Granite River Labs

USB4™ Transmitter Test Method of Implementation (MOI) Using

Keysight / Tektronix Real Time Oscilloscope and GRL-USB4-TX-TEST Automation Software

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1 Introduction

This documentation describes how to use the GRL-USB4-TX-TEST software to provide automation control for calibration and testing of an electrical transmitter (Tx) unit for USB4™ certification using the Keysight DSA90000Q/V/Z Series or Tektronix DX and SX Series Real Time Oscilloscope.

This documentation starts off by explaining how to set up and use the GRL-USB4-TX-TEST automation software as the main body followed by an Appendix describing the SMA cable transfer function setup procedure on the Scope.

The GRL-USB4-TX-TEST automation software provides preset calibration option as well as Tx equalization and compliance tests for USB4 Gen2/Gen3 hosts and devices. GRL-USB4-TX-TEST also enables running the SigTest post processing analysis application to ensure signal quality compliance. When combined with a satisfactory level of interoperability testing, these tests provide a reasonable level of confidence that the devices-under-test (DUT's) will function properly in many USB4 Tx environments.

In summary, below are the main topics that are covered in this documentation:

- Software pre-requisites installation.
- USB4 DUT Tx compliance test setups.
- GRL-USB4-TX-TEST automation software setup for calibration and testing.
- GRL-USB4-TX-TEST test results and report generation.
- Appendix on SMA cable transfer function setup procedure for cable de-embedding.

2 Resource Requirements

2.1 Equipment Requirements

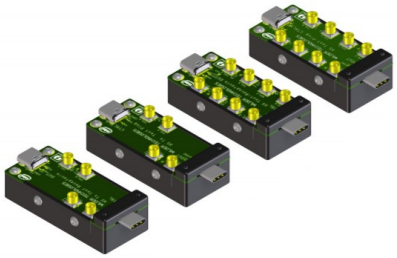
TABLE 1. EQUIPMENT REQUIREMENTS – SYSTEMS

System	Qty.	Description	Key Specification Requirement
Oscilloscope	1	High Performance Real-time Oscilloscope [a]	≥ 21 GHz bandwidth [b] 16GB or above memory RAM
Computer (Optional)	1	External PC for running GRL-USB4-TX-TEST Software	Windows 7+ OS 16GB or above memory RAM

[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 – ACCESSORIES

Accessory	Qty.	Description
USB4 Microcontroller	1	Wilder-Tech USB4 Microcontroller (CG3-TPA-TR) 
USB4 Test Fixture	1	Wilder-Tech USB4 Plug Test Fixture (CG3-TPA-HS) 
2.92mm-to-SMP Adapter	8	
2.92mm(f)-to-2.92mm(f) Adapter	4	
Matched-Paired Cable	4	40G Matched-Paired Cable 2.92m L-1m • Phase matched max ±5° at 40GHz • Insertion loss <1.5dB max in 10GHz 
USB Cable	1	USB 2.0 Cable

2.2 Software Requirements

TABLE 3. SOFTWARE REQUIREMENTS

Software	Source
GRL-USB4-TX-TEST	Granite River Labs USB4 Transmitter Calibration and Test Automation Software – www.graniteriverlabs.com (Support > Download Center)
VISA (Virtual Instrument Software Architecture) API Software	VISA Software is required to be installed on the host PC running GRL-USB4-TX-TEST 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)
Intel Tenlira Test Scripts (For Thunderbolt 3 DUT Tests)	Version 3.18.17 (downloadable from Intel Corporation IBL's website).
USB4 Electrical Test Tool (ETT)	Version 0.9.5 or above (downloadable from USB-IF's website: https://www.usb.org/usb4tools).
ActiveTcl (For Thunderbolt 3 DUT Tests)	Version 8.5.18.0.298892 (downloadable from ActiveState's website: https://www.activestate.com/products/tcl/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.
Python (For Thunderbolt 3 DUT Tests)	Version 2.7.14. amd64 (downloadable from Python's website: https://www.python.org/downloads/).
MATLAB	Version R2019b (9.7) (For SigTest) (downloadable from MATLAB's website: https://ch.mathworks.com/products/compiler/matlab-runtime.html).
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.)*
Microcontroller Drivers	Wilder-Tech Microcontroller Drivers
FTDI Chipset Drivers (For running ETT)	Downloadable from FTDI's website: https://ftdichip.com/drivers/

3 Installing Software Pre-Requisites

Ensure that the following tools are installed on the oscilloscope before proceeding with the next steps.

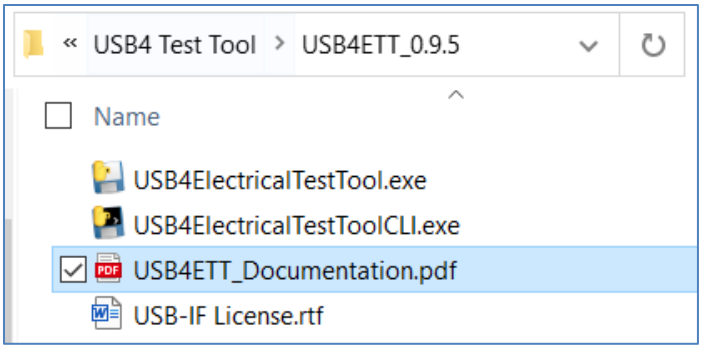
3.1 Download and Install TenLira (Applicable for Thunderbolt 3 DUT's Only)

Download the Intel Tenlira Version 3.18.17 software from Intel Corporation IBL's website and install on the Scope.

3.2 Download and Install ETT (Applicable for USB4 DUT's Only)

Download the USB4 Electrical Test Tool (ETT) Version 0.9.5 or above from the USB-IF official website: https://www.usb.org/usb4tools.

Before running ETT, configure the Scope'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 Scope with the GRL-USB4-TX-TEST software. In this case, the Wilder-Tech microcontroller is required. The DUT is controlled using a 0.8m USB Type-C® cable from the Wilder-Tech microcontroller to the USB4 Test Fixture.

For USB4 Device Testing:

- **Upstream Facing Port (UFP):** The ETT can be loaded on the Scope with the GRL-USB4-TX-TEST software. In this case, the Wilder-Tech microcontroller is required. The DUT is controlled using a 0.8m USB Type-C cable from the Wilder-Tech microcontroller to the USB4 Test Fixture.
- **Downstream Facing Port (DFP):** Connect the DUT's UFP to any USB4 Host via the USB4 based USB-C® cable. The ETT tools can be loaded on the Scope with the GRL-USB4-TX-TEST software. In this case, the Wilder-Tech microcontroller is required. The DUT is controlled using a 0.8m USB Type-C cable from the Wilder-Tech microcontroller 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).*

**Disclaimer: USB Type-C® and USB-C® are registered trademarks of USB Implementers Forum.*

3.3 Download and Install Python (Applicable for Thunderbolt 3 DUT's Only)

1. Download the Python Version 2.7.x tool ("Windows x86-64 MSI Installer" for AMD64/x64) from https://www.python.org/downloads/.
2. Install Python 2.7.x to the "C:\Program Files\Intel Corporation\TenLira\tools" folder on the Scope.

3.4 Download and Install ActiveTcl (Applicable for Thunderbolt 3 DUT's Only)

Download the ActiveTcl Version 8.5.x tool from https://www.activestate.com/products/tcl/downloads/ and install on the Scope. *Note any version other than 8.5.x will not work properly.*

3.5 Download and Install MATLAB (Applicable for USB4 DUT's Only)

Download the MATLAB Version R2019b (9.7) tool from https://ch.mathworks.com/products/compiler/matlab-runtime.html and install on the Scope.

3.6 Download and Install FTDI Drivers (Applicable for USB4 DUT's Only)

Download the latest FTDI drivers from https://ftdichip.com/drivers/ and install on an external PC (where it is referred to as 'controller PC' hereafter).

4 Installing and Setting Up GRL-USB4-TX-TEST Software

This section provides the procedures for installing, configuring and verifying the operation of the GRL-USB4-TX-TEST software. It also helps you familiarize with the basic operation of the GRL software.

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

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

4.1 Download GRL-USB4-TX-TEST Software

Install, launch and set up the GRL-USB4-TX-TEST software on the Scope or a controller PC.

1. If using a controller PC, install VISA (Virtual Instrument Software Architecture) on to the controller PC where the GRL-USB4-TX-TEST is to be used.
2. Download the software ZIP file package from the Granite River Labs support site.
3. The ZIP file contains:
    - **USB4TxTestApplication0xxxxxxxxSetup** – Run this on the controller PC or Scope to install the GRL-USB4-TX-TEST application.
    - **USB4TxTestScopeSetupFilesInstallation0xxxxxxxxxSetup** – Run this on the Scope to install the proper Scope setup files.

4. Launch and set up the GRL software as follows:

   a) 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.

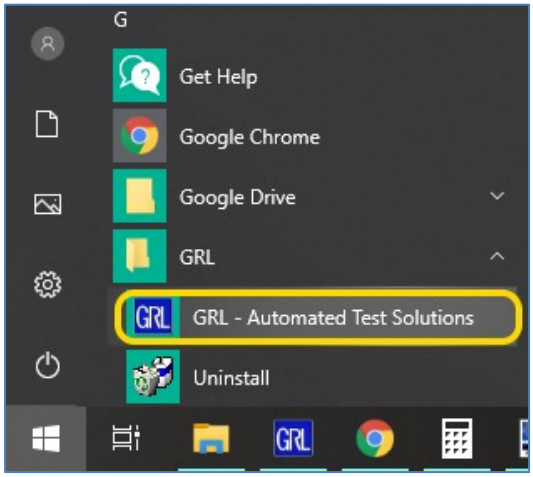


FIGURE 1. LAUNCHING GRL SOFTWARE FRAMEWORK

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

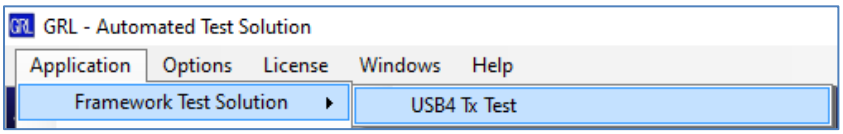


FIGURE 2. LAUNCHING USB4 TX TEST APPLICATION

To enable license, go to License → License Details.

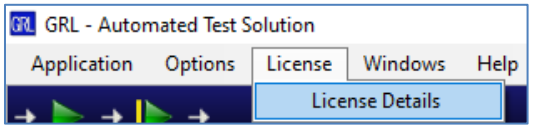


FIGURE 3. LICENSE DETAILS

Review the installed application.

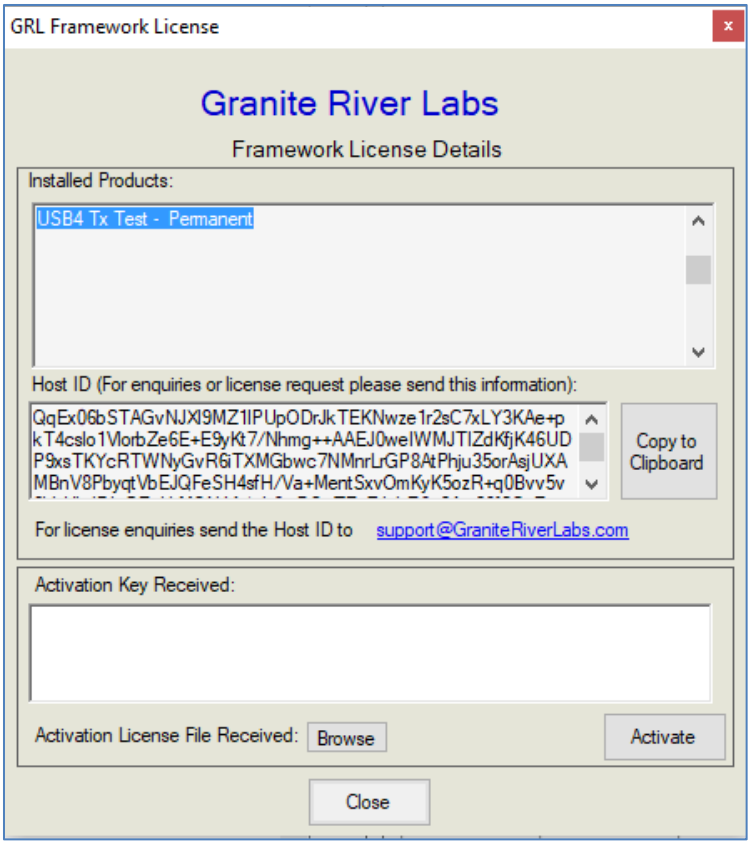


FIGURE 4. INSTALLED APPLICATION

Activate a License:

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

4.2 Connect Oscilloscope with Controller PC

4.2.1 Connect Keysight Oscilloscope

Connect the Keysight Scope with the controller 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 your controller PC.
2. When installed successfully, the IO icon ( ) will appear in the taskbar notification area of your controller PC.

3. Select the IO icon to launch the **Keysight Connection Expert**.
4. Click Rescan.

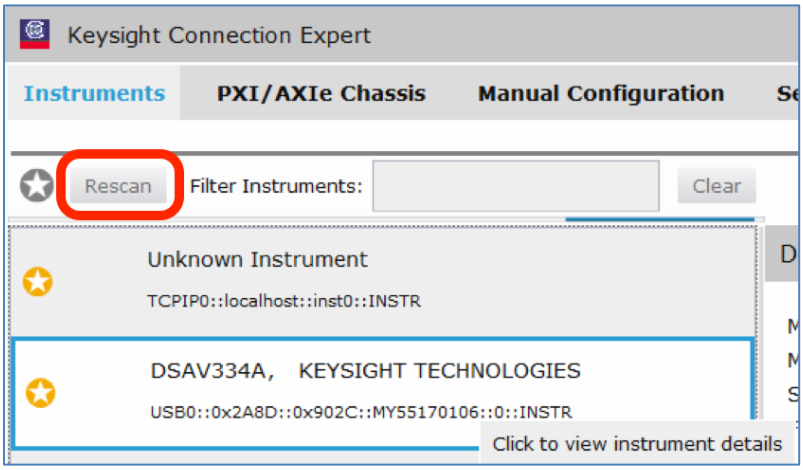


FIGURE 5. KEYSIGHT CONNECTION EXPERT

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

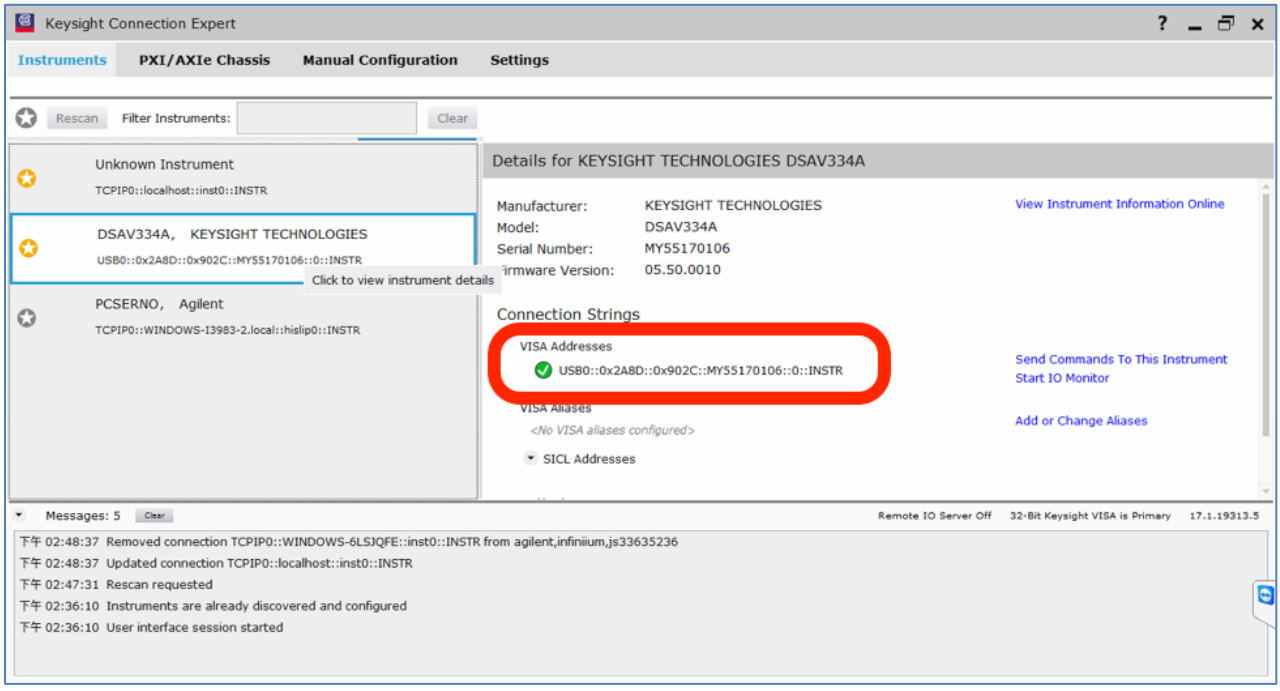


FIGURE 6. OSCILLOSCOPE'S VISA ADDRESS

6. When connecting the Keysight Scope to the controller PC through GPIB/USB, type in the VISA address into the 'Address' field on the Equipment Setup page of the GRL USB4 Tx Test Application. 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 controller 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”.

7. If the USB4 Tx Test Application is installed on the PC to control the Scope, set up the Remote File Server as described in Section 4.3.1.

4.2.2 Connect Tektronix Oscilloscope

Connect the Tektronix Scope with the controller 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.

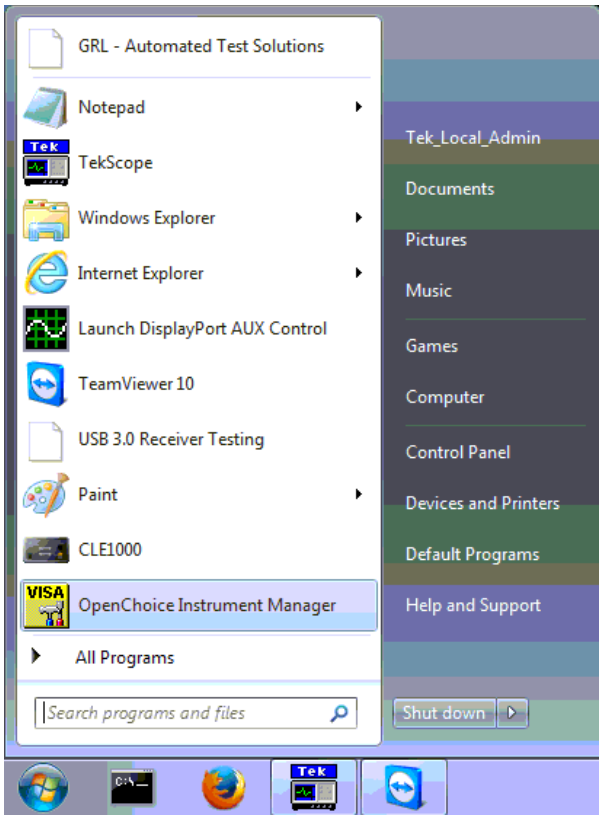


FIGURE 7. OPENCHOICE INSTRUMENT MANAGER IN START MENU

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.

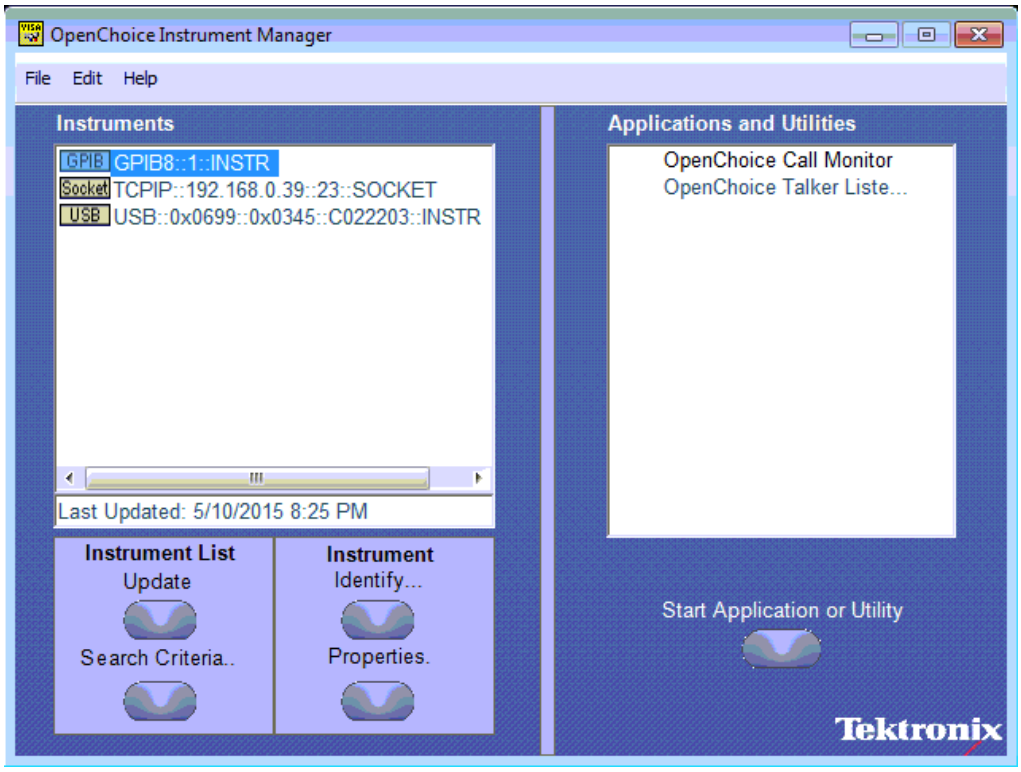


FIGURE 8. OPENCHOICE INSTRUMENT MANAGER MENU

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 USB4 Tx Test Application, type in the Scope address into the ‘Address’ field. 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::192.168.0.100::inst0::INSTR”. Note to ***omit*** the Port number from the address.
7. If the USB4 Tx Test Application is installed on the PC to control the Scope, set up the Remote File Server as described in Section 4.3.1.

4.3 Launch and Set Up GRL-USB4-TX-TEST Software

1. Launch GRL Host Application from Start Menu -> GRL -> GRL – Automated Test Solutions.
2. Select **Application** -> **Framework Test Solution** -> **USB4 Tx Test**.
3. Select the Equipment Setup icon  on the GRL USB4 Tx Test Application menu.
4. If the Oscilloscope is connected to control the PC using LAN, type in the IP Address of the Scope into the "Address" field and click the "lightning" button  . The "lightning" button should turn green  if successfully connected to the Scope.

   If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example "TCPIP0::192.168.0.100::inst0::INSTR". Note to **omit** the Port number from the address. *Refer Section 4.2.1 and 4.2.2 for more information on the Keysight and Tektronix Scope connection requirements.*
5. The "lightning" button should turn green if successfully connected to the Scope.

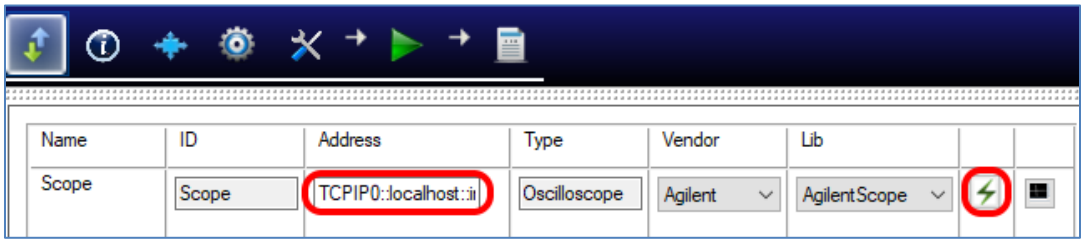


FIGURE 9. CONNECT GRL-USB4-TX-TEST SOFTWARE WITH SCOPE

4.3.1 Set Up Remote File Server

1. The **GRLRemoteProxyServer.exe** will also be installed along with the **USB4TxTestScopeSetupFilesInstallation0xxxxxxxxSetup.exe** on the Scope. The GRLRemoteProxyServer.exe is installed under the C:\GRL\GRLRemoteProxyServer directory.

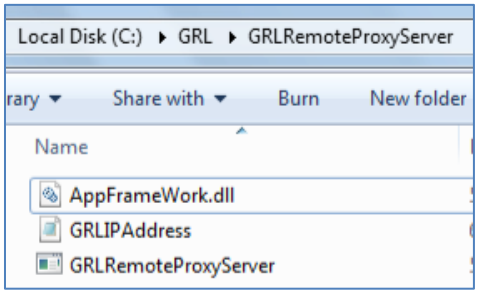


FIGURE 10. INSTALLED GRLREMOTEPROXYSERVER.EXE FILE DIRECTORY

2. If the GRL-USB4-TX-TEST software is installed on the PC to control the Scope and SigTest is selected as the test method to be used (refer Section 6.2), the GRLRemoteProxyServer.exe must be run on the Scope to move large waveform files back to the controller 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 controller PC and Scope are connected to the same network, using IP addresses as in following example:
   - Controller PC IP address: 192.168.100.8
   - Scope IP address: 192.168.100.35

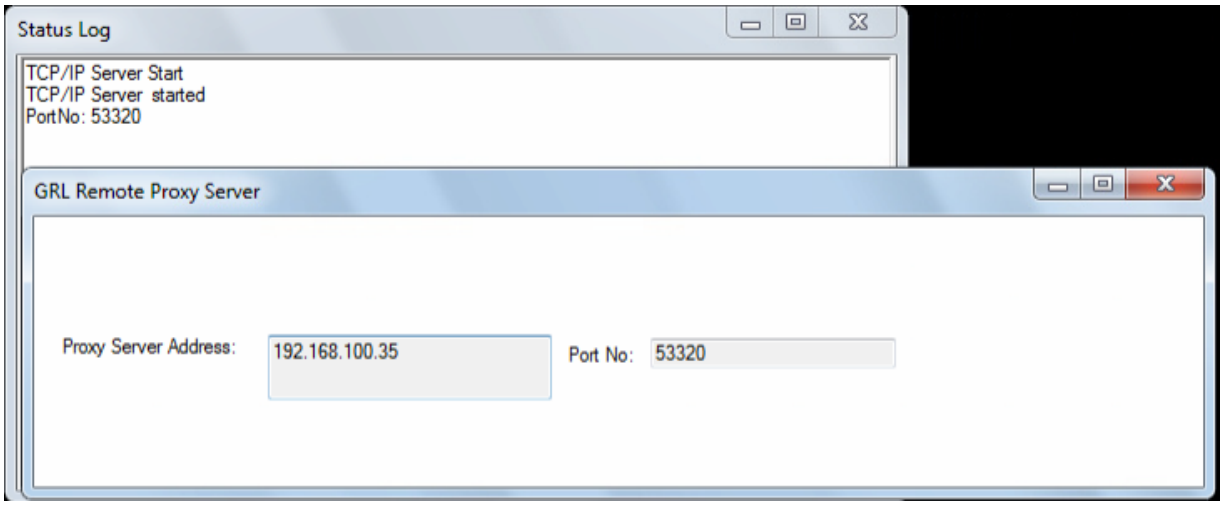


FIGURE 11. VERIFY PROXY SERVER CONNECTION FOR CONTROLLER PC AND SCOPE

4. On the GRL USB4 Tx Test Application, configure the "Remote File Server IP Address" and "Remote File Server Port No" parameters on the Configurations page to match the network settings of the GRL Remote Proxy Server as shown in the example below:

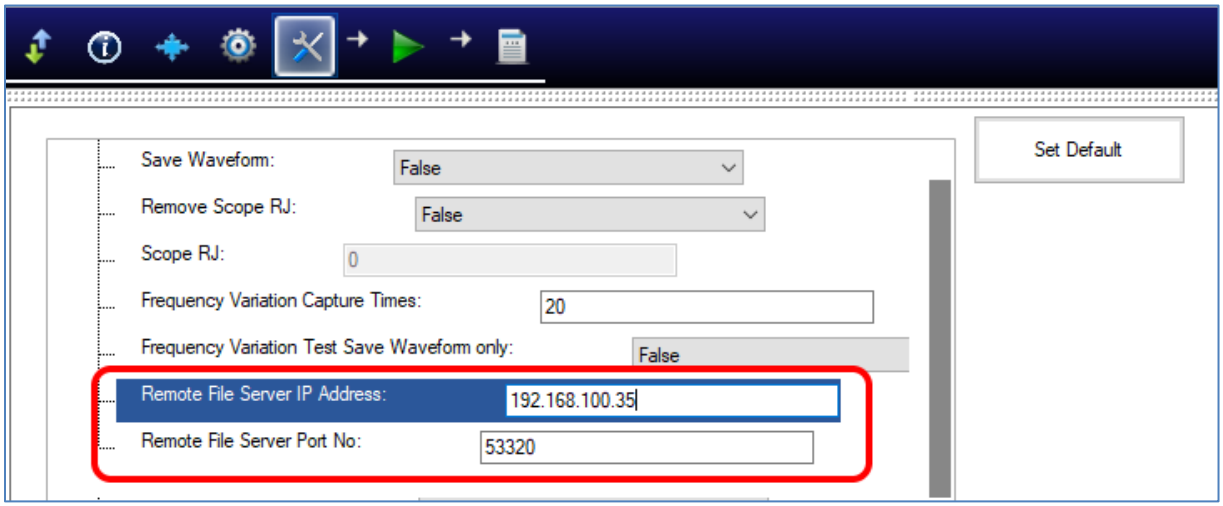


FIGURE 12. CONFIGURE GRL REMOTE PROXY SERVER NETWORK SETTINGS ON GRL SOFTWARE

Refer Section 7.5 for more details on parameters available on the Configurations page.

4.3.2 Session Info

Select the button in the main software menu to access the Test Session Info page.

The information provided will be included in the report.

- The **DUT Info** and **Test Info** are input by the user.
- The **Software Info** is automatically populated.

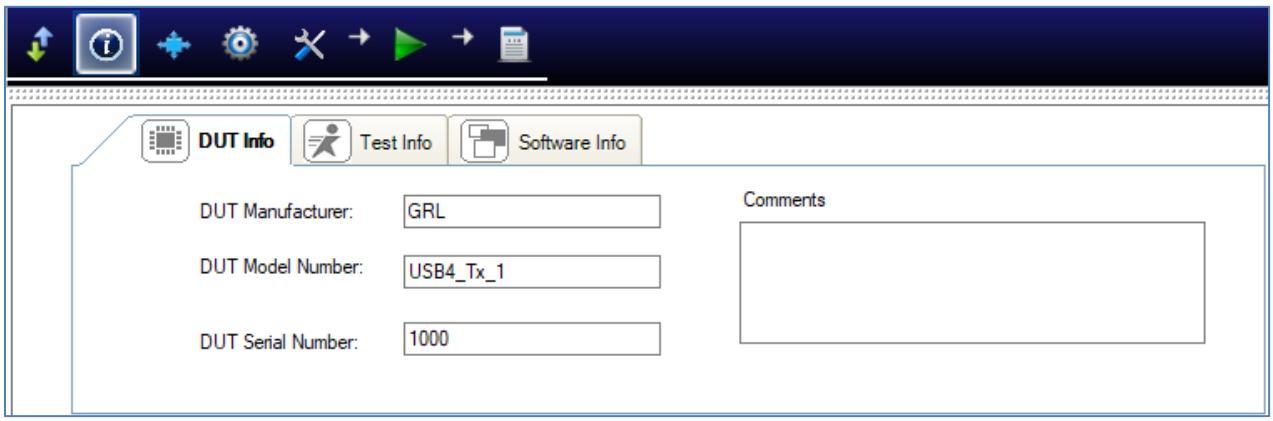


FIGURE 13. SESSION INFO

4.3.3 Test Conditions

Select the  button in the main software menu to access the Test Conditions page.

a) **Lane tab**: Select the DUT Port(s) and Lane(s) to be tested.

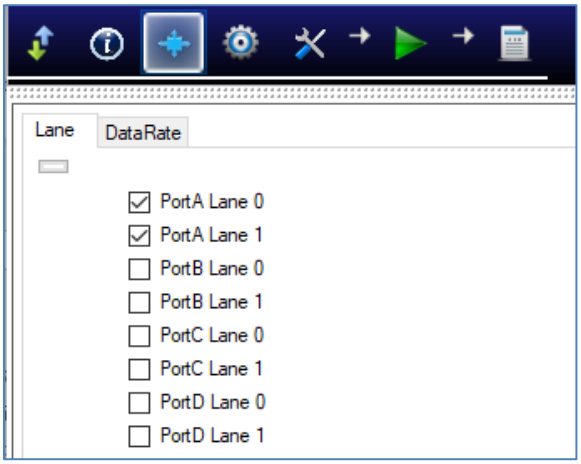


FIGURE 14. SELECT DUT TEST PORT(S) AND LANE(S)

b) **Data Rate tab**: Select the desired data rates.

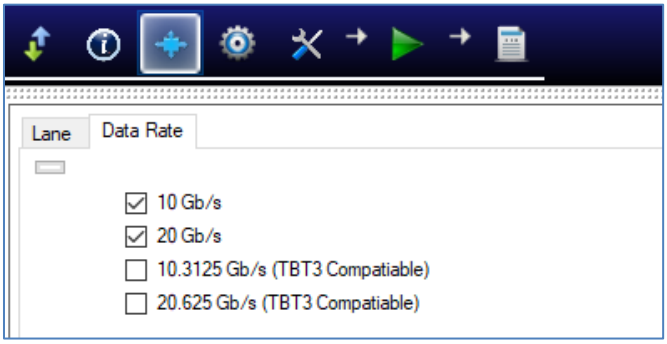


FIGURE 15. SELECT DATA RATE(S)

5 USB4 Transmitter Compliance Test Setups

This section describes the automation test environment setups for the USB4/Thunderbolt™ 3 host/device DUT transmitter using the USB4/Thunderbolt 3 microcontroller or remote test script method. If using the microcontroller method, the microcontroller will directly control the host/device DUT by executing microcontroller test scripts. If a remote test script is being used *(only applicable for the Thunderbolt 3 DUT)*, the test script is loaded onto the host DUT or a Thunderbolt 3 remote host (for the device DUT) which will run the test script during testing.

Note that the test method may be different between host and device DUT's. It is recommended to refer to the release notes of the test scripts being used on how to run the scripts for the host/device DUT.

A Thunderbolt 3 Host can be tested by loading Intel's TenLira directly on the Thunderbolt 3 DUT; a 2-Port Thunderbolt 3 device can be tested using any Thunderbolt 3 Host as a Remote Host Controller; or the Wilder-Tech Microcontroller can be used to test any Thunderbolt 3 Host or Device Port.

[Note: The 2-Port Thunderbolt 3 device test setup is ONLY applicable for the Thunderbolt 3 environment.]

A USB4 Host can be tested by loading USB4 ETT tools directly on the USB4 DUT; or the Wilder-Tech Microcontroller can be used to test any Host or Device Port.

Follow the steps in the below section for setup depending on the configuration chosen.

While running tests, the GRL-USB4-TX-TEST software will guide the user through each of the selected tests by providing step-by-step instructions.

Before proceeding with the following sections, first make sure to de-skew SMA cables through the Scope using a Power Divider:

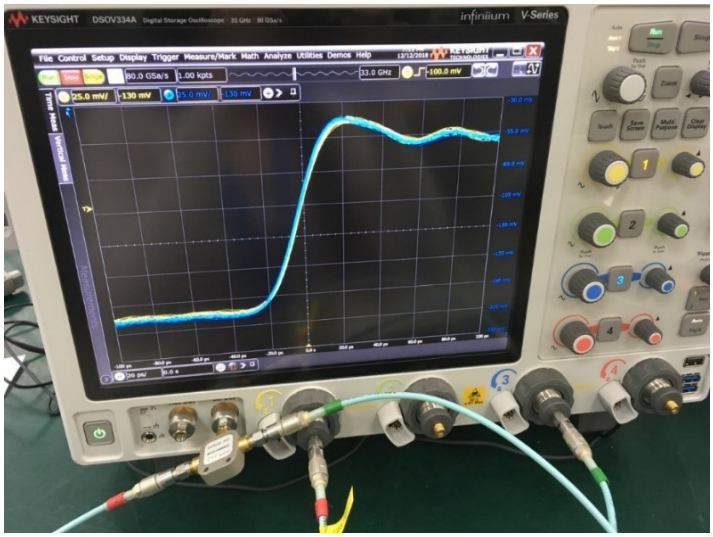


FIGURE 16. PERFORMING SMA CABLE DESKEW

5.1 Host DUT Setup Using Itself as Port Controller

If testing a Host, and the TenLira or ETT tools have been loaded on the Host DUT, follow the below procedure:

1. Connect the equipment as follows:

   Note: Make sure the Power Supply is connected to the USB Type-C Plug Fixture and LED's are lit before connecting to the DUT.

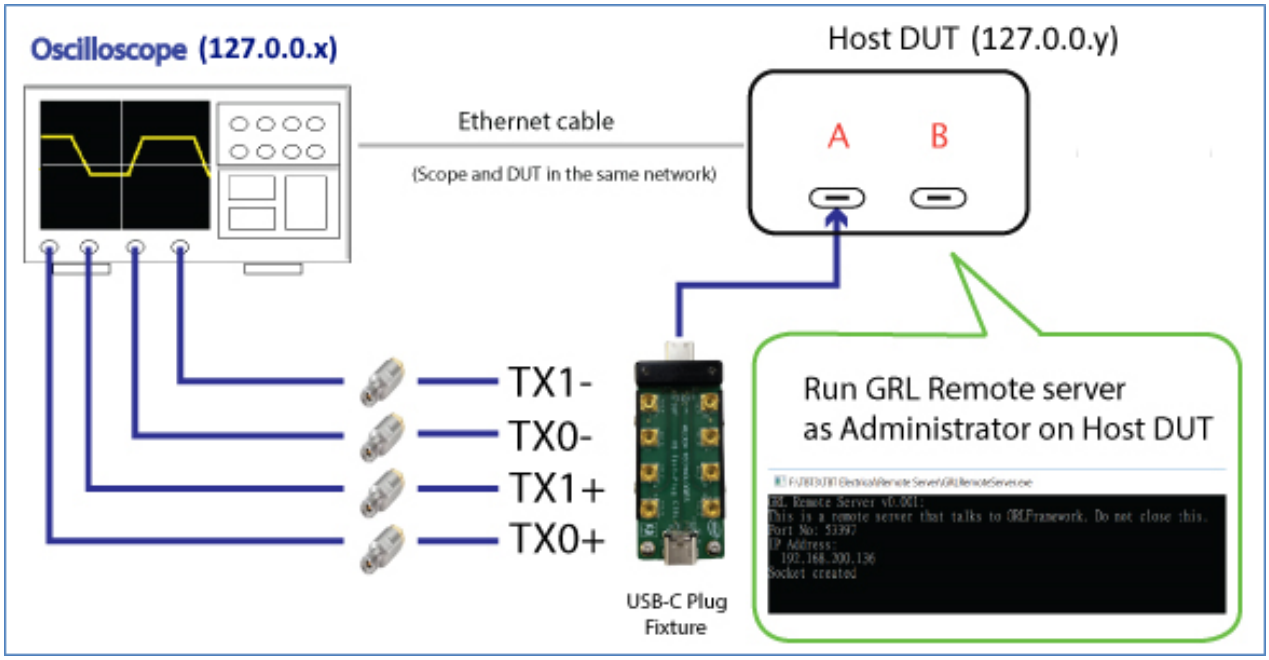
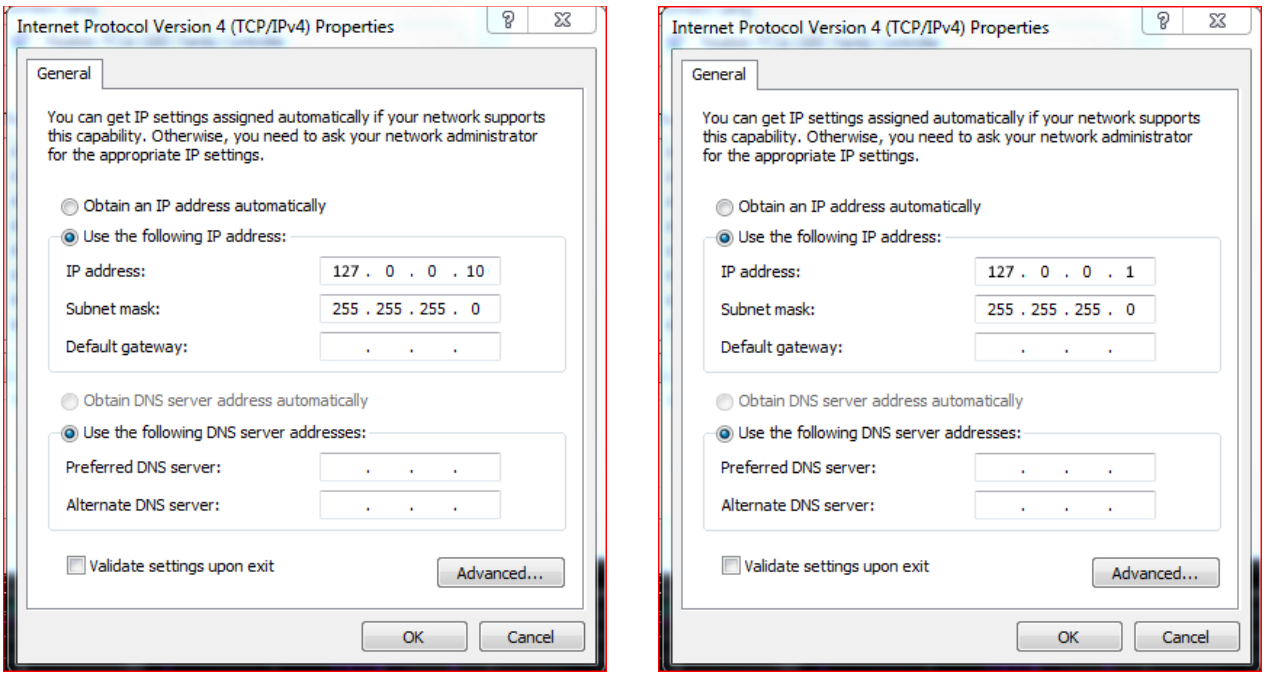


FIGURE 17. TEST SETUP FOR HOST DUT

   a) Connect both the Scope and Host DUT with an Ethernet cable to the same network e.g., using configuration of Scope IP: 127.0.0.1 and Host DUT IP: 127.0.0.10 (refer step 2 below).
   b) Attach the USB-C plug fixture to the DUT Port under test (Port A or Port B).
   c) Connect the Scope channel 1/channel 3 to Tx0+/Tx0- of the USB-C plug fixture through 2.92mm-to-SMP adapters.
   d) Connect the Scope channel 2/channel 4 to Tx1+/ Tx1- of the USB-C plug fixture through 2.92mm-to-SMP adapters.

2. Set up the network environment and remote server as follows:

   a) Connect both the Scope and Host DUT to the same router via Ethernet. Make sure they belong in the same network group using the following example:



Host DUT **Scope**

FIGURE 18. SETTING HOST DUT AND SCOPE NETWORK EXAMPLE

b) Install “GRL Remote Server” on the Host DUT.
c) Run “GRL Remote Server” as administrator.

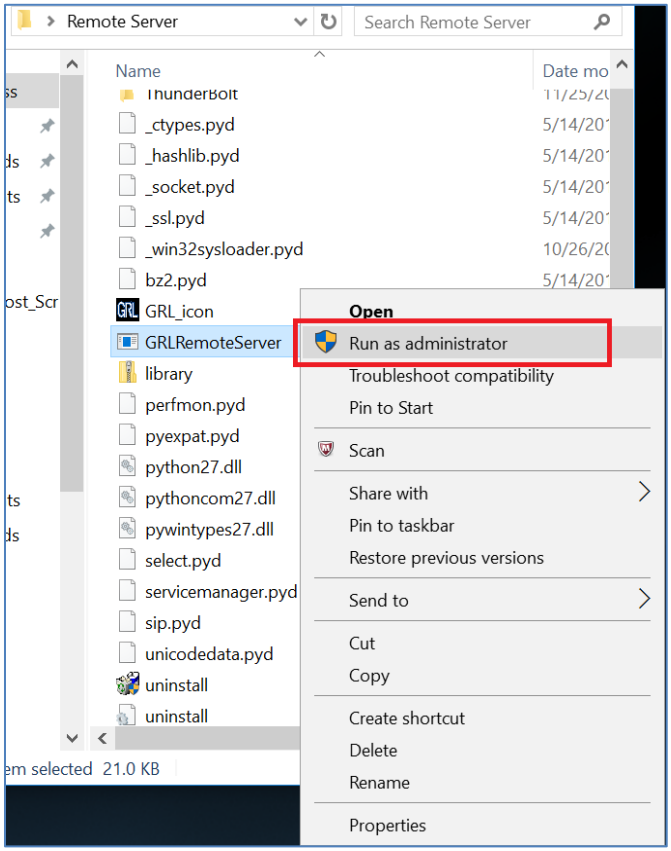


FIGURE 19. RUN GRL REMOTE SERVER AS ADMINISTRATOR ON HOST DUT

d) Copy the USB4 host test scripts to the Host DUT.

e) On the main GRL software menu, select the  button to access the Configurations page.
f) Select "Host" in the **DUT Type** field.
g) Select the version of the test script in the **Script Version** field (refer Section 7.5). If the ETT test script is selected, select "True" to **Run ETT with Tiger Lake** processor if supported by the Host DUT.
h) Select "Remote" in the **USB4 Electrical Scripts Controller** field.
i) Enter the remote server's port number in the **USB4 Electrical Scripts Remote Server Port Number** field.
j) Enter the remote server's IP address (e.g., 127.0.0.1) in the **USB4 Electrical Scripts Remote Server IP Address** field.
k) Specify the directory of the USB4 test script on the Host DUT in the **USB4 Electrical Scripts Remote Path** field.

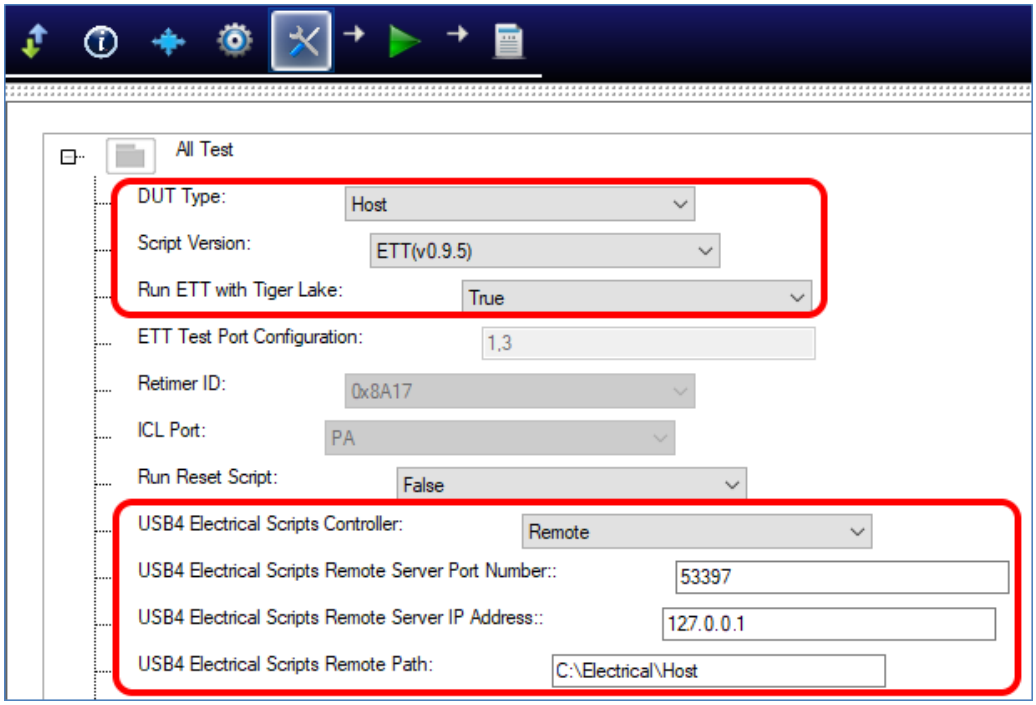


FIGURE 20. CONFIGURE REMOTE HOST DUT EXAMPLE IN GRL-USB4-TX-TEST SOFTWARE

5.2 2-Port Thunderbolt 3 Device DUT Setup Using Any Thunderbolt 3 Host as Port Controller (Applicable for the Thunderbolt 3 DUT Only)

If testing a 2-Port Thunderbolt 3 Device using a Thunderbolt 3 Host as a Remote Controller, the TenLira tools must be loaded on the Thunderbolt 3 remote Host; then follow the below procedure.

[Note: The 2-Port Thunderbolt 3 Device DUT test setup is ONLY applicable for the Thunderbolt 3 environment.]

To set up a 2-Port Thunderbolt 3 Device DUT, connect the device DUT to a Thunderbolt 3 remote Host as described below.

1. Connect the following equipment. *(Note that the non-test port of the device DUT is connected to a Thunderbolt 3 remote host using a compatible Thunderbolt 3 based USB Type-C cable. The DUT's port under test is connected to the Thunderbolt 3 based USB Type-C plug fixture.)*

   Note: Make sure the Power Supply is connected to the Thunderbolt 3 based USB Type-C Plug Fixture and LED's are lit before connecting to the DUT.

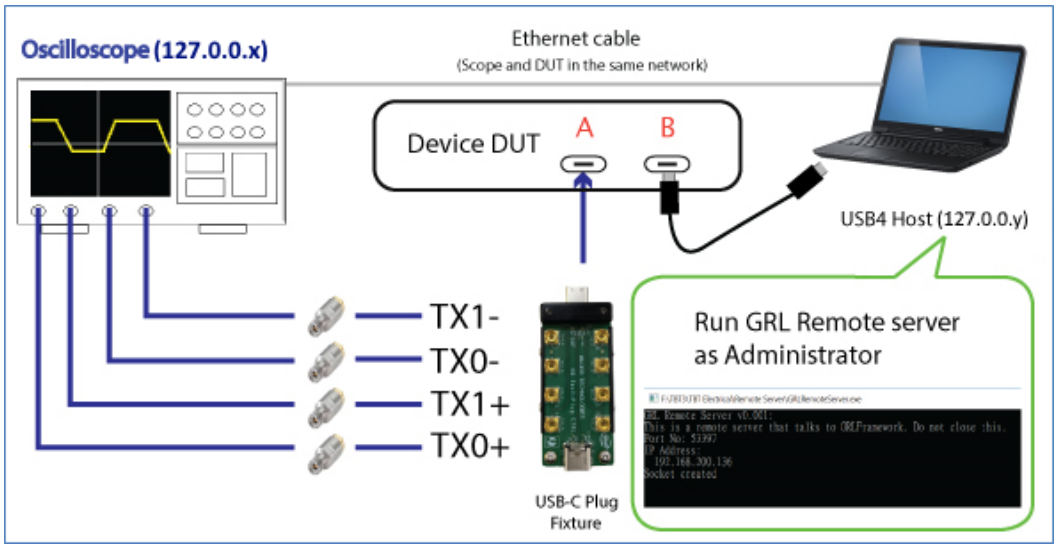
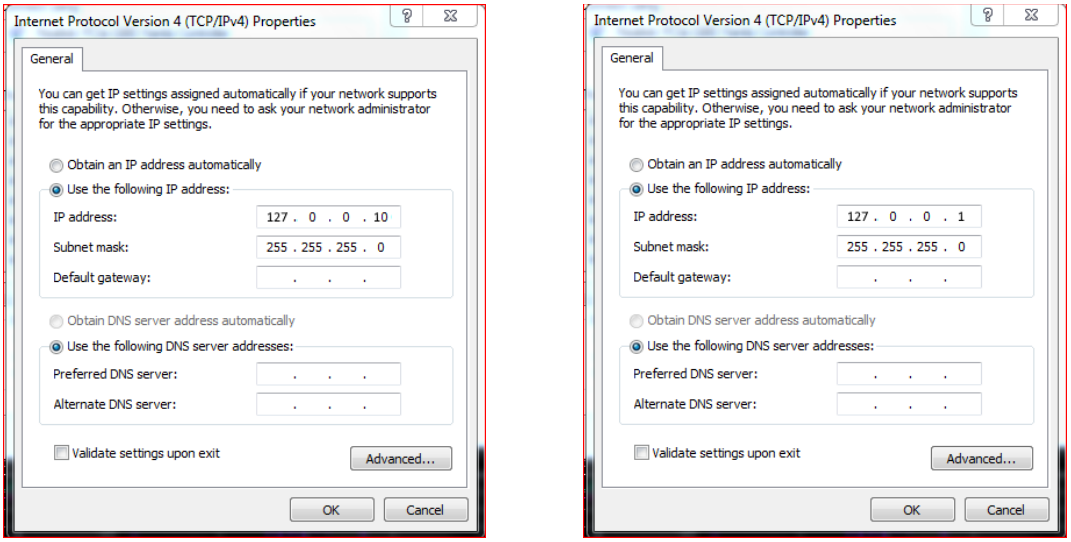


FIGURE 21. TEST SETUP FOR 2-PORT THUNDERBOLT 3 DEVICE DUT USING THUNDERBOLT 3 HOST PC AS CONTROLLER

   a) Connect the non-test port of the device DUT to a Thunderbolt 3 remote Host using a compatible Thunderbolt 3 based USB Type-C cable.
   b) Connect both the Scope and Thunderbolt 3 remote Host with an Ethernet cable to the same network e.g., using configuration of Scope IP: 127.0.0.1 and Host DUT IP: 127.0.0.10 (refer step 2 below).
   c) Attach the Thunderbolt 3 based USB Type-C plug fixture to the DUT Port under test (Port A or Port B).
   d) Connect the Scope channel 1/channel 3 to Tx0+/Tx0- of the USB-C plug fixture through 2.92mm-to-SMP adapters.
   e) Connect the Scope channel 2/channel 4 to Tx1+/ Tx1- of the USB-C plug fixture through 2.92mm-to-SMP adapters.

2. Set up the network environment and remote server as follows:

   a) Connect both the Scope and Thunderbolt 3 remote Host to the same router via Ethernet. Make sure they belong in the same network group using the following example:



Thunderbolt 3 Remote Host **Scope**

FIGURE 22. SETTING THUNDERBOLT 3 REMOTE HOST AND SCOPE NETWORK

b) Install "GRL Remote Server" on the Thunderbolt 3 remote host.
c) Run "GRL Remote Server" as administrator.

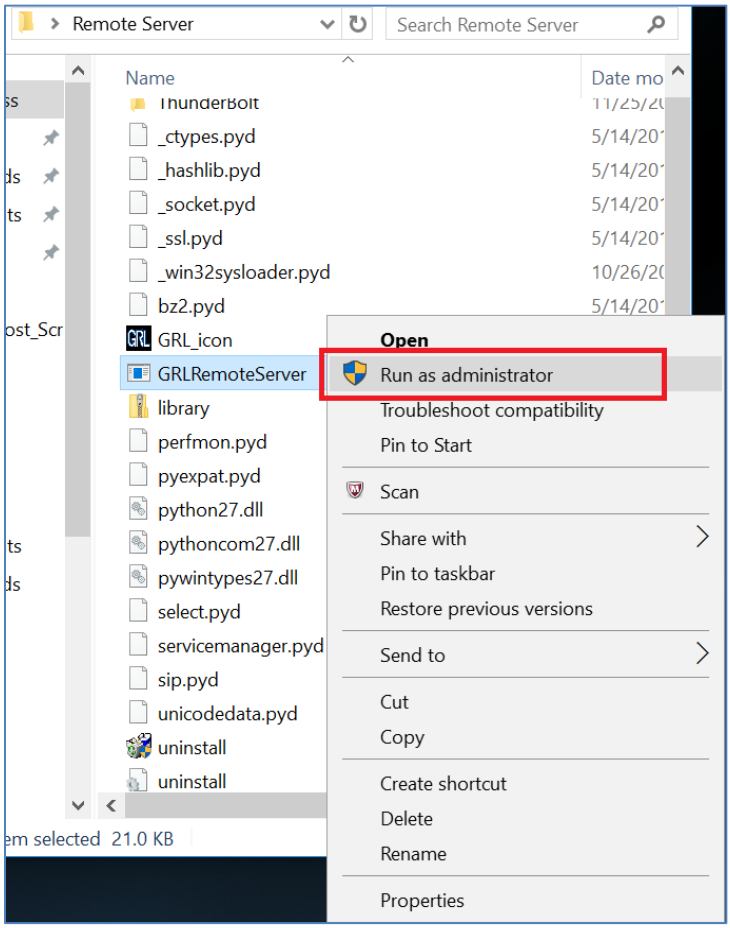


FIGURE 23. RUN GRL REMOTE SERVER AS ADMINISTRATOR ON THUNDERBOLT 3 REMOTE HOST

d) Copy the Thunderbolt 3 device test scripts to the Thunderbolt 3 remote Host.

e) On the main GRL software menu, select the  button to access the Configurations page.
f) Select “Device” in the **DUT Type** field.
g) Select the version of the test script in the **Script Version** field (refer Section 7.5).
h) Select “Remote” in the **USB4 Electrical Scripts Controller** field.
i) Enter the remote server’s port number in the **USB4 Electrical Scripts Remote Server Port Number** field.
j) Enter the remote server’s IP address (e.g., 127.0.0.1) in the **USB4 Electrical Scripts Remote Server IP Address** field.
k) Specify the directory of the test script on the Thunderbolt 3 remote Host in the **USB4 Electrical Scripts Remote Path** field.

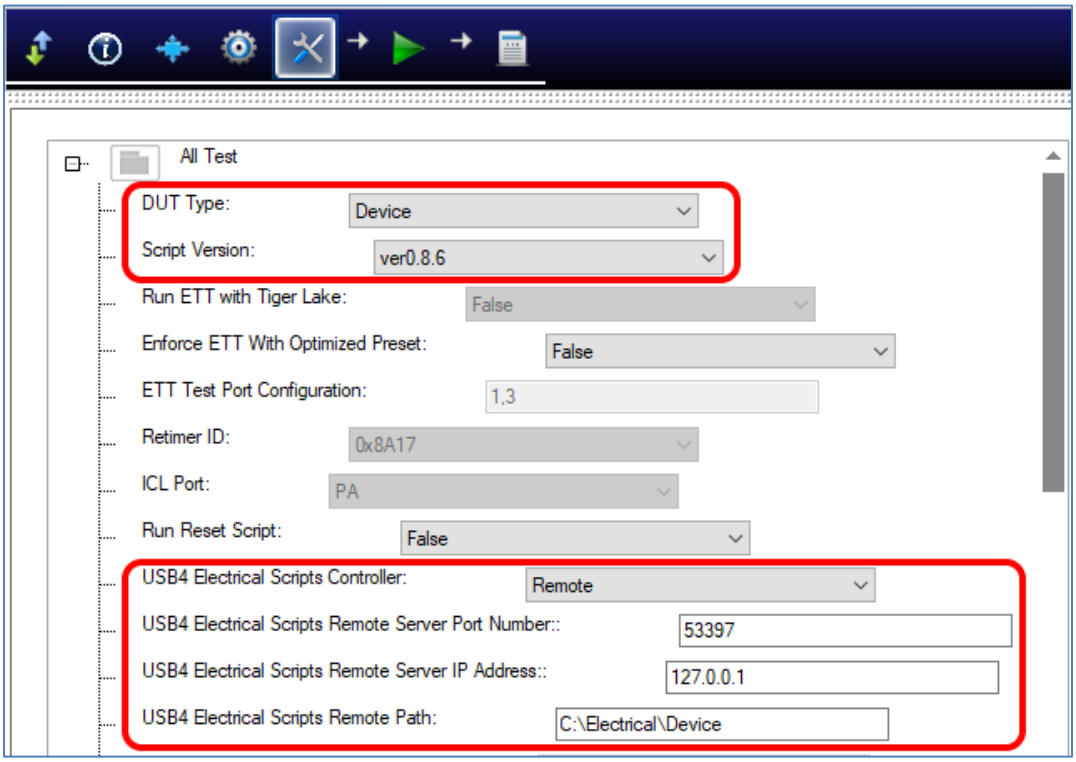


FIGURE 24. CONFIGURE THUNDERBOLT 3 REMOTE HOST FOR 2-PORT THUNDERBOLT 3 DEVICE DUT IN GRL-USB4-TX-TEST SOFTWARE

5.3 Setup For Any Host/Device DUT When Using USB4/Thunderbolt 3 Microcontroller

The Wilder-Tech USB4/Thunderbolt 3 microcontroller can be used to directly control any USB4/Thunderbolt 3 Host/Device DUT (Host, 2-Port Device, or 1-Port Device). The TenLira or ETT tools in this case are installed on the Scope/controller PC where the GRL-USB4-TX-TEST software is loaded. The Scope/controller PC is connected to the microcontroller through a USB cable. A USB-C cable is connected between the USB-C plug fixture and microcontroller to control the DUT.

The following procedure shows how to set up the test environment using the Wilder-Tech USB4/Thunderbolt 3 microcontroller.

1. Connect the equipment for USB4 test setup as follows:

   Note: Make sure the Power Supplies are connected to the USB-C Plug Fixture and the Microcontroller; and LED's are lit before connecting to the DUT.

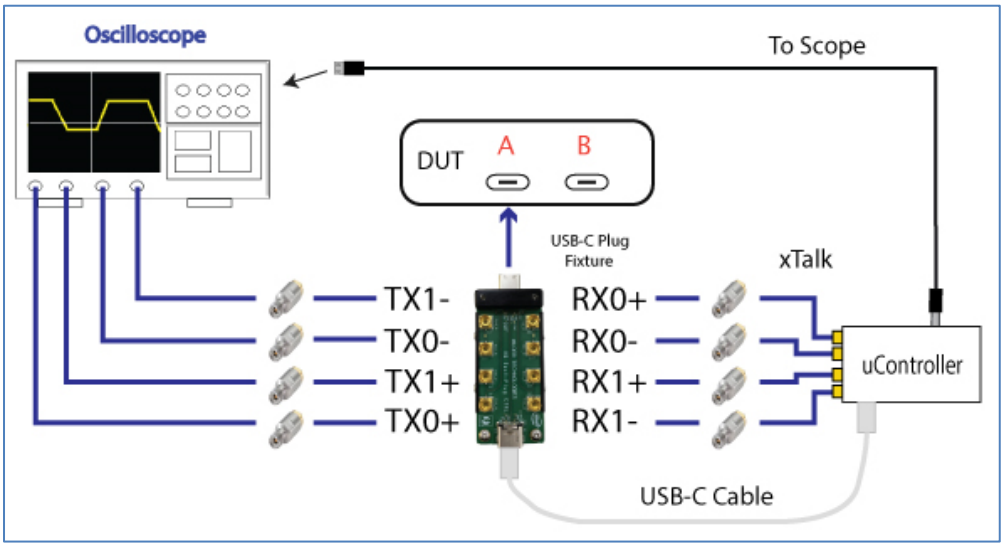


FIGURE 25. TEST SETUP WITH USB4 MICROCONTROLLER

   a) Connect the USB Type-B port of the microcontroller to the USB Type-A connector on the Scope or controller PC using a USB cable. (Note the Scope is used in this test setup.)
   b) Connect the USB-C receptacle port of the USB-C plug fixture to Port A of the microcontroller using a USB-C cable.
   c) Attach the USB-C plug fixture to the DUT Port under test (Port A or Port B).
   d) Connect the Scope channel 1/channel 3 to Tx0+/Tx0- of the USB-C plug fixture through 2.92mm-to-SMP adapters.
   e) Connect the Scope channel 2/channel 4 to Tx1+/ Tx1- of the USB-C plug fixture through 2.92mm-to-SMP adapters.
   f) Connect the microcontroller SMA output ports to Rx0+/Rx0-/Rx1+/Rx1- of the USB-C plug fixture through 2.92mm-to-SMP adapters for crosstalk generation.

2. Set up the test environment as follows:

   a) Copy the USB4 microcontroller test scripts to the controller PC.

   b) On the main GRL software menu, select the  button to access the Configurations page.
   c) Select the type of DUT being used in the **DUT Type** field.
   d) Select the version of the test script in the **Script Version** field (refer Section 7.5).
   e) If "Host" is selected as the **DUT Type** and if the ETT test script is selected in **Script Version**, select "True" to **Run ETT with Tiger Lake** processor if supported by the Host DUT.
   f) If "Device" is selected as the **DUT Type** and if the ETT test script is selected in **Script Version**, specify the test connector lanes to validate **ETT Test Port Configuration** for the Device DUT.

g) Select “uController” in the **USB4 Electrical Scripts Controller** field.
h) Specify the directory of the microcontroller test script on the controller PC in the **USB4 Electrical Scripts Local Path** field.

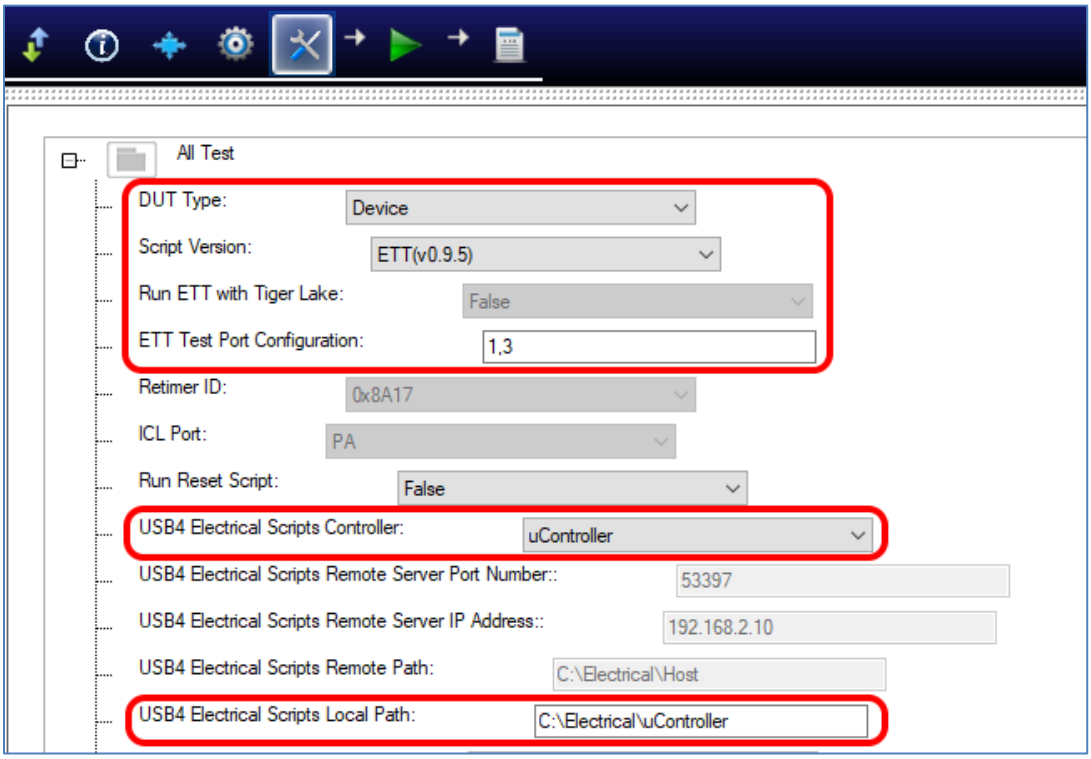


FIGURE 26. CONFIGURE USB4 MICROCONTROLLER EXAMPLE IN GRL-USB4-TX-TEST SOFTWARE

3. Connect the equipment for Thunderbolt 3 test setup as follows:

Note: Make sure the Power Supplies are connected to the USB-C Plug Fixture and the Microcontroller; and LED’s are lit before connecting to the DUT.

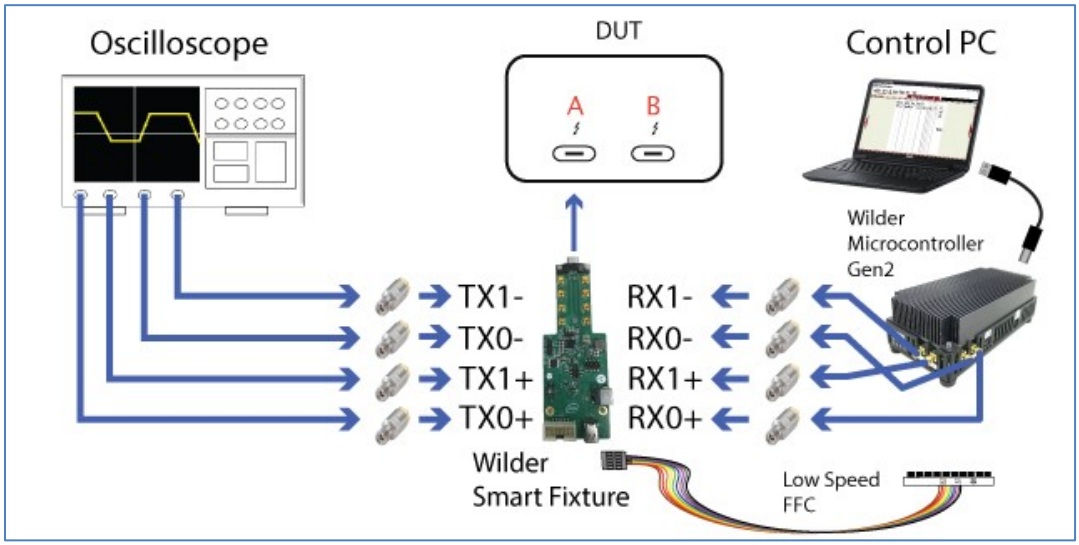


FIGURE 27. TEST SETUP WITH THUNDERBOLT 3 MICROCONTROLLER

a) Connect the USB Type-B port of the microcontroller to the USB Type-A connector on the Scope or controller PC using a USB cable.

b) Connect the Thunderbolt 3 based USB Type-C plug fixture to the microcontroller using a low speed FFC cable.

c) Attach the Thunderbolt 3 based USB Type-C plug fixture to the DUT Port under test (Port A or Port B).

d) Connect the Scope channel 1/channel 3 to Tx0+/Tx0- of the Thunderbolt 3 based USB Type-C plug fixture through 2.92mm-to-SMP adapters.

e) Connect the Scope channel 2/channel 4 to Tx1+/ Tx1- of the Thunderbolt 3 based USB Type-C plug fixture through 2.92mm-to-SMP adapters.

f) Connect the microcontroller SMA output ports to Rx0+/Rx0-/Rx1+/Rx1- of the Thunderbolt 3 based USB Type-C plug fixture through 2.92mm-to-SMP adapters for crosstalk generation.

4. Set up the test environment as follows:

a) Copy the Thunderbolt 3 microcontroller test scripts to the control PC.

b) On the main GRL software menu, select the  button to access the Configurations page.

c) Select the type of DUT being used in the **DUT Type** field.

d) Select the version of the test script in the **Script Version** field (refer Section 7.5).

e) Select "uController" in the **USB4 Electrical Scripts Controller** field.

f) Specify the directory of the microcontroller test script on the controller PC in the **USB4 Electrical Scripts Local Path** field.

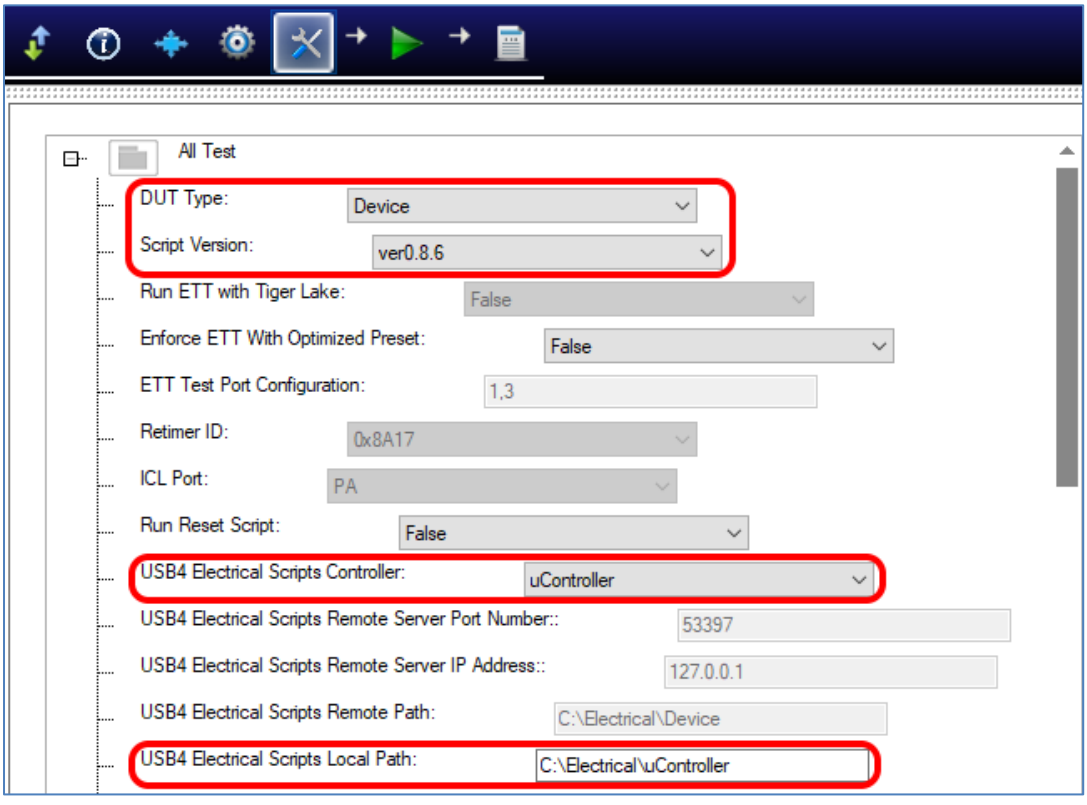


FIGURE 28. CONFIGURE THUNDERBOLT 3 MICROCONTROLLER EXAMPLE IN GRL-USB4-TX-TEST SOFTWARE

6 Calibrating with GRL-USB4-TX-TEST Software

6.1 Select Calibration

The Calibration/Tests selection panel allows calibration and 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 calibration is not completed, the subsequent test runs will show an error message.

The USB4 transmitter should go through a Preset calibration before being tested for compliance. The preset calibration is performed by stepping through preset coefficients of 0 to 15 to obtain an optimized preset which yields the lowest number of DDJ. For the TP3 test case, equalization range of CTLE 0 to -9 will also be applied. A reference equalization will be applied on the oscilloscope to find the optimized eye diagram using the best equalization parameters.

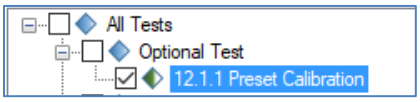


FIGURE 29. SELECT PRESET CALIBRATION

Select the "12.1.1 Preset Calibration" checkbox to perform preset calibration for the USB4 transmitter. The GRL-USB4-TX-TEST software will walk through the user step by step while calibration is being run.

Note: The marking shown on the left of each calibration/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 ✓.

6.2 Setup Configuration

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

- **Tx Preset Calibration** tab: Select from the preset coefficient range of 0 to 15 to be applied in the Preset calibration (see Figure 29 above).

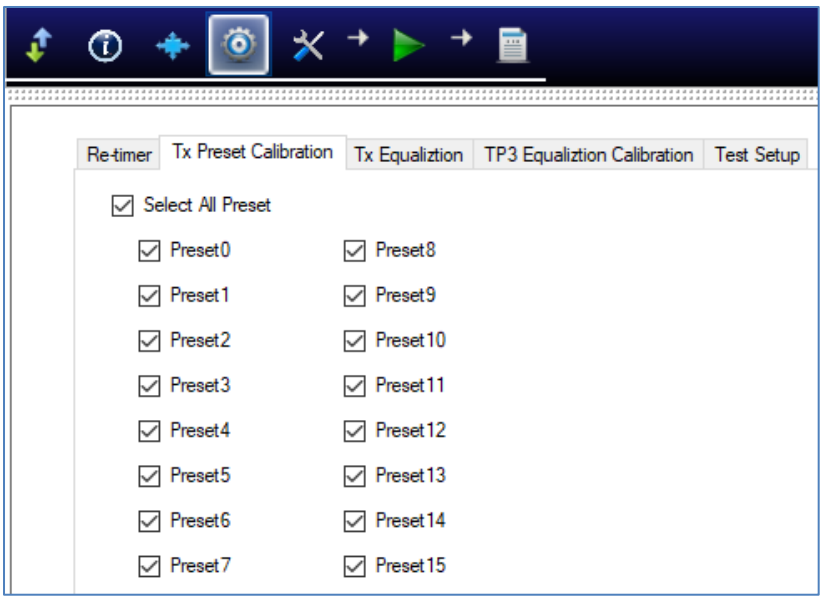


FIGURE 30. SELECT TX PRESET CALIBRATION COEFFICIENT

- **Tx Equalization** tab: Select from the preset coefficient range of 0 to 15 to be applied when running the "3.3.1/3.4.1 Gen2/Gen3 Transmitter Equalization". This is to ensure that the transmitter equalization Pre-shoot/ De-emphasis falls within the limits of the USB4 specification.

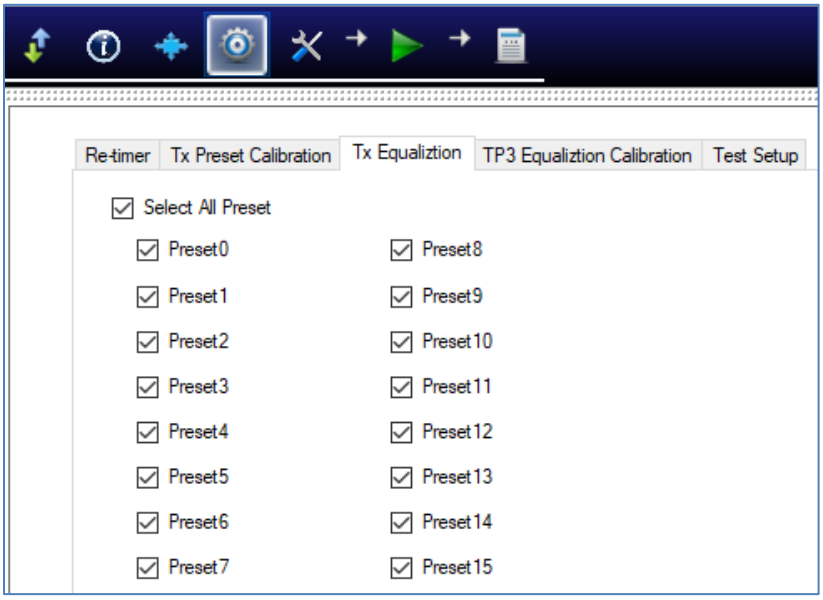


FIGURE 31. SELECT TX EQUALIZATION PRESET COEFFICIENT

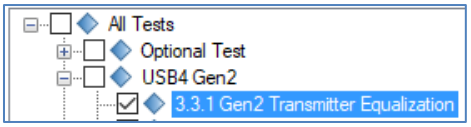


FIGURE 32. SELECT 3.3.1 GEN2 TRANSMITTER EQUALIZATION

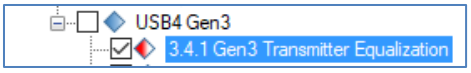


FIGURE 33. SELECT 3.4.1 GEN3 TRANSMITTER EQUALIZATION

[Note: If SigTest is selected as the test method, equalization must be performed for all presets. The GRL software will run equalization for all presets for the USB4 Gen2 & Gen3 Transmitter Equalization tests.]

- **TP3 Equalization Calibration** tab: Select from the equalization range of CTLE 0 to -9 to be applied when running the "Gen2/Gen3 TP3 Equalization Calibration". A reference equalization will be applied on the oscilloscope to find the optimized eye diagram using the best equalization parameters.

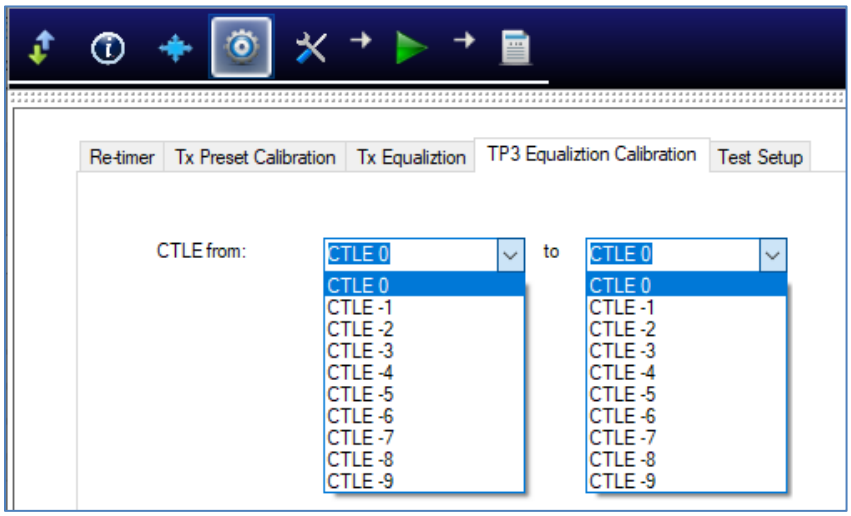


FIGURE 34. SELECT TX EQUALIZATION PRESET COEFFICIENT

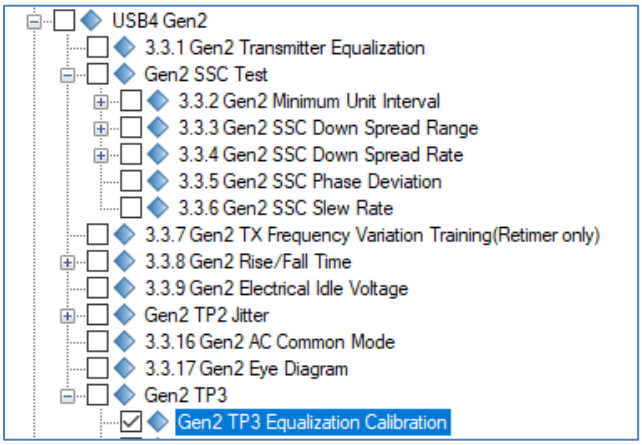


FIGURE 35. SELECT GEN2 TP3 EQUALIZATION CALIBRATION

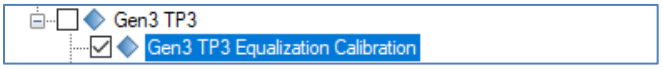


FIGURE 36. SELECT GEN3 TP3 EQUALIZATION CALIBRATION

- **Test Setup** tab: Select to use either the "SigTest" or "Scope" tool as the test measurement method.

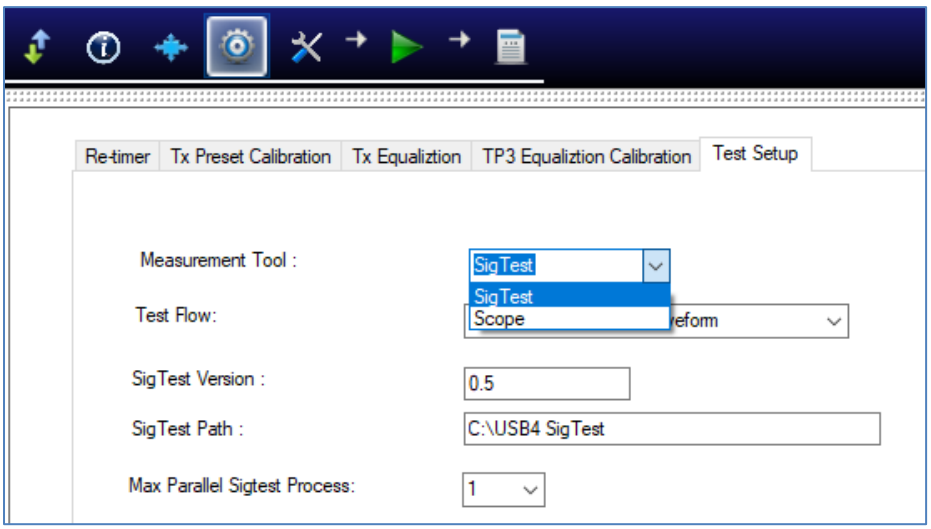


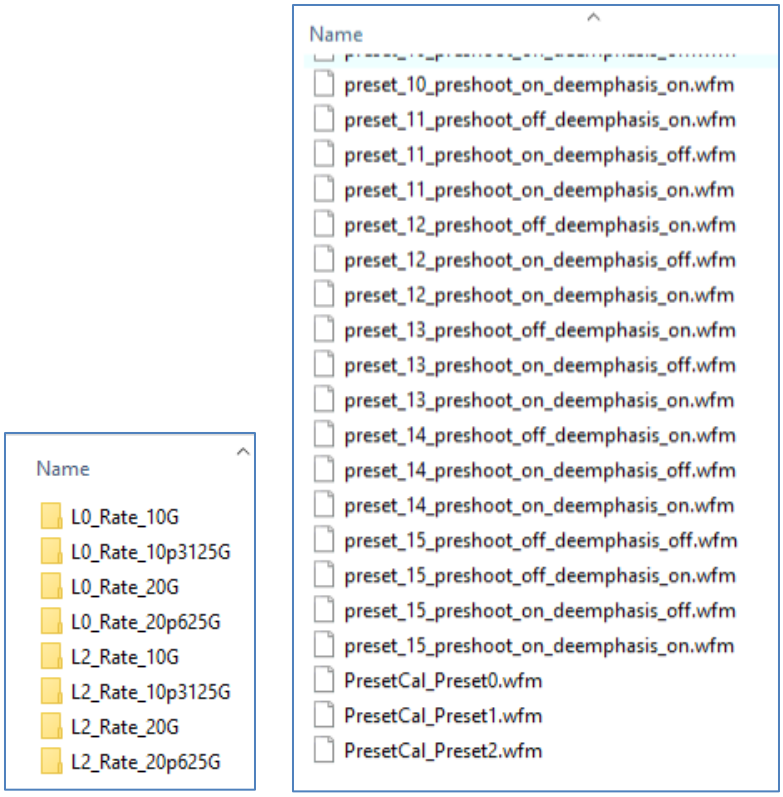
FIGURE 37. SET UP TEST MEASUREMENT TOOL

  - **SigTest** method: This method is supported by both the Keysight and Tektronix oscilloscopes. The GRL-USB4-TX-TEST software will control the scope to capture USB4 transmitter signals and use the SigTest tool to post-process and analyze test results automatically.
  - **Scope** method: This method is only supported by the Keysight oscilloscope. The GRL-USB4-TX-TEST software will control the scope to measure and analyze USB4 transmitter signals and generate test results automatically.

  If the **SigTest** method is selected, configure the following settings. *[Note: These settings are only applicable for SigTest.]*

  - **Test Flow**:
    - **Acquire and Process Waveform**: This option will capture waveform signals and perform SigTest analysis at the same time for selected tests.
    - **Acquire Waveform Only**: This option will only capture waveform signals for selected tests and will not perform SigTest analysis.
    - **Offline Process Waveform Only**: This option will only perform SigTest analysis on existing waveform signals which have been previously saved under a specific file directory.

      Captured waveforms should be saved under the *"C:\GRL\Framework Test Solution\Applications\USB4_TxTest\AppData\Waveforms"* file directory as shown in the following example:



- **SigTest Version**: Enter the version of the SigTest tool to be used.
- **SigTest Path**: Enter the folder path of the SigTest tool to be used.
- **Max Parallel SigTest Process**: Select how many times SigTest is to be run at a time.

6.3 Run Calibration

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

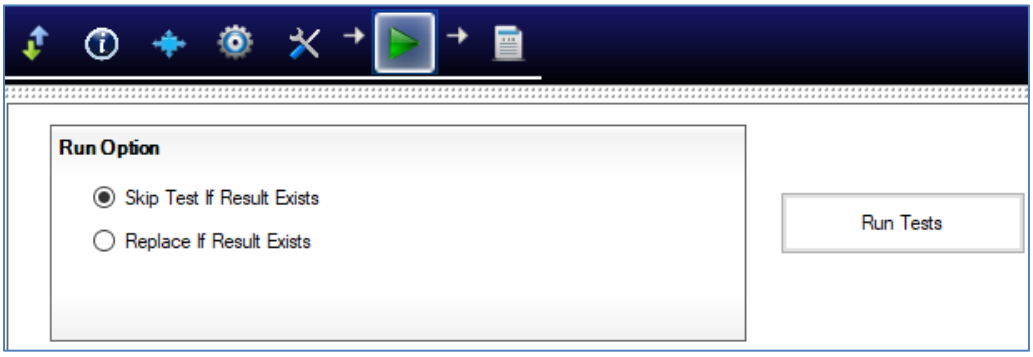


FIGURE 38. RUN TESTS PAGE

TABLE 4. RUN OPTIONS

Run Option	Description
Skip Test If Result Exists	If previous test or calibration results exist, then the software will *skip* the tests/calibration steps that have existing reports.
Replace If Result Exists	If previous test or calibration results exist, then the software will replace each step in the test/calibration with new results.

If you need to re-run only certain calibration/tests on certain conditions, delete these calibration/tests from the Report page and Run with **Skip Test If Result Exists**. The GRL-USB4-TX-TEST software will keep track and only perform the calibration/tests that are missing in the report. See figure example below.

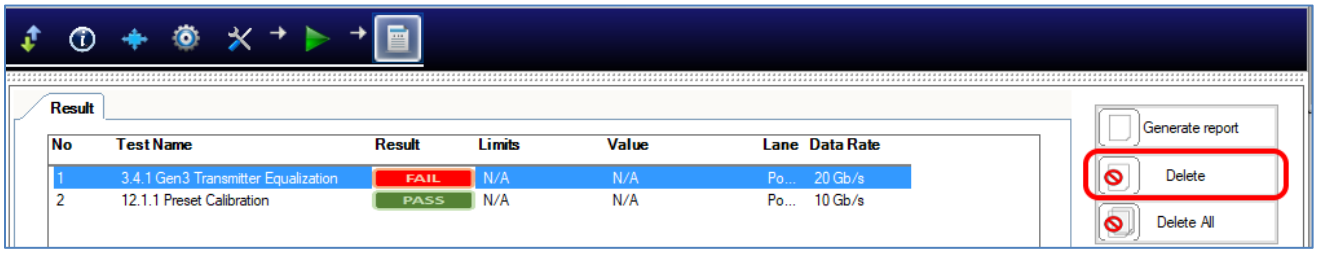


FIGURE 39. DELETE CALIBRATION/TEST RESULTS EXAMPLE

7 DUT Compliance Testing with GRL-USB4-TX-TEST Software

After calibration has completed, testing for DUT compliance can then be performed using the GRL-USB4-TX-TEST automation software.

Note: Prior to running any transmitter test, make sure to perform the Preset Calibration first to obtain an optimized preset which yields the lowest number of DDJ (refer Section 6).

7.1 Select DUT Tests

The Calibration/Tests selection panel allows calibration and tests that need to be performed to be selected.

Un-check the Preset Calibration selection assuming it has been performed and completed in the previous section. Then, select the tests required to be run on the DUT.

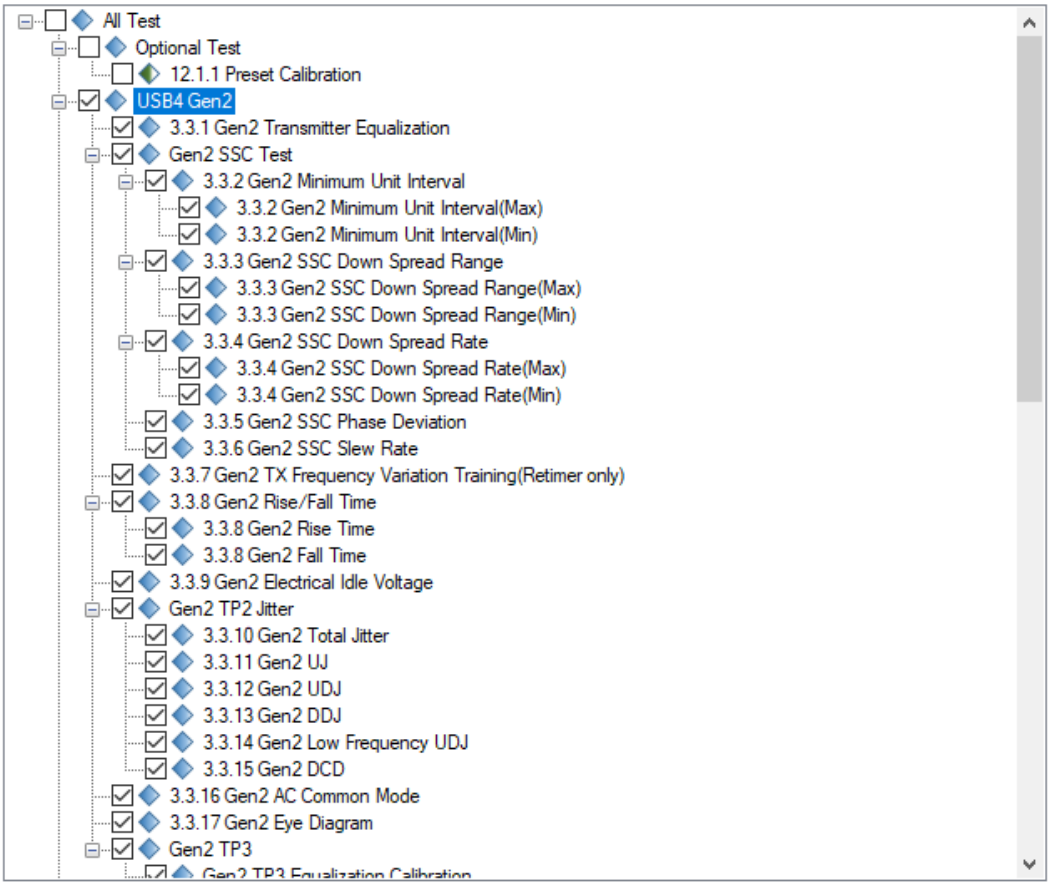


FIGURE 40. SELECT DUT TESTS

Note: The marking shown on the left of each calibration/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 ✓.

7.2 Set Up DUT Re-timer (Applicable for the USB4 DUT Only)

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

Re-timer tab: If the USB4 DUT has an on-board re-timer(s), then select "Yes" at the "DUT contains Re-timer" field. This will apply to the following re-timer based tests- "3.3.7 Gen2 Tx Frequency Variation Training (Re-timer only)" and "3.4.7 Gen3 Tx Frequency Variation Training (Re-timer only)".

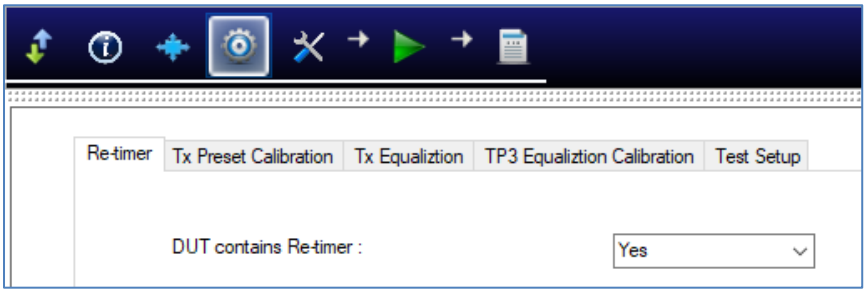


FIGURE 41. SELECT DUT RE-TIMER OPTION

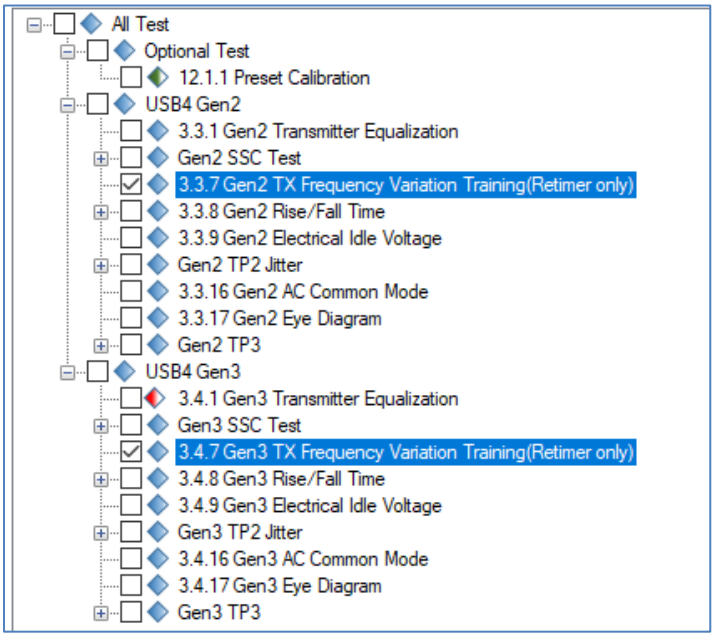


FIGURE 42. SELECT 3.3.7 GEN2 TX FREQUENCY VARIATION TRAINING (RE-TIMER ONLY) TEST AND 3.4.7 GEN3 TX FREQUENCY VARIATION TRAINING (RE-TIMER ONLY) TEST

7.3 Set Up Transmitter Equalization (Tx EQ)

If Tx EQ is selected or has not been performed in the previous section, the user can assign the presets to be applied when running Tx EQ. The presets chosen in the calibration will be negotiated by the DUT during the compliance tests. When running Tx EQ, the DUT will be using the presets assigned for Tx EQ. Refer Section 6.2.

7.4 Set Up TP3 Equalization (TP3 EQ) Calibration

If TP3 EQ Calibration is selected or has not been performed in the previous section, the user can assign the CTLE to be applied when running TP3 EQ calibration. A reference equalization will be applied on the oscilloscope to find the optimized eye diagram using the best equalization parameters. Refer Section 6.2.

7.5 Configure Test Parameters

Select the  button in the main software menu to access the Configurations page. Set the parameters required for the test setup.

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

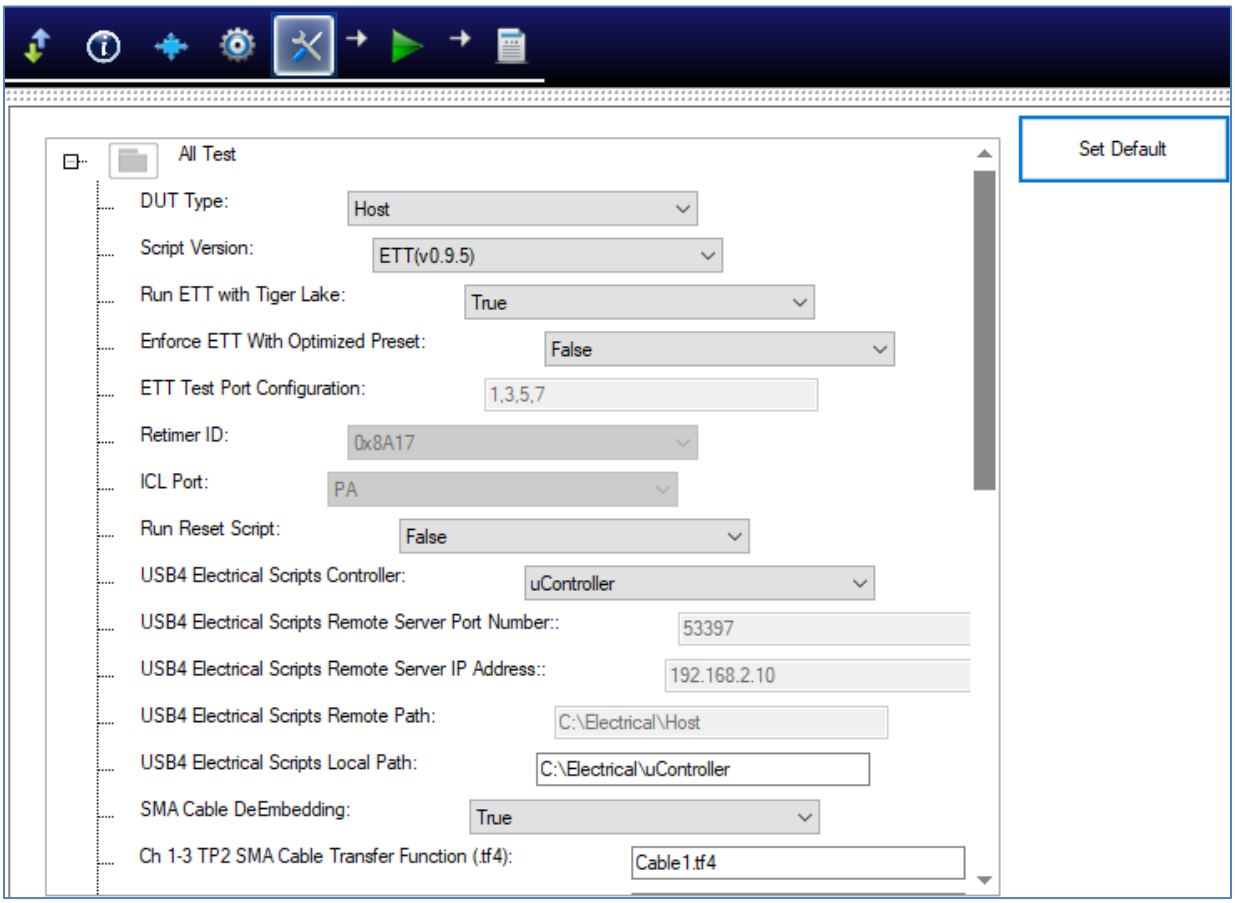


FIGURE 43. TEST CONFIGURATION PAGE

TABLE 5. TEST PARAMETERS

Parameter	Description
DUT Type	Select 'Host' or 'Device' if using a host or device DUT respectively.
Script Version	Select the version of the test script to be used: TenLira ("ver 0.8.4" or above) or ETT ["ETT(v0.9.4)" or "ETT(v0.9.5)"] or

	IceLake or Gatkex test script. *Note: If you want to use the latest script version, select from the drop-down list any available latest version supported in the current GRL-USB4-TX-TEST software release. In the event of test script commands being modified in future releases, GRL will proceed to update the GRL-USB4-TX-TEST software accordingly.* *Note: The **GRL Remote Server** must be used with the **IceLake** version.*
Run ETT with Tiger Lake	If the **Host** DUT is selected as the "DUT Type" and if the **ETT** test script is selected in the "Script Version" field, set to "True" to run the ETT script on Intel's Tiger Lake processor if supported by the Host DUT.
Enforce ETT with Optimized Preset	This is only applicable when using the ETT test script. Select 'True' to force the USB4 DUT to output signals with optimized preset using the value from the '12.1.1 Preset Calibration' test result. Select 'False' for the USB4 DUT to output signals with original preset.
ETT Test Port Configuration	If the **Device** DUT is selected as the "DUT Type" and if the **ETT** test script is selected in the "Script Version" field, specify the test connector lanes to validate the port mapping of the Device DUT connectors.
Retimer ID	Select the re-timer ID if the DUT has a re-timer on board. *This field will be available only if **IceLake** is selected from the "Script Version" field:* • *Ice Lake re-timer ID options: 0x8A17 or 0x8A0D* • *Tiger Lake re-timer ID options: 0x9A1D or 0x9A1B* *Note: Ensure that the DUT re-timer option is selected from the Setup Configuration page (refer Section 7.2).*
ICL Port	Select the inter-chassis link (ICL) port type. *This field will be available only if **IceLake** is selected from the "Script Version" field.*
Run Reset Script	Select 'True' to perform a reset operation before running the test script.
USB4 Electrical Scripts Controller	Select 'Remote' if using a remote test script on the Host DUT/USB4 Host or 'uController' if using a USB4 microcontroller board to control the DUT. If the DUT supports the JTAG technology, select 'JTAG' to apply the JTAG based test script. Otherwise, select 'Manual' if using a manual test script.
USB4 Electrical Scripts Remote Server Port Number	Specify the remote server's port number of the controller host of the test script. *This field will be available only if **Remote** is selected from the "USB4 Electrical Scripts Controller" field.*
USB4 Electrical Scripts Remote Server IP Address	Specify the remote server's IP address of the controller host of the test script. *This field will be available only if **Remote** is selected from the "USB4 Electrical Scripts Controller" field.*
USB4 Electrical Scripts	Set the working directory to the path where the remote test script is

Remote Path	installed. *This field will be available only if **Remote** is selected from the "USB4 Electrical Scripts Controller" field.*
USB4 Electrical Scripts Local Path	Set the working directory to the path where the local test script is installed. *This field will be available only if **uController** or **JTAG** is selected from the "USB4 Electrical Scripts Controller" field.*
SMA Cable DeEmbedding	Select 'True' to perform de-embedding of the connected SMA cable.
Ch 1-3 / Ch 2-4 TP2 SMA Cable Transfer Function (.tf4/.flt)	If 'True' is selected from the "SMA Cable DeEmbedding" field, specify the SMA cable transfer function files that will be used to de-embed the SMA cable connected to the Scope channel pair (1 & 3 or 2 & 4) at the TP2 test point. Refer Appendix on how to set up the SMA cable transfer function files. *Note: The .tf4 file format will be used for the Keysight scope while the .flt file format will be used for the Tektronix scope.*
Ch 1-3 / Ch 2-4 TP2 SMA Cable Transfer Function for E-idle (.tf4/.flt)	If 'True' is selected from the "SMA Cable DeEmbedding" field, specify the SMA cable transfer function files that will be used to de-embed the SMA cable connected to the Scope channel pair (1 & 3 or 2 & 4) in the Electrical Idle state at the TP2 test point. Refer Appendix on how to set up the SMA cable transfer function files. *Note: The .tf4 file format will be used for the Keysight scope while the .flt file format will be used for the Tektronix scope.*
Ch 1-3 / Ch 2-4 Gen2 TP3 SMA with 2m Cable Transfer Function (.tf4/.flt)	If 'True' is selected from the "SMA Cable DeEmbedding" field, specify the SMA cable transfer function files that will be used to de-embed the SMA cable with embedded 2m passive cable connected to the Scope channel pair (1 & 3 or 2 & 4) for the USB4 Gen2 host/device DUT at the TP3 test point. Refer Appendix on how to set up the SMA cable transfer function files. *Note: The .tf4 file format will be used for the Keysight scope while the .flt file format will be used for the Tektronix scope.*
Ch 1-3 / Ch 2-4 Gen3 TP3 SMA with 0.8m Cable Transfer Function (.tf4/.flt)	If 'True' is selected from the "SMA Cable DeEmbedding" field, specify the SMA cable transfer function files that will be used to de-embed the SMA cable with embedded 0.8m passive cable connected to the Scope channel pair (1 & 3 or 2 & 4) for the USB4 Gen3 host/device DUT at the TP3 test point. Refer Appendix on how to set up the SMA cable transfer function files. *Note: The .tf4 file format will be used for the Keysight scope while the .flt file format will be used for the Tektronix scope.*
Number of TP3 Eye Run Times	Define the number of eye heights to acquire during TP3 eye diagram optimization.
Equalization Calibration Mask	Select 'Enable' to perform a search for eye masks during TP3 equalization calibration for the DUT.
Screenshots Mode	Select the type of screenshots to be captured when saving test results to a test report: • "Full Screen": Image of the waveform along with the measurement

	area. • "Grid": Image of only the waveform without showing the measurement area.
Save Waveform	Select 'True' to enable saving the waveform acquisition to a file.
Remove Scope RJ	Select 'True' to remove the effects of intrinsic Scope random jitter (RJ) components from measurements.
Scope RJ	If 'True' is selected from the "Remove Scope RJ" field, enter the Scope RJ values to be removed.
Frequency Variation Capture Times	Enter the number of times to perform frequency variation over the signal transmitted by the re-timer.
Frequency Variation Test Save Waveform Only	Select 'True' to only enable waveform signals to be saved while frequency variation is running.
Remote File Server IP Address	Enter the IP address for the GRL Remote Proxy Server. See Section 4.3.1 on how to set up the remote file server.
Remote File Server Port No.	Enter the Port number for the GRL Remote Proxy Server. See Section 4.3.1 on how to set up the remote file server.

7.6 Perform Tx Measurements

The following example describes how to use the GRL-USB4-TX-TEST software to run a typical automation test on the DUT transmitter lanes.

Note: Prior to running measurements, it is recommended that the Preset calibration as described in Section 6 has been completed. Also make sure that the relevant test setups for the DUT as described in Section 5 have been completed.

1. Select the required DUT port(s) and lane(s) as well as data rates to be tested in the Test Conditions  page. Refer Section 4.3.3.
2. Select the tests to be run. Refer Section 7.1.
3. If the DUT has a re-timer on board, select the DUT re-timer option in the Setup Configuration  page. Refer Section 7.2.
4. If Tx EQ is selected to be run, set up the presets for Tx EQ in the Setup Configuration  page. Refer Section 6.2.
5. If TP3 EQ Calibration is selected to be run, set up the CTLE for TP3 EQ Calibration in the Setup Configuration  page. Refer Section 6.2.
6. Set up the test parameters for the selected tests in the Configurations  page. Refer Section 7.5.

7. Go to the Run Tests page and select the **Run Tests** button to begin testing. Refer Section 6.3.
8. Follow the software instructions step by step to set up the connection and perform the selected tests.
9. Once tests have completed, the test results will be saved automatically and populated on the Report page. Select the **Generate report** button to view the details of each result.

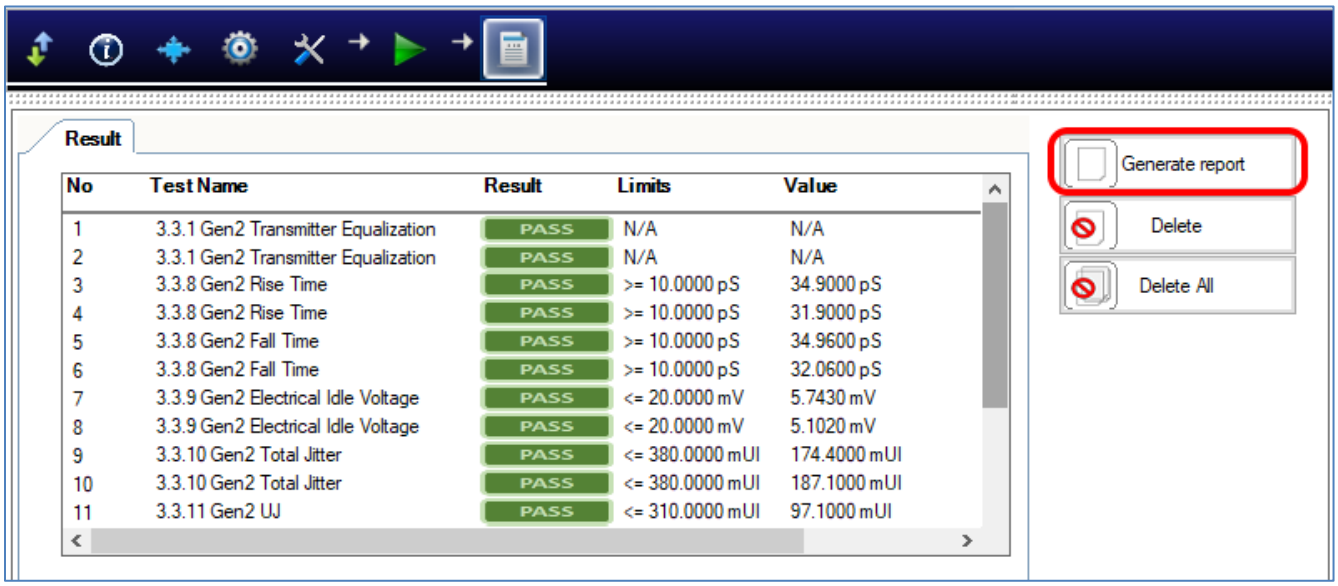


FIGURE 44. VIEW TEST RESULTS EXAMPLE

8 Test Results and Reports with GRL-USB4-TX-TEST Software

The **Report**  page displays the results from all calibration and test runs. If some of the results are not desired, they can be individually deleted by selecting the **Delete** button. Also for a PDF report, select the **Generate report** button.

8.1 Generate Test Report

Select the **Generate report** button for the detailed calibration and tests report.

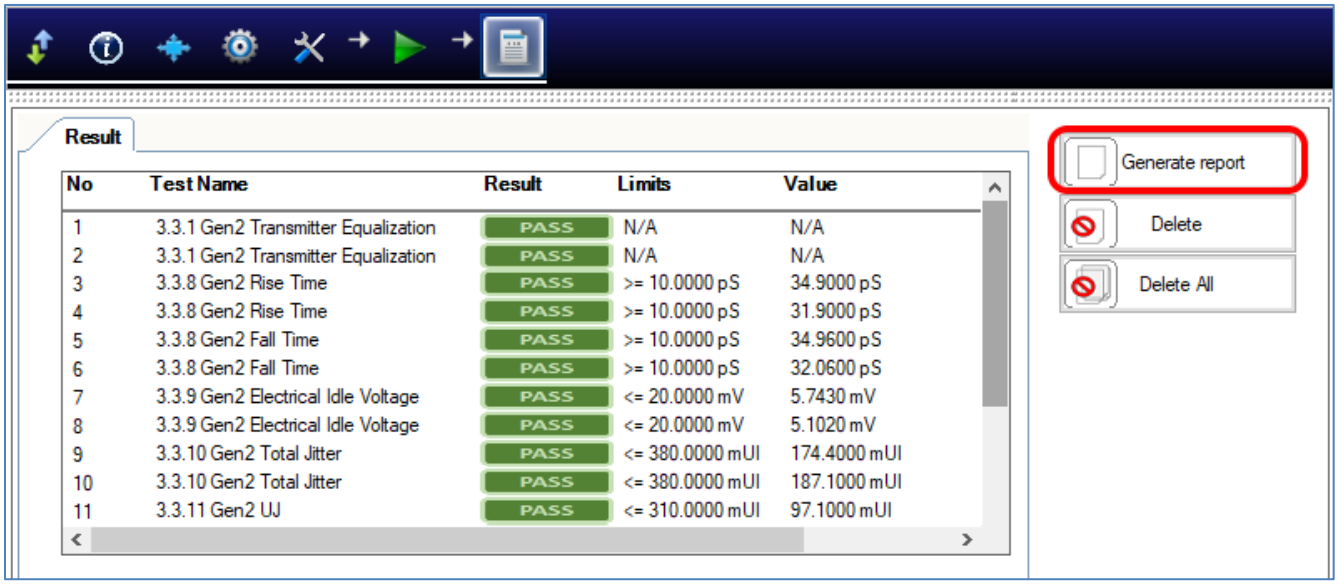


FIGURE 45. GENERATE REPORT PAGE

8.1.1 Test Session Information

This portion is populated from the information entered in the **Session Info** page (refer Section 4.3.2).

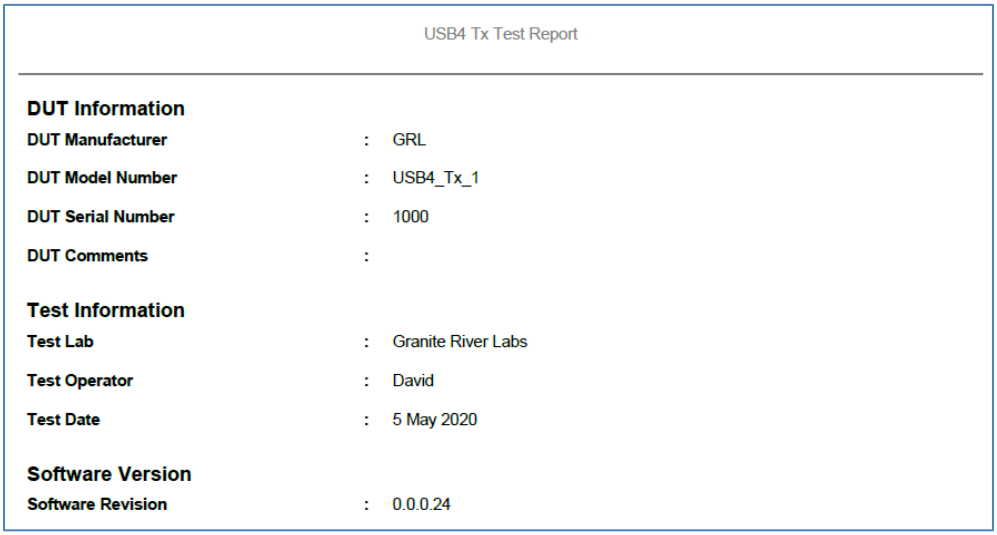


FIGURE 46. TEST SESSION INFORMATION

8.1.2 Test Results Summary Table

This portion is populated from the tests and calibration performed and their results. This gives a summarized view of all the results and test conditions.

USB4 Tx Test Report

No	TestName	Limits	Value	Results	Lane	DataRate
1	12.1.1 Preset Calibration	N/A	N/A	Pass	PortA Lane 0	Rate_10G
2	12.1.1 Preset Calibration	N/A	N/A	Pass	PortA Lane 0	Rate_20G
3	12.1.1 Preset Calibration	N/A	N/A	Pass	PortA Lane 0	Rate_10p3125G
4	12.1.1 Preset Calibration	N/A	N/A	Pass	PortA Lane 0	Rate_20p625G
5	3.3.1 Gen2 Transmitter Equalization	N/A	N/A	Pass	PortA Lane 0	Rate_10G
6	3.3.1 Gen2 Transmitter Equalization	N/A	N/A	Pass	PortA Lane 0	Rate_10p3125G

FIGURE 47. TEST RESULTS SUMMARY TABLE EXAMPLE

8.1.3 Test Result Details

This portion is populated from each of the test and calibration results. Here the results are explained in depth with supporting data points and screenshots.

105. 3.4.21 Gen3 Eye Diagram TP3 [Rate_20G,L0]

Pass/Fail Stats	:	Pass
Test Limits	:	= 0 Points
Result	:	0.0000 Points
Tap	:	0.192(28.8 mV)
Eye Height:	:	138.3000 mV
Eye Width:	:	36.1400 ps
Test completed time	:	07 April 2020 17:41:17 PM

Rate_20G_TP3 Eye_L0 Screenshots

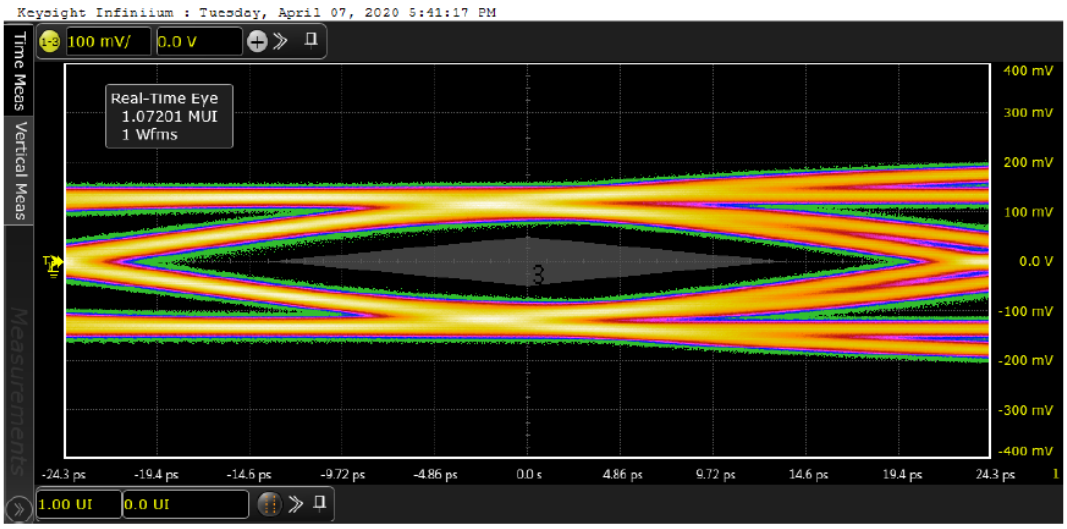


FIGURE 48. TEST RESULT DETAILS EXAMPLE

8.2 Delete Reports

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

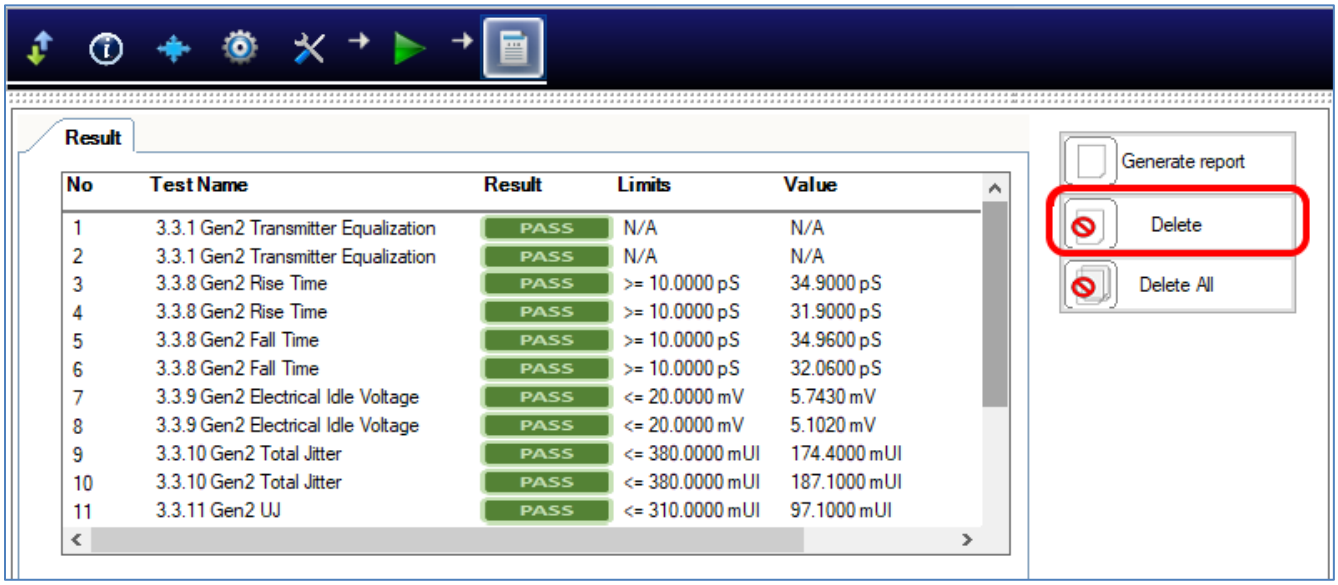


FIGURE 49. DELETE INDIVIDUAL CALIBRATION/TEST RESULTS EXAMPLE

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

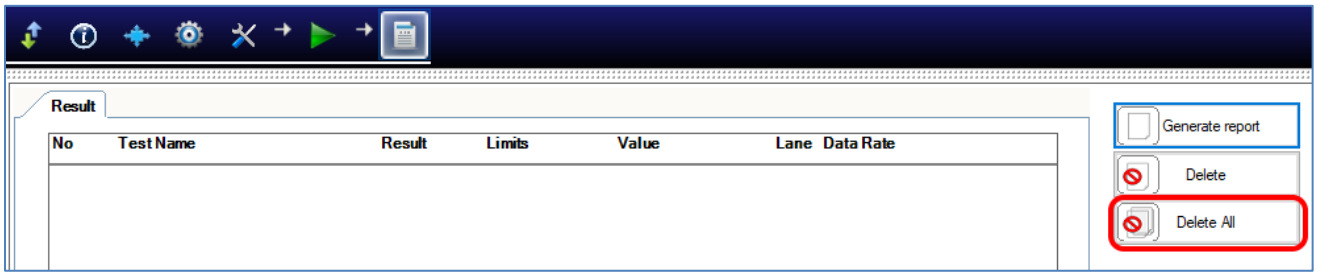


FIGURE 50. DELETE ALL RESULTS

9 Saving and Loading Test Sessions

The usage model for the GRL-USB4-TX-TEST automation software is that Calibration and Test Results are created and maintained as a 'Live Session' in the software. This allows you to Quit the software 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, test results, and any waveforms, select **Options** on the menu bar and select **Save Session**.

To Load a session back into the software, including the saved parameter settings, select **Options** on the menu bar and select **Load Session**.

To create a New session and return the software to the default configuration, select **Options** on the menu bar and select **New Session**.

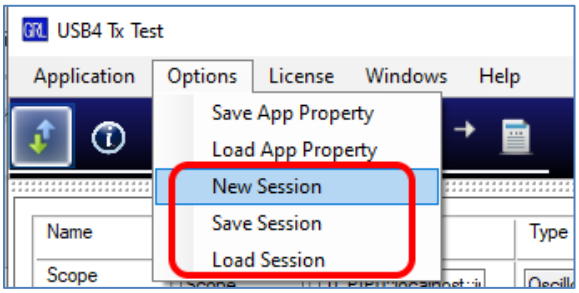


FIGURE 51. SAVING AND LOADING CALIBRATION AND TEST SESSIONS

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: 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.

The following TP3 embedding files are required for the creation of transfer (.tf4) files and filter (.flt) files and can be downloaded from USB-IF:

- USB4 Gen3 TP3 Embedding File
- USB4 Gen2 TP3 Embedding File

[Note: Permission from USB-IF must be obtained to gain access to these files.]

The GRL-USB4-TX-TEST software enables the following transfer function options:

Ch 1-3 TP2 SMA Cable Transfer Function (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable on the Scope channels 1 & 3 at the TP2 test point.
Ch 2-4 TP2 SMA Cable Transfer Function (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable on the Scope channels 2 & 4 at the TP2 test point.
Ch 1-3 TP2 SMA Cable Transfer Function for E-idle (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable on the Scope channels 1 & 3 in the Electrical Idle state at the TP2 test point.
Ch 2-4 TP2 SMA Cable Transfer Function for E-idle (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable on the Scope channels 2 & 4 in the Electrical Idle state at the TP2 test point.
Ch 1-3 Gen2 TP3 SMA with 2m cable Transfer Function (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable with embedded 2m passive cable on the Scope channels 1 & 3 at the TP3 test point for the USB4 Gen2 DUT.
Ch 2-4 Gen2 TP3 SMA with 2m cable Transfer Function (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable with embedded 2m passive cable on the Scope channels 2 & 4 at the TP3 test point for the USB4 Gen2 DUT.
Ch 1-3 Gen3 TP3 SMA with 0.8m cable Transfer Function (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable with embedded 0.8m passive cable on the Scope channels 1 & 3 at the TP3 test point for the USB4 Gen3 DUT.
Ch 2-4 Gen3 TP3 SMA with 0.8m cable Transfer Function (.tf4/.flt)	Select a .tf4/.flt file to de-embed the SMA cable with embedded 0.8m passive cable on the Scope channels 2 & 4 at the TP3 test point for the USB4 Gen3 DUT.

10.1 Set Up Transfer Function for the Keysight Scope

1. **For SMA Cable De-embedding on Scope Channels 1 & 3**:

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

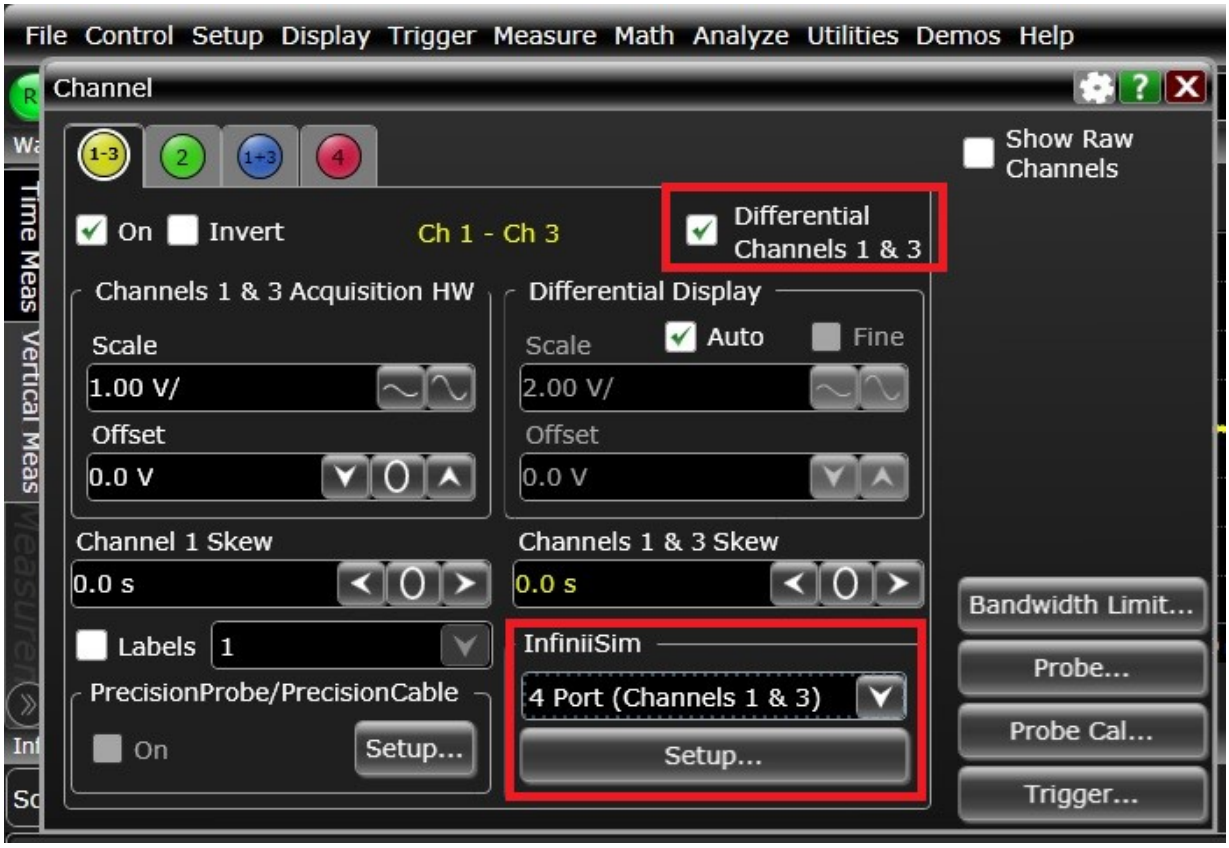


FIGURE 52. SMA CABLE TRANSFER FUNCTION– SET UP SCOPE CHANNELS 1 & 3

2. **For SMA Cable De-embedding on Scope Channels 2 & 4**:

   On the Keysight Scope, select **Setup** → **Channel 2** → **Differential Channels 2 & 4** → **4 Port (Channels 2 & 4)** in the "InfiniiSim" pane → **Setup**.

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

FIGURE 53. SMA CABLE TRANSFER FUNCTION– SELECT SETUP WIZARD ON SCOPE

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

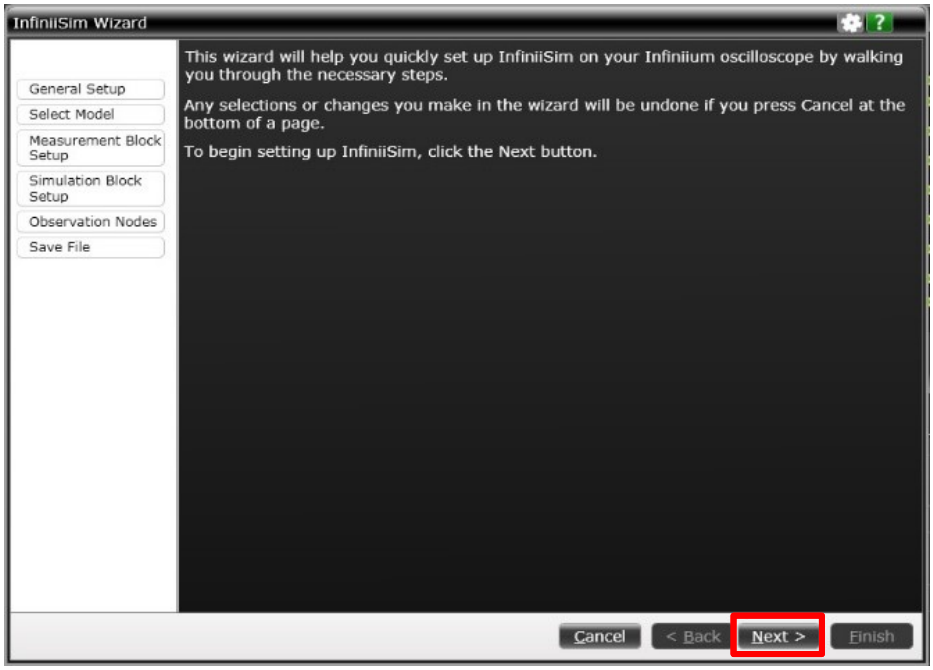


FIGURE 54. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #1

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

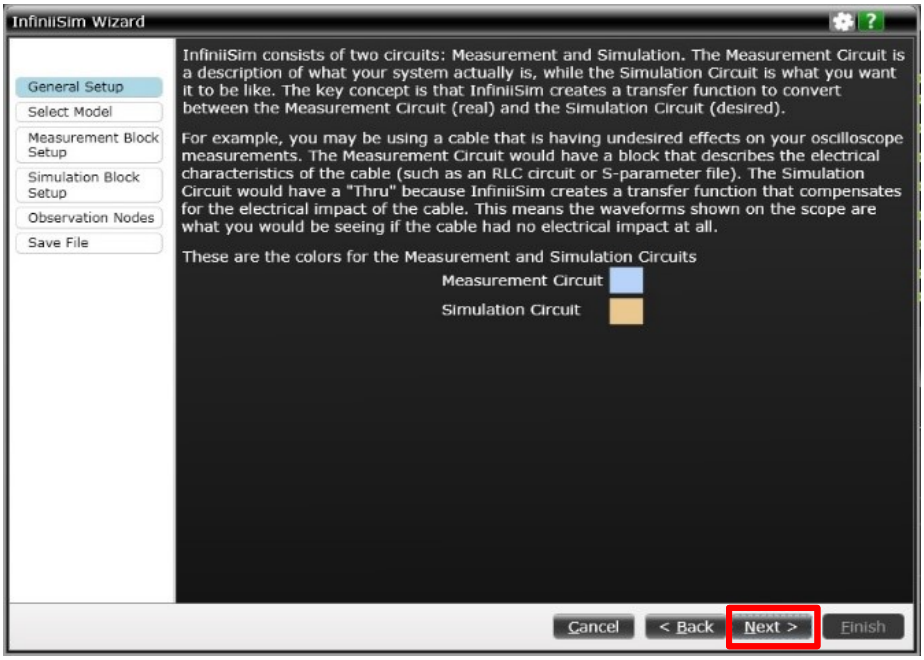


FIGURE 55. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #2

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

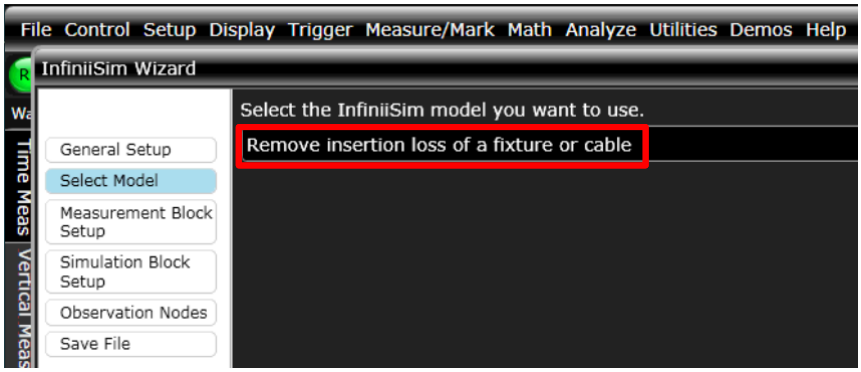


FIGURE 56. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #3

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

   Select **Next** to proceed.

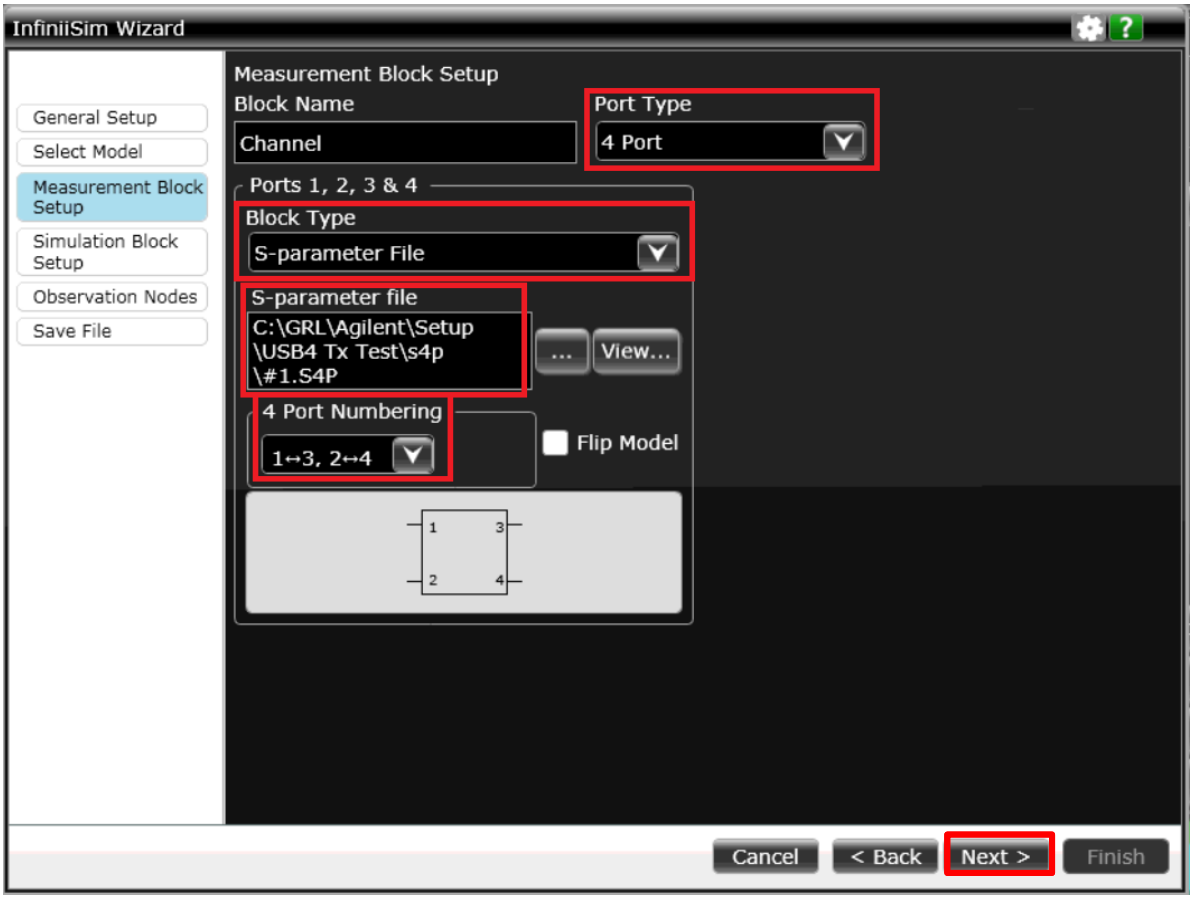


FIGURE 57. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #4

8. On the InfiniiSim Wizard > Simulation Block Setup" screen, set the following parameters for adding a passive cable.

   a) For the Channel 1 TP2 SMA cable de-embedding file:

      - In the "Block Type" pane, select **Ideal Thru**:

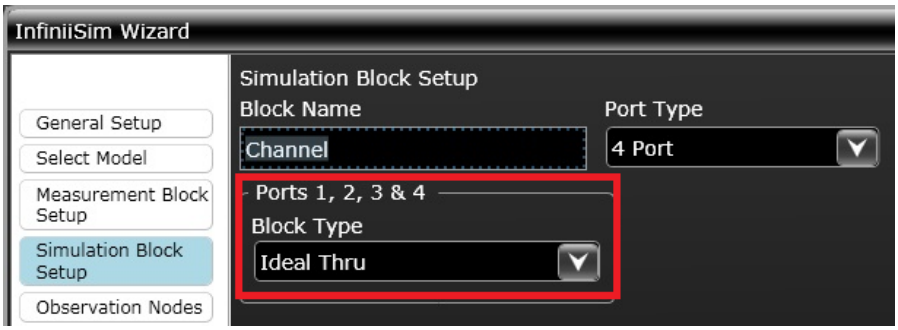


FIGURE 58. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #5

   b) For the Channel 1 TP2 E-idle test:

      - In the "Port Type" pane, select **(2) 2 Port**.
      - In both Ports 1 → 2 and Ports 3 → 4 panes, set the following parameters:
        - Block Type: **RLC**

- Circuit Element: **Parallel Shunt**
- Resistance: **1.00000 MΩ**
- Capacitance: **5.0930 pF**

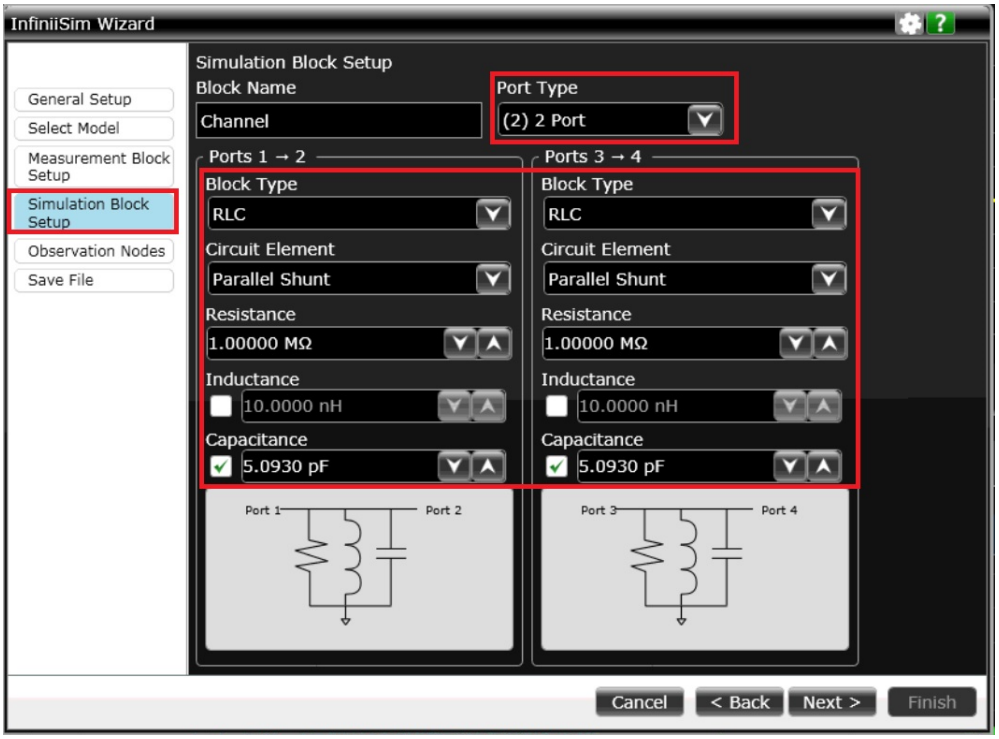


FIGURE 59. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #6

c) For the Channel 1 USB4 Gen3 TP3 test (SMA cable de-embedding file with 0.8m passive cable):

- In the "Block Type" pane, select **S-parameter File**.
- In the "S-parameter file" pane, browse and select the passive cable S4P file which has been measured using the ENA vector network analyzer.
- In the "4 Port Numbering" pane, select **1↔2, 3↔4**.

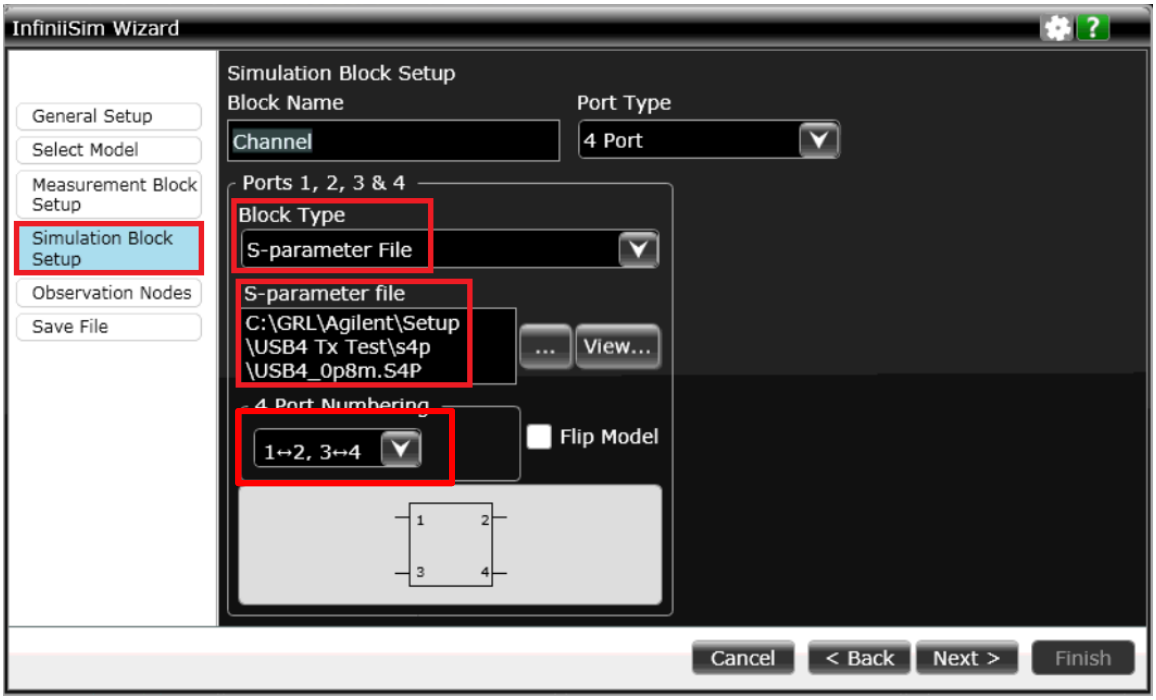
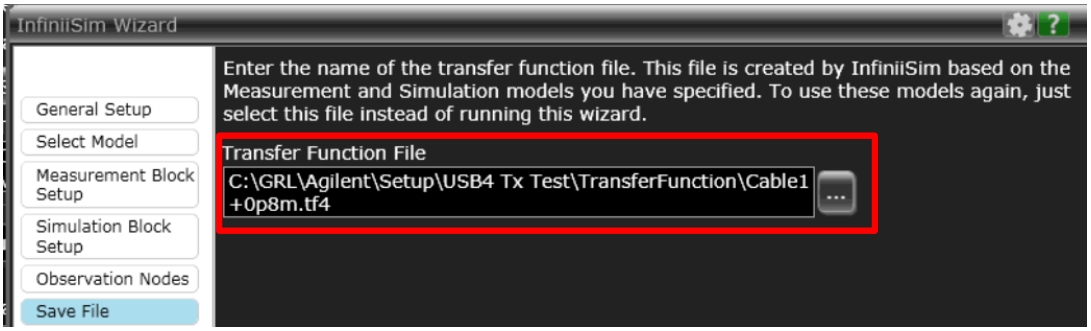


FIGURE 60. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #7

9. Select **Next** to proceed.
10. 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\USB4 Tx Test\TransferFunction\xxx"* on the Scope and then select **Next** → **OK** → **Finish**.



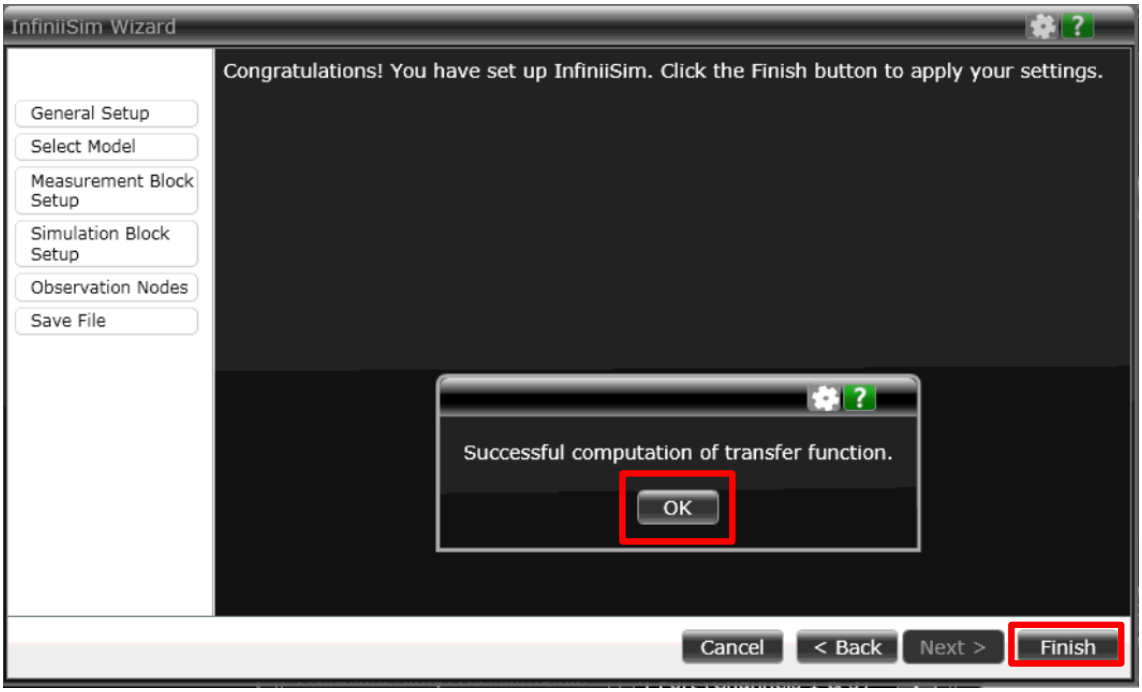
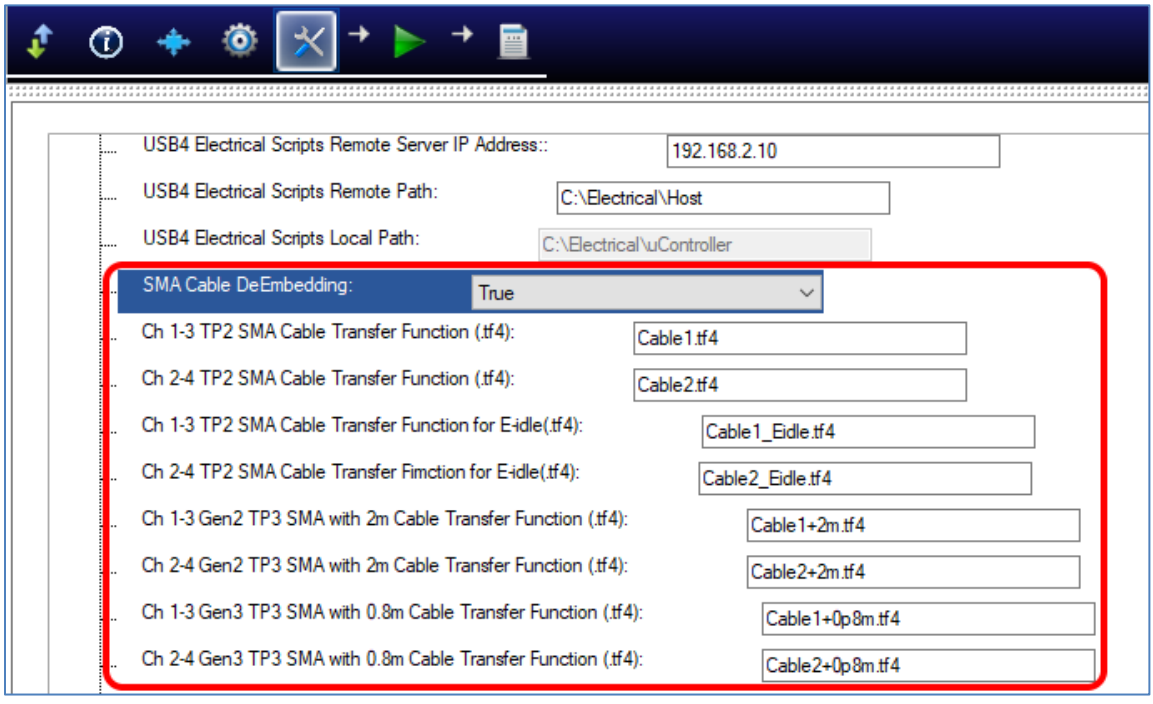


FIGURE 61. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE COMPLETED

11. On the GRL-USB4-TX-TEST application -> Configurations  page, select **True** for "SMA Cable DeEmbedding" and specify the transfer function files to be used.



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

10.2 Create Filter Files for the Tektronix Scope

10.2.1 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**:

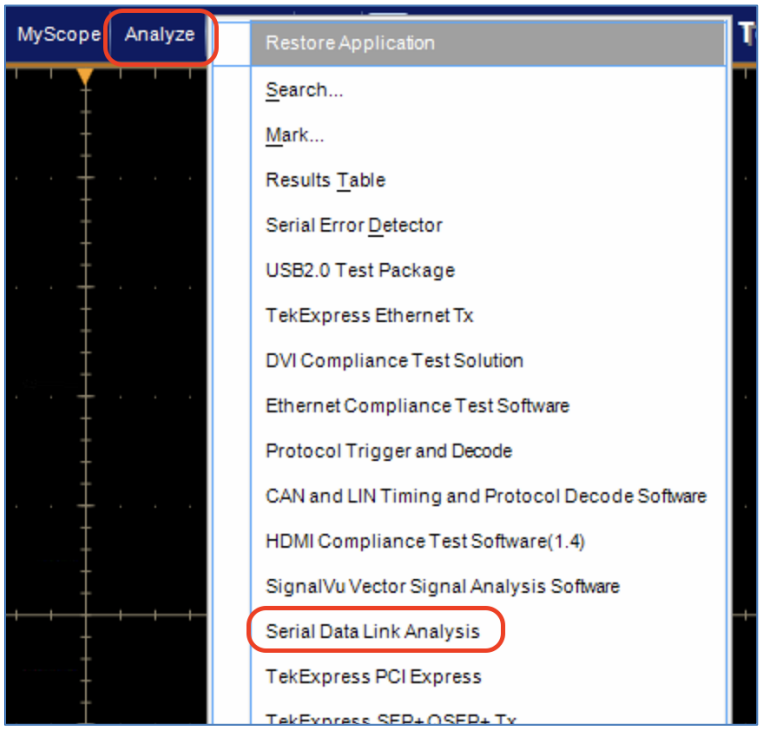


FIGURE 62. SELECT AND OPEN SERIAL DATA LINK ANALYSIS ON TEKTRONIX SCOPE

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.

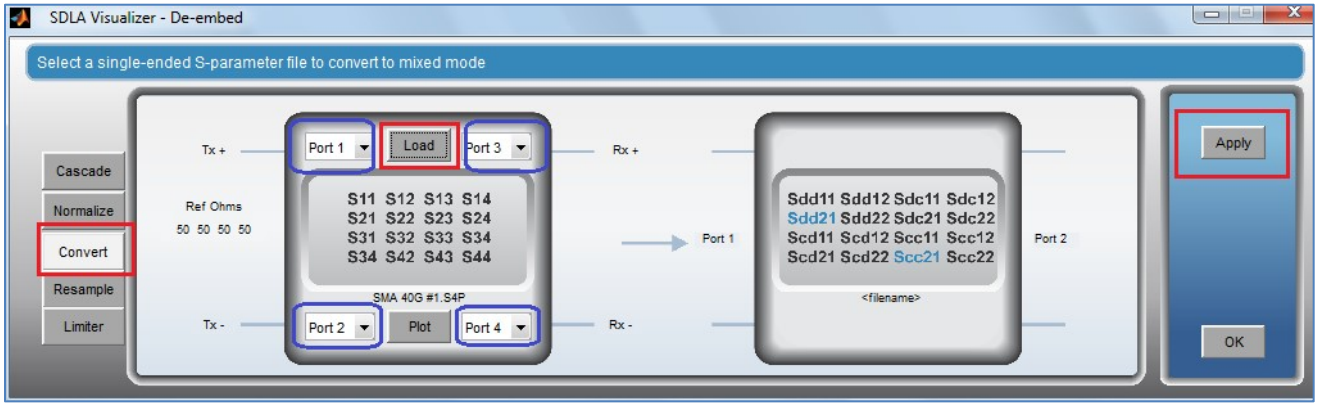


FIGURE 63. CONVERT TO MIXED MODE S-PARAMETERS

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

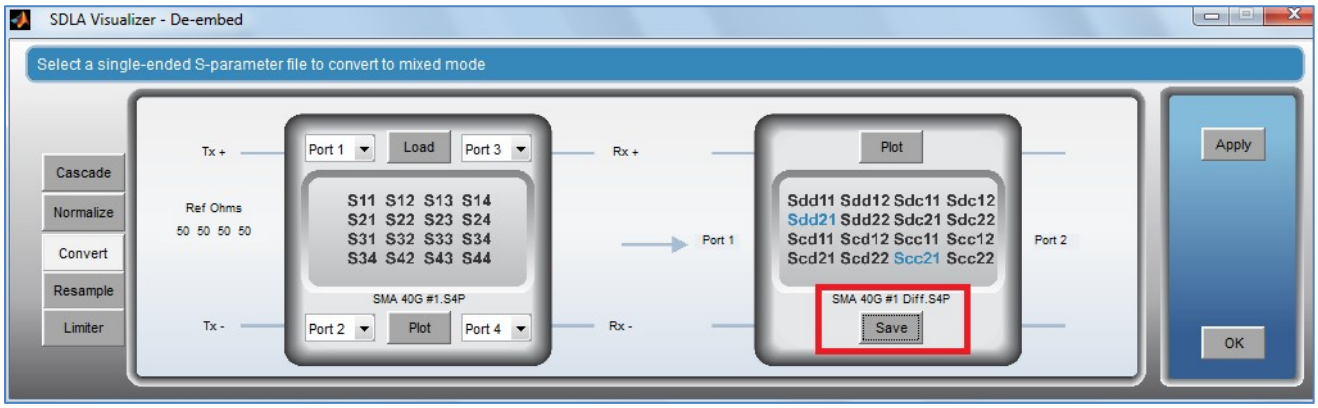


FIGURE 64. SAVE CONVERTED MIXED MODE S-PARAMETERS

8. Repeat steps 2 to 7 for all single-ended S-parameters that are used for de-embedding, including the "USB4_Gen2_2m.s4p" and "USB4_Gen3_0p8m.S4P" files downloaded from USB-IF's website. Examples of these files are as shown below:

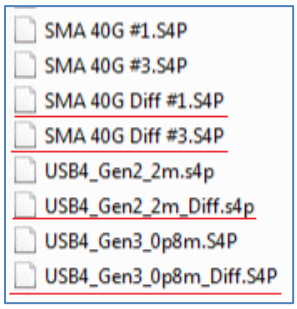


FIGURE 65. SINGLE-ENDED S-PARAMETER FILE EXAMPLES

10.2.2 Create SMA Cable De-embedding Files for Scope Channels 1 & 3 and Channels 2 & 4

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

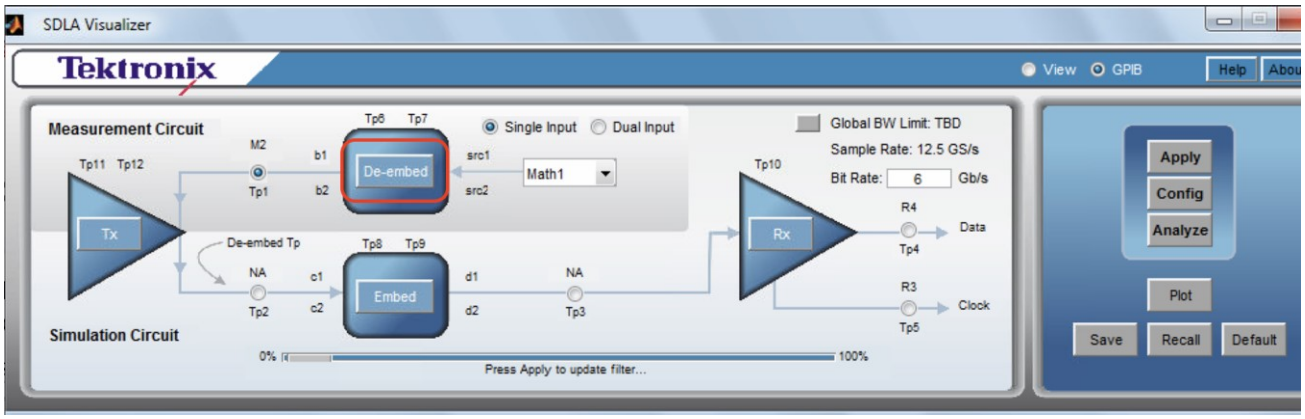


FIGURE 66. CREATE SMA CABLE DE-EMBEDDING FILES – #1

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

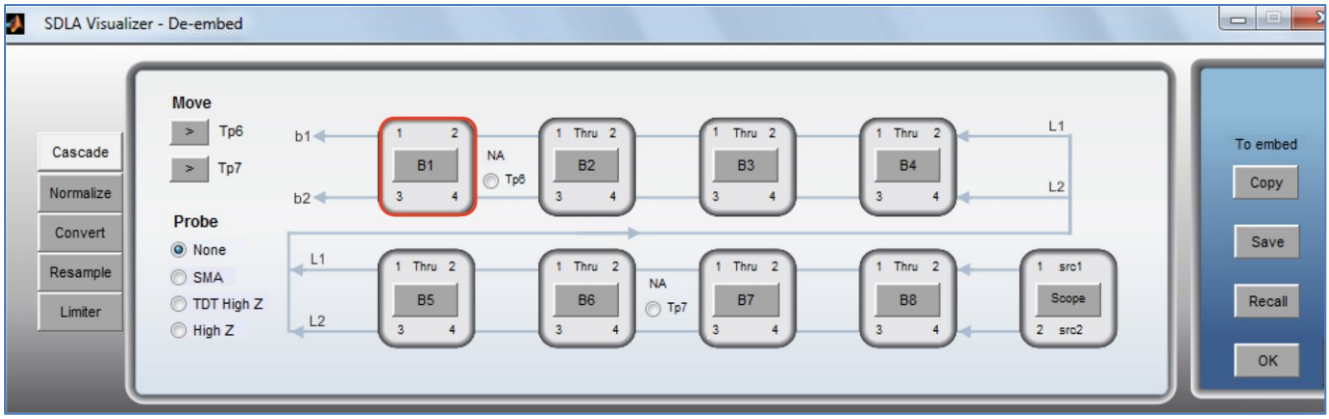


FIGURE 67. CREATE SMA CABLE DE-EMBEDDING FILES – #2

3. Click on the **Browse** button to load the mixed mode S-parameter file that has been created from Section 10.2.1. Then click **OK**.

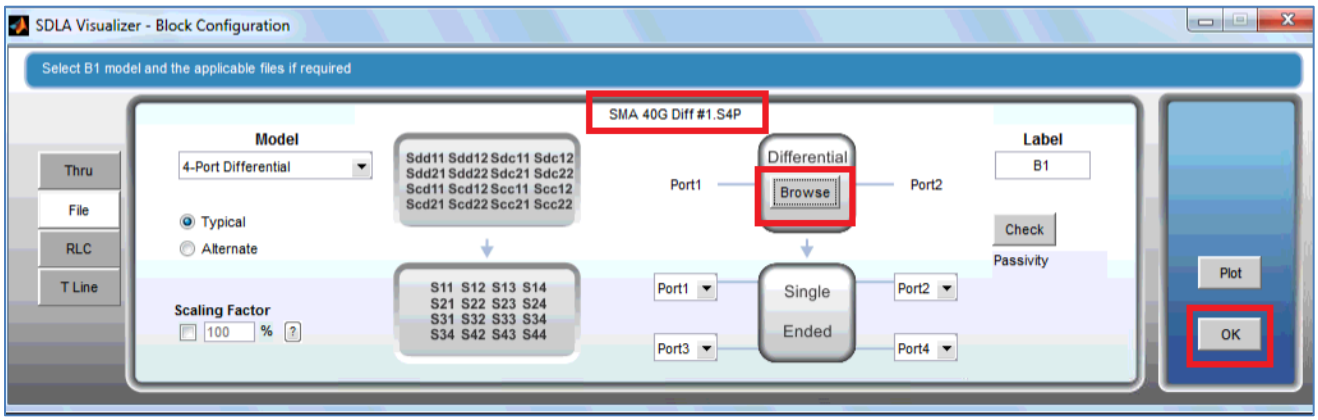


FIGURE 68. CREATE SMA CABLE DE-EMBEDDING FILES – #3

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

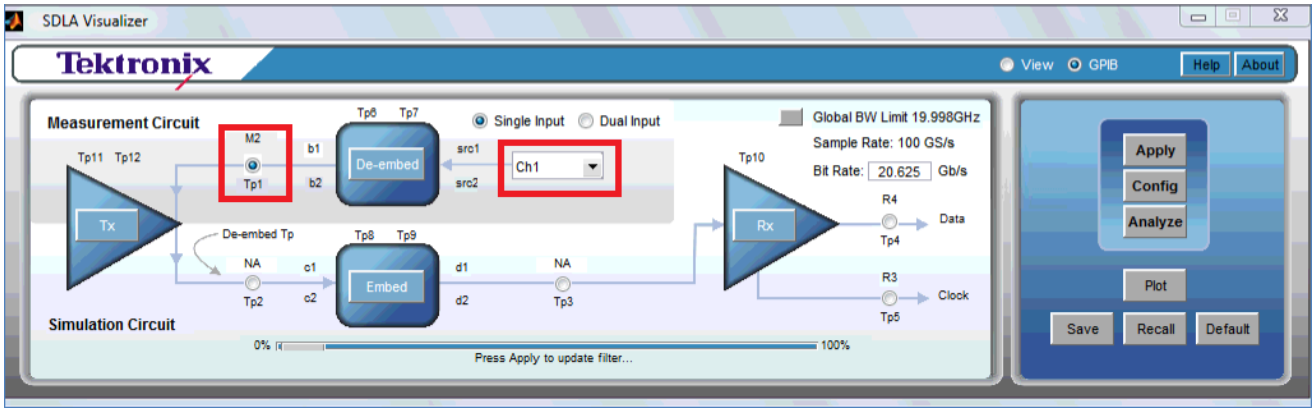


FIGURE 69. CREATE SMA CABLE DE-EMBEDDING FILES – #4

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

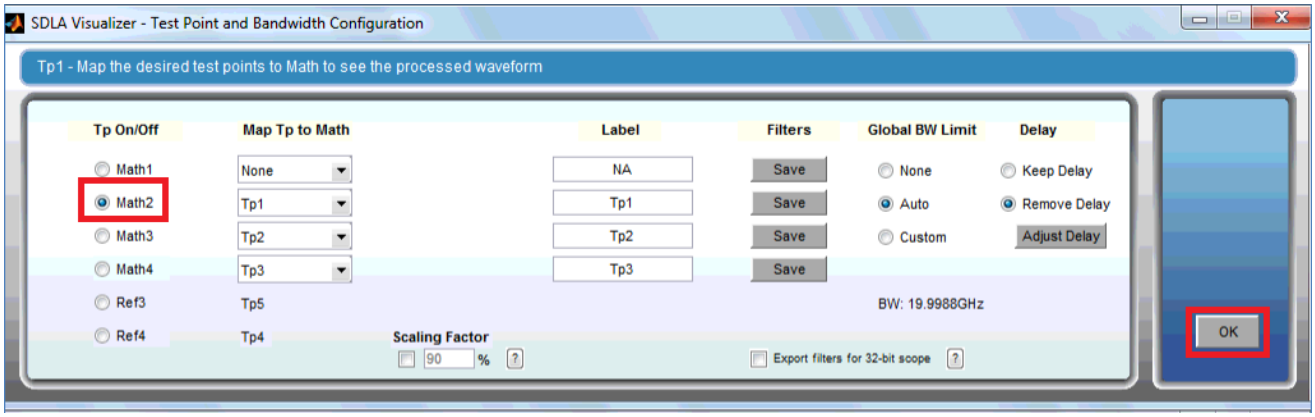


FIGURE 70. CREATE SMA CABLE DE-EMBEDDING FILES – #5

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

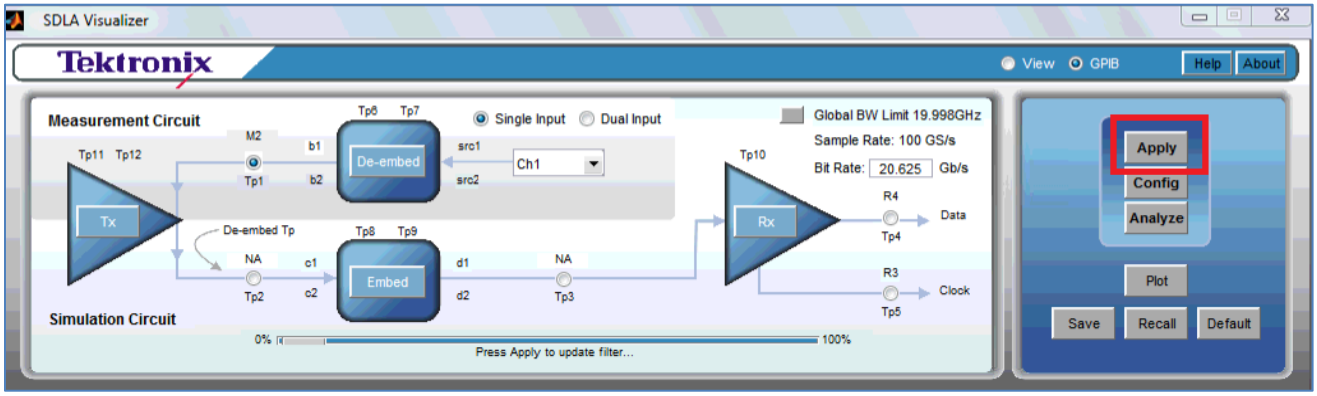


FIGURE 71. CREATE SMA CABLE DE-EMBEDDING FILES – #6

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\USB4 Tx Test\TransferFunction"*** directory on the Tektronix scope and rename the file for de-embedding of channels 1 & 3.
9. Repeat above steps for channels 2 & 4.

10.2.3 Create SMA Cable De-embedding + TP3 Embedding Files for Scope Channels 1 & 3 and Channels 2 & 4

1. Repeat steps 1 to 8 from Section 10.2.2 above to combine the TP3 embedding file with the SMA cable de-embedding file.
2. Click on the **Embed** button to combine the TP3 embedding file, e.g., "0.8m s4p" file.

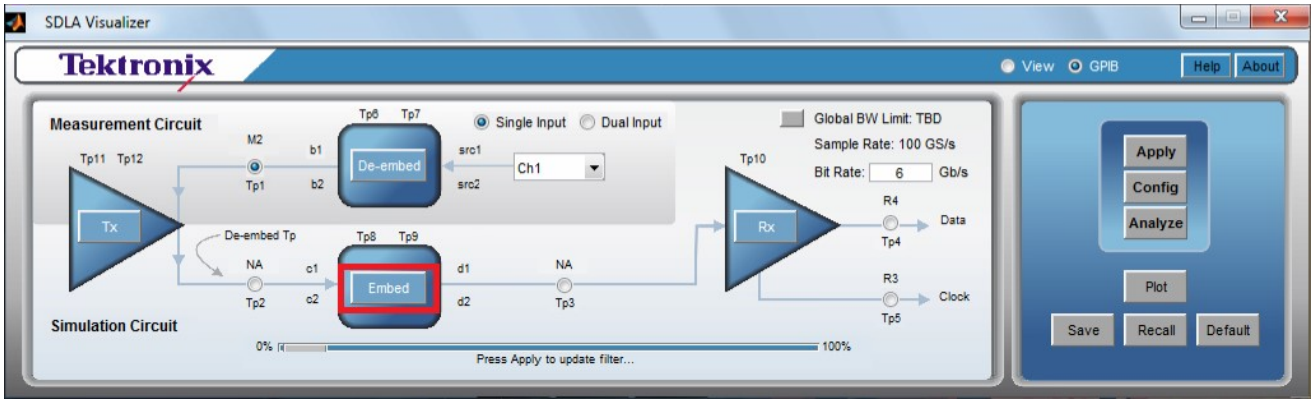


FIGURE 72. CREATE SMA CABLE DE-EMBEDDING + TP3 EMBEDDING FILES – #1

3. Click on the **B1** button.

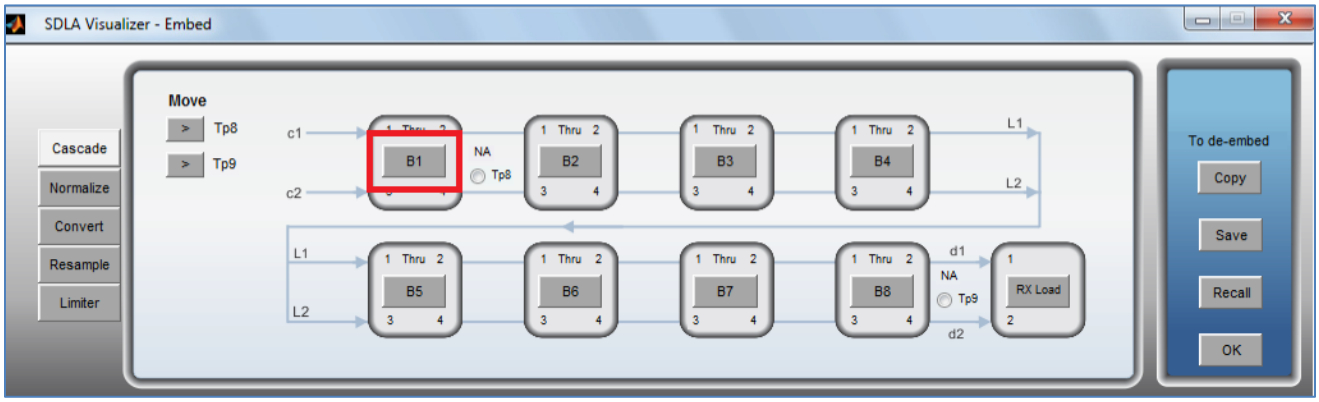


FIGURE 73. CREATE SMA CABLE DE-EMBEDDING + TP3 EMBEDDING FILES – #2

4. Click on the **File** tab button.
5. Select the **4-Port Differential** model from the Model drop-down menu.
6. Click on the **Browse** button and load the TP3 embedding file which has been converted to the mixed-mode S-parameter file.
7. Click **OK**.

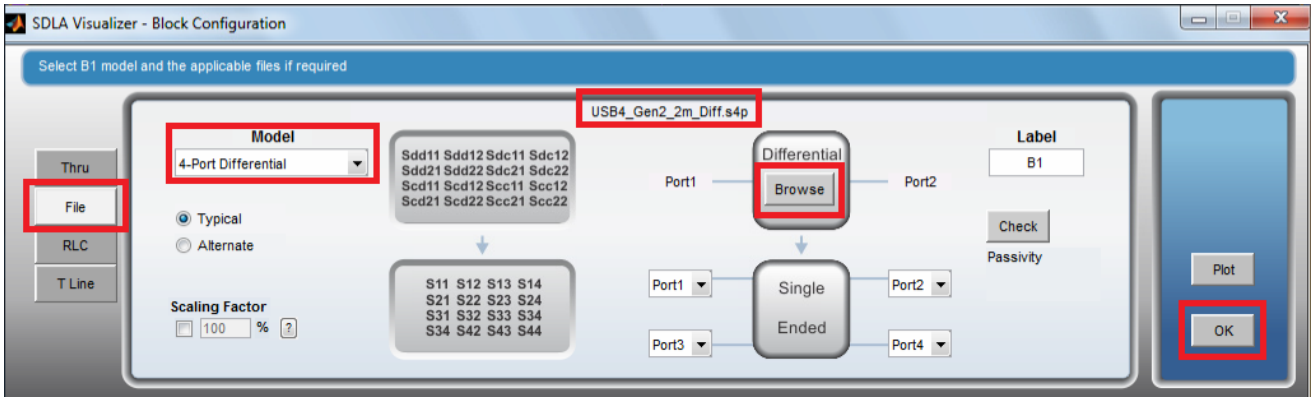


FIGURE 74. CREATE SMA CABLE DE-EMBEDDING + TP3 EMBEDDING FILES – #3

8. Select the **Tp3** radio button.

9. Click on the **Apply** button.

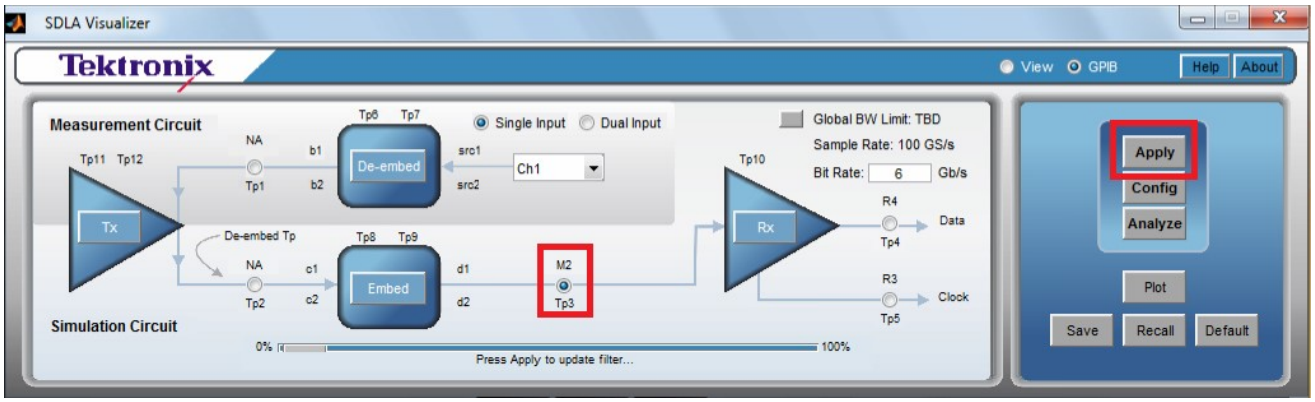


FIGURE 75. CREATE SMA CABLE DE-EMBEDDING + TP3 EMBEDDING FILES – #4

10. The filter file will be created at *"C:\Users\Public\Tektronix\TekApplications\SDLA\output filters\sdlatp3.flt"*. Copy this file to the ***"C:\TekApplications\DPOJET\Setups\USB4 Tx Test\TransferFunction"*** directory on the Tektronix scope and rename the file for de-embedding of channels 1 & 3.
11. Repeat above steps for channels 2 & 4.
12. Repeat above steps for the "2m.s4p" file.

10.2.4 Create SMA Cable De-embedding + Electrical Idle Files for Scope Channels 1 & 3 and Channels 2 & 4

1. Repeat steps 1 to 8 from Section 10.2.2 to combine the electrical idle file with the SMA cable de-embedding file.
2. Click on the **Embed** button.

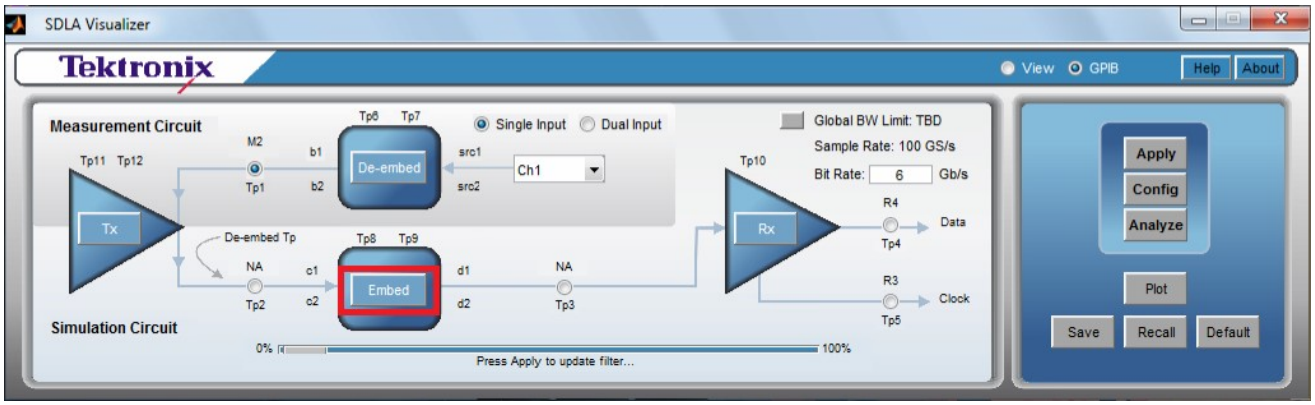


FIGURE 76. CREATE SMA CABLE DE-EMBEDDING + ELECTRICAL IDLE FILES – #1

3. Click on the **B1** button.

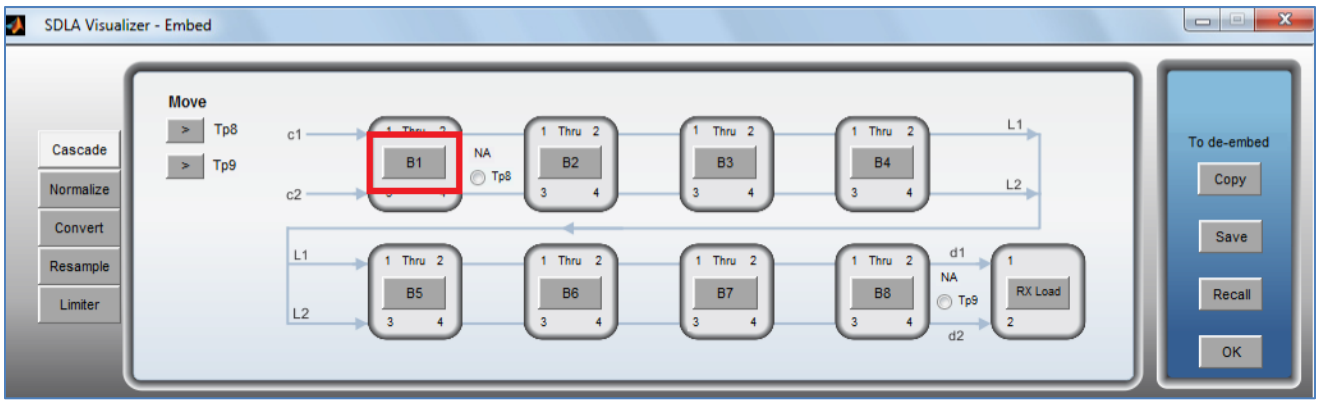


FIGURE 77. CREATE SMA CABLE DE-EMBEDDING + ELECTRICAL IDLE FILES – #2

4. Click on the **RLC** tab button.
5. Select the **Shunt2** model from the Model drop-down menu.
6. Select the **R ohms** checkbox and type in **1000000** in the textbox.
7. Select the **C pF** checkbox and type in **5.093** in the textbox.
8. Click **OK**.

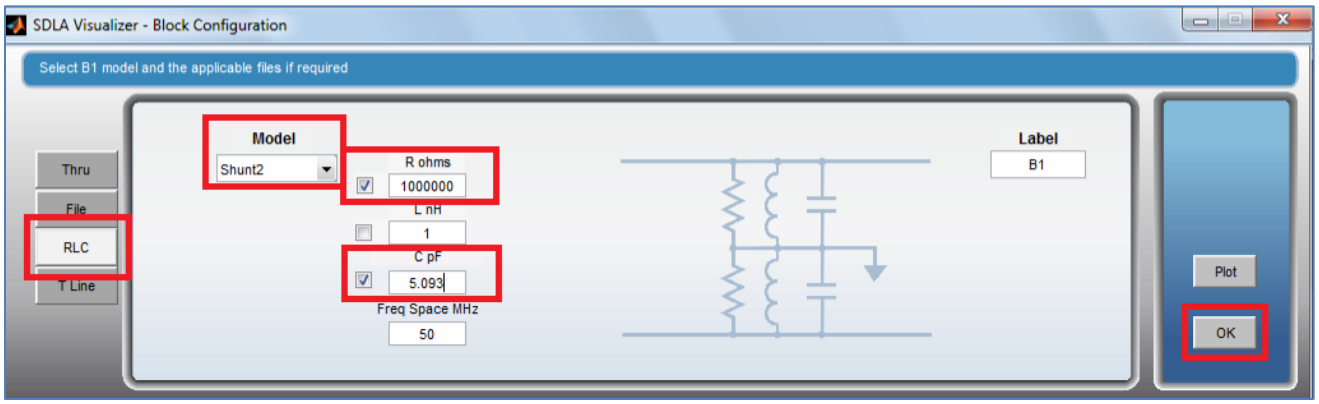


FIGURE 78. CREATE SMA CABLE DE-EMBEDDING + ELECTRICAL IDLE FILES – #3

9. Select the **Tp3** radio button.
10. Click on the **Apply** button.

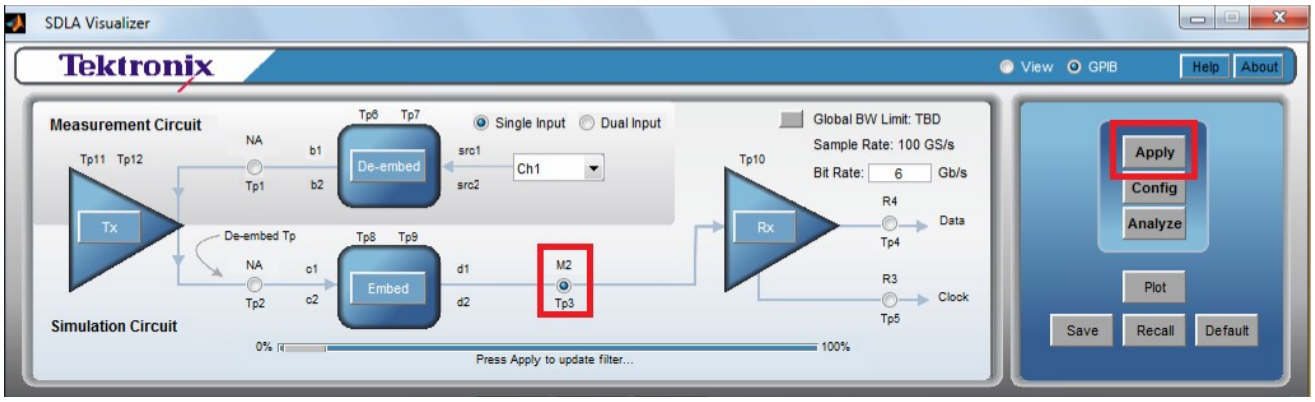
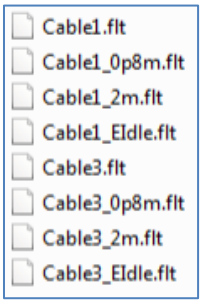
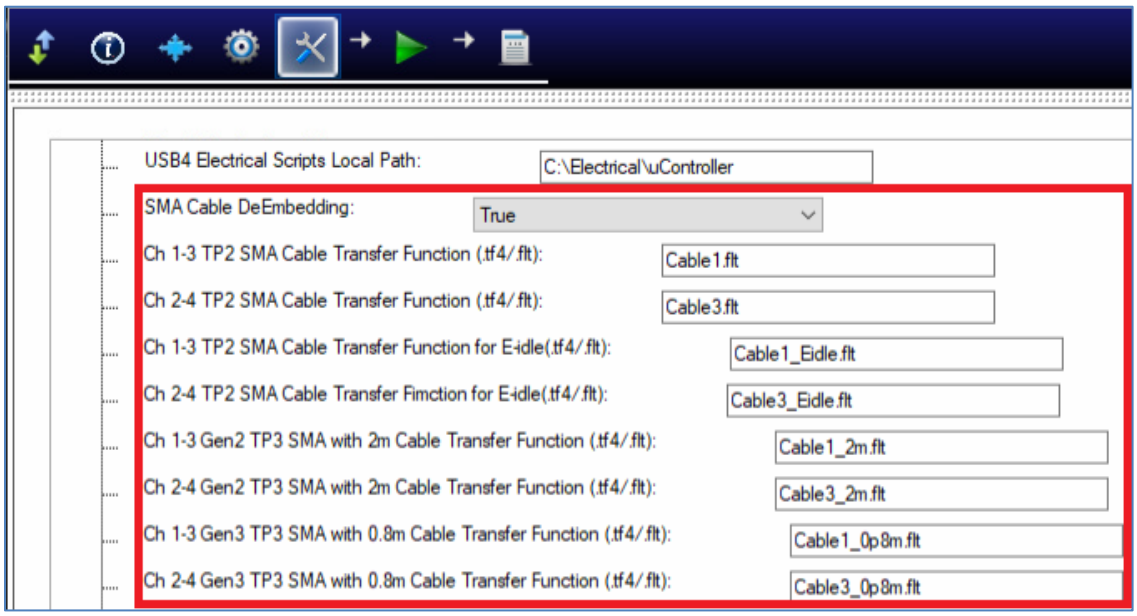


FIGURE 79. CREATE SMA CABLE DE-EMBEDDING + ELECTRICAL IDLE FILES – #4

11. The filter file will be created at *"C:\Users\Public\Tektronix\TekApplications\SDLA\output filters\sdlatp3.flt"*. Copy this file to the ***"C:\TekApplications\DPOJET\Setups\USB4 Tx Test\TransferFunction"*** directory on the Tektronix scope and rename the file for de-embedding of channels 1 & 3.
12. Repeat above steps for channels 2 & 4.
13. Make sure that all filter file folders contain 8 filter files, e.g.:



14. On the GRL-USB4-TX-TEST application -> Configurations  page, select **True** for "SMA Cable DeEmbedding" and specify the filter files to be used.



11 Appendix B: Burn Optimized Presets for Platform

11.1 Locate Optimized Preset Values

1. On the GRL-USB4-TX-TEST software, select **12.1.1 Preset Calibration** from the Calibration/Tests selection panel (refer Section 6.1).
2. On the Test Conditions page, select the 10G data rate (either **10 Gb/s** or **10.3125 Gb/s**) and the 20G data rate (either **20 Gb/s** or **20.625 Gb/s**) (refer Section 4.3.3).
3. Run the Preset calibration (refer Section 6.3). When completed, generate the test report and find the optimized preset values.
4. For example:

   Port A:

   10G (10 Gb/s or 10.3125 Gb/s), Lane 0 is 1 (optimized preset value).

   10G (10 Gb/s or 10.3125 Gb/s), Lane 1 is 1.

   20G (20 Gb/s or 20.625 Gb/s), Lane 0 is 2.

   20G (20 Gb/s or 20.625 Gb/s), Lane 1 is 1.

   Port B:

   10G (10 Gb/s or 10.3125 Gb/s), Lane 2 is 0.

   10G (10 Gb/s or 10.3125 Gb/s), Lane 3 is 0.

   20G (20 Gb/s or 20.625 Gb/s), Lane 2 is 1.

   20G (20 Gb/s or 20.625 Gb/s), Lane 3 is 1.

USB4 Tx Test Report

1. 12.1.1 Preset Calibration [Rate_10p3125G,L0]

Pass/Fail Stats	:	Pass
Preset 0 TP2 DDJ :	:	108.4000 mUI
Preset 1 TP2 DDJ :	:	93.3000 mUI
Preset 2 TP2 DDJ :	:	118.0000 mUI
Optimized Tx Preset Cal	:	Preset 1
Test completed time	:	13 July 2020 14:31:58 PM

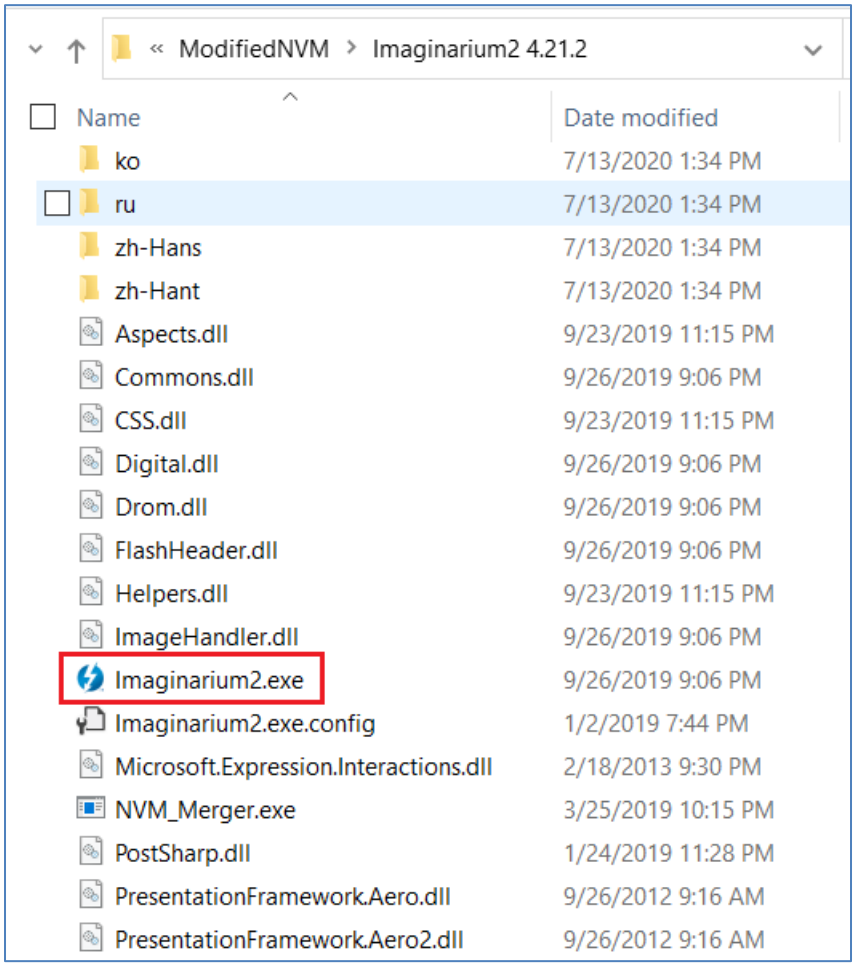
USB4 Tx Test Report

2. 12.1.1 Preset Calibration [Rate_20p625G,L0]

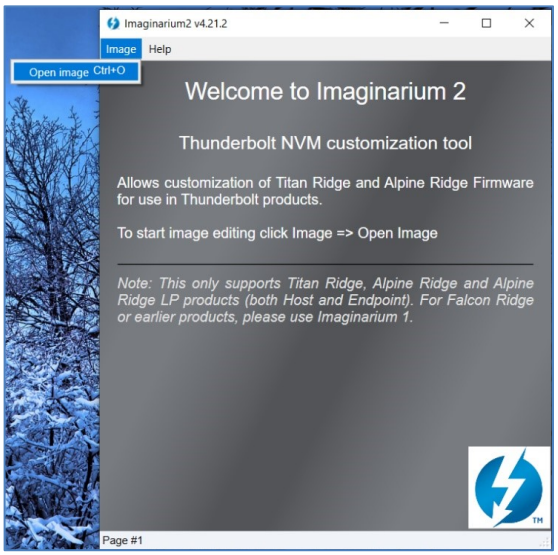
Pass/Fail Stats	:	Pass
Preset 0 TP2 DDJ :	:	263.8000 mUI
Preset 1 TP2 DDJ :	:	188.0000 mUI
Preset 2 TP2 DDJ :	:	159.0000 mUI
Optimized Tx Preset Cal	:	Preset 2
Test completed time	:	13 July 2020 14:37:10 PM

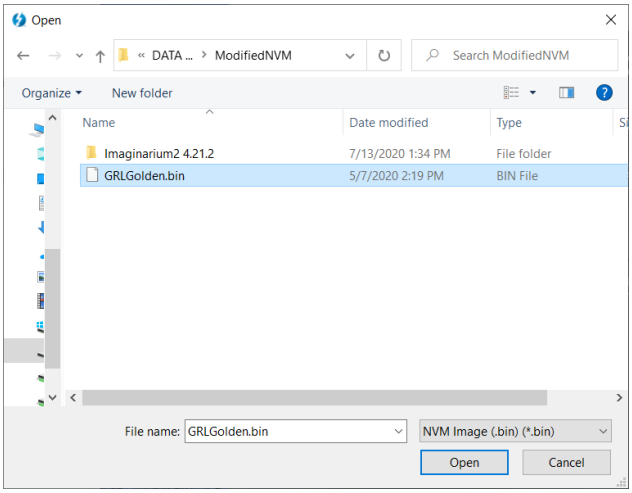
11.2 Create NVM with Optimized Presets

1. Download **Imaginarium2** from the Intel IBL website and run the tool.



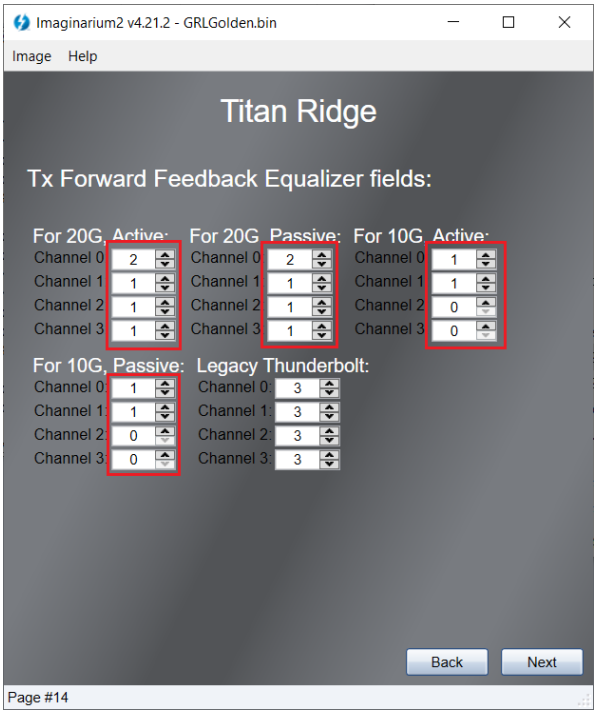
2. Select the NVM file that you want to modify and click on **Open**.



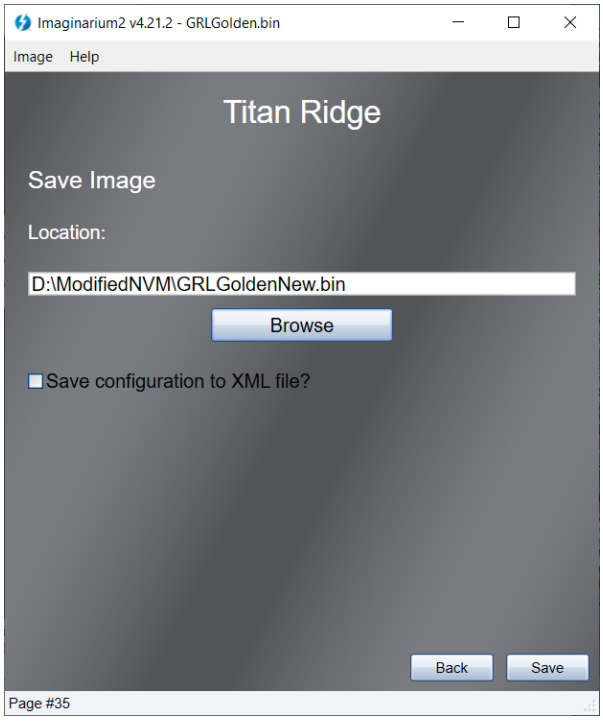


3. Click on **Next** until the following page appears. Enter the optimized preset values that have been determined from the GRL-USB4-TX-TEST software test report.

   In below example, Channel 0 and Channel 1 refer to Port A's Lane 0 and Lane 1 respectively while Channel 2 and Channel 3 refer to Port B's Lane 2 and Lane 3 respectively.

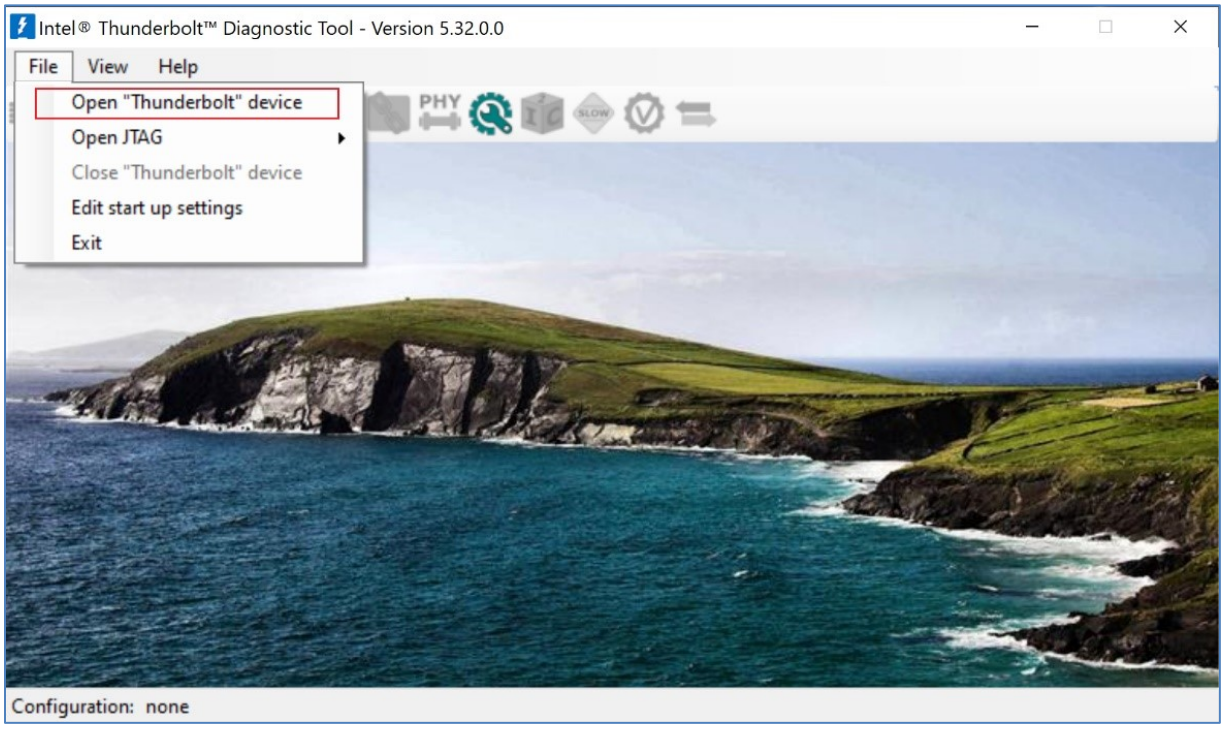


4. Save the new NVM to a file as shown below.

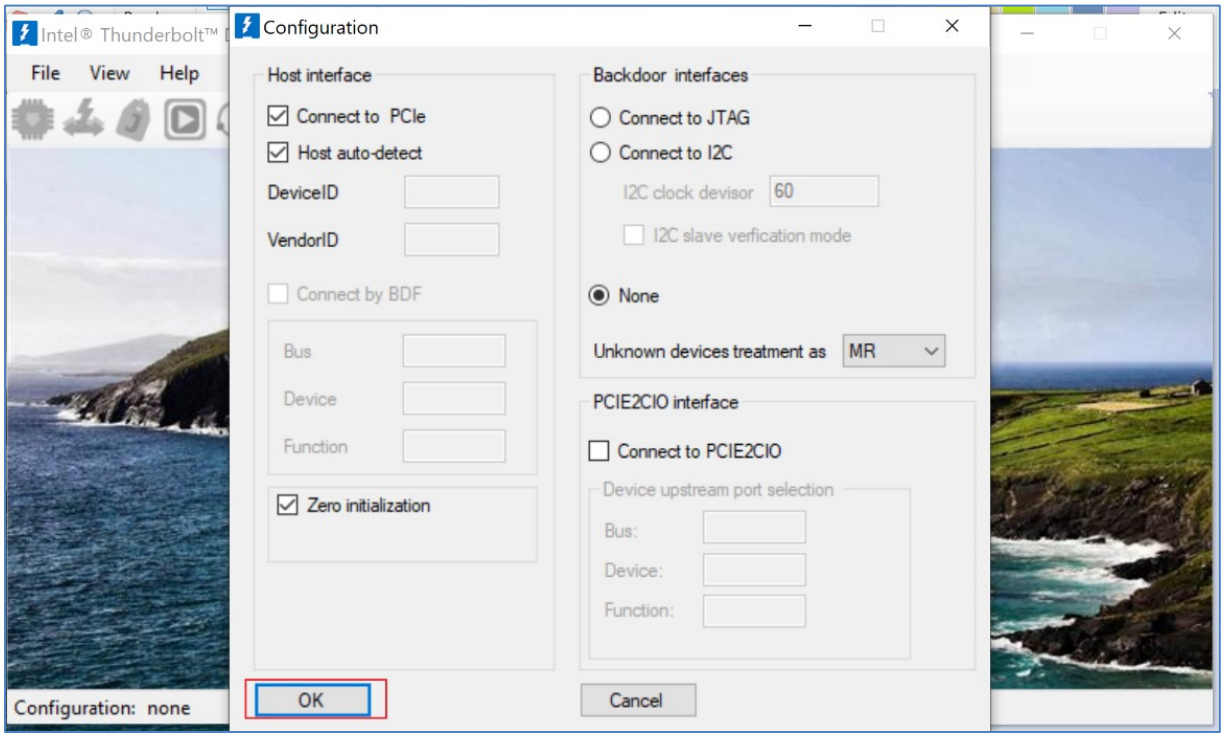


11.3 Burn NVM

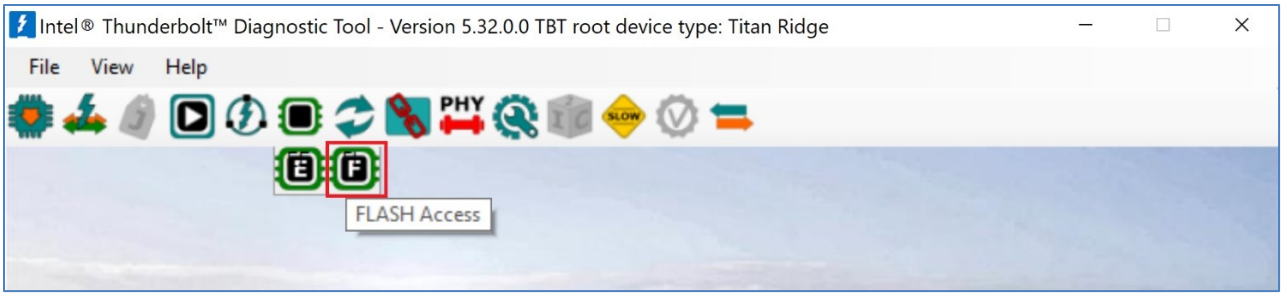
1. Open the Intel Thunderbolt Diagnostic Tool on the platform. Select **Open "Thunderbolt" device**.



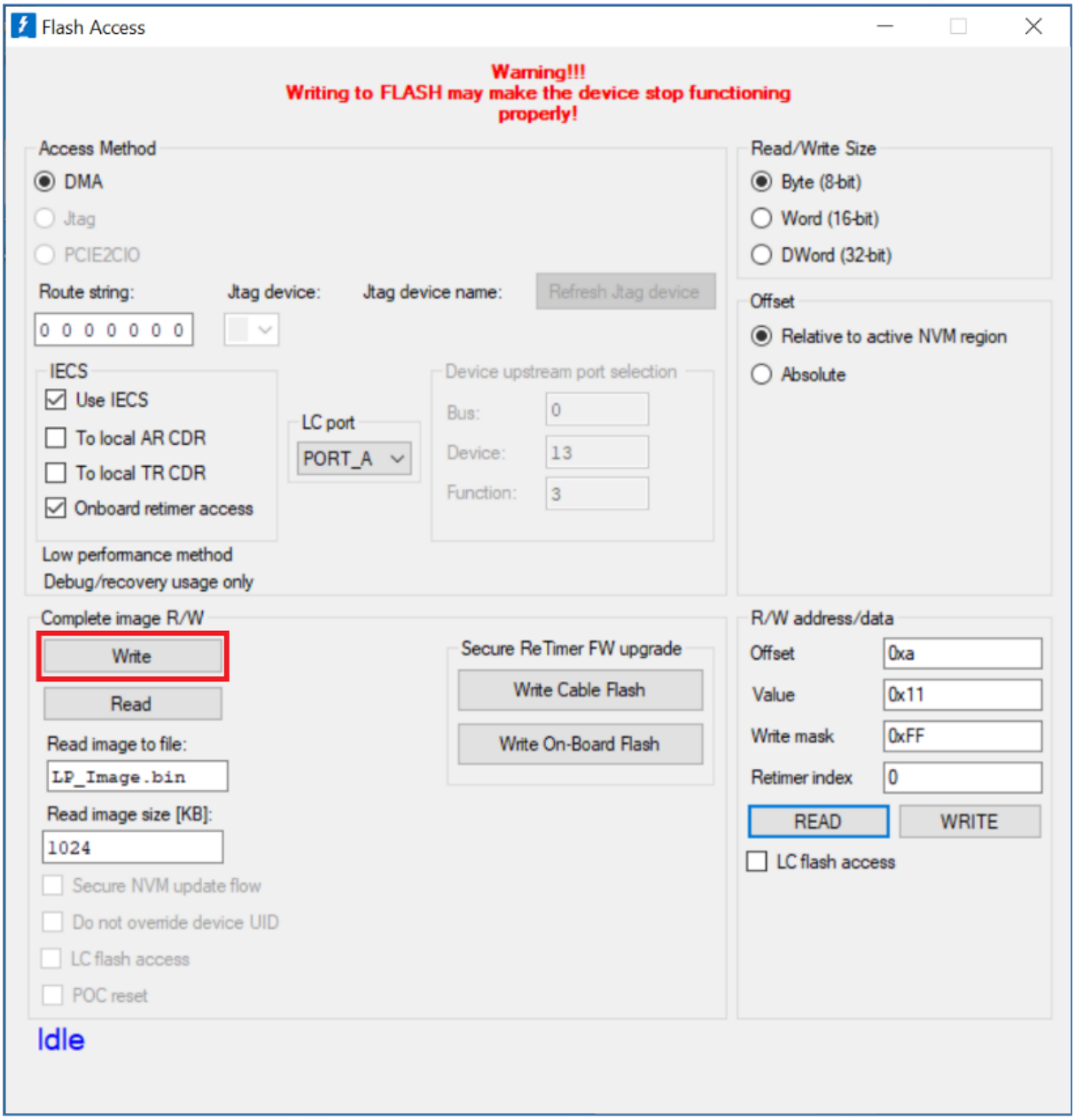
2. Click on **OK** to continue.



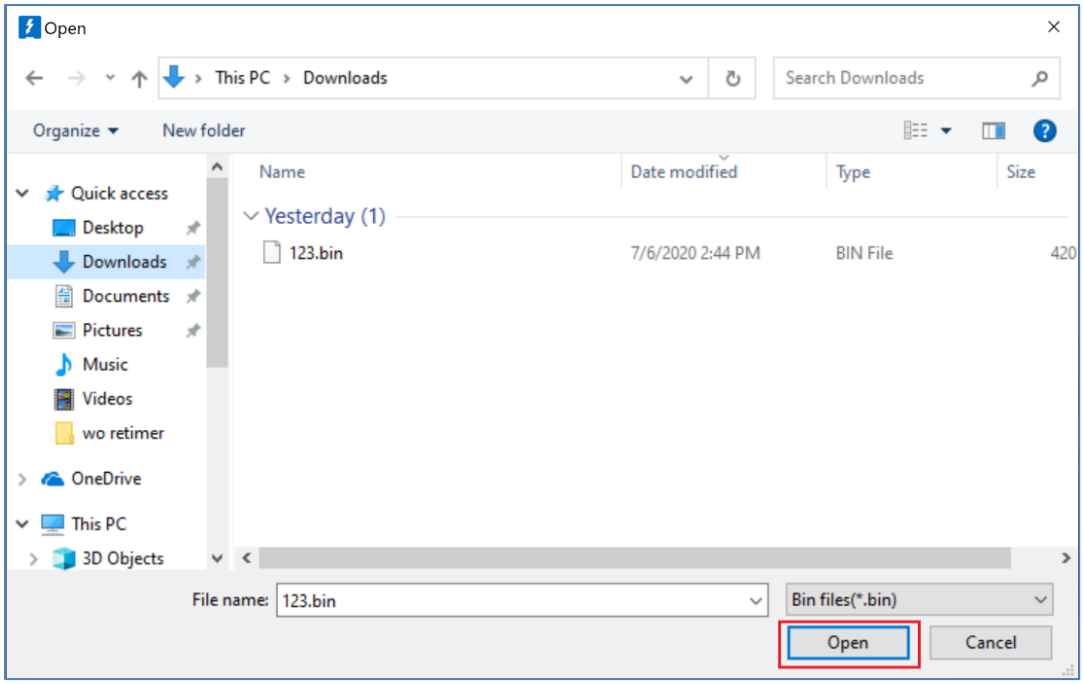
3. Select the **FLASH Access** icon.



4. Select **Write** to burn NVM.



5. Select the NVM file that you want to burn NVM to the platform.



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