# Granite River Labs

## USB4$^{TM}$ Return Loss Test Method of Implementation (MOI) & User Guide
## Using

## Anritsu MS46524B Vector Network Analyzer and GRL-USB4RL-AN Automation Software

All product names are trademarks, registered trademarks, or service marks of their respective owners.

The GRL disclaims all warranties and liability for the use of this document and the information contained herein and assumes no responsibility for any errors that may appear in this document, nor does the GRL make a commitment to update the information contained herein.

Contact the GRL office to obtain the latest revision of this document.

Questions regarding this document in the GRL may be forwarded to:

Granite River Labs 3500 Thomas Road, Suite A, Santa Clara, CA 95054

Phone: 408-627-7608 Fax: 408-912-1810

E-mail: info@graniteriverlabs.com

http://www.graniteriverlabs.com

# TABLE OF CONTENTS

# List of Figures

# List of Tables

# 1 Introduction

This MOI & User Guide documentation describes how to perform automated Calibration and Testing of the USB4™ Return Loss using Anritsu (MS46524B) Vector Network Analyzer and GRL-USB4RL-AN Automation Software.

The GRL automation software includes calibrating for time and frequency domain and measuring impedance and return loss for USB4 devices under test. When combined with a satisfactory level of interoperability testing, these tests provide a reasonable level of confidence that the device under test will function properly in many USB4 environments.

This MOI & User Guide documentation mainly covers the following for USB4 Return Loss calibration and testing.

1. Equipment required for calibration and testing.

2. GRL-USB4RL-AN Automation Software setup for calibration and testing.

3. Specification Standard automated calibration and test procedures.

# 2 Resource Requirements

## 2.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – SYSTEMS

| System | Qty. | Description | Key Specification |
|---|---|---|---|
| Vector Network Analyzer (VNA) | 1 | Anritsu MS46524B ShockLine™ 4-Port Performance Vector Network Analyzer<br><br>• MS46524B-020 – Frequency Domain option (50 kHz to 20 GHz)<br>• MS46524B-002 – Time Domain option (with time gating)<br>Firmware Version: V2018.2.1 or above | 40GHz<br>140dB max |

TABLE 2. EQUIPMENT REQUIREMENTS – ACCESSORIES

| Accessory | Qty. | Description | Key Specification |
|---|---|---|---|
| Computer | 1 | External PC for running GRL-USB4RL-AN Software | Windows 7+ OS |
| Calibration Kit | 1 | Anritsu TOSLKF50A-20 Coaxial Calibration Kit | Type K(f), DC to 20GHz, 50 ohms |
| USB4 Microcontroller | 1 | Wilder-Tech USB4 Gen3 µController<br>(USB4-TPA-UC-K, Kit Part No. 640-0961-000) | Optional for some test configurations, see Section 3.1.2 |
| USB4 Test Fixture | 1 | Wilder-Tech USB4 CIO Plug board<br>(USB4-TPA-UC-K, Kit, Part No. 600-1191-100) | |
| SMA-SMP Adapter or SMA-SMP Cables | 4 | Rosenberger 02K118-K00S3 Straight RPC-2.92 Jack-Mini-SMP Jack Adapter<br><br>  - Or –<br><br>Wilder-Tech Part No. 415-0080-004 – 9" High Performance Phase Aligned Flexible Coaxial Cables w/ Female 2.92mm to Female SMP | DC to 40 GHz, 50 ohms |
| Matched Cable Pairs | 2 pairs | Rosenberger UFC142A 2.92m (x2), 1m SMA cable | Phase matched ±2° at 40GHz<br><br>Insertion loss 1dB max in 10GHz |

*Note that gentle handling of the fixture coaxial cable connections is required to avoid damage. For instance, when connecting to the fixture, the coaxial cables should not be twisted, bended, or have tension applied where possible. The fixture should also be connected to the DUT prior to making any SMP connections. Refer to the user documentation by Wilder Technologies for the full list of precaution steps to observe when using the cables.*

## 2.2 Software Requirements

TABLE 3. SOFTWARE REQUIREMENTS

| Software | Source |
|---|---|
| GRL-USB4RL-AN | Granite River Labs USB4 Return Loss 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-USB4RL-AN software. GRL's software framework has been tested to work with all three versions of VISA available on the Market:<br><br>1. NI-VISA: http://www.ni.com/download/ni-visa-17.0/6646/en/<br><br>2. Keysight IO Libraries: www.keysight.com (Search on IO Libraries)<br><br>3. Tektronix TekVisa: www.tek.com (Downloads > Software > TekVisa) |
| USB4 Electrical Test Tool (ETT) | Downloadable from USB-IF's website. See Section 3.1.2 for more details. |

# 3 Installation and Setup of GRL-USB4RL-AN Software

This section provides procedures for installing, configuring, and verifying the operation of the GRL USB4 Return Loss Test solution and USB4 electrical test toolset. It also helps you familiarize with the basic operation of the GRL-USB4RL-AN software.

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

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

## 3.1 Download GRL-USB4RL-AN Software

Install, launch and set up the GRL-USB4RL-AN software on a PC (where the GRL-USB4RL-AN is referred to as 'Control PC' in this MOI & User Guide).

1. Install VISA (Virtual Instrument Software Architecture) on to the PC where GRL-USB4RL-AN is to be used (see Section 2.2).
2. Download the software ZIP file package from the Granite River Labs support site.
3. The ZIP file contains:

   - **AnritsuUSB4ReturnLoss00xxxxxxxSetup.exe** – Run this on the PC to install the application.

   - **AnritsuUSB4ReturnLossSetupFileInstallation00xxxxxxxSetup.exe** – Run this on the VNA to install the proper 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.
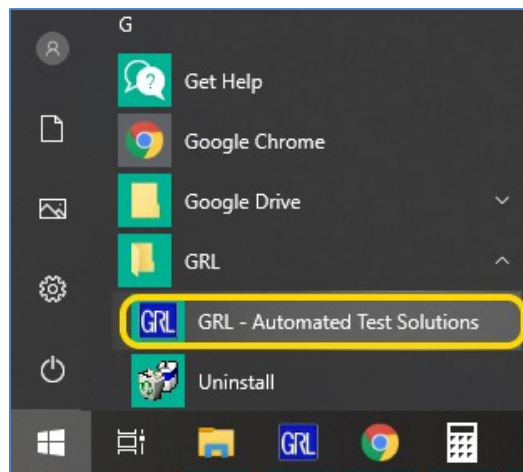


FIGURE 1. LAUNCHING GRL SOFTWARE FRAMEWORK

   b) From the **Application → Framework Test Solution** drop-down menu, select **Anritsu USB4 Return Loss Test Application**. If the selection is grayed out, it means your license has expired.
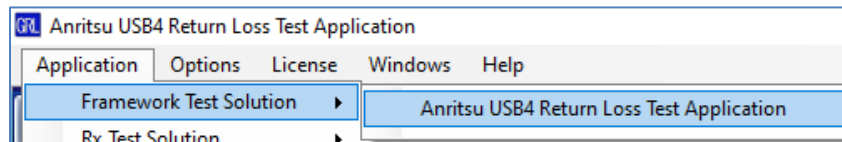
FIGURE 2. LAUNCHING GRL-USB4RL-AN APPLICATION

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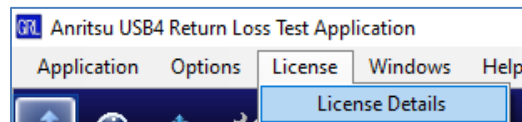


FIGURE 3. LICENSE DETAILS
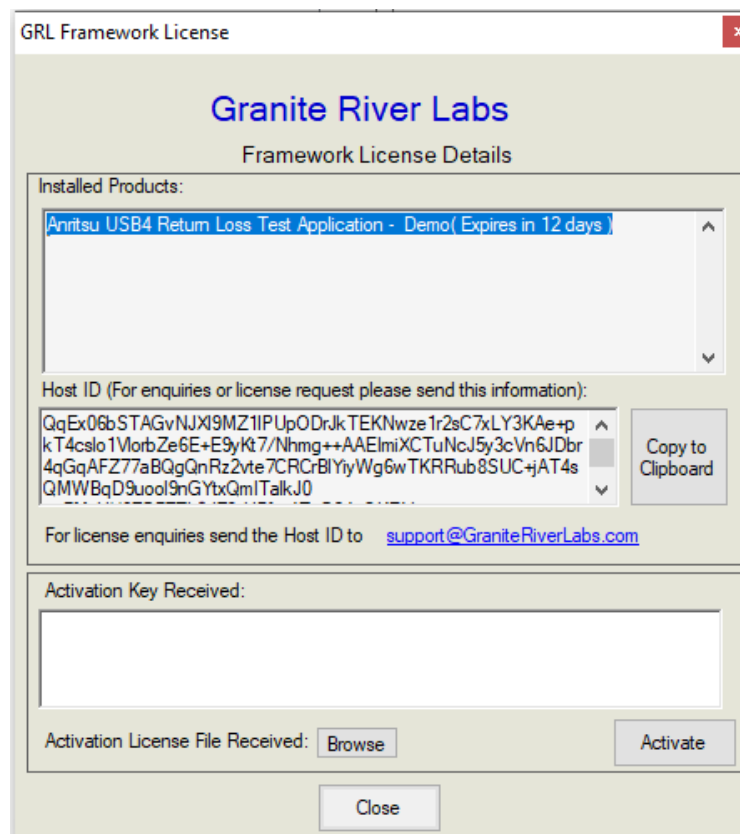
    ii)  Review the installed application.



FIGURE 4. INSTALLED APPLICATION

    iii) Activate a License:

    [1]  If you have an Activation Key, please 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 PC. The demo software is also limited in its capability, in that it will only calibrate the*

*maximum frequency for each data rate. Thus, the demo version cannot be used to fully calibrate and test a device.*

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

### 3.1.1   Connect Anritsu Vector Network Analyzer with PC

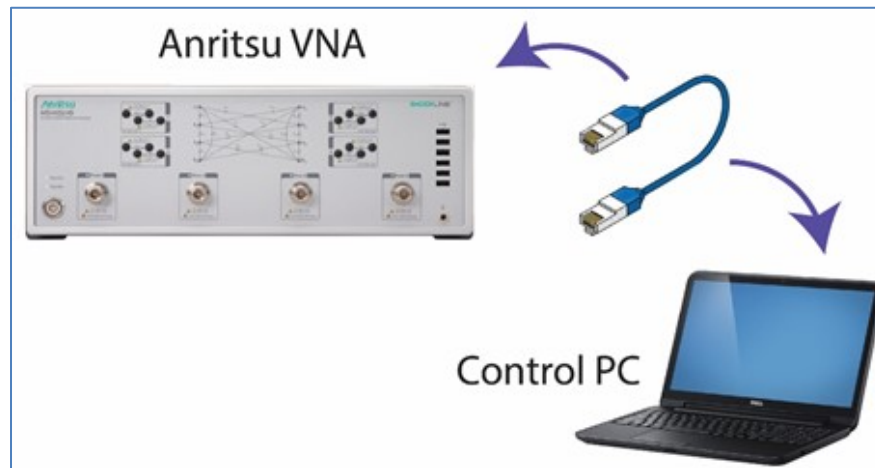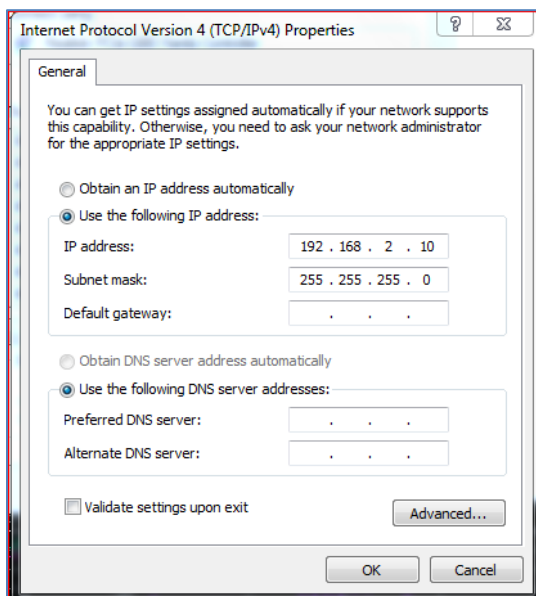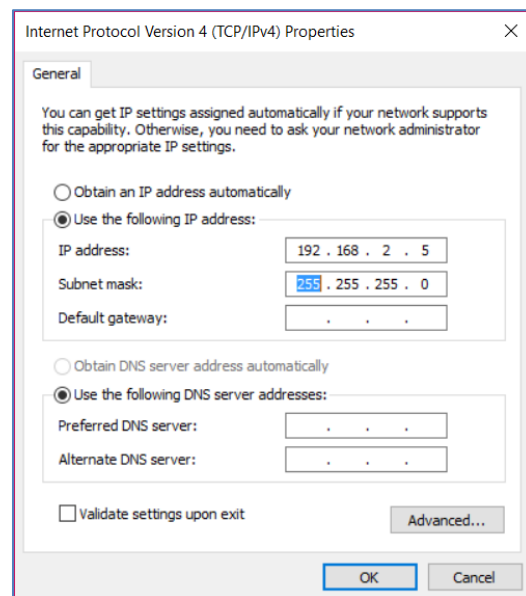1. Connect the Anritsu VNA with the control PC using an Ethernet cable.



FIGURE 5. CONNECTING ANRITSU VNA WITH CONTROL PC

2. Set both VNA and PC to the same network.



**VNA**

**Control PC**

FIGURE 6. SETTING VNA AND PC NETWORK

---

### 3.1.2 Download and Install USB4 Electrical Test Tools (ETT)

For USB4 Return Loss measurements, the Host/Device's CIO PHY must be in an active state during testing. Its transmitters shall be transmitting PRBS-31 into the VNA 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 return loss 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.
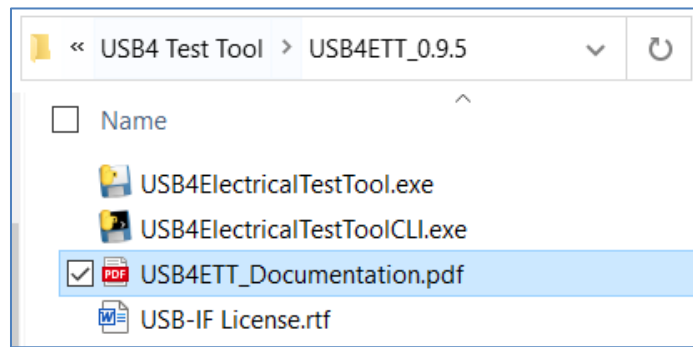


**For USB4 Host Testing:**

- The ETT can be loaded on the Control PC with the GRL-USB4RL-AN software. In this case, the Wilder-Tech µController is required. The DUT is controlled using an Apple 0.8m USB Type-C® cable from the Wilder-Tech µController to the Wilder-Tech USB4 Test Fixture.

**For USB4 Device Testing:**

- **Upstream Facing Port (UFP):** The ETT can be loaded on the Control PC with the GRL-USB4RL-AN software. In this case, the Wilder-Tech µController is required. The DUT is controlled using an Apple 0.8m USB Type-C cable from the Wilder-Tech µController to the Wilder-Tech 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 Control PC with the GRL-USB4RL-AN software. In this case, the Wilder-Tech µController is required. The DUT is controlled using an Apple 0.8m USB Type-C cable from the Wilder-Tech µController to the Wilder-Tech USB4 Test Fixture.

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

### 3.1.3 Launch and Set Up Software

#### 3.1.3.1 On the Control PC

1. Launch GRL Host Application from Start Menu -> GRL -> GRL – Automated Test Solutions.
2. Select Application -> Framework Test Solution -> Anritsu USB4 Return Loss Test Application.

3. Type in the IP Address of the Anritsu VNA into the "Address" field and click the "lightning" button ( ⚡ ) . The "lightning" button should turn green ( ⚡ ) if successfully connected to the equipment.
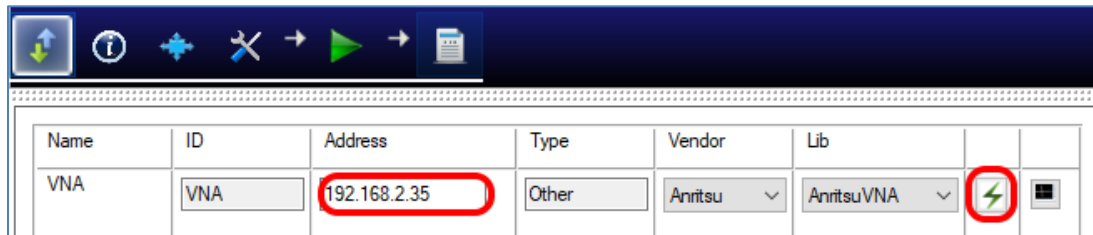


FIGURE 7. GRL TEST SOLUTION IP ADDRESSING ON VNA

### 3.1.3.2  Session Info

Select the ⓘ button in the main software menu to access the Session Info page. The information provided will be included in the report.

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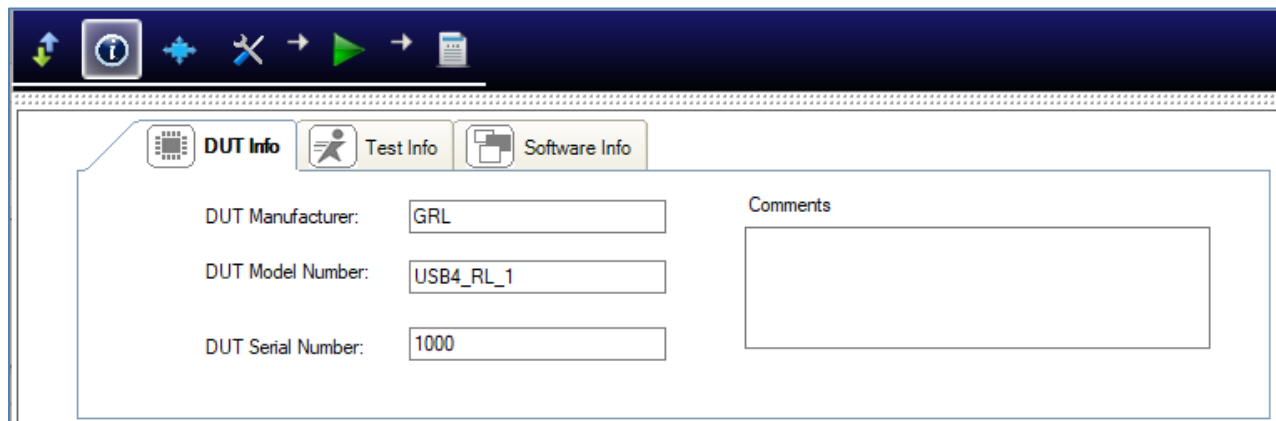- The **Software Info** is automatically populated.



FIGURE 8. SESSION INFO PAGE

### 3.1.3.3  Test Conditions

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

a) **Test Port tab**: Select the test ports on the device under test.
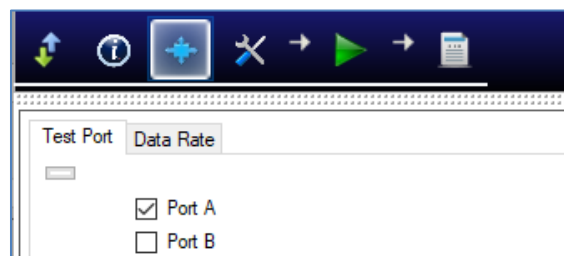
FIGURE 9. SELECT TEST PORT

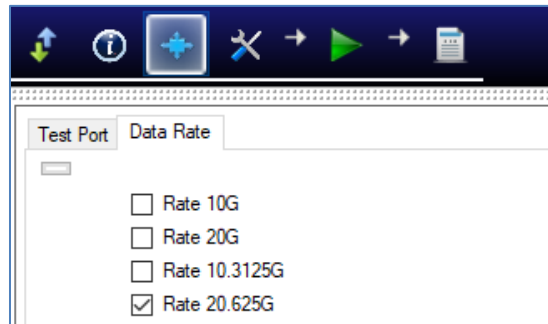b) **Data Rate tab**: Select the desired data rate.



FIGURE 10. SELECT DATA RATE

# 4 Time and Frequency Domain Calibration Setups

Calibration is to be performed for RF effects such as delay, loss or mismatch of RF cables and SMA-SMP adapters using "SOLT" and "Reference Plane" calibration methods before running measurements. Calibration must be performed for both the time domain (Channel 1) and frequency domain (Channel 2).

*Note: The test fixture is not used for calibration.*

The figures below show the calibration setup diagrams for time and frequency domain, which require the Anritsu TOSLKF50A-20 VNA calibration kit and Rosenberger SMP jack adapters.
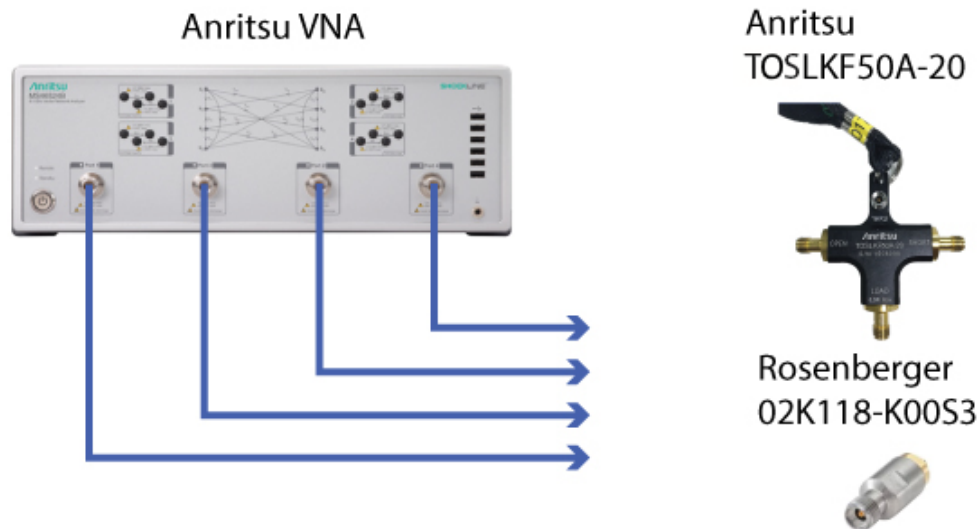


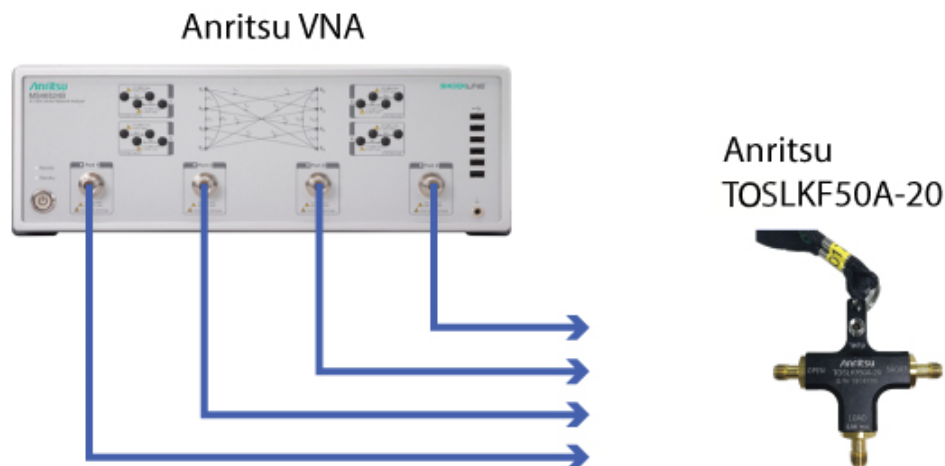FIGURE 11. CALIBRATION SETUP FOR TIME DOMAIN CALIBRATION



FIGURE 12. CALIBRATION SETUP FOR FREQUENCY DOMAIN CALIBRATION

*Note: The Anritsu TOSLKF50A-20 VNA calibration kit is required for SOLT calibration, while the Rosenberger SMP jack adapters are required for Reference Plane calibration.*

The GRL-USB4RL-AN software will guide user step by step on how to connect the equipment and perform the SOLT calibration and Reference Plane calibration.
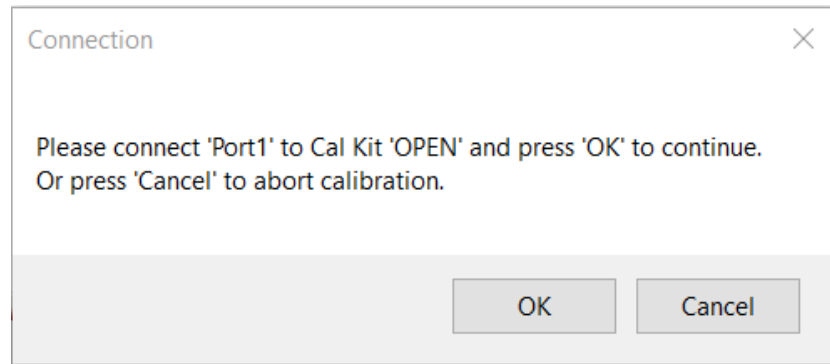


The following shows another pop-up example by the GRL-USB4RL-AN software to guide user to connect the SMP jack adapters to perform the Reference Plane calibration.
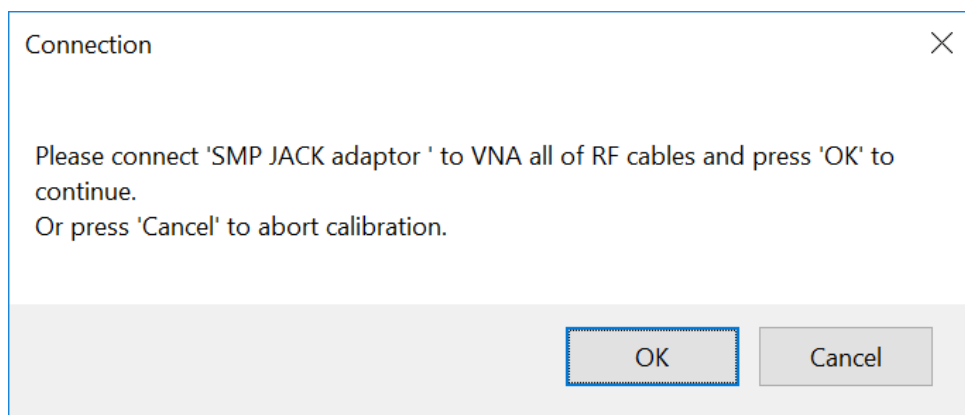


FIGURE 13. SOFTWARE CALIBRATION GUIDE EXAMPLE

# 5 Calibrating with GRL-USB4RL-AN Software

## 5.1 Select Calibration

The Select Tests page is the place where the calibration and tests that need to be performed are 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 tests will show an error message.
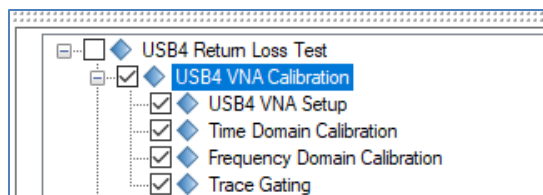


FIGURE 14. SELECT CALIBRATION TYPES

Select the USB4 VNA Calibration group to set up the VNA test environment and perform time and frequency domain calibration and trace gating. The GRL-USB4RL-AN software will guide the user step by step while calibration is being run.

*Note: All calibrations must be performed for both the time domain and frequency domain.*

## 5.2 Configure Calibration Parameters

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

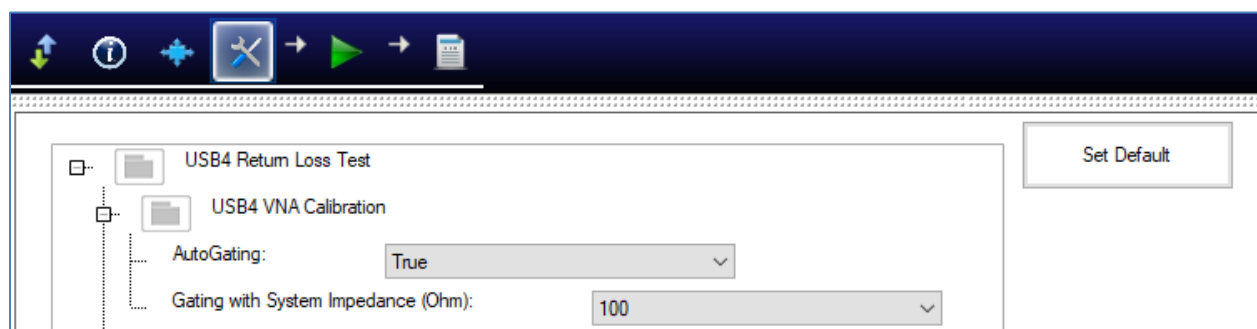To return all parameters to their default values, select the 'Set Default' button.



FIGURE 15. CALIBRATION CONFIGURATION PAGE

TABLE 4. CALIBRATION PARAMETERS

| Parameter | Description |
|---|---|
| **AutoGating** | Select 'True' to enable auto gating method when performing trace gating. |
| **Gating with System Impedance (Ohm)** | Select to apply 85 or 100 ohms impedance for trace gating. For compliance testing, 85 ohms should be selected for both calibration and testing. |

## 5.3    Run Calibration

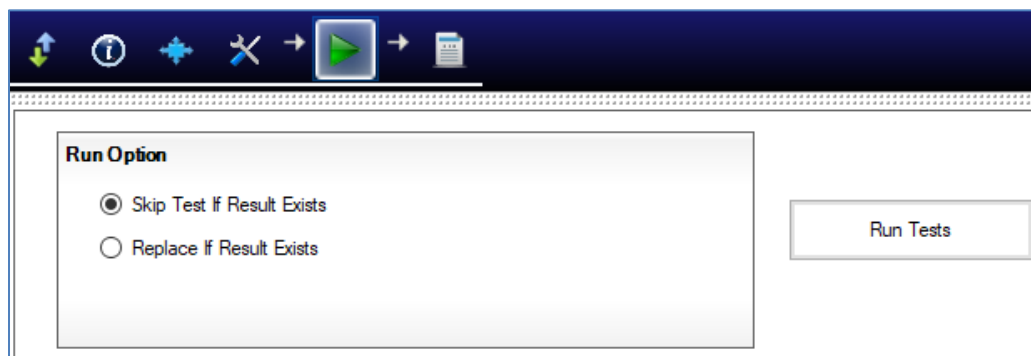Select the [▶] button in the main software menu to access the Run Tests page.

FIGURE 16. RUN TESTS PAGE

TABLE 5. 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, please delete the calibration/tests from the Report page (see Section 9.2 for example) and Run with **Skip Test if Result Exists**. The GRL-USB4RL-AN software will keep track of the missing calibration/tests in the report and perform those tests only.

# 6    Configure Proper Setup in Configurations Menu

After calibration has completed, testing for DUT compliance can then be performed. The USB4 Return Loss VNA test setup consists of Impedance measurement (informative) and Return Loss measurement on receiver/transmitter lanes of the DUT. The USB4 ETT as listed in Section 2.2 is required to run the automation tests.

Refer to Section 3.1.2 for options on how to configure the test setup. The ETT can be loaded on the control PC. The Wilder-Tech µController can be used to test any Host or Device Port. 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). Follow the steps in the below section for setup depending on the configuration chosen.

*Note that careful handling is needed when making coaxial connections on to the test fixture. Refer to the Wilder-Tech user documentation for detailed precautions (see Section 2.1).*

## 6.1    Host DUT Setup

If testing a Host, and the ETT have been loaded on the Control PC, and the µController has been connected to the Control PC via a USB cable, follow the below procedure:
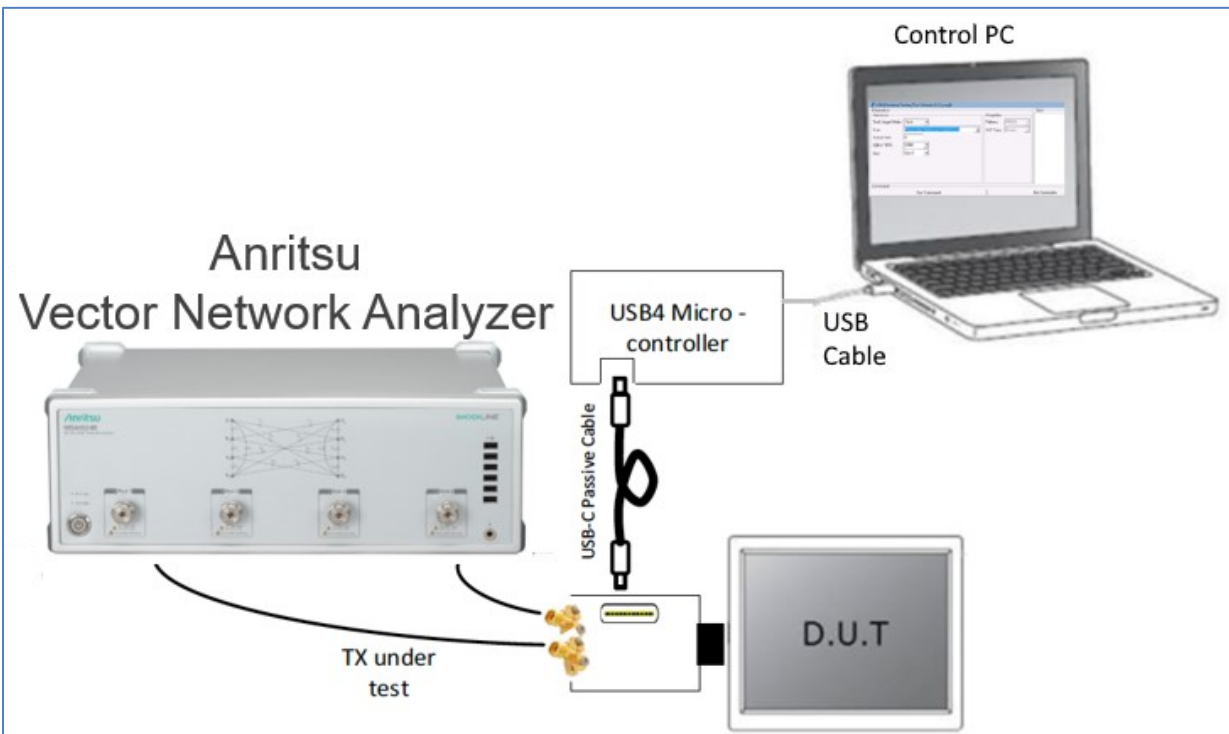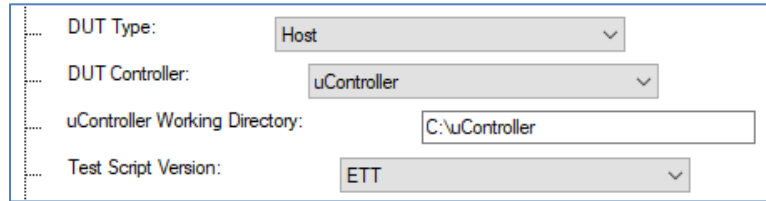
1.  Connect the equipment as follows:



FIGURE 17. TEST SETUP FOR HOST DUT

2.  On the main GRL software menu, select the [⚒] button to access the Configurations page.

    a)  Select "Host" in the "DUT Type" field.

b) Select "uController" in the "DUT Controller" field.
c) Select "ETT" in the "Test Script Version" field.
d) Specify the directory of the ETT on the Host DUT in the "uController Working Directory" field.
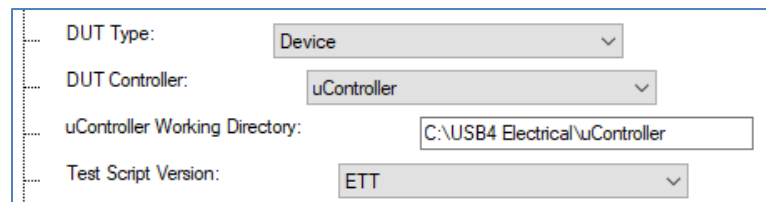


FIGURE 18. CONFIGURE HOST DUT EXAMPLE IN GRL-USB4RL-AN SOFTWARE

## 6.2 Device DUT Setup for UFP

If testing a Device's UFP, connect the equipment similar to the Host DUT setup in Section 6.1. Then, follow the below procedure:

On the main GRL software menu, select the [wrench icon] button to access the Configurations page.

a) Select "Device" in the "DUT Type" field.
b) Select "uController" in the "DUT Controller" field.
c) Select "ETT" in the "Test Script Version" field.
d) Specify the directory of the ETT on the USB4 remote host in the "uController Working Directory" field.



FIGURE 19. CONFIGURE DEVICE DUT (UFP) EXAMPLE IN GRL-USB4RL-AN SOFTWARE

## 6.3 Device DUT Setup for DFP

If testing a Device's DFP, connect the equipment similar to the Host DUT setup in Section 6.1. Take note that the DUT's UFP should be connected to a USB4 host port.

Follow the same procedure as for the Device's UFP setup in Section 6.2 above.

# 7    Perform Trace Gating

Trace gating can be performed to remove SMP connector effects between the SMP jack adapter and the test fixture.

*Note: Prior to running trace gating, make sure that the above relevant test setup (Section 6.1 to 6.3) has been completed.*

1.  On the Select Tests page, select "Trace Gating", and click "Run Tests" under  to start running trace gating.
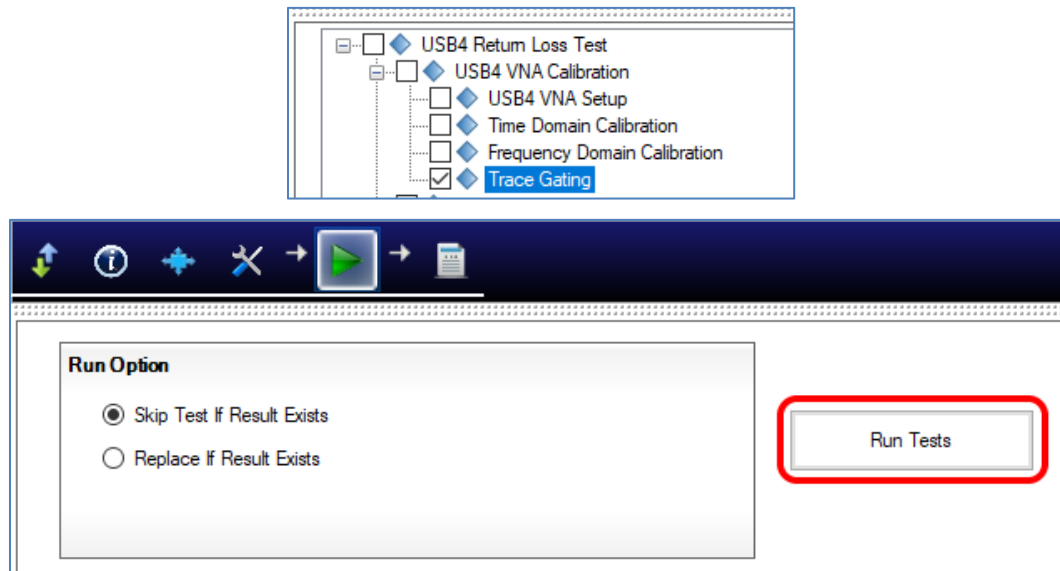


FIGURE 20. SELECT AND RUN TRACE GATING

2.  Follow the software instructions step by step to complete the process.

# 8 DUT Compliance Testing with GRL-USB4RL-AN Software

## 8.1 Select Tests

On the Select Tests page, un-check all Calibration Selections as they have been performed and completed in the previous section. Then select the tests required to be run.

*Note: GRL recommends running Rx and Tx Tests Separately in this version of GRL-USB4RL-AN. Otherwise for each data rate a prompt will come up to change from Rx to Tx on the Fixture. If Rx and Tx are tested separately, then all Rx will be tested and then all Tx will be tested with only one change needed to the fixture.*
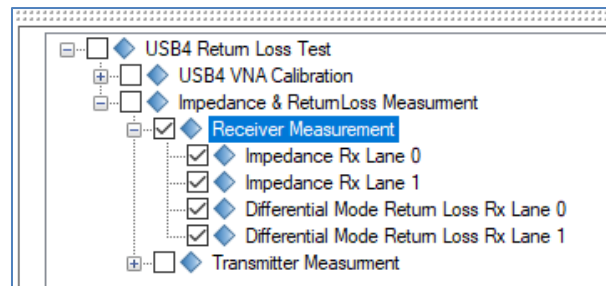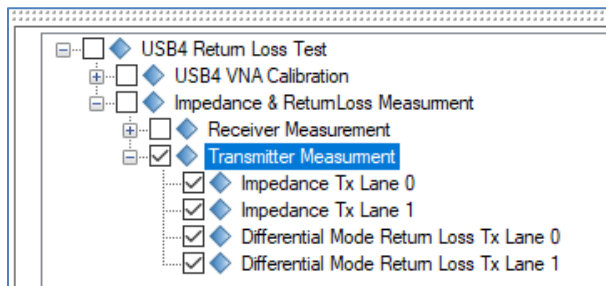
FIGURE 21. SELECT RX MEASUREMENT TESTS

FIGURE 22. SELECT TX MEASUREMENT TESTS

## 8.2 Configure Test Parameters

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

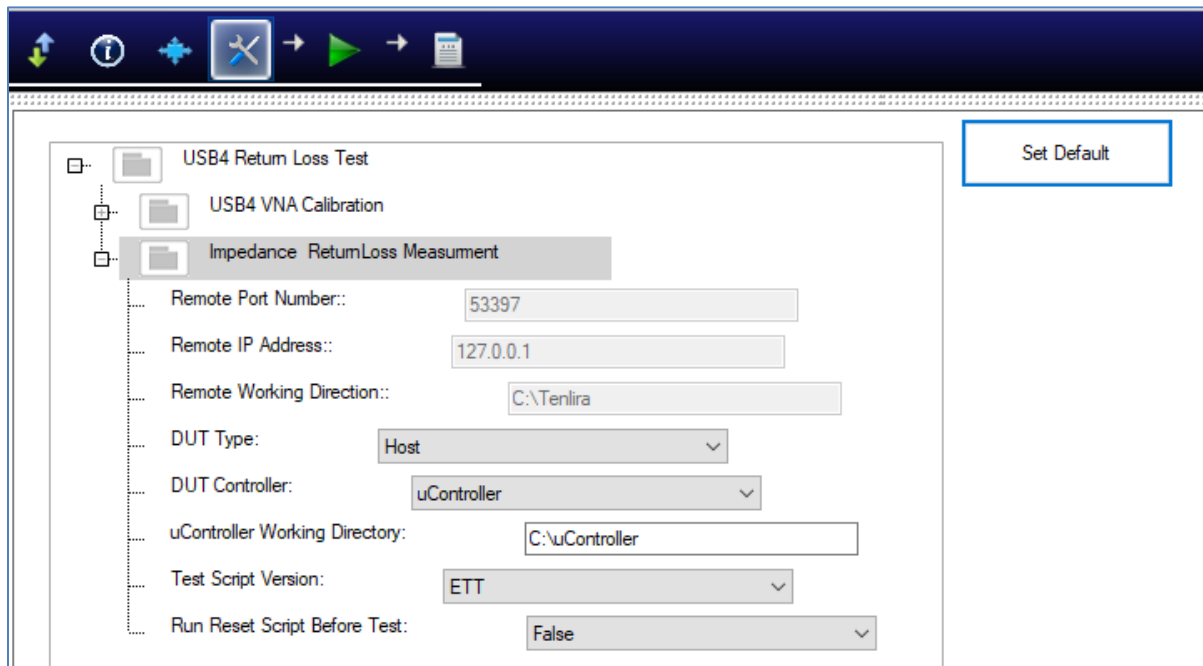To return all parameters to their default values, select the 'Set Default' button.

FIGURE 23. TEST CONFIGURATION PAGE

TABLE 6. TEST PARAMETERS

| Parameter | Description |
|---|---|
| **DUT Type** | *Select this first.* Select whether DUT is **Host** or **Device** or **Tethered Device** (if DUT has tethering capability). |
| **DUT Controller** | *Select this second.* Select whether port will be controlled by **Remote USB4 Host** or **uController** or **JTAG** (if DUT supports JTAG technology). |
| **Remote Port Number** | If **DUT Controlled By: Remote Host and DUT is TBT3**, specify the remote server's port number of the controller host of the test script. |
| **Remote IP Address** | If **DUT Controlled By: Remote Host and DUT is TBT3**, specify the remote server's IP address of the controller host of the test script. |
| **Remote Working Directory** | If **DUT Controlled By: Remote Host and DUT is TBT3**, set the working directory to the path where the test script is installed in the remote controller host. |
| **uController Working Directory** | If **DUT Controlled By: uController**, set the working directory to the path where the µController test script or ETT is installed on the control PC. |
| **Test Script Version** | Select **ETT** to run ETT or **0.8.6 and above** to run Tenlira script. |
| **Run Reset Script Before Test** | Select **True** to enable the GRL-USB4RL-AN software to reset the µController before running the test script or ETT command each time. |

## 8.3    Performing Impedance and Return Loss Measurement

The following example describes how to measure impedance and return loss. Impedance is measured at the time domain while return loss is measured at the frequency domain. Measurement should be performed on both the transmitter and receiver lanes.

*Note: The impedance measurement is carried out for information purpose only, meaning it has no test limit specification.*

*Note: Prior to running measurements, make sure that the relevant test setup described in Section 6 has been completed.*

1.    Select the ▶ button in the main GRL-USB4RL-AN software menu to access the Run Tests page and click "Run Tests". Select whether to Skip existing results or Replace if results exist.
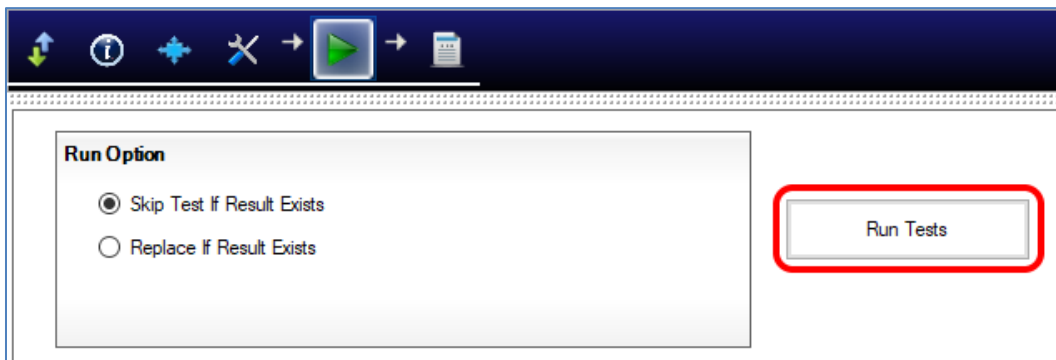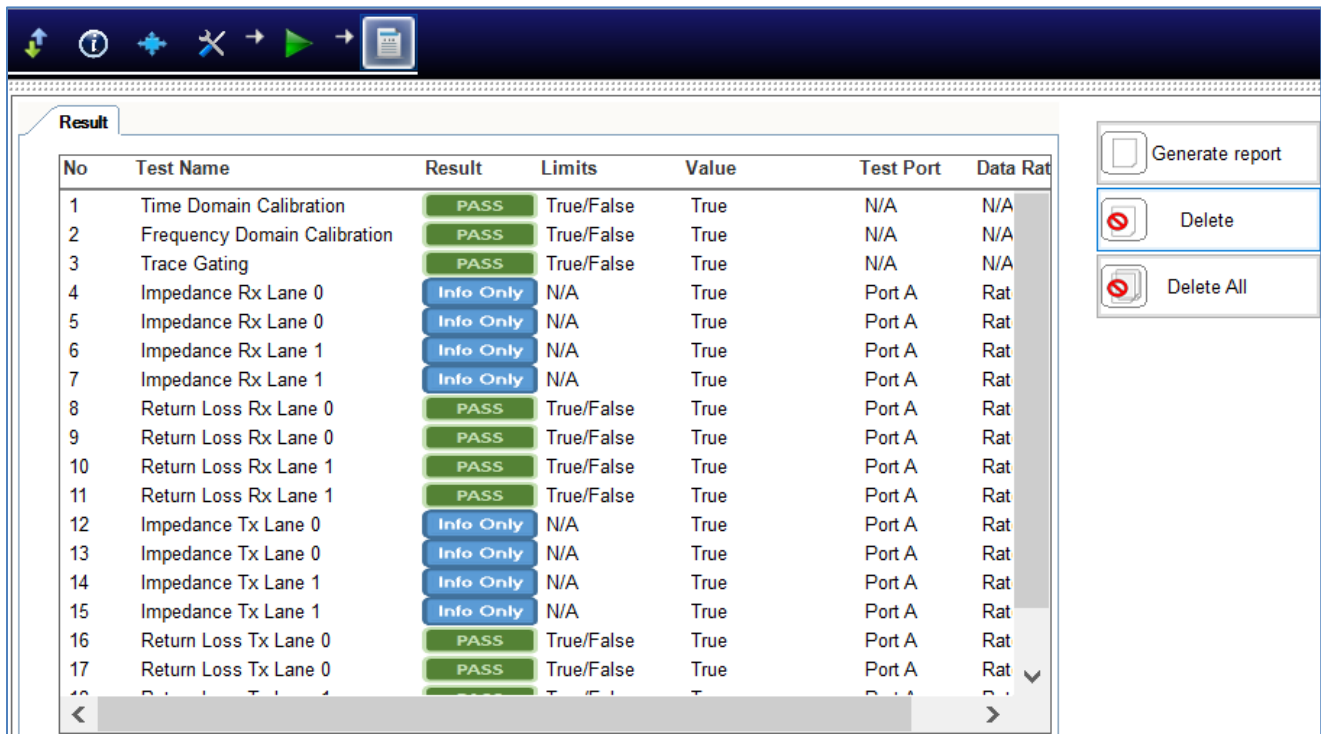


FIGURE 24. RUN TESTS PAGE

2.    Follow the software instructions step by step to set up the connection and run the selected tests.

3.    Once tests have completed, the test results will be saved automatically and populated on the Report page (select the 🖫 button on the main GRL software menu). Click "Generate report" to view the details of each result.
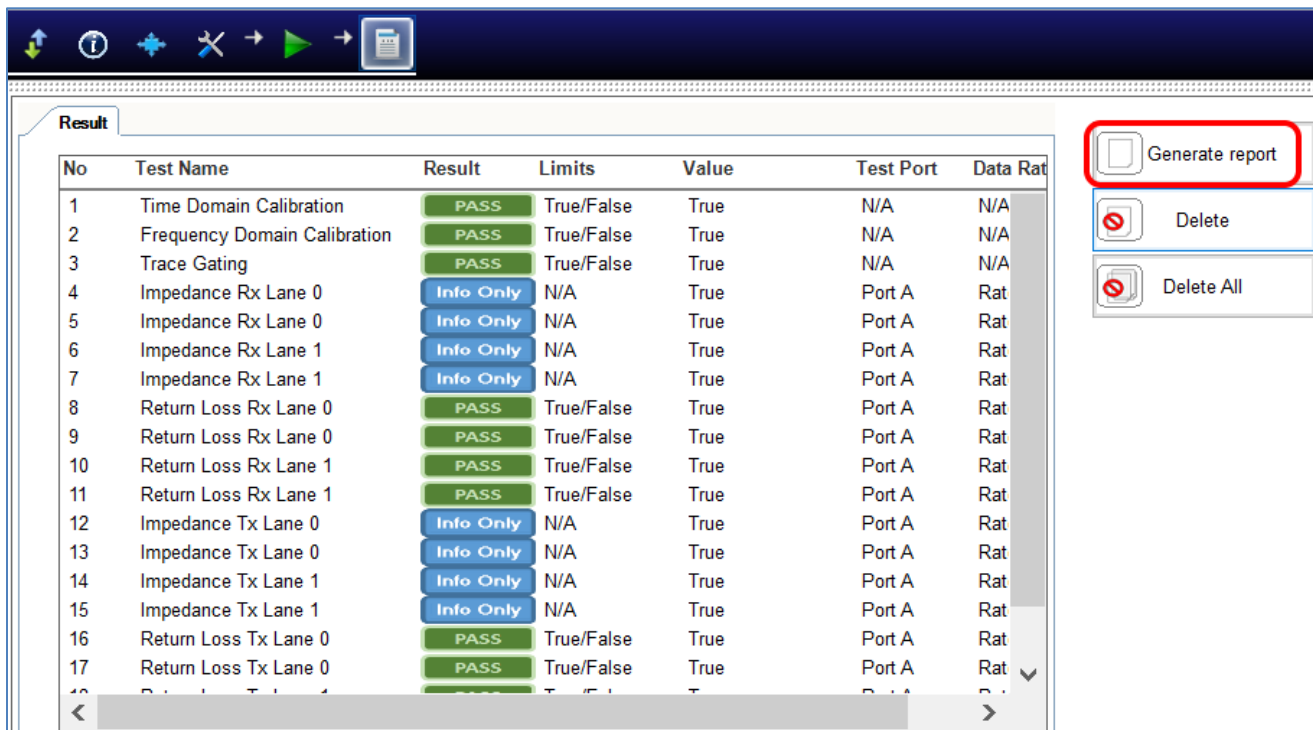
FIGURE 25. VIEW TEST RESULTS EXAMPLE

# 9 Test Results and Reports with GRL-USB4RL-AN Software

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

## 9.1 Generate Test Report

The Report page shows all the results of tests and calibration. Select **Generate report** for the detailed report.



FIGURE 26. GENERATE REPORT PAGE

### 9.1.1    DUT Information

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



FIGURE 27. DUT INFORMATION

### 9.1.2    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.

**Anritsu USB4 Return Loss Test Application Report**

| No | TestName | Limits | Value | Results | Test Port | Data Rate |
|---|---|---|---|---|---|---|
| 1 | USB4 VNA Setup | N/A | N/A | Pass | | |
| 2 | Time Domain Calibration | N/A | N/A | Pass | | |
| 3 | Frequency Domain Calibration | N/A | N/A | Pass | | |
| 4 | Trace Gating | N/A | N/A | Pass | | |
| 5 | Impedance Rx Lane 0 | N/A | N/A | InfoOnly | PortA | Rate10G |
| 6 | Impedance Rx Lane 0 | N/A | N/A | InfoOnly | PortA | Rate20p6G |
| 7 | Impedance Rx Lane 1 | N/A | N/A | InfoOnly | PortA | Rate10G |
| 8 | Impedance Rx Lane 1 | N/A | N/A | InfoOnly | PortA | Rate20p6G |
| 9 | Differential Mode Return Loss Rx Lane 0 | N/A | N/A | Pass | PortA | Rate10G |
| 10 | Differential Mode Return Loss Rx Lane 0 | N/A | N/A | Pass | PortA | Rate20p6G |
| 11 | Differential Mode Return Loss Rx Lane 1 | N/A | N/A | Pass | PortA | Rate10G |
| 12 | Differential Mode Return Loss Rx Lane 1 | N/A | N/A | Pass | PortA | Rate20p6G |
| 13 | Impedance Tx Lane 0 | N/A | N/A | InfoOnly | PortA | Rate10G |
| 14 | Impedance Tx Lane 0 | N/A | N/A | InfoOnly | PortA | Rate20G |
| 15 | Impedance Tx Lane 1 | N/A | N/A | InfoOnly | PortA | Rate10G |
| 16 | Differential Mode Return Loss Tx Lane 0 | N/A | N/A | Pass | PortA | Rate10G |
| 17 | Differential Mode Return Loss Tx Lane 1 | N/A | N/A | Pass | PortA | Rate10G |

FIGURE 28. SUMMARY TABLE

### 9.1.3   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.
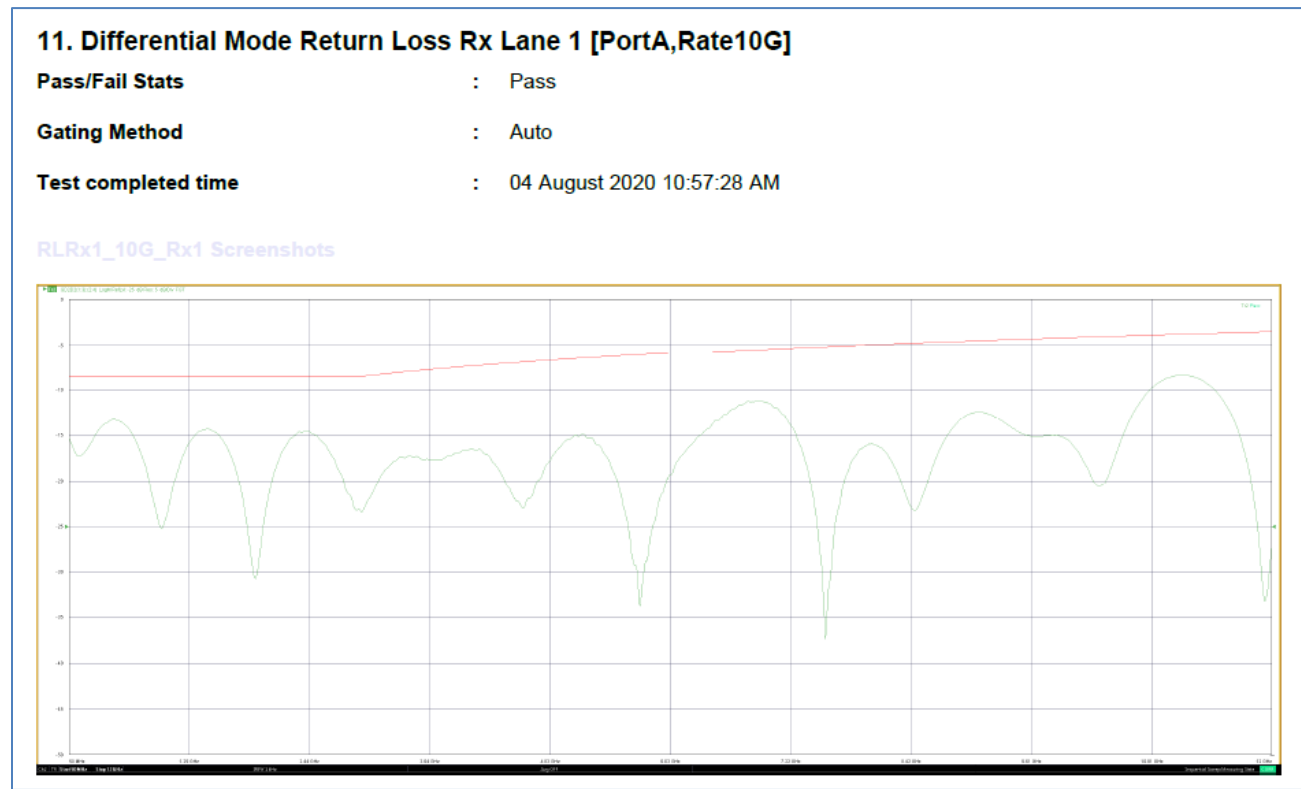


FIGURE 29. TEST RESULT DETAILS EXAMPLE

## 9.2    Delete Reports

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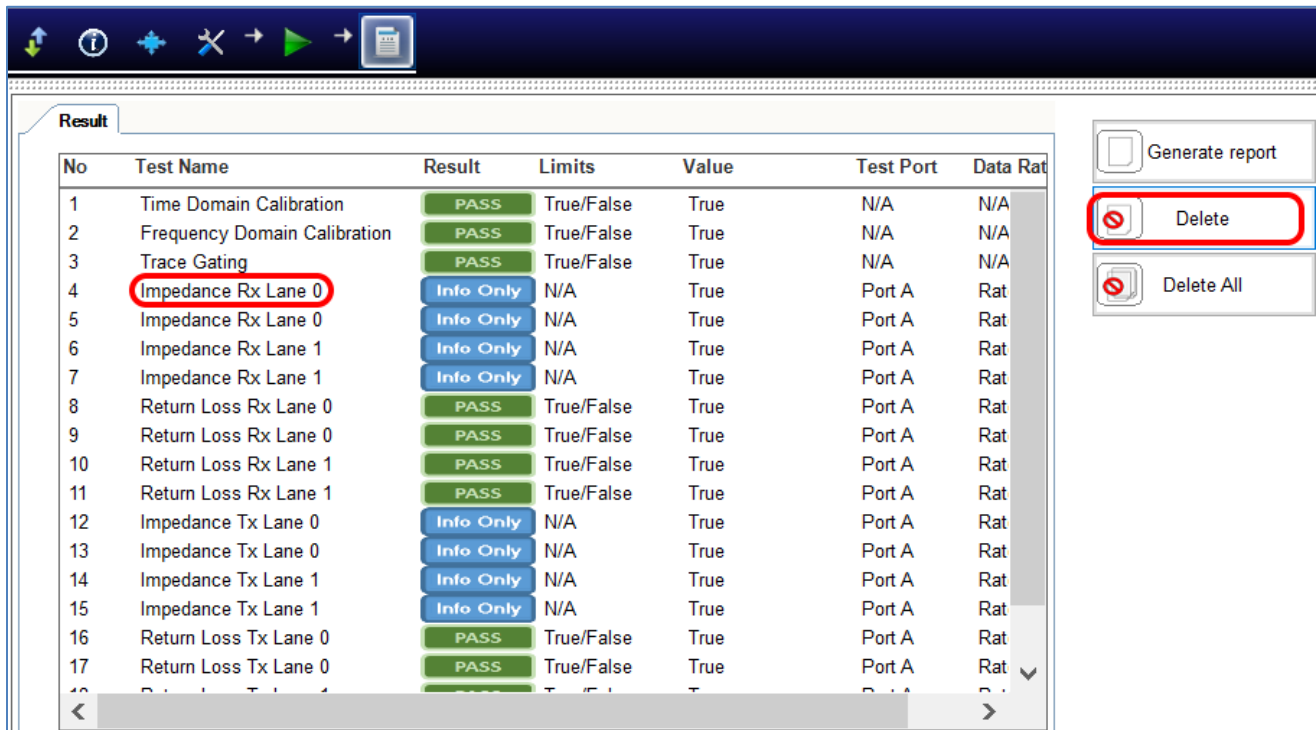


FIGURE 30. DELETE INDIVIDUAL CALIBRATION/TEST RESULTS EXAMPLE

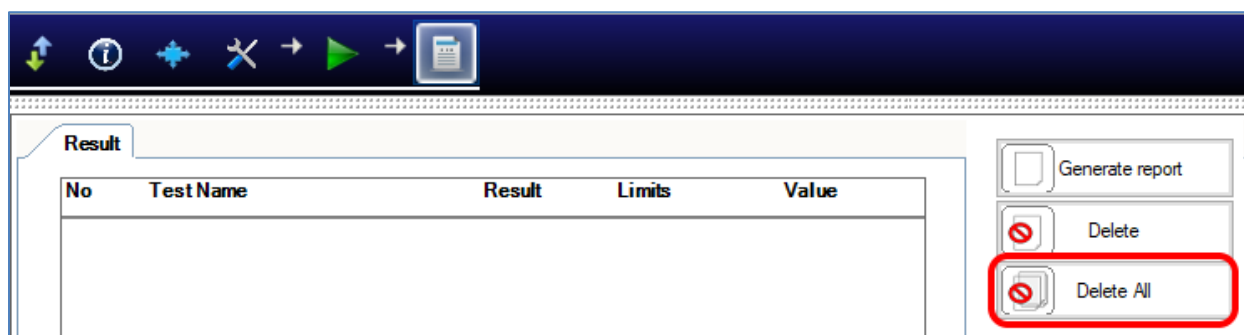To remove all results, select the "Delete All" button.



FIGURE 31. DELETE ALL RESULTS

# 10    Troubleshooting GRL-USB4RL-AN Errors

If an error is thrown by the GRL-USB4RL-AN software, it may be due to one of the following common issues:

1.  The VNA's firmware needs to be updated – Confirm that the VNA's firmware is V2018.2.1 or above.

2.  USB4 ETT is not properly installed – To troubleshoot this, follow the ETT PDF User Guide and confirm that **USB4ElectricalTestTool.exe** can be run manually from the ETT folder. If ETT is not properly installed, a software error may occur.

3.  After checking the above and error persists, contact [support@graniteriverlabs.com](mailto:support@graniteriverlabs.com) for further support.

**END_OF_DOCUMENT**