOR TENLIRA ENVIRONMENT

To set up the software to call the TenLira script from a remote host:

1. Set the **BER Automation** field to "Tenlira".
2. Select the **TenLira Script Version** to be used.

3. Select the number of ports for the **Ridge** DUT.
4. Select the supported **DUT Chipset**.
5. Set the **Remote/Local Working Directory** field to the path where the TenLira script is installed in the host PC.
6. Provide the **Remote IP Address** and **Remote Port Number** of the remote host.
7. Enter the name of the **Remote Script** to be used.

6.8 Set Up USB4 ETT Environment

Select  from the software menu to access the Configurations page.

The fields for setting up the ETT environment are as shown below:

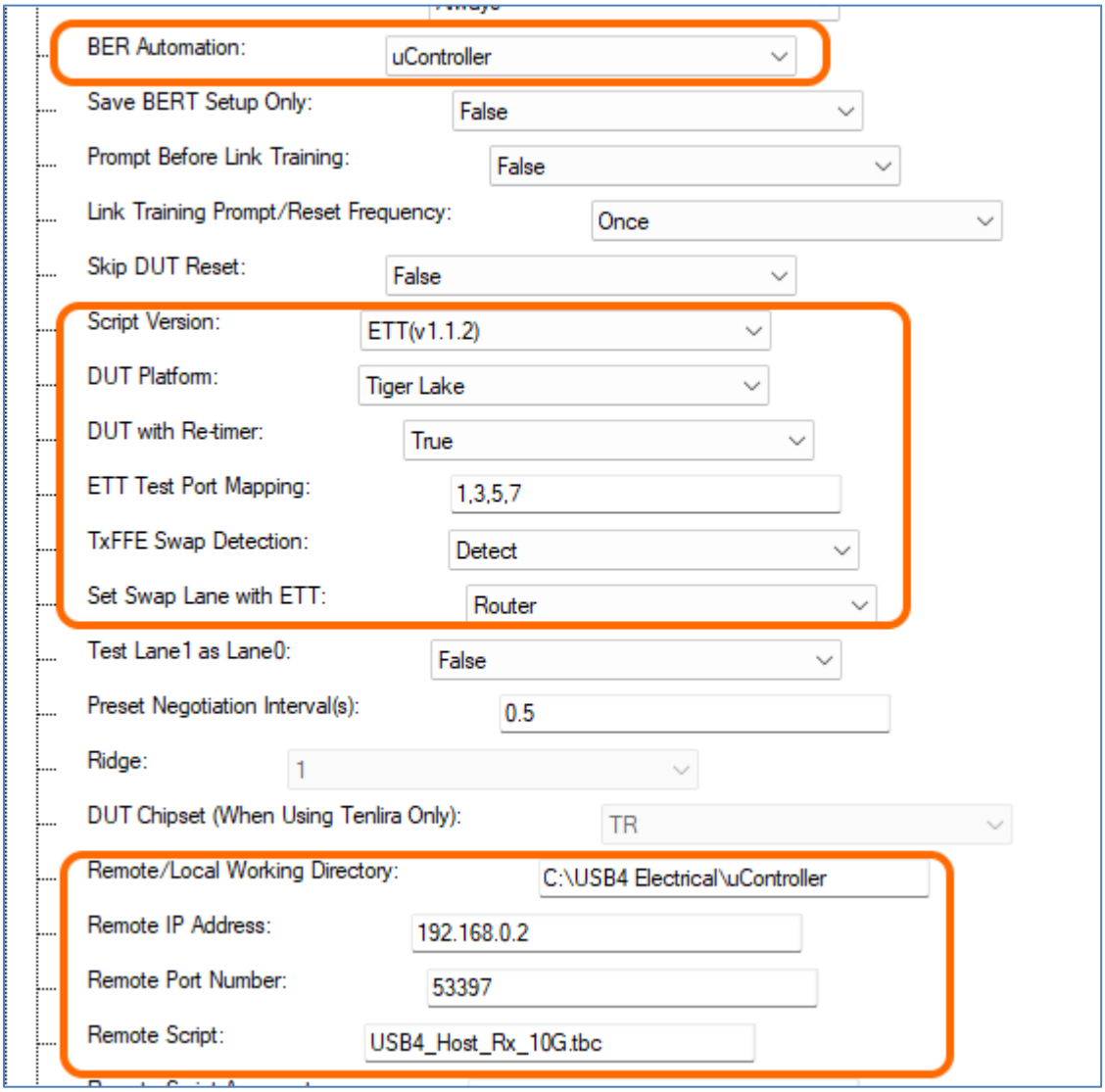


FIGURE 31. SETUP FOR ETT ENVIRONMENT

To set up the software to call the ETT script from a remote host:

1. Set the **BER Automation** field to “uController”.
2. Select the **ETT Script Version** to be used.
3. Select the **DUT Platform** as supported by the DUT.
4. Select “True” to use the **DUT with Re-timer**.
5. Specify the test connector lanes of the DUT to validate for **ETT Test Port Mapping**.
6. If re-timers are present, select the option for **TxFFE Swap Detection** to detect or force swap during USB4 Link TxFFE handshake.

7. To perform lane switching for the DUT, select the router and/or re-timer setup in the **Set Swap Lane with ETT** field.
8. Set the **Remote/Local Working Directory** field to the path where the ETT script is installed in the host PC.
9. Provide the **Remote IP Address** and **Remote Port Number** of the remote host.
10. Enter the name of the **Remote Script** to be used.

6.9 Run DUT Rx Tests

Select  from the 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 5.6; refer for more details.)*

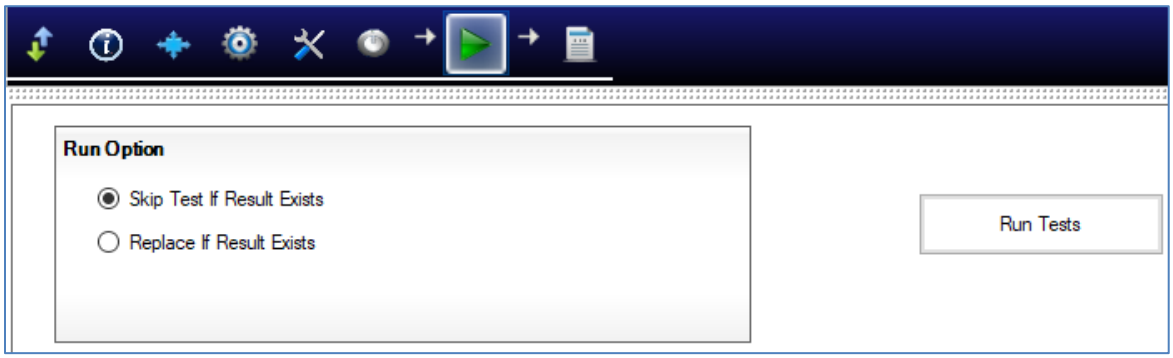


FIGURE 32. RUN TESTS

7 Test Results and Reports Using GRL-USB4-RX-KS 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.

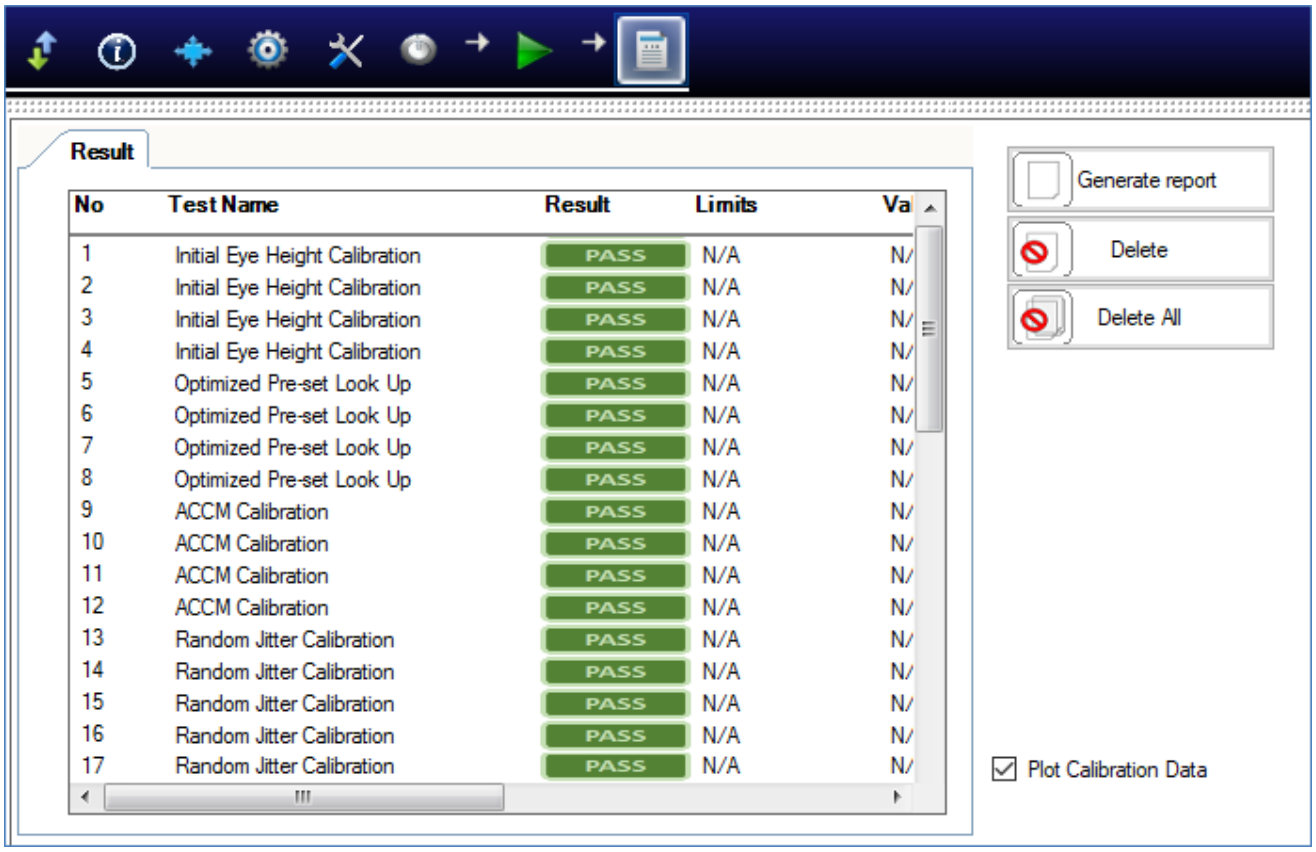
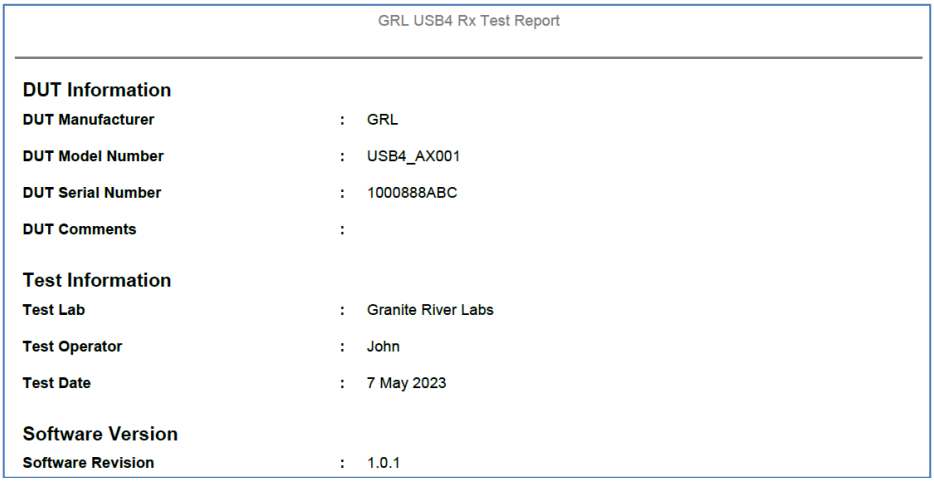


FIGURE 33. REPORT RESULTS PAGE

7.1.1 DUT Information

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


GRL USB4 Rx Test Report

DUT Information

DUT Manufacturer	:	GRL
DUT Model Number	:	USB4_AX001
DUT Serial Number	:	1000888ABC
DUT Comments	:	

Test Information

Test Lab	:	Granite River Labs
Test Operator	:	John
Test Date	:	7 May 2023

Software Version

Software Revision	:	1.0.1

FIGURE 34. DUT INFORMATION

7.1.2 Results 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	Test Point	Lane	Data Rate	SJ Frequency
1	Optimized Pre-set Look Up	N/A	N/A	Pass	Case1	N/A	Rate_10G	N/A
2	Optimized Pre-set Look Up	N/A	N/A	Pass	Case1	N/A	Rate_20G	N/A
3	Initial Eye Height Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	N/A
4	Initial Eye Height Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	N/A
5	ACCM Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	N/A
6	ACCM Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	N/A
7	Random Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	N/A
8	Random Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	N/A
9	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ1
10	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ5
11	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ2
12	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ3
13	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ4
14	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ1
15	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ2
16	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ3
17	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ4
18	Periodic Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ5
19	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ1
20	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ5
21	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ2
22	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ3
23	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ4
24	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ1
25	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ2
26	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ3
27	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ4
28	Case 1, Total Jitter Calibration	N/A	N/A	Pass	Case1	N/A	Rate_20G	SJ5
29	Case 1, Eye Height Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ1
30	Case 1, Eye Height Calibration	N/A	N/A	Pass	Case1	N/A	Rate_10G	SJ5

FIGURE 35. RESULTS SUMMARY TABLE EXAMPLE

7.1.3 Compliance Test Results

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

Case1 10G BER at TP3'

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	PASS(0)
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

Case1 10p3125G BER at TP3'

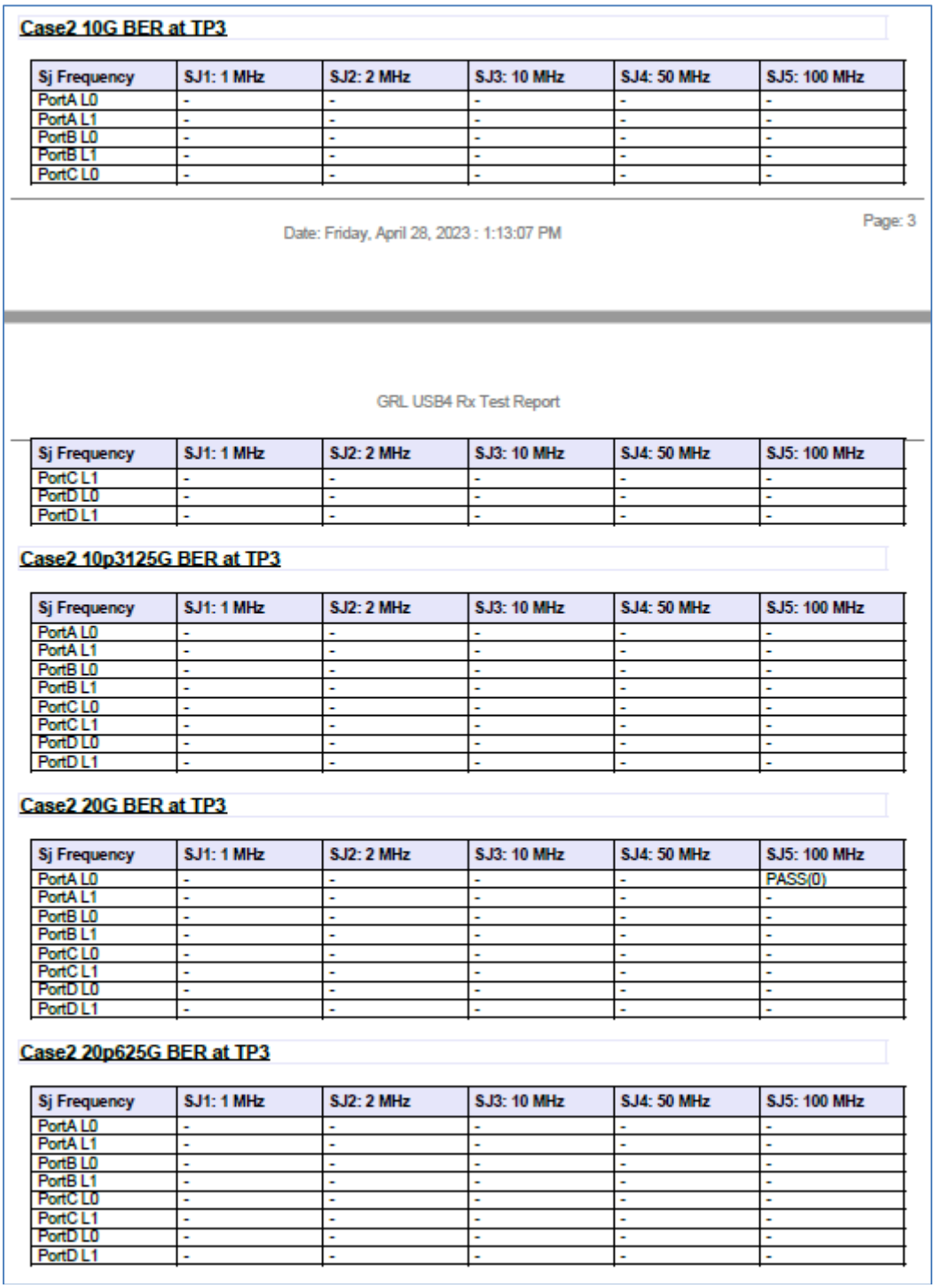
Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	-
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

Case1 20G BER at TP3'

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	PASS(0)
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

Case1 20p625G BER at TP3'

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	-
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-



Case2 10G BER at TP3

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	-
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-

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Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

Case2 10p3125G BER at TP3

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	-
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

Case2 20G BER at TP3

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	PASS(0)
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

Case2 20p625G BER at TP3

Sj Frequency	SJ1: 1 MHz	SJ2: 2 MHz	SJ3: 10 MHz	SJ4: 50 MHz	SJ5: 100 MHz
PortA L0	-	-	-	-	-
PortA L1	-	-	-	-	-
PortB L0	-	-	-	-	-
PortB L1	-	-	-	-	-
PortC L0	-	-	-	-	-
PortC L1	-	-	-	-	-
PortD L0	-	-	-	-	-
PortD L1	-	-	-	-	-

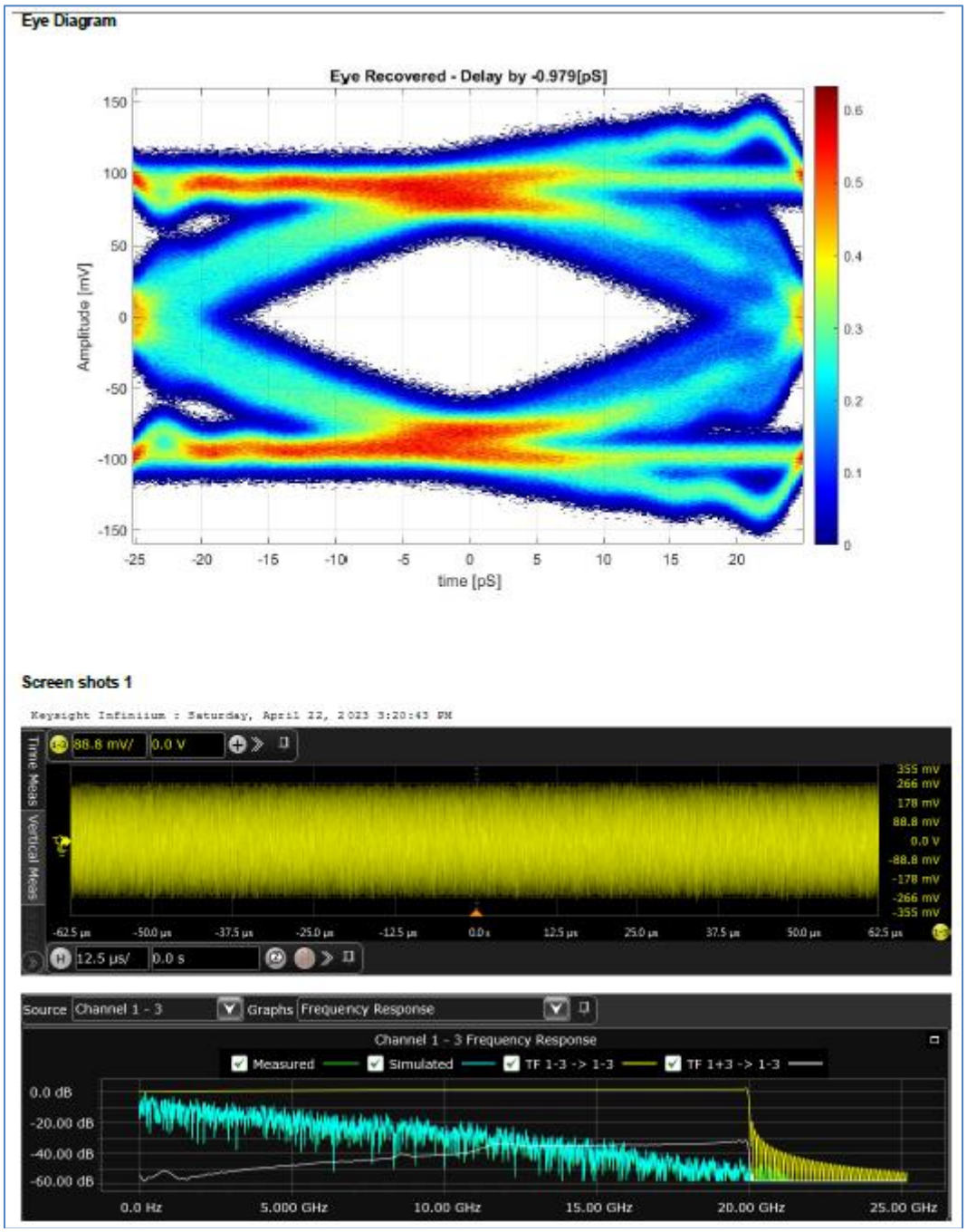
FIGURE 36. COMPLIANCE TEST RESULTS EXAMPLE

7.1.4 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.

58. Case 2, Eye Height Calibration [Case2,Rate_20G,SJ5]

Pass/Fail Stats	:	Pass
Cal Parameter	:	Final Eye Height_Rate_20G__Case2__SJ5
CTLE 6 ADC	:	501.0000 m
CTLE 6 Eye Area Average	:	2.8294 Vps
CTLE 6 DFE	:	22.7000 mV
CTLE 6 EH Trial 1	:	97.2700 mV
CTLE 6 EW Trial 1	:	28.9880 ps
CTLE 6 EH Trial 2	:	99.6060 mV
CTLE 6 EW Trial 2	:	28.4000 ps
CTLE 6 EH Trial 3	:	97.9600 mV
CTLE 6 EW Trial 3	:	28.9860 ps
CTLE 6 EH Trial 4	:	95.4730 mV
CTLE 6 EW Trial 4	:	28.7930 ps
CTLE 6 EH Trial 5	:	99.0510 mV
CTLE 6 EW Trial 5	:	29.3790 ps
Eye Width	:	576.5643 mUI
Optimized CTLE	:	EQ-6
Settings Parameter	:	Eye Amplitude
Settings	:	450.0000 mV
Measured Parameter	:	Eye Height
Measured Value	:	97.8719 mV
Sj Frequency	:	100.0000 MHz
Test completed time	:	22 April 2023 15:16:59 PM


Eye Diagram
Eye Recovered - Delay by -0.979[pS]
Amplitude [mV]
time [pS]
Screen shots 1
Keysight Infiniium : Saturday, April 22, 2023 3:20:43 PM
88.8 mV/
0.0 V
12.5 µs/
0.0 s
Source
Channel 1 - 3
Graphs
Frequency Response
Channel 1 - 3 Frequency Response
Measured
Simulated
TF 1-3 -> 1-3
TF 1+3 -> 1-3
0.0 dB
-20.00 dB
-40.00 dB
-60.00 dB
0.0 Hz
5.000 GHz
10.00 GHz
15.00 GHz
20.00 GHz
25.00 GHz

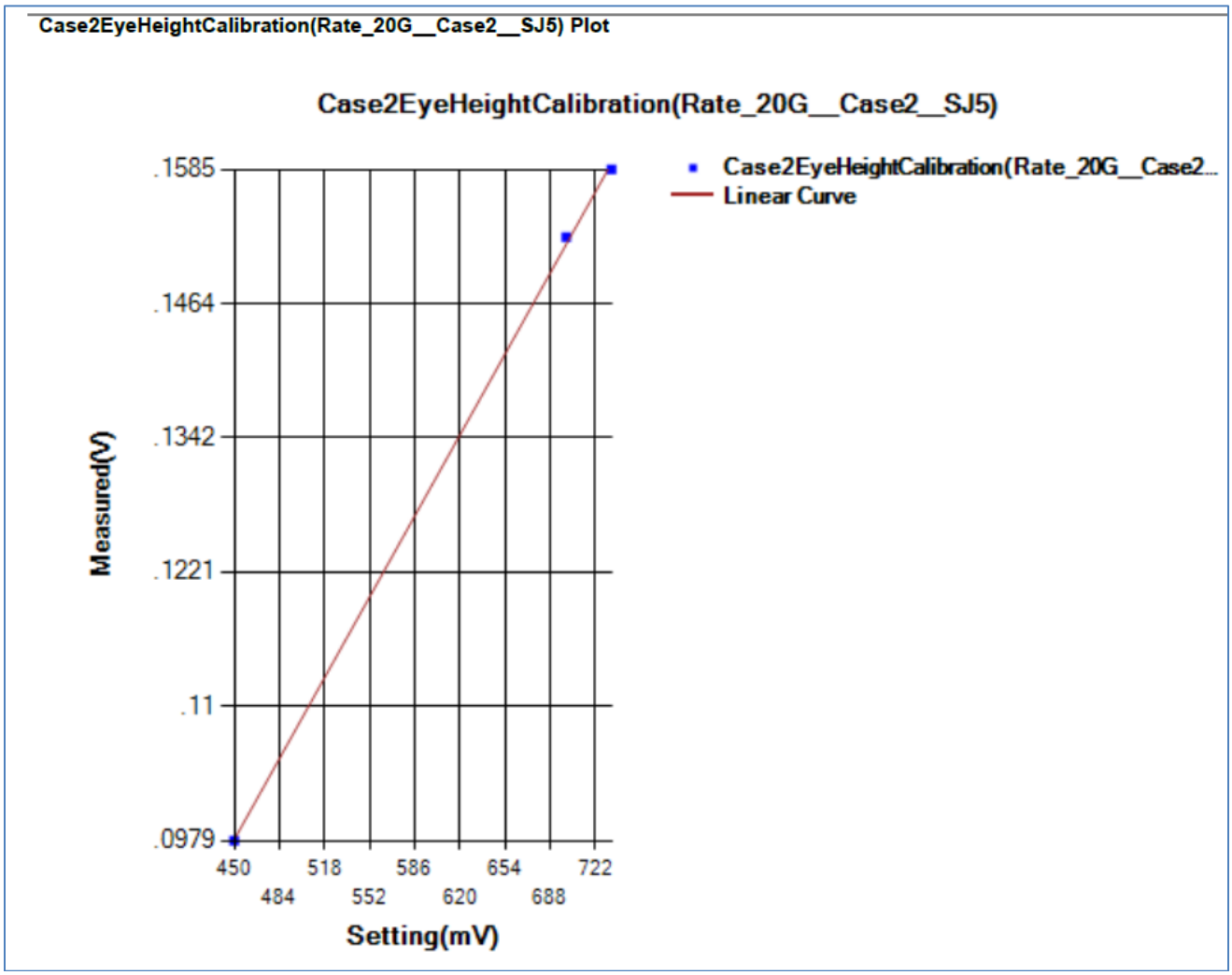


FIGURE 37. CALIBRATION/TEST RESULT DETAILS EXAMPLE

7.2 Delete Test Results

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

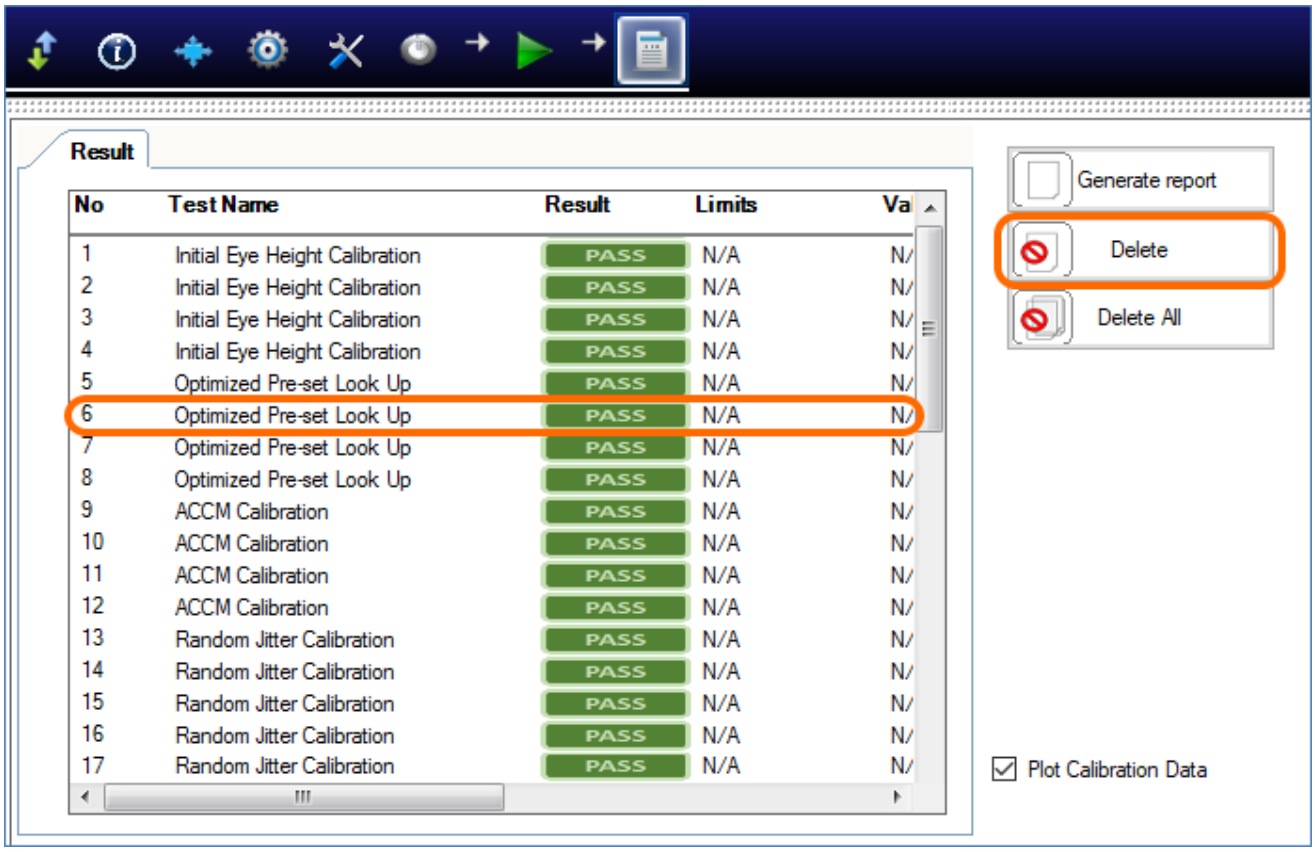


FIGURE 38. DELETE INDIVIDUAL CALIBRATION/TEST RESULTS EXAMPLE

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

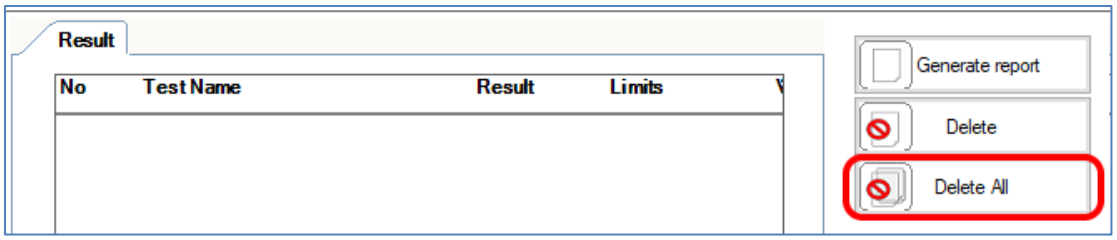


FIGURE 39. DELETE ALL RESULTS

8 Saving and Loading Test Sessions

The GRL-USB4-RX-KS 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.

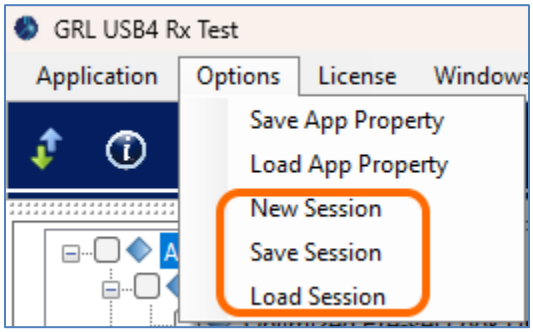


FIGURE 40. SAVING AND LOADING CALIBRATION AND TEST SESSIONS

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.

9 Appendix A: Receiver Stressed Eye Calibration Using SigTest

The SigTest post processing analysis application can be run to ensure signal quality compliance for the USB4 receiver stressed eye calibration.

Below provides a summary of SigTest requirements. Please refer to the USB4 SigTest User Manual from USB-IF for the full set of instructions to perform SigTest measurements.

Note: It is required that you are a member of USB-IF and have attained the proper permissions from USB-IF in order to have access to the USB4 SigTest User Manual.

9.1 Install and Run SigTest

[Note: The following procedure was extracted from the "USB4 SigTest installation and running:" section in the USB4 SigTest User Manual.]

First, make sure that ≥ 16GB RAM *(or recommended 32GB RAM and higher)* is available on the Control PC or Scope where SigTest is to be run.

1. Install Matlab Runtime Compiler MCR R2019b (9.7).
2. Create a new folder, for example "SigTest_USB4_CTS" and place the "USB4_SigTest.exe" file into the folder. Run the "USB4_SigTest.exe".
3. Open PowerShell window from the folder by pressing SHIFT + Right mouse button and then click on "Open PowerShell window here".

9.2 Set Up Scope for Saving Waveforms

[Note: The following description was extracted from the "Scope definitions for saving waveforms:" section in the USB4 SigTest User Manual.]

a) Scope requirements and settings:
   - Sampling Rate: ≥ 80GSa/s
   - Evaluated record length: 500µs per channel
   - No CDR, no average, no interpolation and no equalization applied
   - Bandwidth: 16GHz (for USB4 Gen2) or 21GHz (for USB4 Gen3)
   - Adjust vertical scale to fit signal into Scope screen

b) The saved waveforms for all receiver tests should be differential (for example: CH1 - CH3), except of the waveform for the AC Common Mode test that should be common (for example: (CH1 + CH3)/2).

c) De-embedding and embedding of the waveform should be applied for the following receiver compliance test points:

- TP3_Prime test point: No de-embedding and no embedding should be applied.
- TP3 test point: De-embedding of the cable connecting from the last receptacle to the Scope should be applied.

d) The waveforms should use the correct test pattern type and length for the respective test as specified in the CTS to avoid test interruption and termination.

10 Appendix B: 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 control PC. The Keysight Scope can be connected to the control 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 control PC.
2. When installed successfully, the IO icon ( ) will appear in the taskbar notification area of the control PC.
3. Select the IO icon to launch the **Keysight Connection Expert**.
4. Click Rescan.

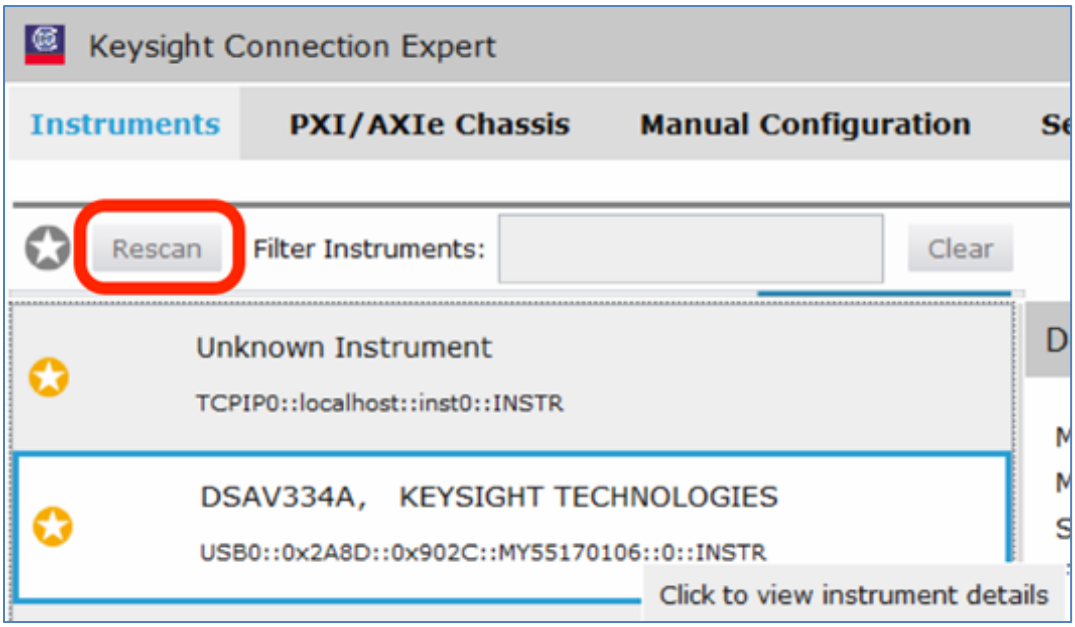


FIGURE 41. KEYSIGHT CONNECTION EXPERT

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

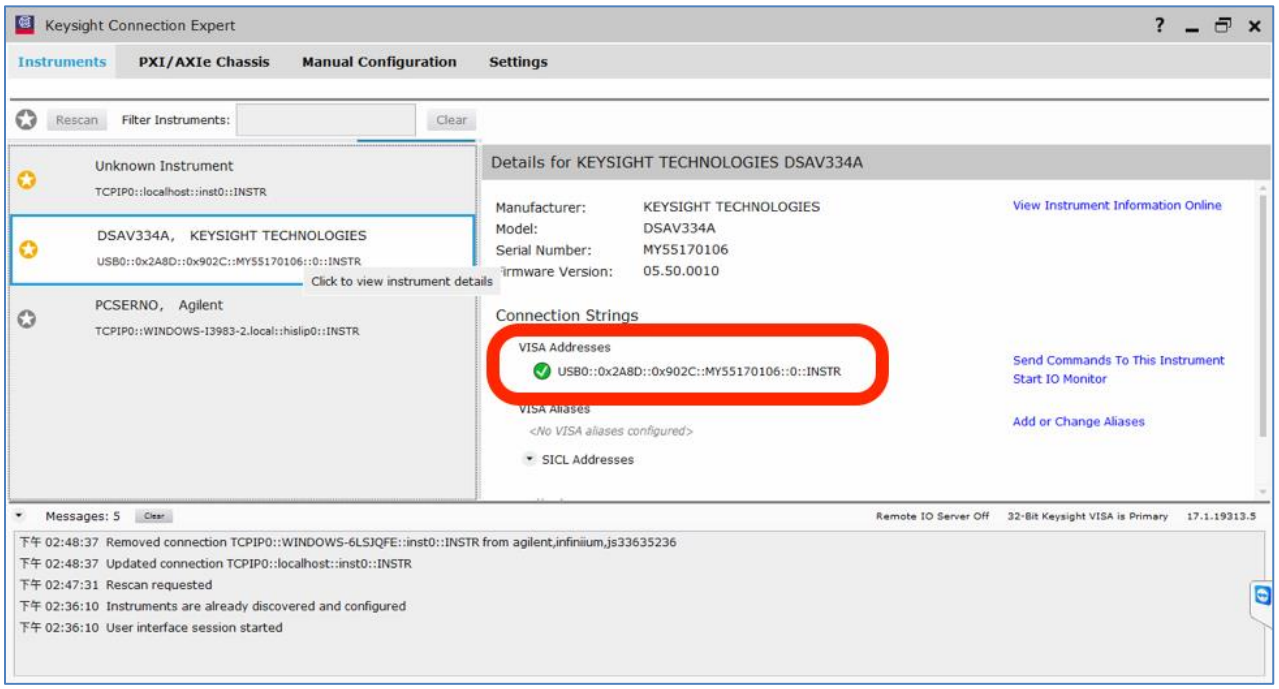


FIGURE 42. OSCILLOSCOPE'S VISA ADDRESS

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 USB4 Rx Test Application. If the GRL USB4 Rx Test Application is installed on the Keysight Scope, type in the Scope IP address, for example "TCPIP0::127.0.0.1::inst0::INSTR". If the GRL software is installed on the control PC to control the Scope via LAN, type in the Scope IP address, for example "TCPIP0::192.168.0.100::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:: 192.168.0.100::5025::SOCKET".

11 Appendix C: 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 control PC. The Tektronix Scope can be connected to the control PC through GPIB, USB, or LAN.

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

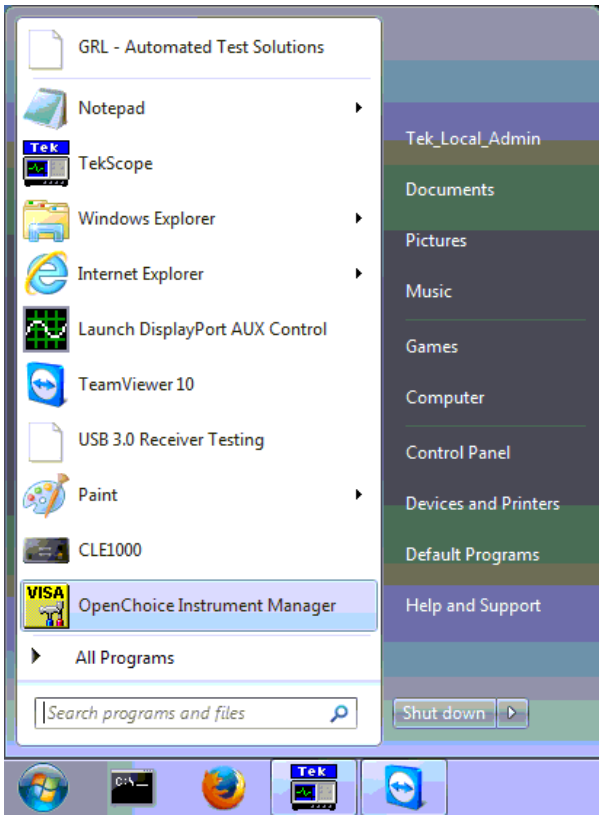


FIGURE 43. OPENCHOICE INSTRUMENT MANAGER IN START MENU

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 control 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.

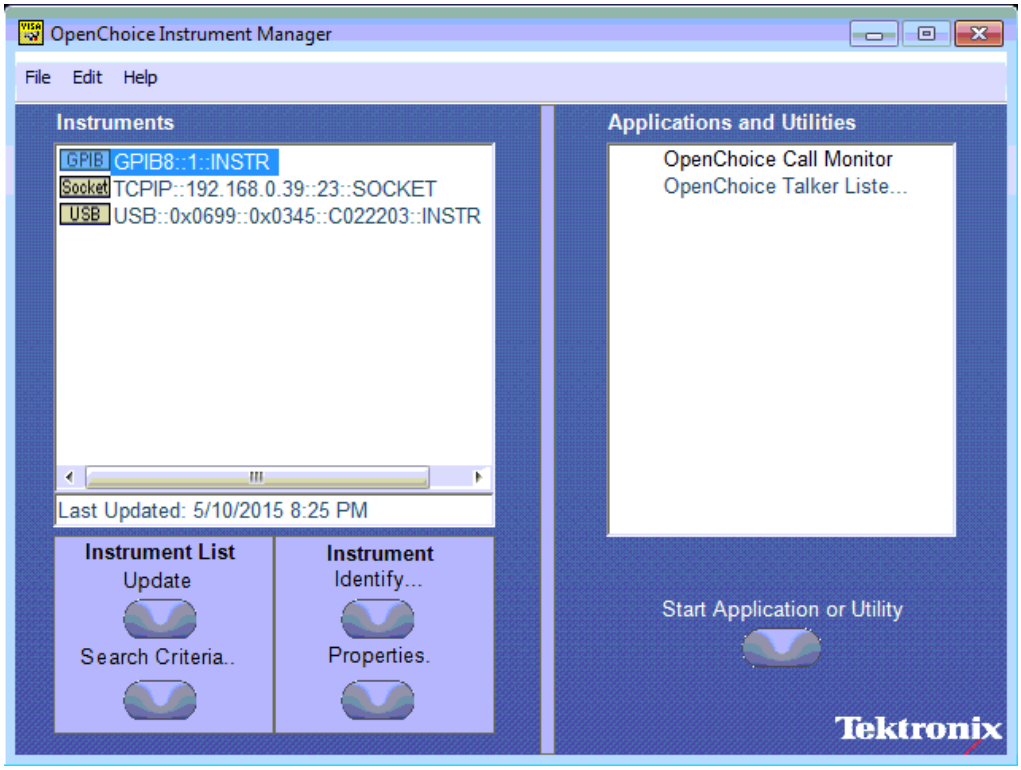


FIGURE 44. OPENCHOICE INSTRUMENT MANAGER MENU

4. If connecting the Tektronix Scope to the control 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 control 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 USB4 Rx Test Application, type in the Scope address into the 'Address' field. If the GRL USB4 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 control PC to control the Scope, type in the Scope IP address, for example "TCPIP0:: 192.168.0.100::inst0::INSTR". Note to ***omit*** the Port number from the address.

12 Appendix D: Connecting Teledyne LeCroy Oscilloscope to PC

If using a Teledyne LeCroy oscilloscope, refer to the following procedure on how to connect the scope to be used with a PC. The Teledyne LeCroy scope can be connected to the PC through LAN.

1. From the oscilloscope main menu bar, select **Utilities → Utilities Setup…**.

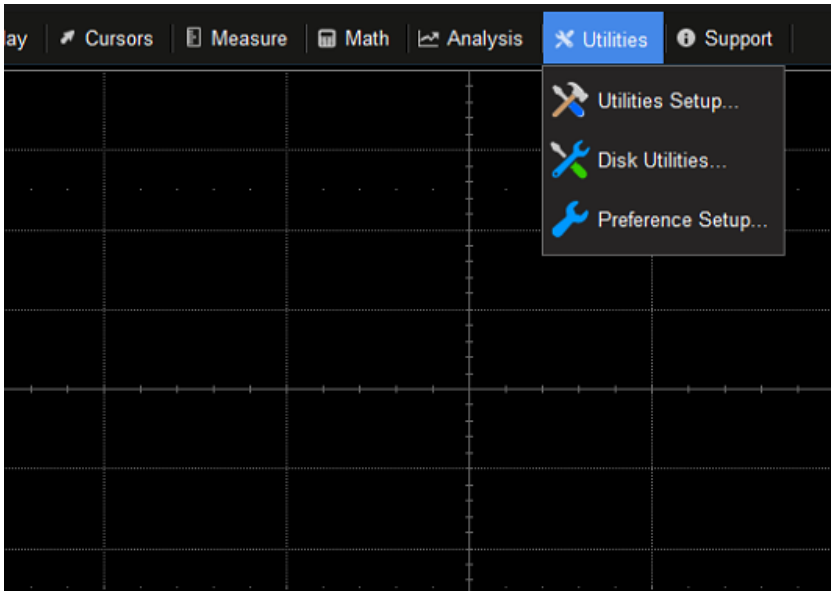


FIGURE 45. UTILITIES SETUP MENU

2. In the **Remote** tab, set the **Control from** settings to **LXI (VXI11)**. Note down the IP address of the scope.

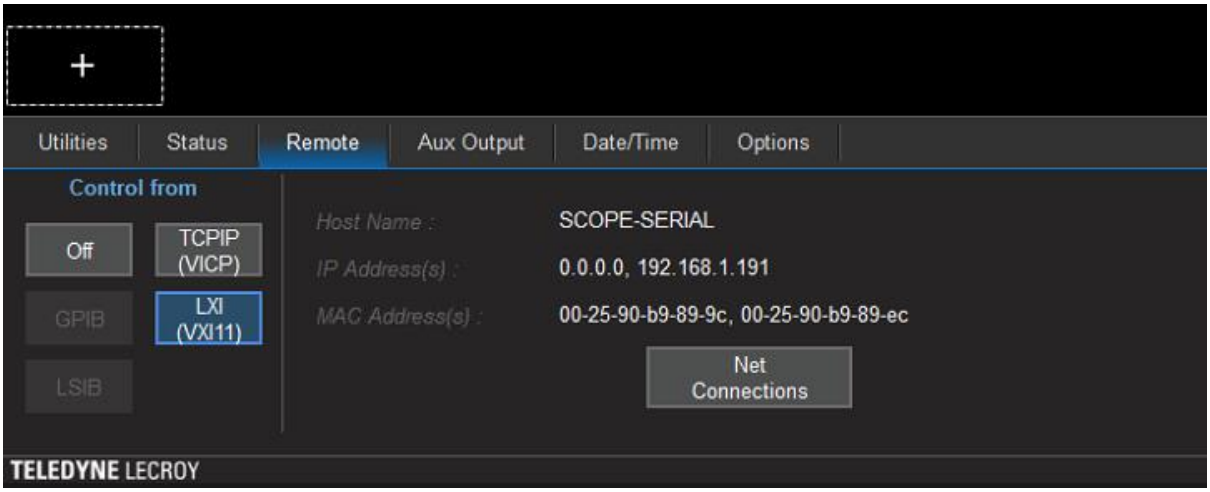


FIGURE 46. OSCILLOSCOPE'S IP ADDRESS

3. On the Equipment Setup page of the GRL USB4 Rx Test Application, type in the Scope IP address into the 'Address' field.

13 Appendix E: SMA Cable Transfer Function Setup Procedure for Cable De-embedding

This section describes how to create and set up transfer function on the Scope for de-embedding of SMA cables.

13.1 Set Up Transfer Function for the Keysight Scope

13.1.1 For SMA Cable De-embedding on Scope Channels 1 & 3

1. On the Keysight Scope, select **Setup** → **Channel 1** → **Differential Channels 1 & 3** → **4 Port (Channels 1 & 3)** on the InfiniiSim pane:

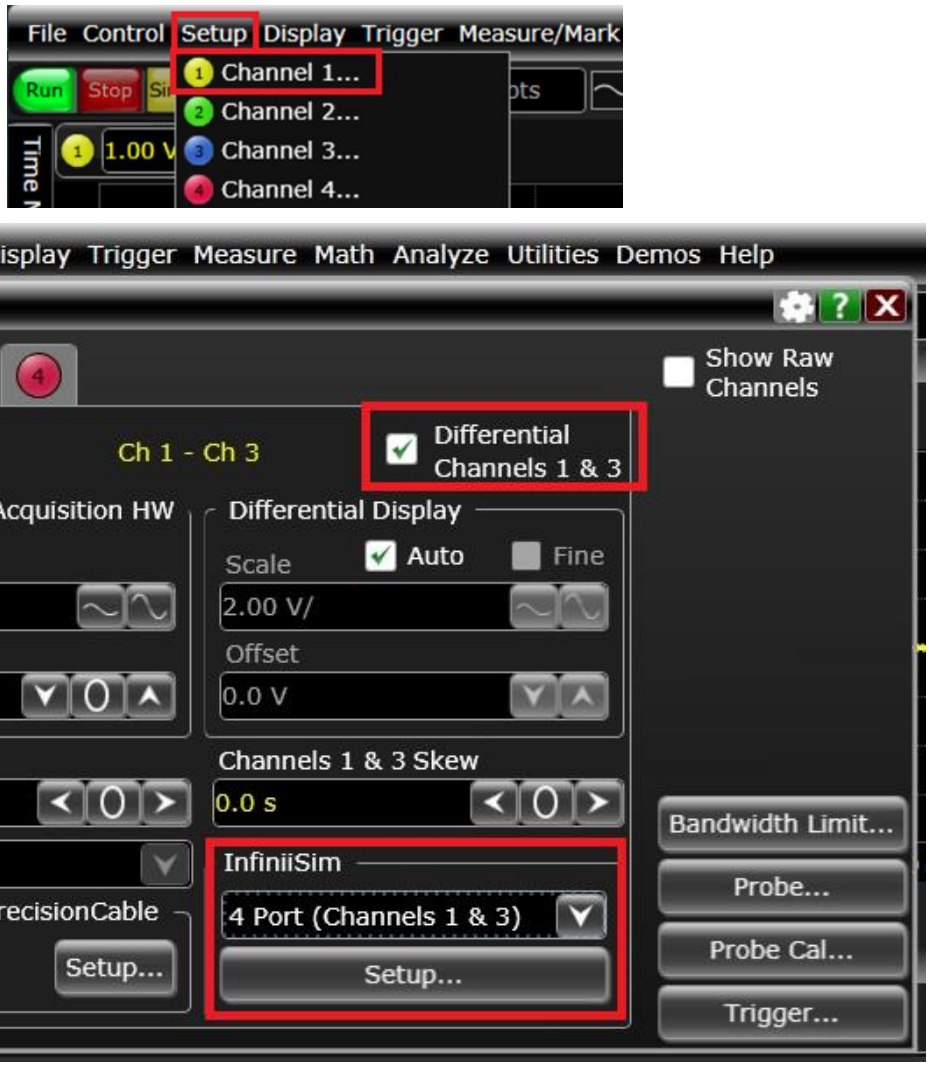


FIGURE 47. SMA CABLE TRANSFER FUNCTION– SET UP SCOPE CHANNELS 1 & 3

2. On the InfiniiSim Setup screen, select **Setup Wizard**:

FIGURE 48. SMA CABLE TRANSFER FUNCTION– SELECT SETUP WIZARD ON SCOPE

3. On the InfiniiSim Wizard screen, select **Next**:

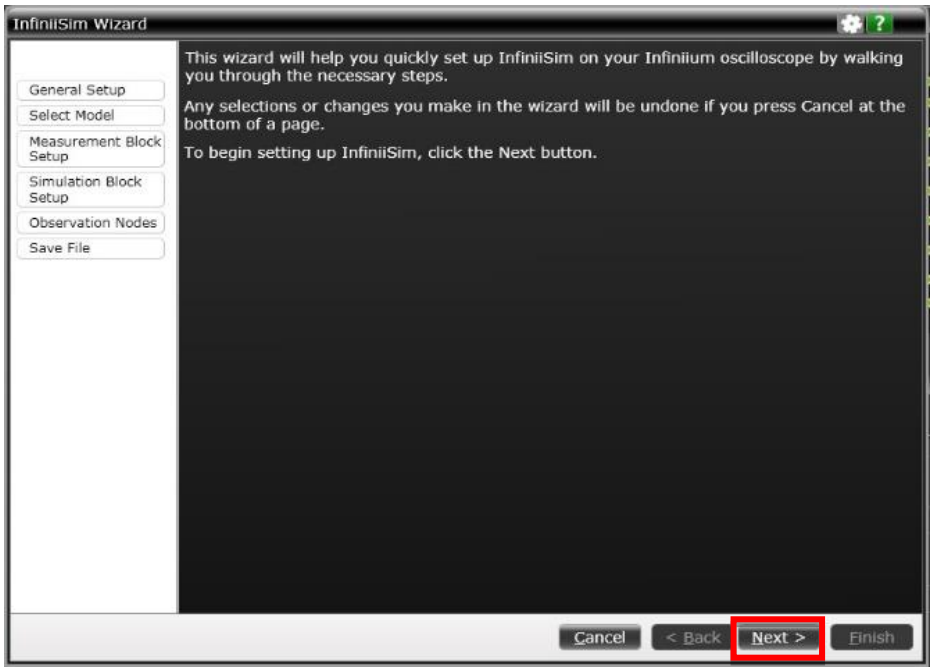


FIGURE 49. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #1

4. On the InfiniiSim Wizard > General Setup screen, select **Next**:

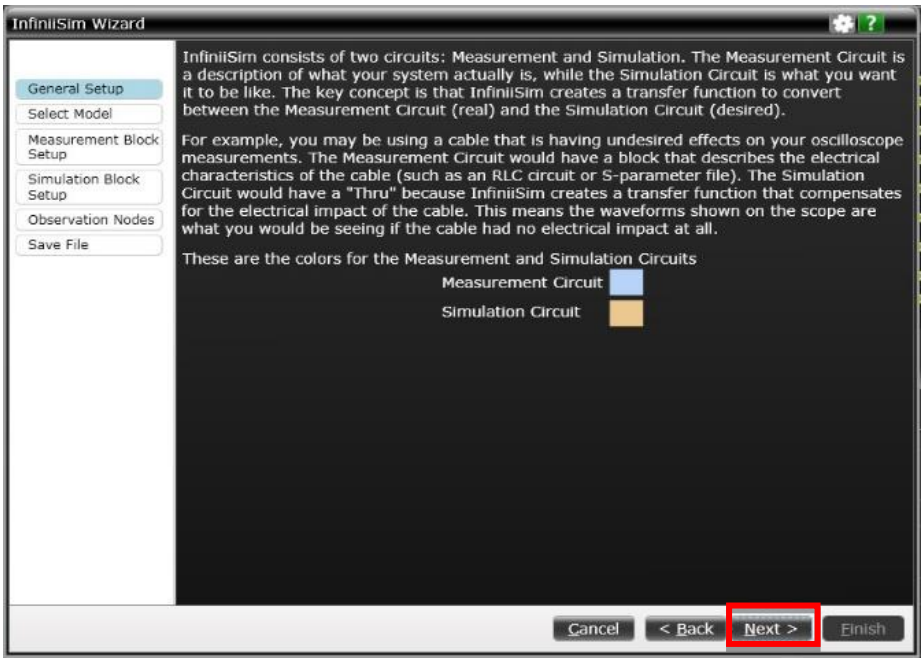


FIGURE 50. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #2

5. On the InfiniiSim Wizard > Select Model screen, select **Remove insertion loss of a fixture or cable** → **Next**:

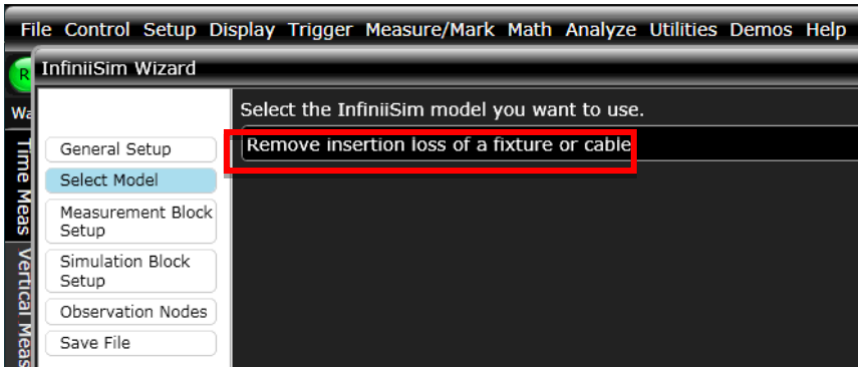


FIGURE 51. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #3

6. On the InfiniiSim Wizard > Measurement Block Setup screen, set the following parameters for de-embedding of the SMA cable:
   - In the" Port Type" field, select **4 Port**.
   - In the "Block Type" field, select **S-parameter File**.
   - In the "S-parameter file" field, browse and select the SMA cable S4P file which has been measured using the ENA vector network analyzer.
   - In the "4 Port Numbering" field, select **1↔3, 2↔4**.

   Select **Next** to proceed.

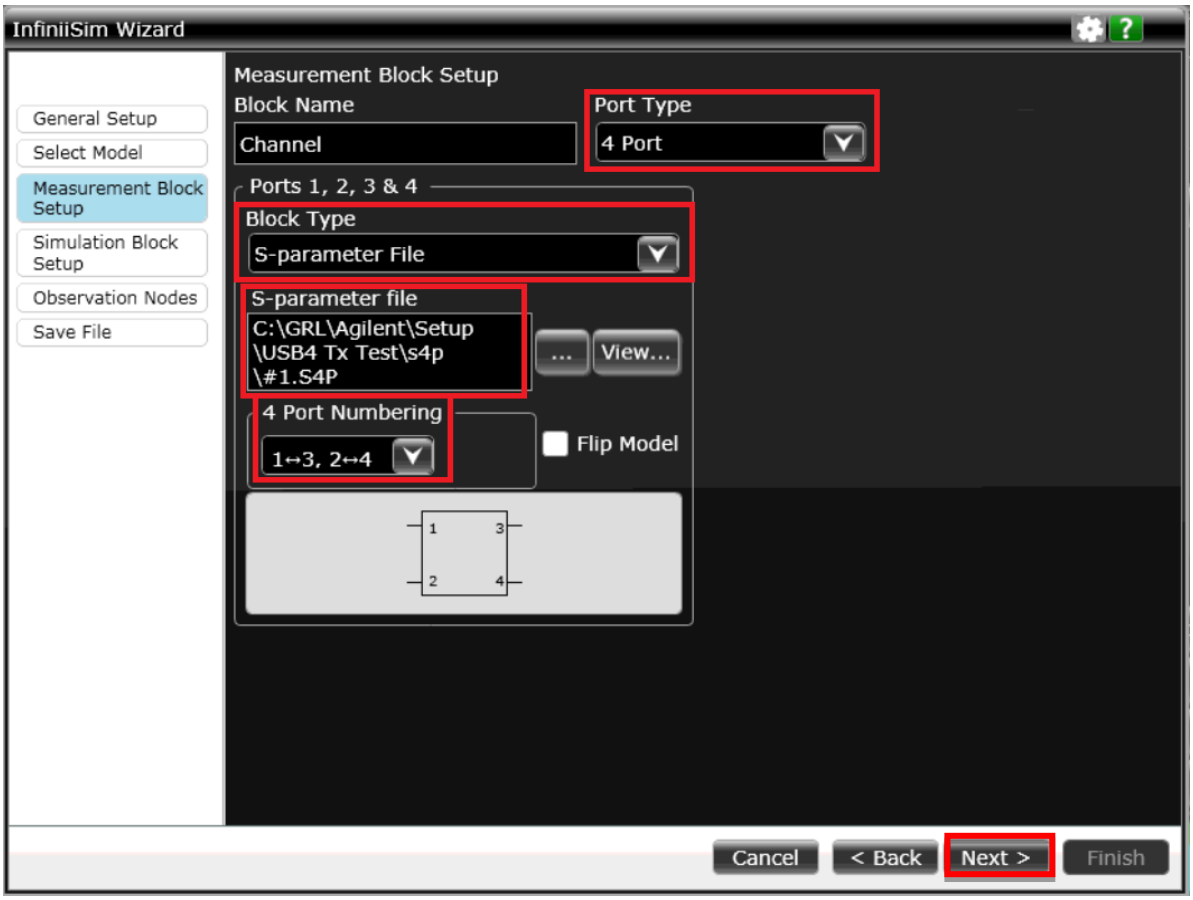
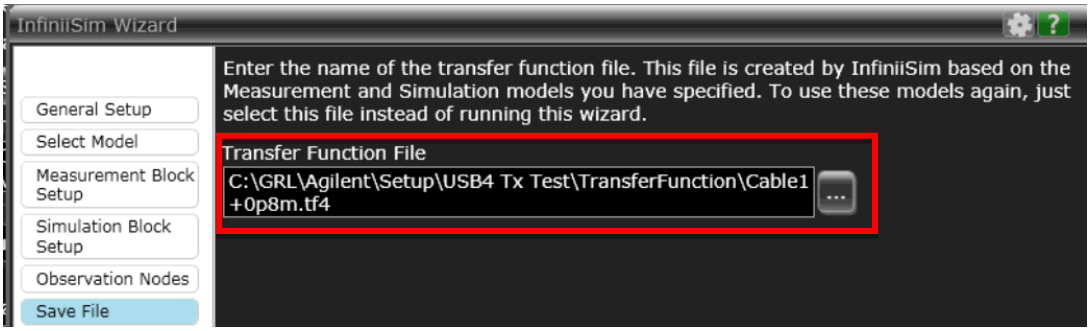


FIGURE 52. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #4

7. On the InfiniiSim Wizard > Save File" screen, specify the file name for the newly created transfer function file. Make sure the file is saved to the following default location– *"C:\GRL\Agilent\Setup\GRL USB4 Rx Test\TransferFunction\xxx.tf4"* on the Scope and then select **Next** → **OK** → **Finish**.



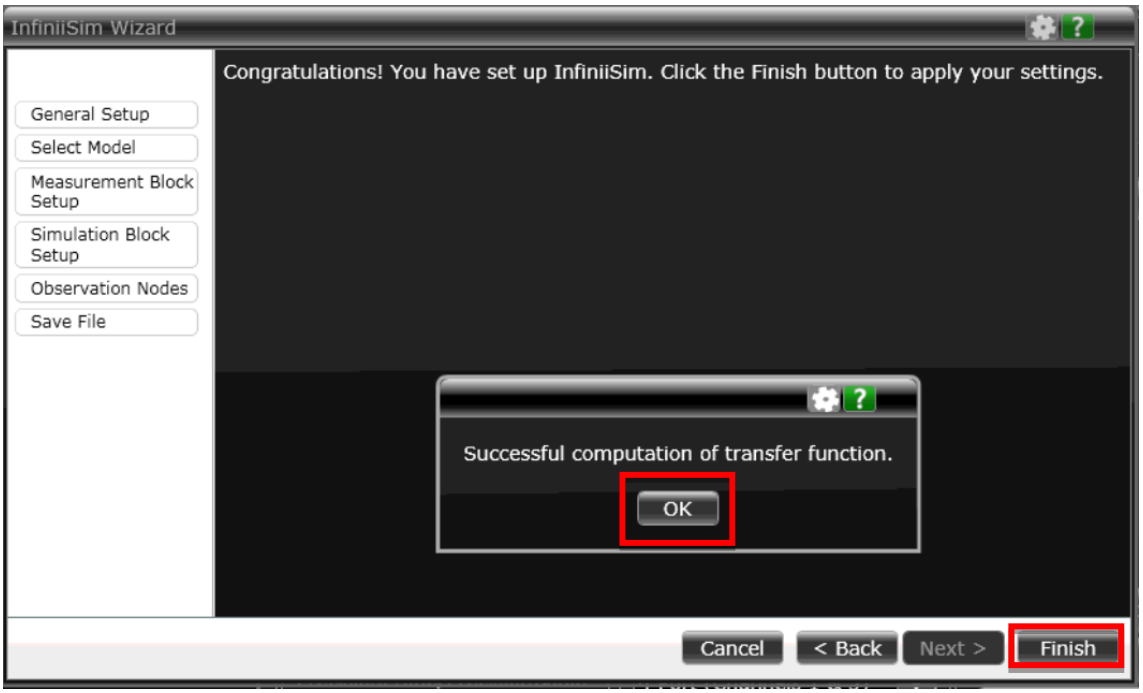
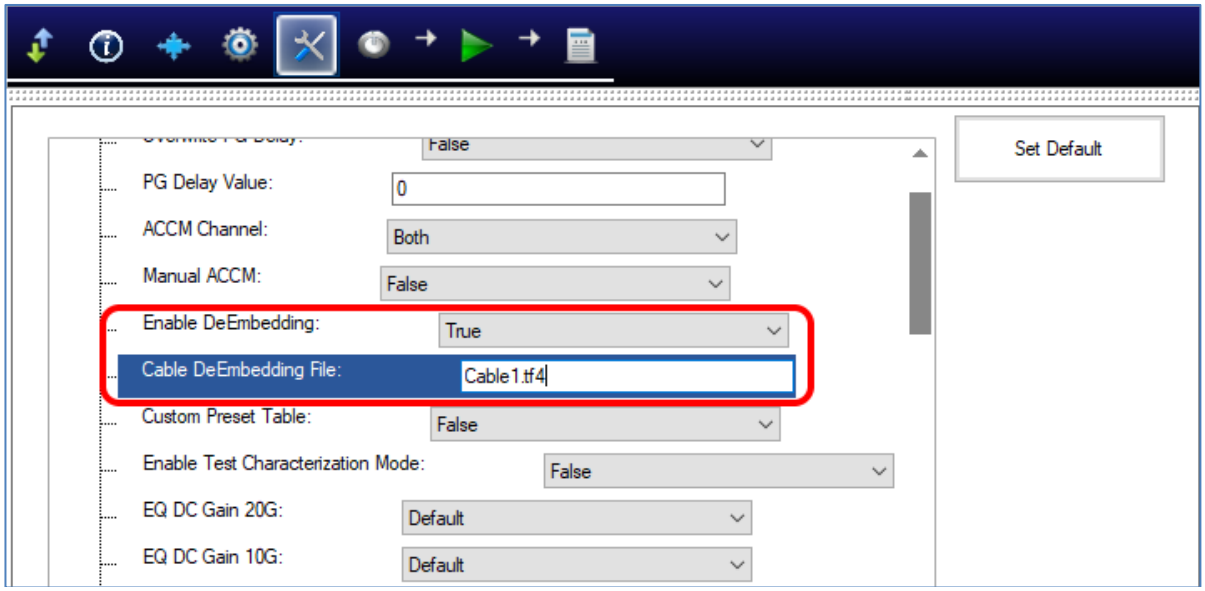


FIGURE 53. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE COMPLETED

8. On the GRL USB4 Rx Test Application → Configurations page, select **True** for the "Enable DeEmbedding" field and specify the transfer function file to be used in the "Cable DeEmbedding File" field.



9. Repeat all the above steps to generate a new transfer function as required.

13.2 Create Filter Files for the Tektronix Scope

13.2.1 Convert Single-Ended S-Parameter Files to Mixed Mode

1. Turn on the "Serial Data Link Analysis" (SDLA) software on the Tektronix scope.
2. Select **Analyze** → **Serial Data Link Analysis**:

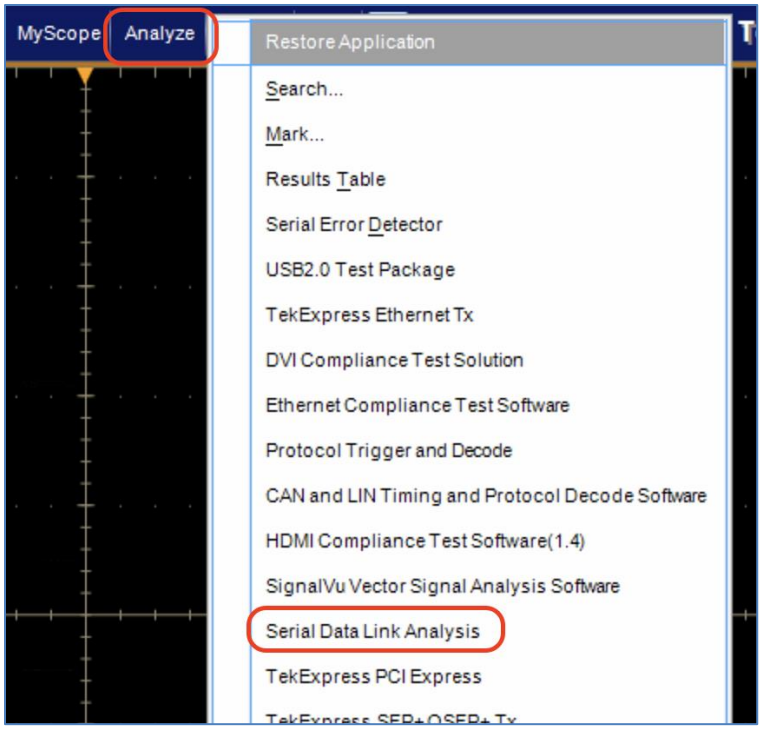


FIGURE 54. SELECT AND OPEN SERIAL DATA LINK ANALYSIS ON TEKTRONIX SCOPE

3. On the SDLA Visualizer screen, select the **Convert** tab button.
4. Click on the **Load** button to load the SMA cable S-parameters.
5. Select the correct port definition for the S-parameter file.
6. Click on the **Apply** button.

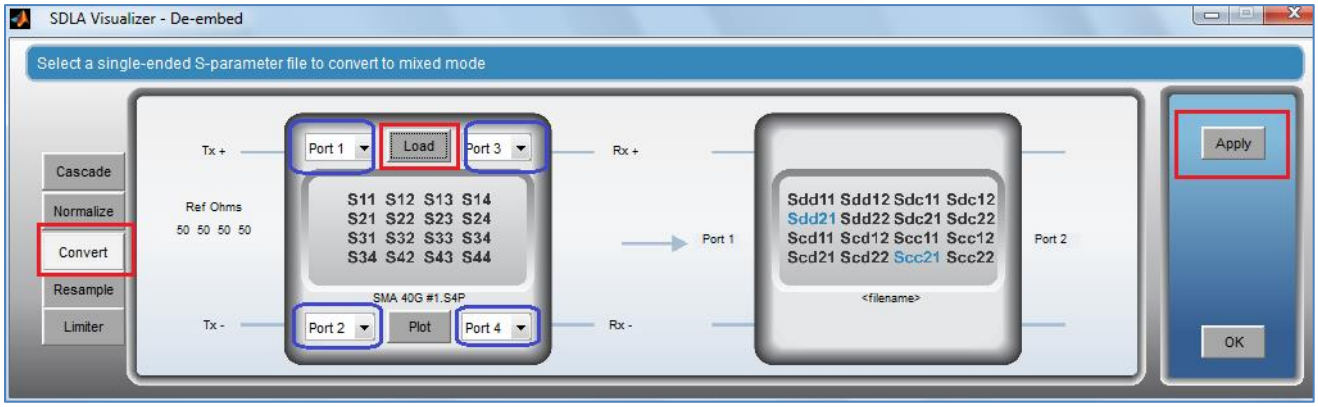


FIGURE 55. CONVERT TO MIXED MODE S-PARAMETERS

7. Click on the **Save** button to save the mixed mode S-parameters after conversion.

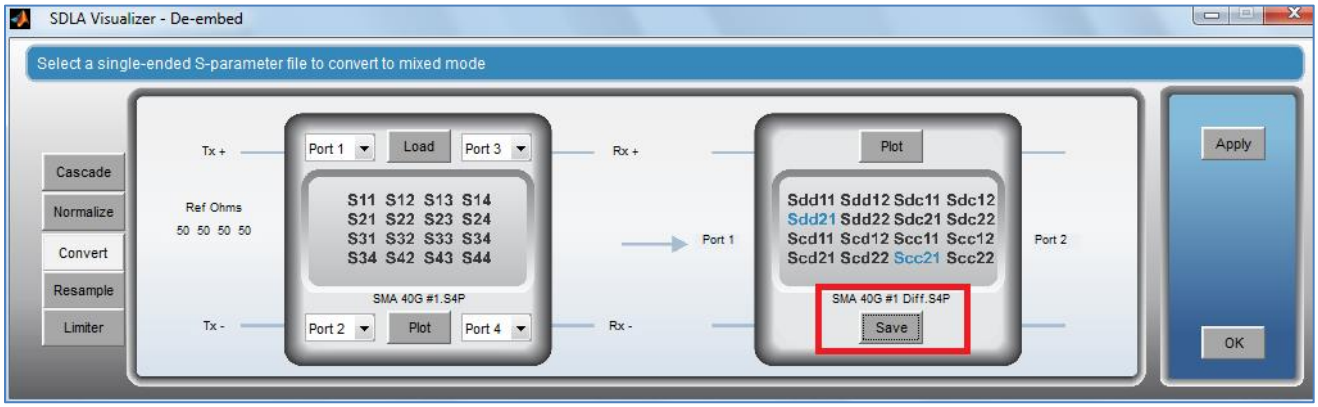


FIGURE 56. SAVE CONVERTED MIXED MODE S-PARAMETERS

13.2.2 Create SMA Cable De-embedding Files for Scope Channels 1 & 3

1. On the Tektronix Scope, click on the **De-embed** button on the SDLA Visualizer screen.

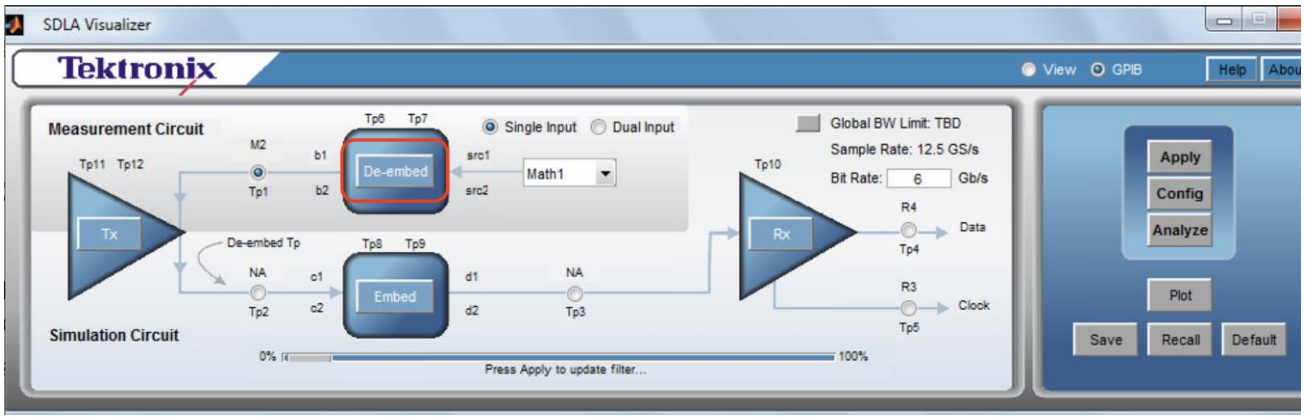


FIGURE 57. CREATE SMA CABLE DE-EMBEDDING FILES – #1

2. Click on the **B1** button.

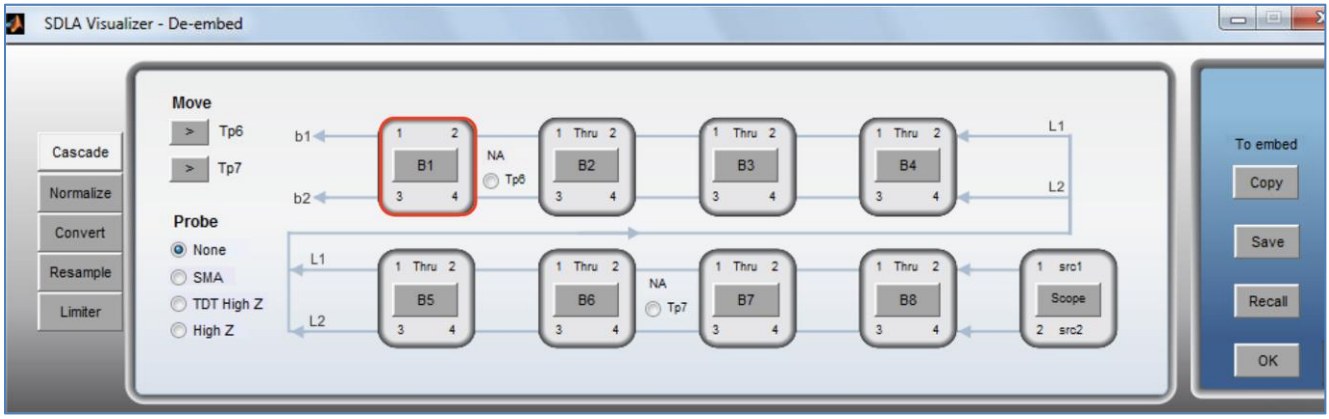


FIGURE 58. CREATE SMA CABLE DE-EMBEDDING FILES – #2

3. Click on the **Browse** button to load the mixed mode S-parameter file that has been created from Section 13.2.1. Then click **OK**.

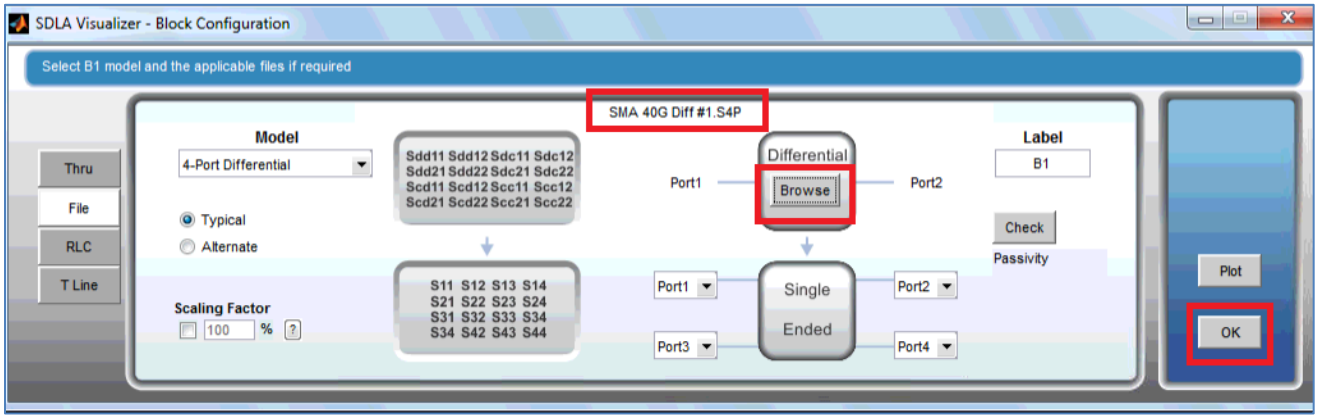


FIGURE 59. CREATE SMA CABLE DE-EMBEDDING FILES – #3

4. Make sure signals are actively flowing through **Channel 1** on the scope.
5. Select the **Tp1** radio button.

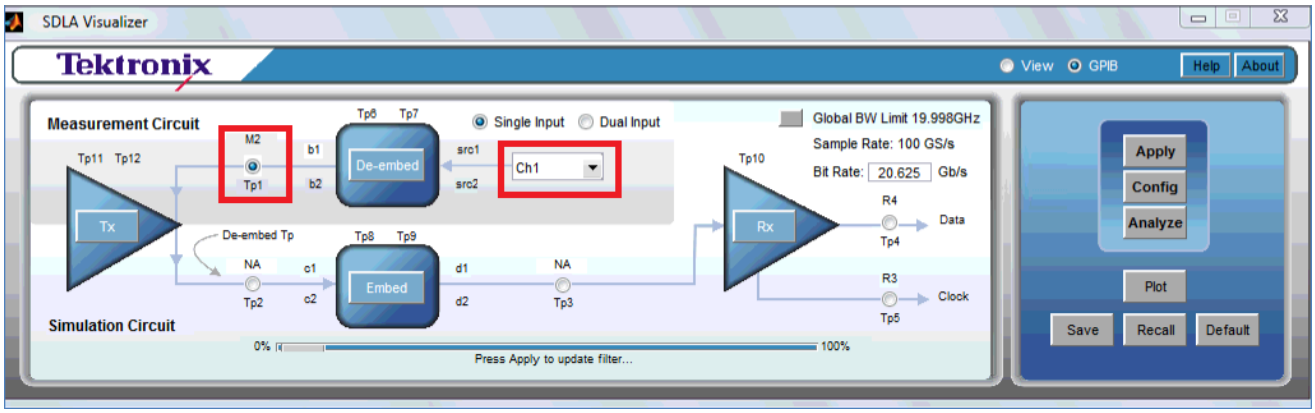


FIGURE 60. CREATE SMA CABLE DE-EMBEDDING FILES – #4

6. Select the **Math2** radio button and then click **OK**.

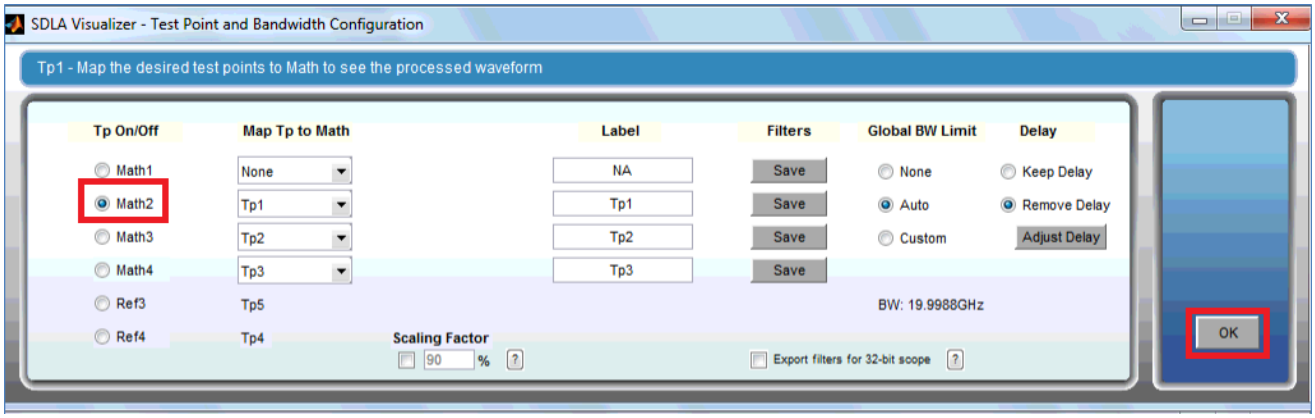


FIGURE 61. CREATE SMA CABLE DE-EMBEDDING FILES – #5

7. Click on the **Apply** button.

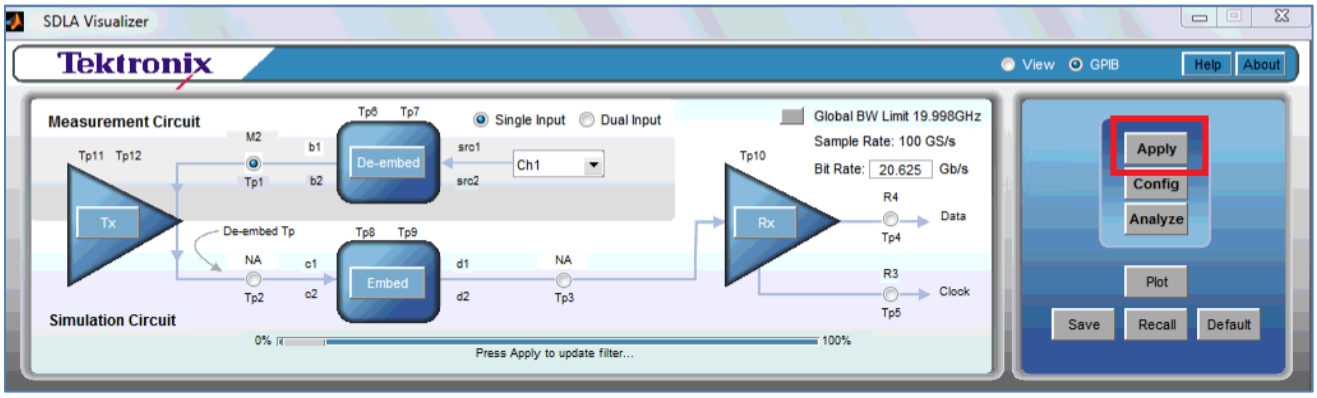
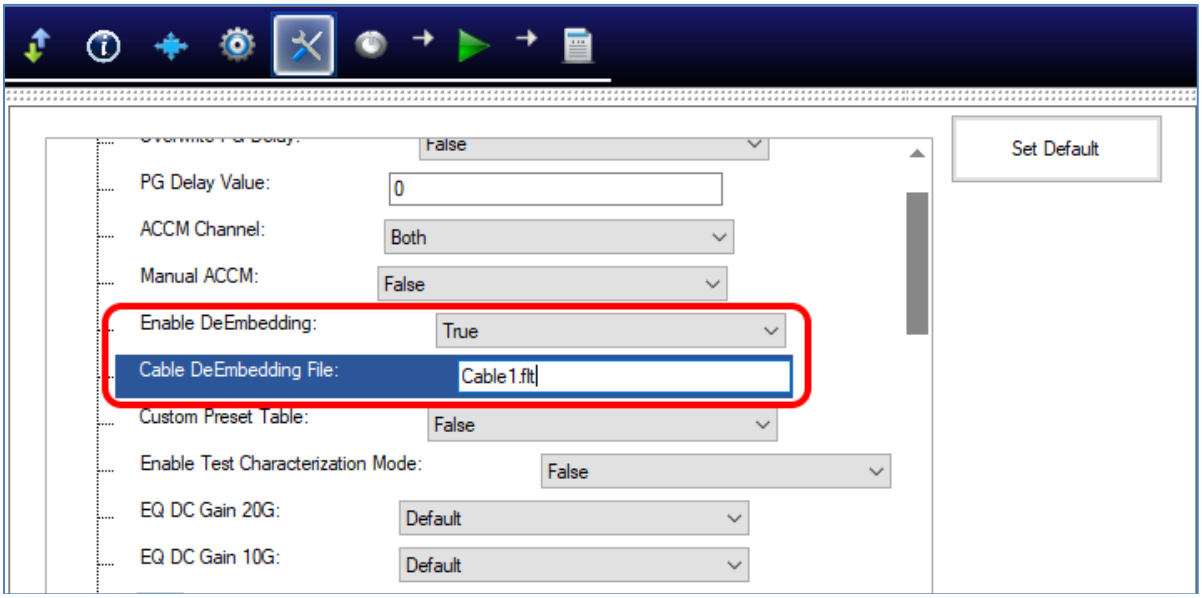


FIGURE 62. CREATE SMA CABLE DE-EMBEDDING FILES – #6

8. The filter file will be created at *"C:\Users\Public\Tektronix\TekApplications\SDLA\output filters\sdlatp1.flt"*. Copy this file to the ***"C:\TekApplications\DPOJET\Setups\GRL USB4 Rx Test\TransferFunction"*** directory on the Tektronix scope and rename the file for de-embedding of channels 1 & 3.

9. On the GRL USB4 Rx Test Application → Configurations  page, select **True** for the "Enable DeEmbedding" field and specify the filter file to be used in the "Cable DeEmbedding File" field.



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