Granite River Labs

# USB4® Receiver Test Method of Implementation (MOI) Using Anritsu MP1900A BERT, High Performance Real-time Oscilloscope, and GRL-USB4-RXA Calibration and Test Automation Software

*Published on 03 February 2023*

DISCLAIMER

## TABLE OF CONTENTS

## List of Figures

## List of Tables

# 1 Introduction

This MOI & User Guide contains the procedure for testing an electrical receiver for USB4® certification using the Anritsu MP1900A BERT, High Performance Real-Time Oscilloscope, and GRL-USB4-RXA Test Automation Software as per USB-IF standards.

The main body of this MOI & User Guide describes how to perform automated Calibration and Testing of USB4 Gen2/Gen3 Hosts and Devices using the GRL-USB4-RXA Software, with an appendix describing the manual calibration process as a technical reference.

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

For Devices and Hosts with a USB Type-C® Connector, the USB-IF, VESA (DisplayPort over USB Type-C), and Thunderbolt™ Compliance programs all require USB4 Gen2/Gen3 receiver compliance testing.

The solution in this MOI can also be used for USB4 receiver compliance for USB Type-A, USB Type-B and USB Type-B Micro Hosts and Devices.

In summary, this User Guide & MOI basically describes using the GRL-USB4-RXA software to:

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

# 2 Reference Documents

[1] Universal Serial Bus 4 (USB Type-C) Router Assembly Electrical Compliance Test Specification, Revision 0.96, January 30, 2020.

[2] Universal Serial Bus 4 (USB4®) Specification Version 1.0, August 2019, and associated ECNs.

# 3 Resource Requirements

## 3.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – SYSTEMS AND ACCESSORIES

| System | Qty. | Description | Key Specification Requirement |
|---|---|---|---|
| Oscilloscope | 1 | High Performance Real-time Oscilloscope[a] | ≥ 21 GHz bandwidth[b]<br>16 GB and above memory RAM |
| BERT | 1 | Anritsu MP1900A Signal Quality Analyzer (SQA) | SQA Software Version 4.00.00 or above |
| | | MP1900A Signal Quality Analyzer, with following modules:<br>• MU181000A/B 12.5 GHz Synthesizer<br>• MU181500B Jitter Modulation Source<br>• MU195020A 32G bit/s SI Pulse Pattern Generator<br>• MU195050A Noise Generator | |
| **Accessory** | **Qty.** | **Description** | **Key Specification Requirement** |
| TP3' Plug Test Fixture | 1 | Test Point 3' (Case 1) Plug Test Fixture | |
| TP3 Channel Components | 2 | Test Point 3 (Case 2) Receptacle Fixture | |
| TP3 Fixed ISI Trace | 1 | Test Point 3 (Case 2) Fixed ISI Board | |
| TP3 Test Cables | 1 | 2m USB Type-C Cable | Insertion Loss -18dB at 5GHz |
| | 1 | 0.8m USB Type-C Cable | Insertion Loss -16.5dB at 10GHz |
| USB4 Controller | 1 | Wilder-Tech USB4 Microcontroller | CG3-TPA-TR, with USB Cable [c]<br>• *Optional for some test configurations, see Appendix F.* |
| Cable Deskew Fixture | 1 | Anritsu Splitter | K241B |
| DC Block | 2 | | Bandwidth of at least 33GHz |
| Computer | 1 | Laptop or Desktop PC | Windows 7+ OS<br>For automation control (running GRL-USB4-RXA software) |

*[a] Oscilloscope with scope software requirements as specified in vendor specific MOI's. For example, when using the Keysight Scope, scope software such as 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 and the Teledyne LeCroy Scope with SDAIII analysis tool for making measurements.*

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

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

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

TABLE 2. EQUIPMENT REQUIREMENTS – CONNECTION CABLES

| Connection Cable | Qty. | Key Specification Requirement |
|---|---|---|
| MU181000A/B to MU181500B | 1 | Anritsu J1624A SMA-SMA cable (0.3m) |
| MU181500B to MU195020A | 1 | Anritsu J1624A SMA-SMA cable (0.3m) |
| MU195020A to MU195050A | 1 pair | Anritsu J1746A K-K skew matched pair short semirigid cable |
| Matched Cable Pairs | 3 | Phase Matched ±5° at 40GHz<br>Insertion Loss 1dB maximum in 10GHz |
| RPC-2.92 Jack to SMP Jack | 4 | Rosenberger 02K119-K00E3 |
| JTAG Ribbon Cable | 1 | For connecting USB4 microcontroller and test fixture |
| USB Type-C Cable | 1 | For connecting controller PC to DUT |

## 3.2 Software Requirements

| Software | Source |
|---|---|
| GRL-USB4-RXA | Granite River Labs USB4 Receiver Calibration and Test Automation Software – www.graniteriverlabs.com (Support > Download Center)<br>Includes test setup and pattern files for USB4 Rx testing<br>Included with Node Locked License to single oscilloscope or PC OS |
| VISA (Virtual Instrument Software Architecture) API Software | VISA Software is required to be installed on the controller PC running GRL-USB4-RXA software. GRL's software framework has been tested to work with all three versions of VISA available on the Market:<br>1. NI-VISA: http://www.ni.com/download/ni-visa-17.0/6646/en/<br>2. Keysight IO Libraries: www.keysight.com *(Search on IO Libraries)*<br>3. Tektronix TekVISA: www.tek.com *(Downloads > Software > TekVisa)* |

| Software | Source |
|---|---|
| MX190000A | Anritsu High-Speed Serial Data Test Software – Mainframe MX190000A SQA Control Software (Version 4.00.00 or above). This software is located on the BERT. |
| SigTest Application | Downloadable from USB-IF's website. *(Note: Approval and NDA as a USB-IF Adopter is required to gain access to USB-IF products.)* |
| USB4 Electrical Test Tool (ETT) | Downloadable from USB-IF's website. *See Section 4.1.1 for more details.* |
| Intel TenLira Test Scripts (For Thunderbolt 3 DUT's) | Downloadable from Intel Corporation IBL's website. |
| ActiveTcl (For Thunderbolt 3 DUT's) | Version 8.5.18.0 or above (downloadable from ActiveState's website: http://www.activestate.com/activetcl/downloads).<br>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. |

# 4 Installing and Setting Up GRL-USB4-RXA Software

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

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

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

## 4.1 Download and Set Up GRL-USB4-RXA Software

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

1. Install VISA (Virtual Instrument Software Architecture) on to the PC/Scope where GRL-USB4-RXA is to be used (see Section 3.2).
2. Download the GRL-USB4-RXA ZIP file package from the Granite River Labs support site.
3. The ZIP file contains:
   a) **USB4RxANPatternFilesInstallation00xxxxxxxxSetup.exe** – Run this on the Anritsu Signal Quality Analyzer to install the test pattern setup files.
   b) **USB4RxANTestApplication00xxxxxxxxSetup.exe** – Run this on the controller PC or scope to install the GRL-USB4-RXA application.
   c) **USB4RxANTestScopeSetupFilesInstallation00xxxxxxxx.exe** – Run this on the scope to install the scope setup files.
4. Launch and set up the 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.

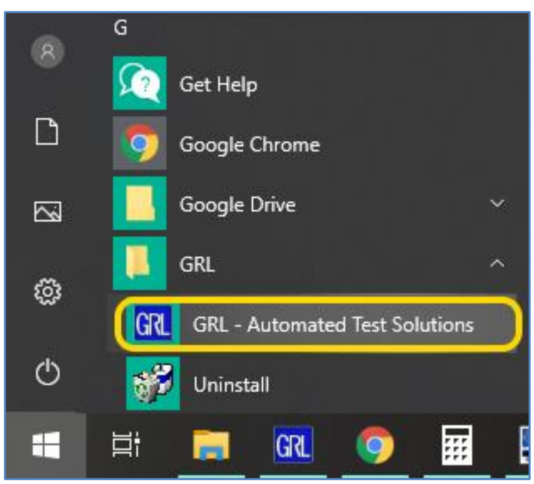



FIGURE 1. LAUNCHING GRL SOFTWARE FRAMEWORK

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

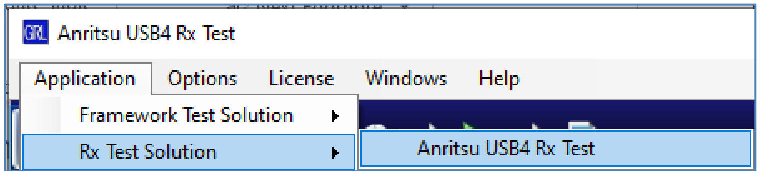



FIGURE 2. LAUNCHING ANRITSU USB4 RX TEST APPLICATION

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

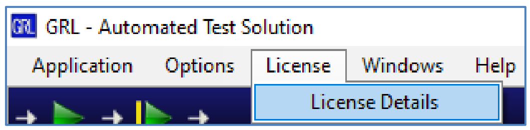



FIGURE 3. LICENSE DETAILS

ii) Review the installed application.

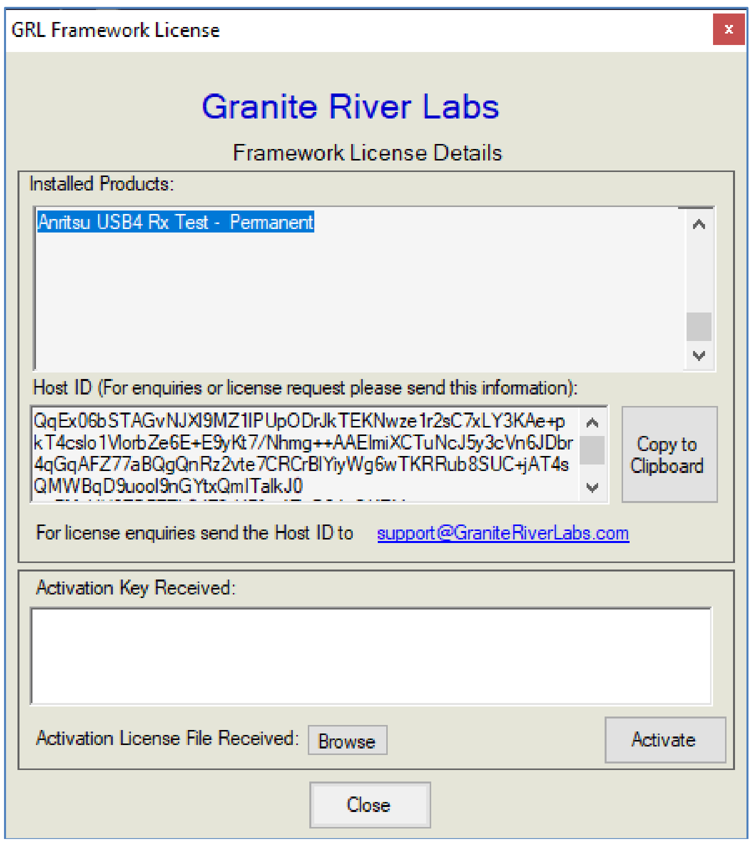



FIGURE 4. INSTALLED APPLICATION

iii) Activate a License:

[1] If you have an Activation Key, enter it in the box provided, and select **Activate**.

[2] If you do not have an Activation Key, select **Close** to use the software for 10 days free of charge.

***Note:*** *Once the 10-day trial times out, you will need to request an Activation Key for future usage on the same computer or oscilloscope. The demo software is also limited in its capability, in that it will only calibrate the maximum frequency for each data rate. Thus, the demo version cannot be used to full calibrate and test a device.*

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

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

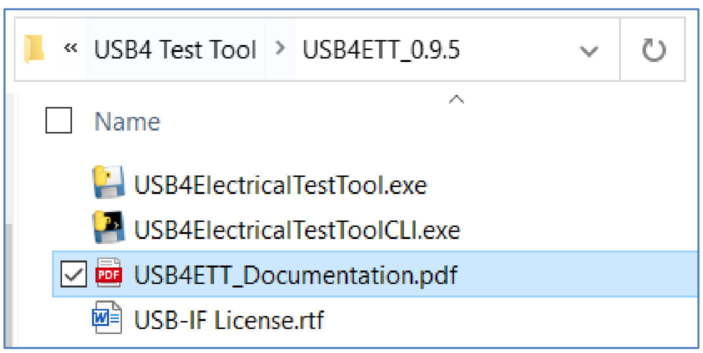
For USB4 Rx measurements, the Host/Device's CIO PHY must be in an active state during testing. Its transmitters shall be transmitting PRBS31 into the analyzer measurement channel during testing and its receivers shall have their terminations enabled during testing. Thus, a PHY microcontroller must be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

**Download ETT:**

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

**Install ETT:**

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




**For USB4 Host Testing:**

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

**For USB4 Device Testing:**

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

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

### 4.1.2 Launch and Set Up GRL-USB4-RXA Software

#### 4.1.2.1 On the Scope or Controller PC

1. Launch GRL Host Application from **Start Menu** -> **GRL** -> **GRL – Automated Test Solutions**.
2. Select **Application** -> **Rx Test Solution** -> **Anritsu USB4 Rx Test**.
3. Select the Equipment Setup icon  on the GRL-Anritsu USB4 Rx Test Application menu.
4. Connect the Anritsu MP1900A BERT via LAN to the GRL automation control enabled Scope or PC. The BERT and MX190000A software can be connected using connection string formats similar to the following examples:
   - BERT: "TCPIP0::192.168.0.14::5001::SOCKET" or "192.168.0.14:5001"
   - MX190000A: "TCPIP0::192.168.0.14::5000::SOCKET" or "192.168.0.14:5000"

   Note the IP addresses listed above are only examples and should be changed according to the actual network connection being used.
5. On the Scope or controller PC, obtain the network addresses for all the connected instruments from the device settings. Note these addresses as they will be used to connect the instruments to the GRL automation software.
6. On the Equipment Setup page of the GRL-Anritsu USB4 Rx Test Application, type in the address of each connected instrument into the 'Address' field.
7. *(Note: If the GRL software is installed on the **Tektronix Scope**, ensure the Scope is connected via GPIB and type in the GPIB network address, for example "GPIB8::1::INSTR".)*

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

   If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example "TCPIP0::192.168.0.35::inst0::INSTR". Note to ***omit*** the Port number from the address.

   *(Note: If the GRL software is installed on the **Keysight Scope**, and if there is error in connection, type in the Scope IP address as "TCPIP0::192.168.0.35::5025::SOCKET".)*
8. If the GRL software is installed on the PC to control the Scope, set up the Remote File Server as described in Section 4.1.3.
9. Then select the "lightning" button () for each connected instrument.

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

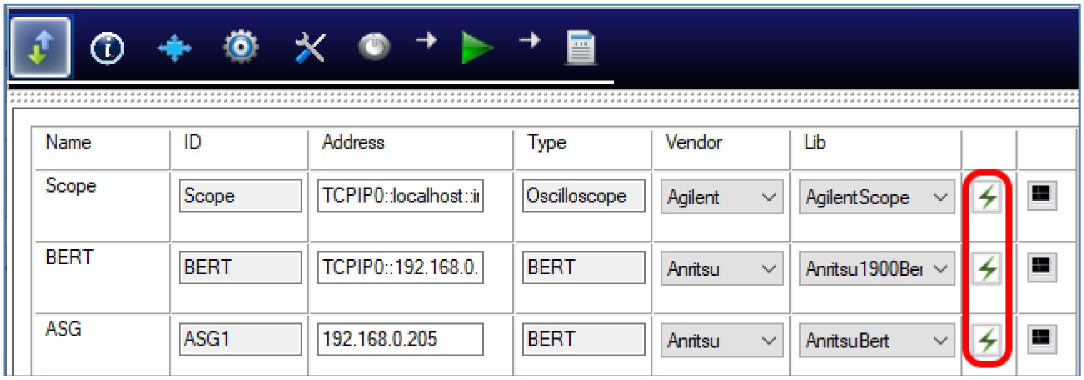



FIGURE 5. GRL SOFTWARE INSTRUMENT CONNECTION SETUP

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

### 4.1.3 Set Up Remote File Server

1. The **GRLRemoteProxyServer.exe** will also be installed along with the **USB4RxANTestScopeSetupFilesInstallation0xxxxxxxxSetup.exe** on the Scope. The GRLRemoteProxyServer.exe is installed under the *“C:\GRL\GRLRemoteProxyServer”* directory.

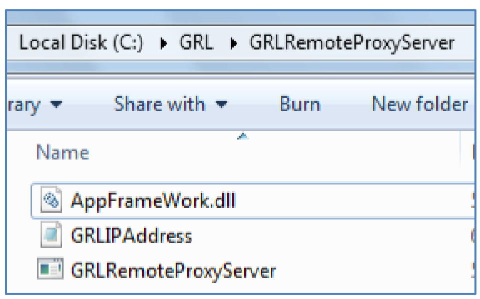



FIGURE 6. INSTALLED GRLREMOTEPROXYSERVER.EXE FILE DIRECTORY

2. If the GRL software is installed on the PC to control the Scope and SigTest is selected as the test method to be used (refer Section 6.4), 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

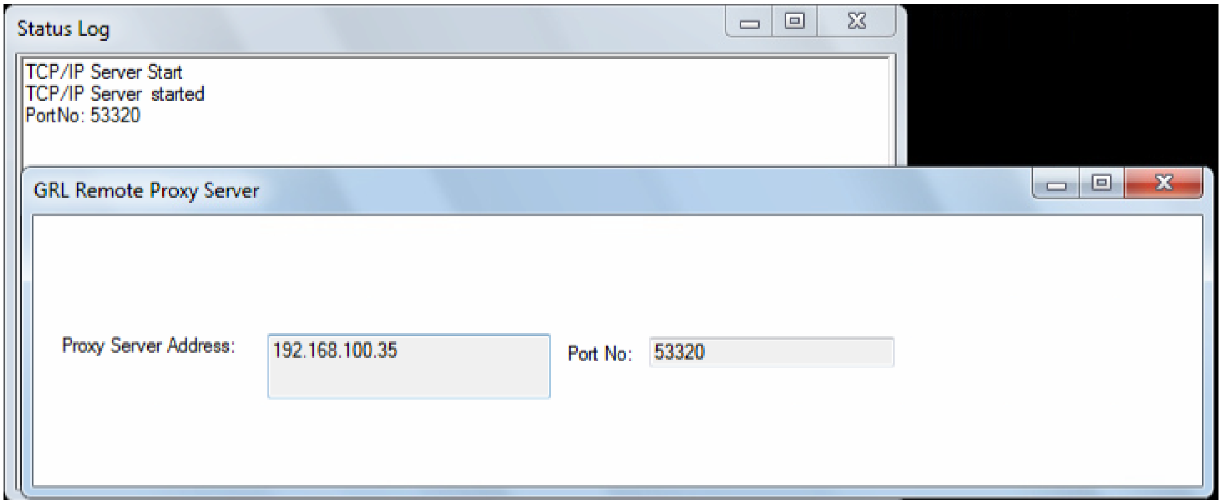



FIGURE 7. VERIFY PROXY SERVER CONNECTION FOR CONTROLLER PC AND SCOPE

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

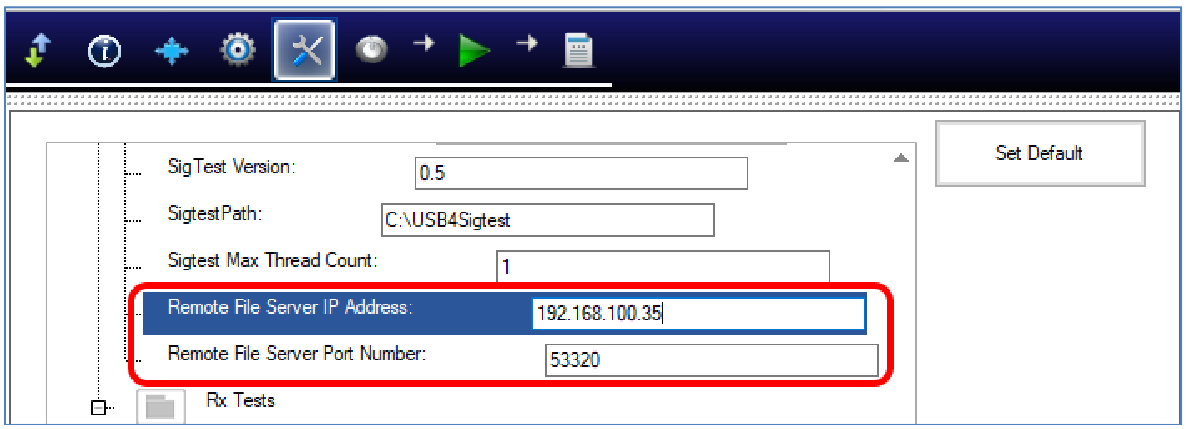



FIGURE 8. CONFIGURE GRL REMOTE PROXY SERVER NETWORK SETTINGS ON GRL SOFTWARE

Refer Section 6.4 for more details on parameters available on the Configurations page.

# 5 Receiver Calibration Setups

The following sections show the setup connection diagrams for the Anritsu MP1900A BERT Calibration. The fixtures and channels used for USB4 Compliance testing are available from the USB-IF.

## 5.1 Connection Setup for Anritsu MP1900A BERT Generator Set

Figure 9 shows the connection setup between each module of the Anritsu MP1900A BERT Generator Set.

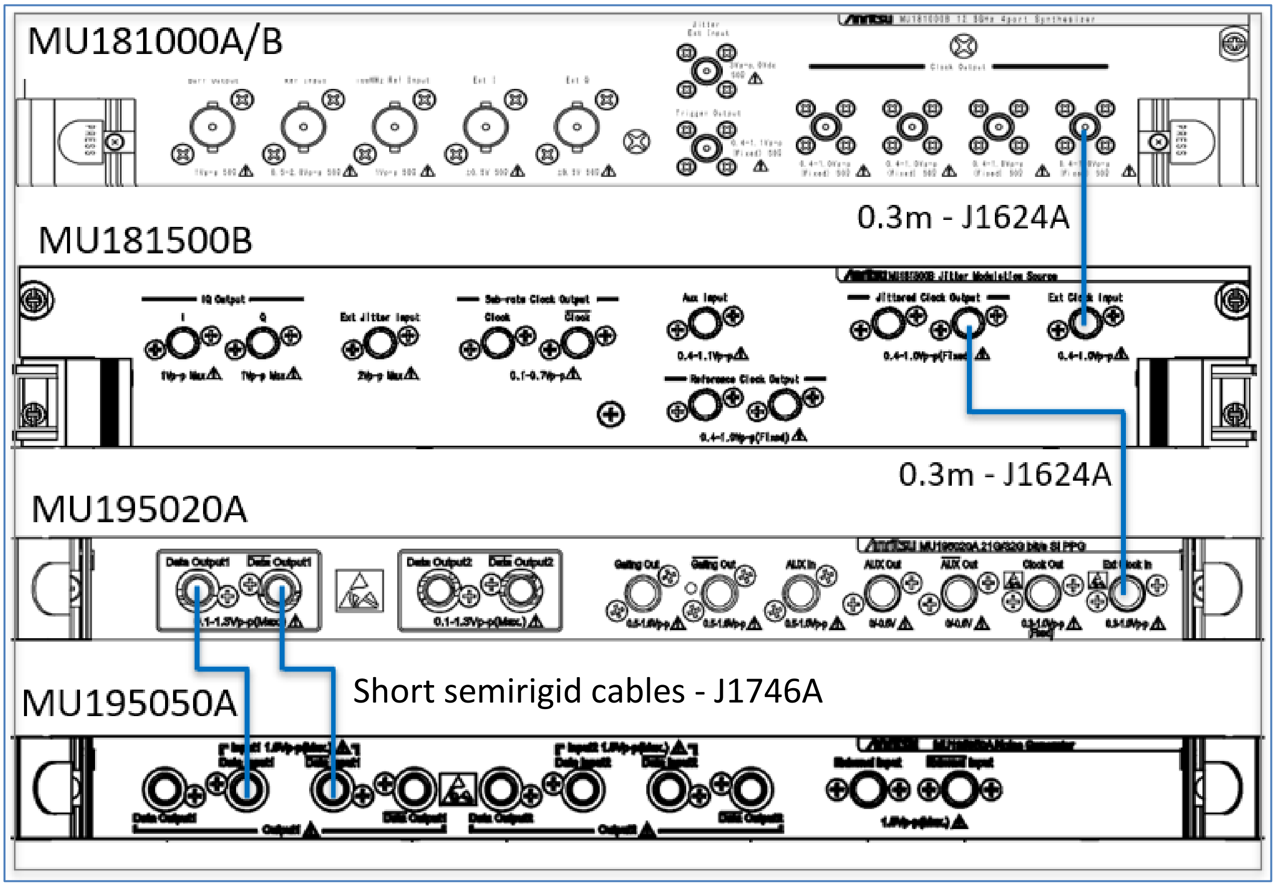



FIGURE 9. CONNECTION SETUP FOR MP1900A BERT GENERATOR SET MODULES

Connection Steps:

1. Using the J1624A SMA-SMA (0.3m) cable, connect the Clock Output of the MU181000A/B Synthesizer to the Ext Clock Input of the MU181500B Jitter Modulator.
2. Using the J1624A SMA-SMA (0.3m) cable, connect the Jittered Clock Output of the MU181500B Jitter Modulator to the Ext Clock Input of the MU195020A Pulse Pattern Generator.
3. Using the J1746A K-K skew matched pair short semirigid cable, connect the MU195020A Data Outputs to the MU195050A Data Inputs.

## 5.2 Connection Setup for TP3’ (Case 1) Calibration

Figure 10 shows the calibration setup diagram for TP3’ (Test Point 3’) using the Anritsu MP1900A BERT. TP3’ (Case 1) is a physical test point for calibration without the effect of a channel.

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

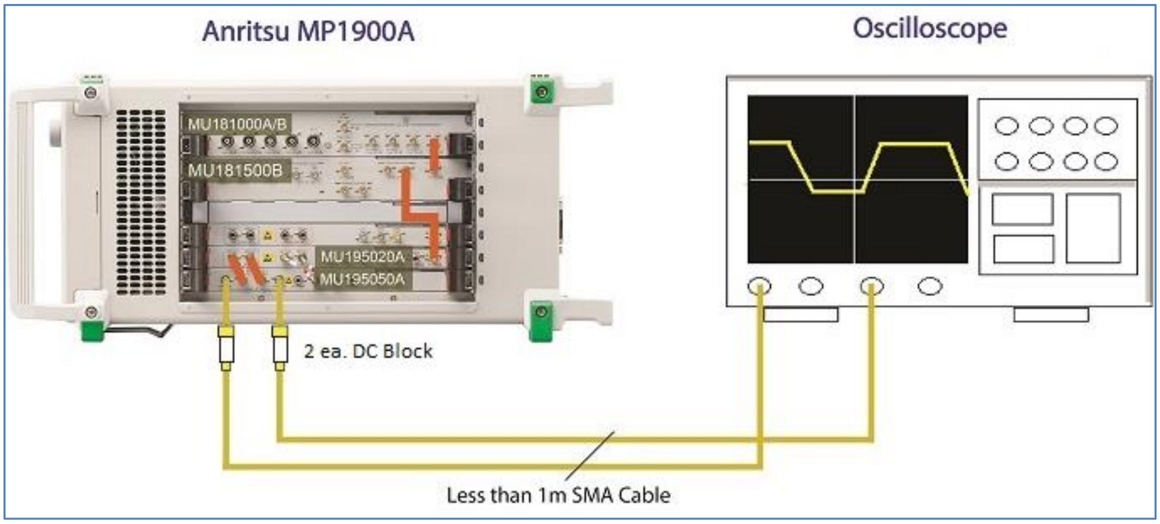



FIGURE 10. SETUP FOR TP3’ (CASE 1) CALIBRATION

Connection Step:

Using the MP1900A BERT setup connections (Section 5.1), connect the MU195050A data outputs through DC blocks to Channels 1 and 3 on the scope using phase matched K-K coaxial cables.

## 5.3 Connection Setup for TP3 (Case 2) Calibration

Figure 11 and Figure 12 show the calibration setup diagrams for TP3 (Test Point 3) using the Anritsu MP1900A BERT. TP3 (Case 2) is a physical test point that will affect the eye opening due to the sum of a fixed channel length (representing the fixed ISI on the transmitter side of a host or device) and a physical USB Type-C Cable.

For USB4 Gen2 speed (10Gb/s) or Thunderbolt 3 compatible Gen2 speed (10.3125Gb/s), the total Insertion Loss is -18dB at 5GHz, which uses a 2M USB Type-C cable.

For USB4 Gen3 speed (20Gb/s) or Thunderbolt 3 compatible Gen3 speed (20.625Gb/s), the total Insertion Loss is -16.5dB at 10GHz, which uses a 0.8M USB Type-C cable. The cable’s downstream plug connector is connected to a calibration fixture to measure the signal with the scope. The scope uses software equalization to open the eye for calibration.

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

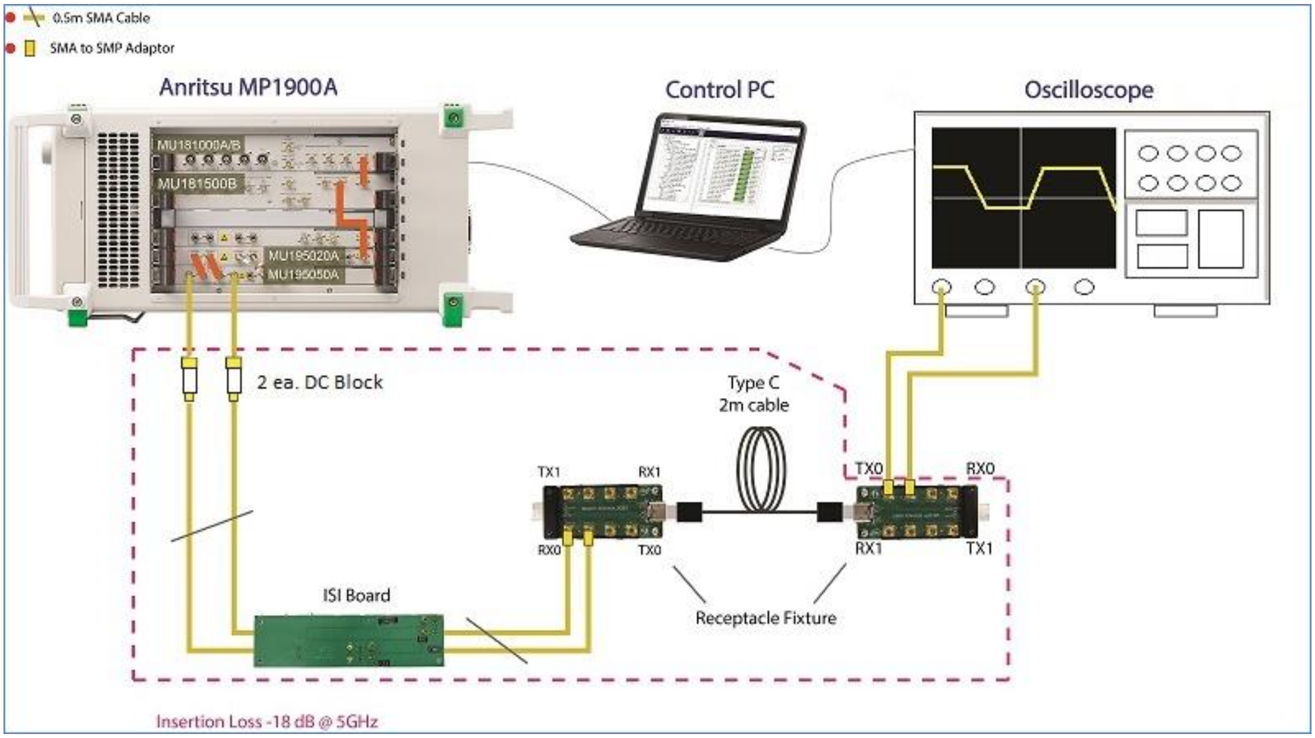



FIGURE 11. SETUP FOR TP3 (CASE 2) CALIBRATION AT 10G OR 10.3125G

Connection Steps:

1. Continuing from the MP1900A BERT TP3' (Case 1) calibration setup (Section 5.1), disconnect the MU195050A data outputs from the scope channels.
2. Connect the MU195050A data outputs through DC blocks to ISI channels (for 10Gb/s or 10.3125Gb/s) and then to the test fixtures with a 2M USB Type-C cable, and then to Channels 1 and 3 on the scope.

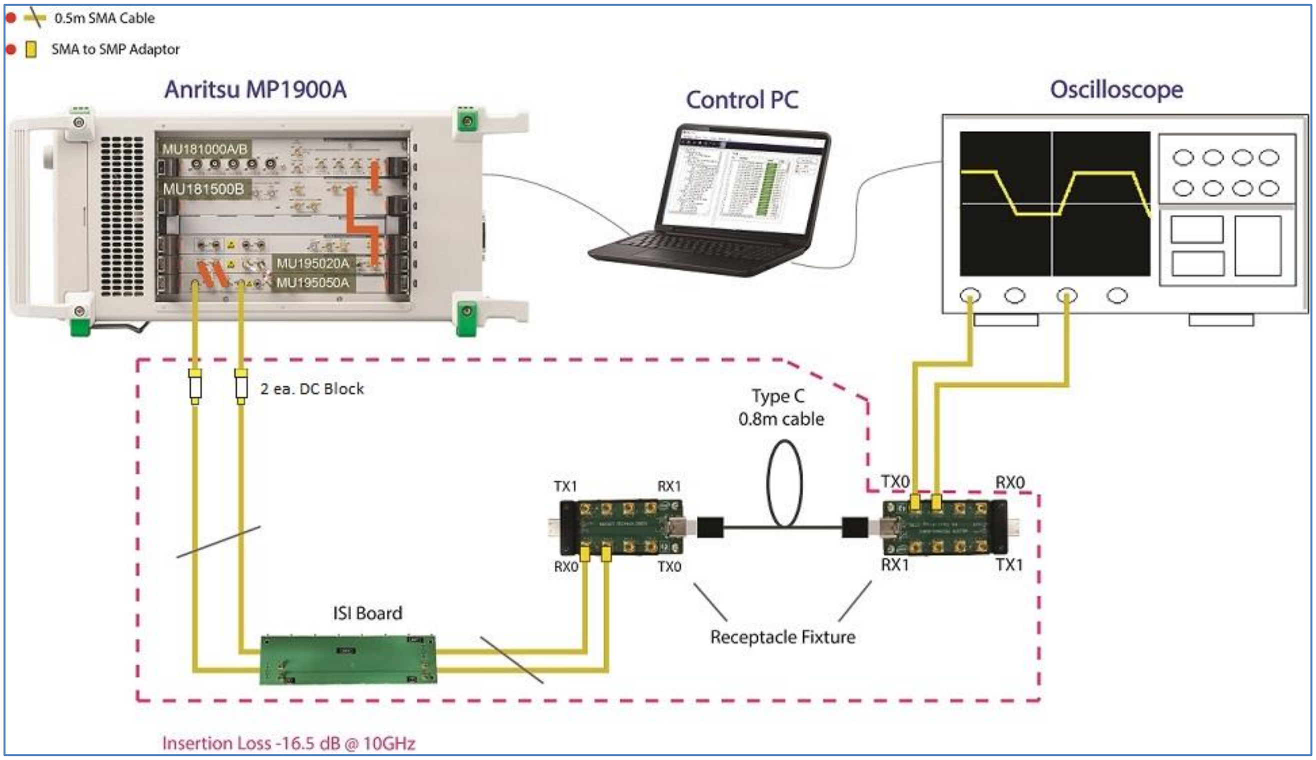



FIGURE 12. SETUP FOR TP3 (CASE 2) CALIBRATION AT 20G OR 20.625G

Connection Steps:

1. Continuing from the MP1900A BERT TP3' (Case 1) calibration setup (Section 5.1), disconnect the MU195050A data outputs from the scope channels.
2. Connect the MU195050A data outputs through DC blocks to ISI channels (for 20Gb/s or 20.625Gb/s) and then to the test fixtures with a 0.8M USB Type-C cable, and then to Channels 1 and 3 on the scope.

# 6 Calibrating Using GRL-USB4-RXA Software

## 6.1 Enter Calibration/Test Session Information

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

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

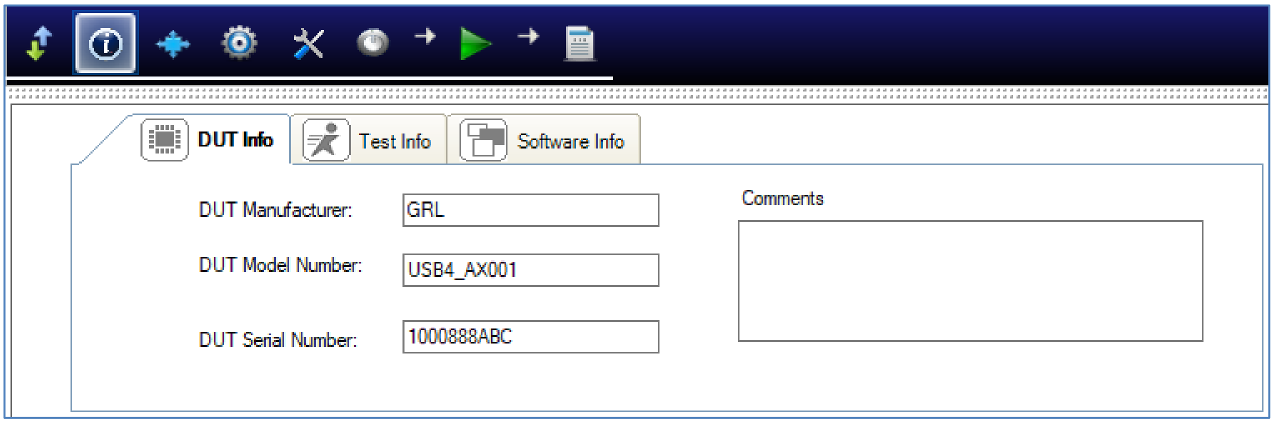



FIGURE 13. ENTER CALIBRATION/TEST SESSION INFORMATION

## 6.2 Set Up Conditions for Calibration/Testing

Select from the software menu to access the Conditions page.

In this section, conditions for Testing and Calibration will need to be set.

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

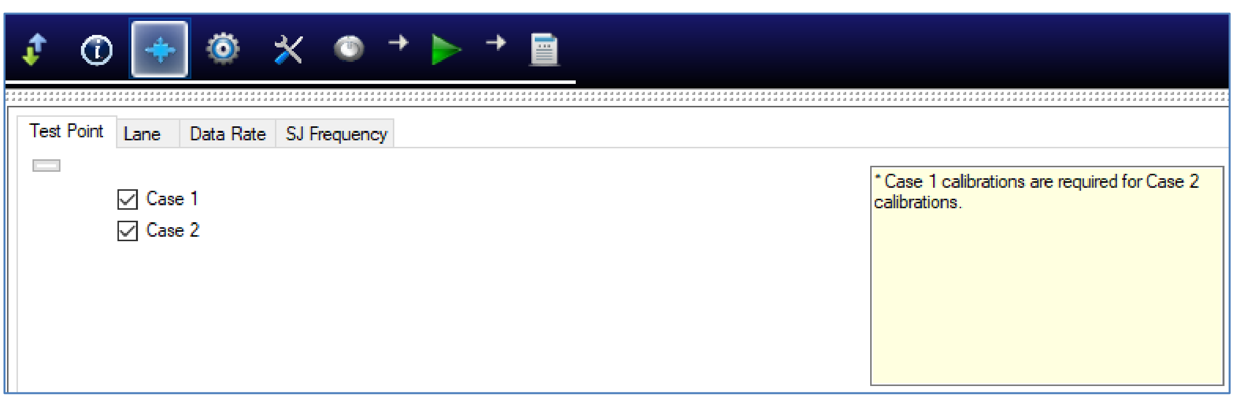



FIGURE 14. SELECT TEST POINT

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

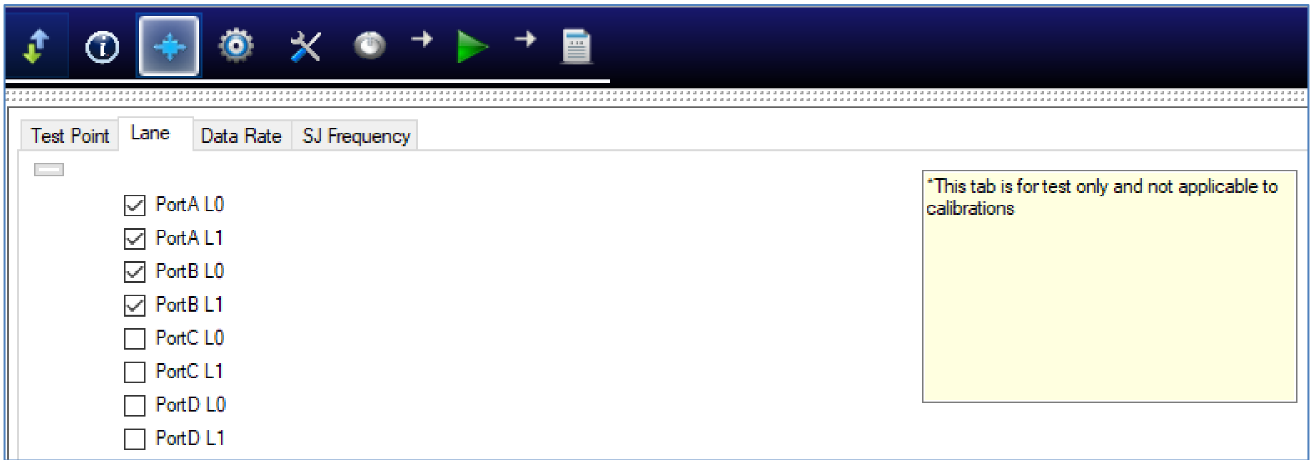



FIGURE 15. SELECT DUT PORT AND LANE UNDER TEST

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

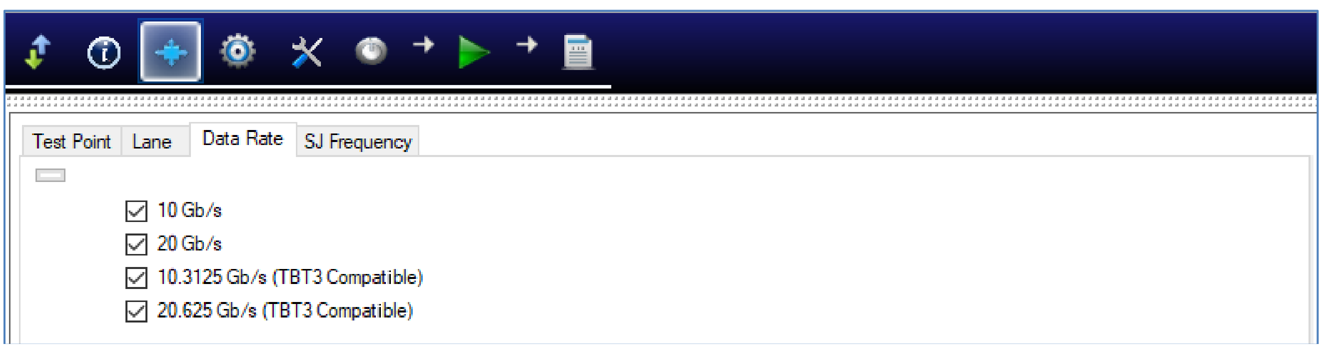



FIGURE 16. SELECT DATA RATE

4. Select the SJ Frequency.

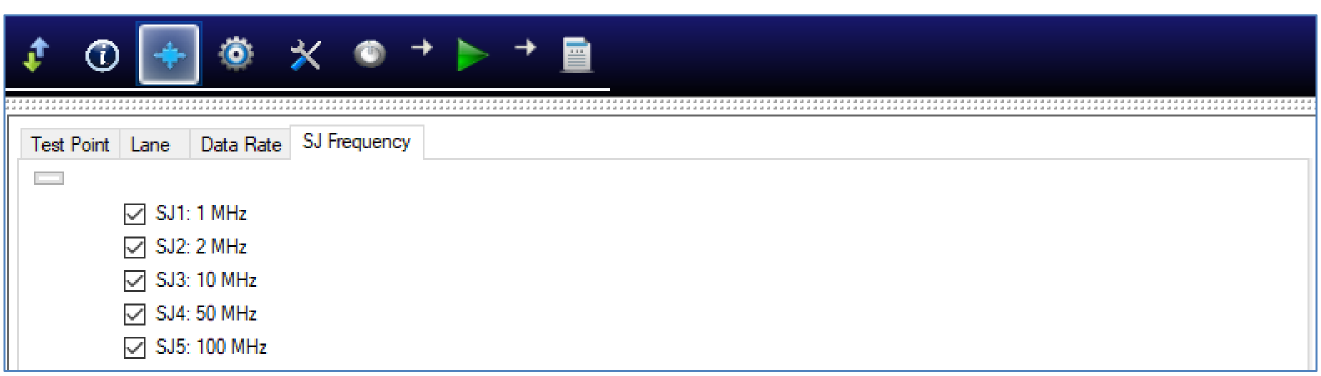



FIGURE 17. SELECT SJ FREQUENCY

## 6.3 Select Calibration

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

The GRL-USB4-RXA software automatically runs the selected calibration when initiated. See Section 6.6 on running the calibration.

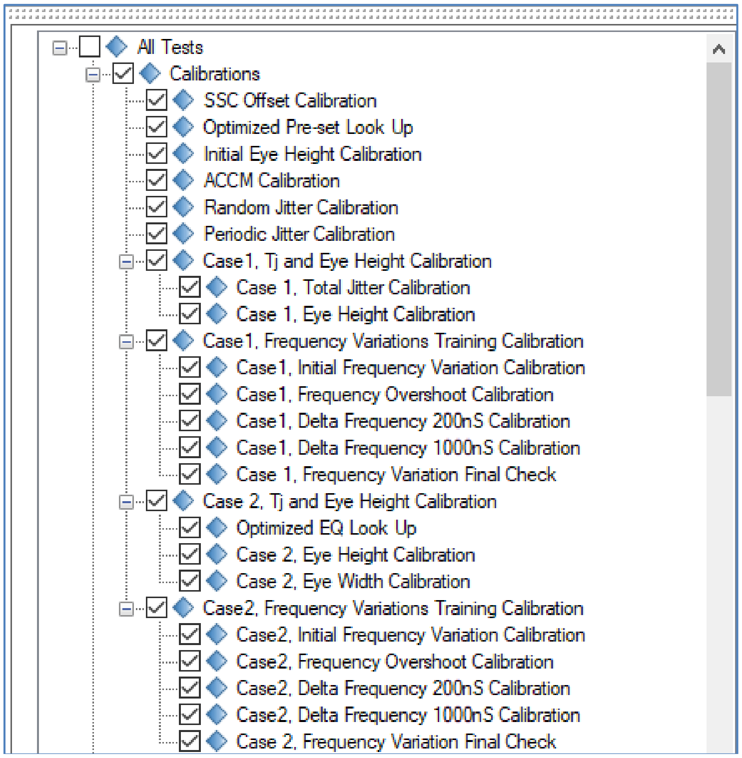



FIGURE 18. SELECT CALIBRATION

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

### 6.3.1 Calibrations Group

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

TABLE 3. SUPPORTED CALIBRATION

| Calibration | Description |
|---|---|
| SSC Offset | Calibrates the frequency offset to achieve the start of the Spread Spectrum Clock |

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

## 6.4 Configure Calibration/Test Parameters

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

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

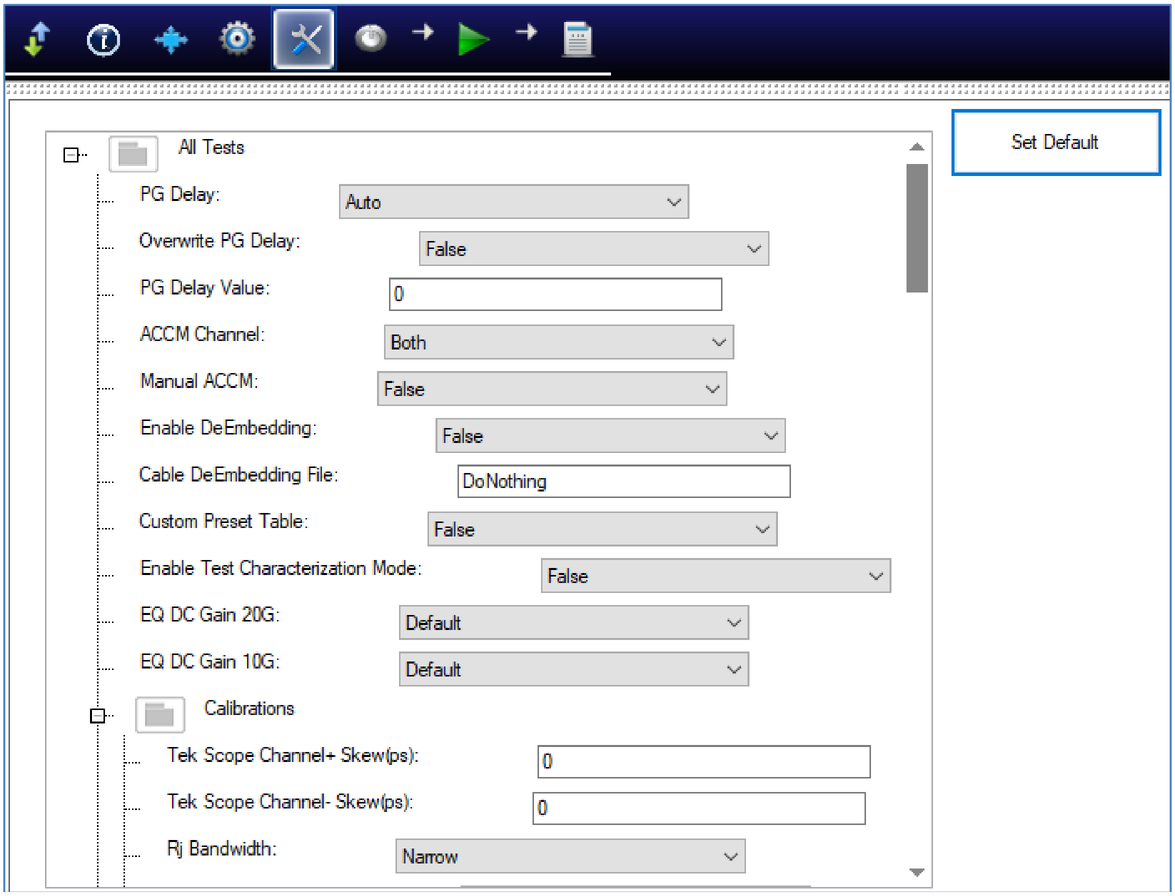



FIGURE 19. CONFIGURE CALIBRATION/TEST PARAMETERS

TABLE 4. CALIBRATION/TEST PARAMETERS DESCRIPTION

| Parameter | Description |
|---|---|
| **PG Delay** | Set input Data and Clock delay of the Pulse Pattern Generator (PPG) if used. “Auto” is usually the case. Select “Manual” only if you are sure that the PPG does not require any calibration. |
| **Overwrite PG Delay** | “False” is usually the case. If you change this to “True”, then you will need to provide a value in the “PG Delay Value” field. |
| **PG Delay Value** | If the “Overwrite PG Delay” field is set to “True”, enter the Delay value of the PPG. |
| **ACCM Channel** | Select “Both” or single channel (splitter required) as the AC Common Mode (ACCM) source if used. |
| **Manual ACCM** | Set to “True” to manually set the ACCM source or “False” to apply calibrated values from ACCM calibration. |
| **Enable DeEmbedding** | Set to “True” to de-embed cable while calibrating. |
| **Cable DeEmbedding File** | Define the cable transfer function file. Applicable only when the “Enable |

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

| | |
|---|---|
| | calibration to ensure waveform compliance. Make sure that the SigTest application is already installed in the test controller system. |
| **SigTest Path** | Enter the full path of the SigTest location in the test controller system. |
| **SigTest Max Thread Count** | Set the maximum process threads to generate for checking the Rx device functionality when running SigTest. |
| **Remote File Server IP Address** | Enter the IP address for the GRL Remote Proxy Server. See Section 4.1.3 on how to set up the remote file server. |
| **Remote File Server Port Number** | Enter the Port number for the GRL Remote Proxy Server. See Section 4.1.3 on how to set up the remote file server. |
| **Perform Link Training** | Select the option to run or disable link training for Rx test. |
| **BER Automation** | Select the method to be used to run Rx BER tests. |
| **Save BERT Setup Only** | "False" is usually the case. Set to "True" if you are sure that you only want to save the BERT test setup in the Rx test. |
| **Prompt Before Link Training** | "False" is usually the case. Set to "True" if you want to be prompted prior to start running link training. Ensure that the "Always" or "Once" run option is selected in the "Perform Link Training" field. |
| **Skip DUT Reset** | "False" is usually the case. Set to "True" if you want to reset the DUT when performing tests. |
| **Script Version** | Select the version of the TenLira test script ("ver 0.8.3" or above) or the ETT test script ["ETT(v0.9.4)" or "ETT(v0.9.5)"] to be used. |
| **DUT Platform** | Select the platform/processor as supported by the DUT for running test scripts. |
| **DUT with Re-timer** | If the **ETT** test script is selected in the "Script Version" field, set to "True" if the DUT has additional re-timer. |
| **ETT Test Port Mapping** | If the **ETT** test script is selected in the "Script Version" field, specify the test connector lanes to validate the port mapping of the DUT connectors. |
| **Set Swap Lane with ETT** | If the **ETT** test script is selected in the "Script Version" field, select the router and/or re-timer setup to perform lane switching for the DUT. |
| **Preset Negotiation Interval(s)** | Set the time interval in seconds between preset negotiations. |
| **Ridge** | If the **Tenlira** test script is selected in the "Script Version" field, select the number of ports to be tested for the ridge DUT. |
| **DUT Chipset (When Using Tenlira Only)** | If the **Tenlira** test script is selected in the "Script Version" field, select the Titan Ridge "TR" or Alpine Ridge "AR" processor as supported by the DUT. |
| **Remote/Local Working Directory** | Set the working directory to the path where the test script is installed in the host PC. |

| | |
|---|---|
| **Remote IP Address** | Enter the IP address of the remote host of the test script. |
| **Remote Port Number** | Enter the port number of the remote host of the test script. |
| **Remote Script** | Enter the name of the remote test script. |
| **Remote Script Arguments** | Set the arguments for executing the remote test script. |
| **Run Post Test Script** | Select the option to run the remote test script in the post-test stage. |
| **Post Test Remote Script** | Enter the name of the remote test script for post-test. |
| **Post Test Remote Script Directory** | Set the working directory to the path where the post-test script is installed in the host PC. |
| **Short Test Link Training Cycle** | Define the number of times to perform link training for short BER loopback. |
| **Maximum Error** | Define the maximum error count for error checking during Rx test. |
| **Prompt When BER Overflow** | “False” is usually the case. Set to “True” if you want to be prompted if there is buffer overflow during BER testing. |
| **Case 1 Preset Mapping** | Select “Active” or “Passive” mapping for presets for Case 1 setup at TP3’. |
| **Load User Calibration Data** | “False” is usually the case. Set to “True” if you want to recall and use a saved calibrated setup in the Rx test. |
| **10G & 20G Compliance Test Duration** | Set how long it would take (in seconds) to test the DUT for 10G or 20G compliance. |
| **Frequency Variation Test Trials** | Set the number of times to run the Rx signal frequency variations training test for each DUT lane. |
| **Frequency Variation Test with SSC Profile** | “True” is usually the case. Set to “False” if SSC is not supported by the DUT when running the Rx signal frequency variations training test. |
| **Use Calibrated SSC Profile** | “True” is usually the case. Set to “False” if you do not want to use a saved calibrated SSC profile setup when running the Rx signal frequency variations training test. |
| **Margin Step Size (%)** | Set the step size for stepping through SJ or amplitude margins when running the optional margin search tests. |
| **Maximum Margin Test Error** | Define the maximum error count for error checking during margin search tests. |
| **Maximum Steps** | Define the maximum number of steps to step through margins. |
| **10G & 20G Margin Test Duration(s)** | Set how long it would take (in seconds) to run full margin search tests for the 10G and 20G data rates. |
| **Short Margin Test Duration** | Set the duration in seconds to run a brief margin search test. |
| **Quick Margin Search Scan** | Set to “True” to perform a quick scan for worst-case margins during margin search tests. |

| | |
|---|---|
| **Margin Limit Line** | Select the option to use a limit based on calibrated or specification values for margin search tests. |
| **Final Eye Preset** | Select the option to use a preset from calibration or link training for final eye measurements. |
| **CTLE DC Gain** | Select the DC Gain value to be used based on the CTLE model to measure eye heights for TP3_EQ tests. |
| **10G & 20G User Defined CTLE Gain** | If "User Defined" is selected in the "TP3 CTLE DC Gain" field, select the optimized CTLE Gain setting index for the 10G and 20G TP3_EQ systems. |

## 6.5 Configure Calibration Target Values

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

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

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

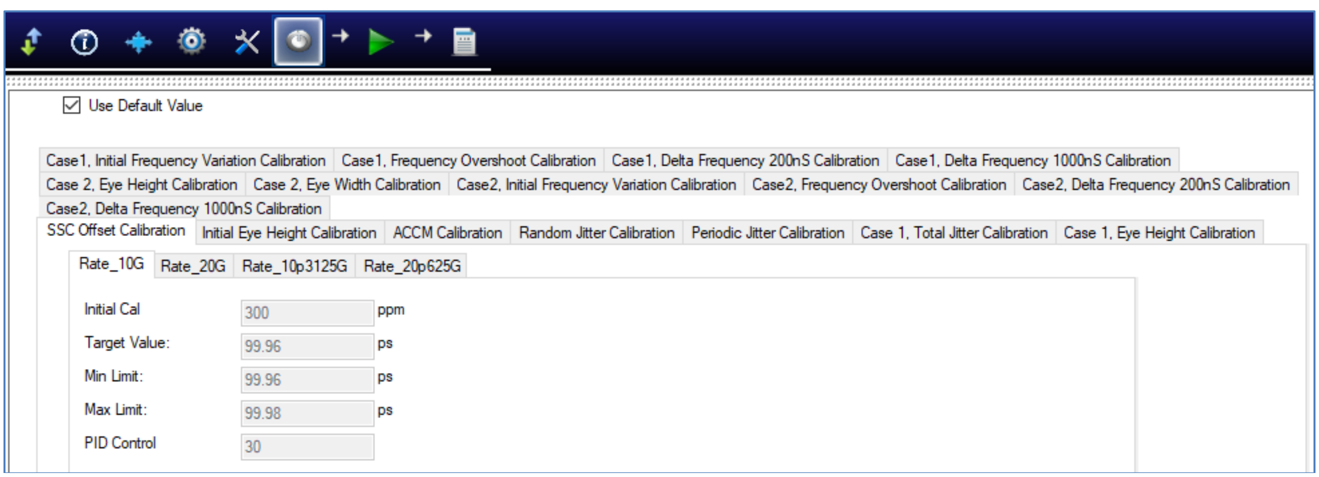
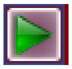



FIGURE 20. OVERWRITE EXISTING CALIBRATION TARGETS

## 6.6 Run Calibration

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

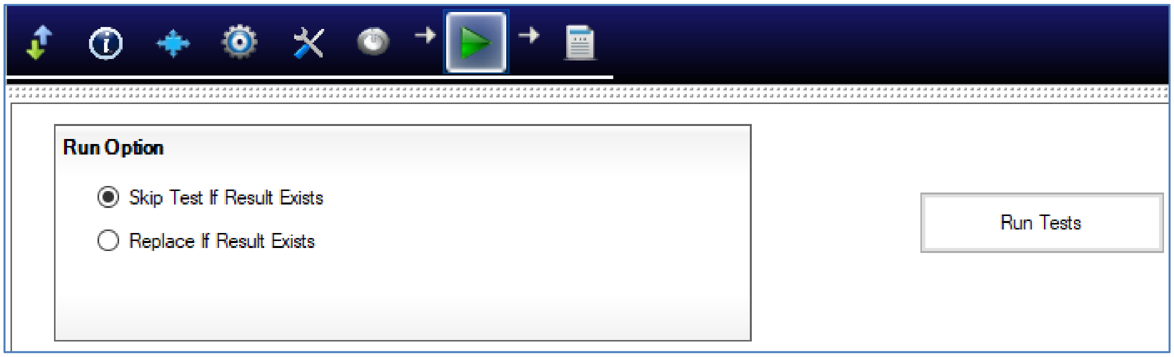



FIGURE 21. RUN CALIBRATION

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

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

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

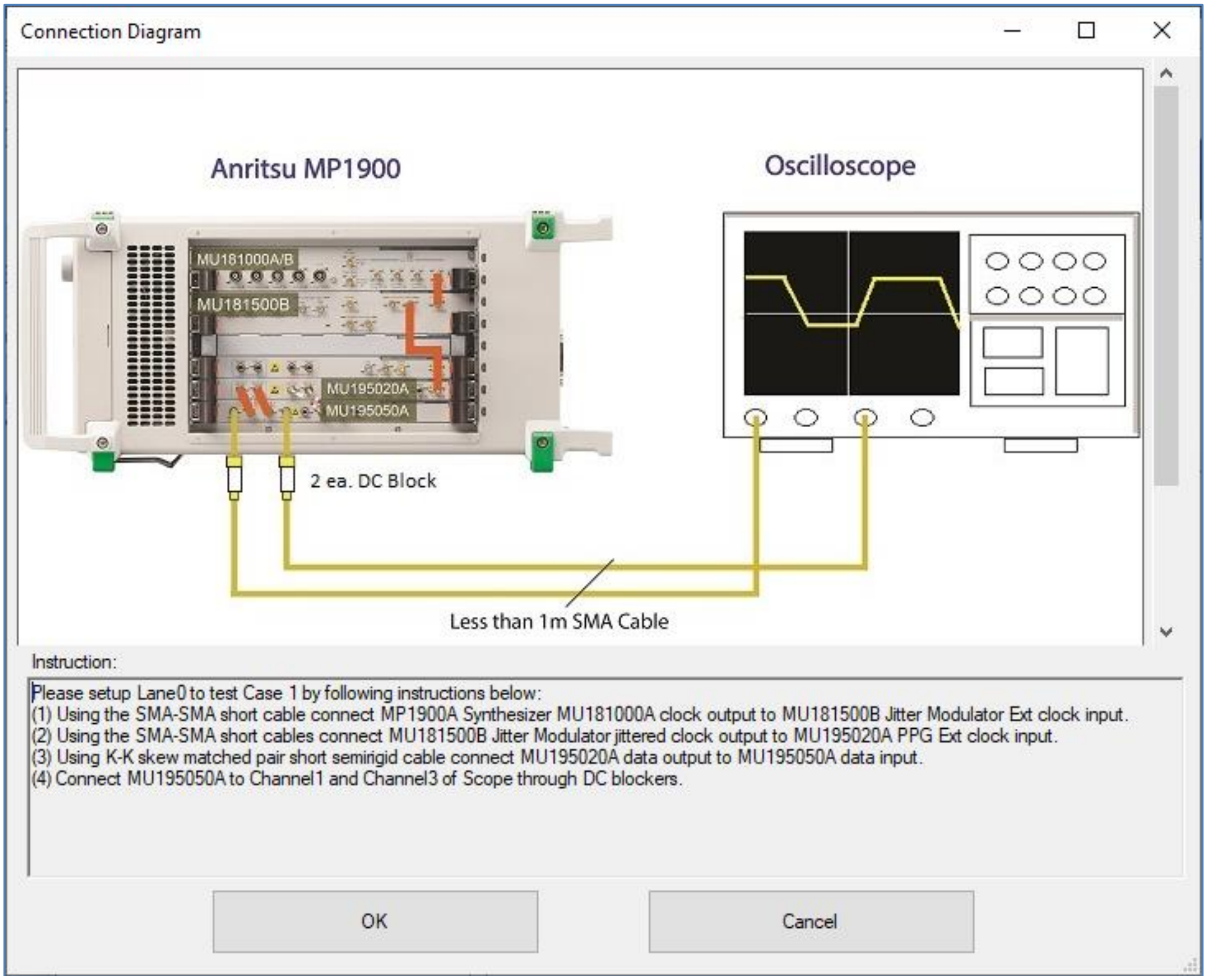



FIGURE 22. CONNECTION SETUP DIAGRAM DIALOG EXAMPLE

If you need to re-run only certain calibration on certain conditions, delete the calibration results from the Report tab and Run with **Skip Test if Result Exists.** The GRL software will keep track of the missing calibration results in the report and perform those calibration only. See Section 8.2, Delete Test Results for details.

# 7 Compliance Testing Using GRL-USB4-RXA Software

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

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

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

## 7.1 Connection Setups for BER Testing

This section describes the test setups for the host/device DUT using the USB4 microcontroller and MP1900A BERT. Test scripts as listed in Section 3.2 are required to run the automation tests. Also refer to Section 4.1.1 or Appendix F for options on how to configure the test setup.

### 7.1.1 BER Test Setup for TP3' (Using USB4 Microcontroller Method and MP1900A BERT)

Figure 23 shows the USB4 host/device DUT test setup diagram for TP3' (Test Point 3', Case 1) using the USB4 microcontroller method and the MP1900A BERT. The calibrated stressed signal is attached to a plug style test fixture and crosstalk is added to the fixture from the DUT which generates crosstalk signals. The microcontroller is used to directly control the DUT by executing microcontroller test scripts.

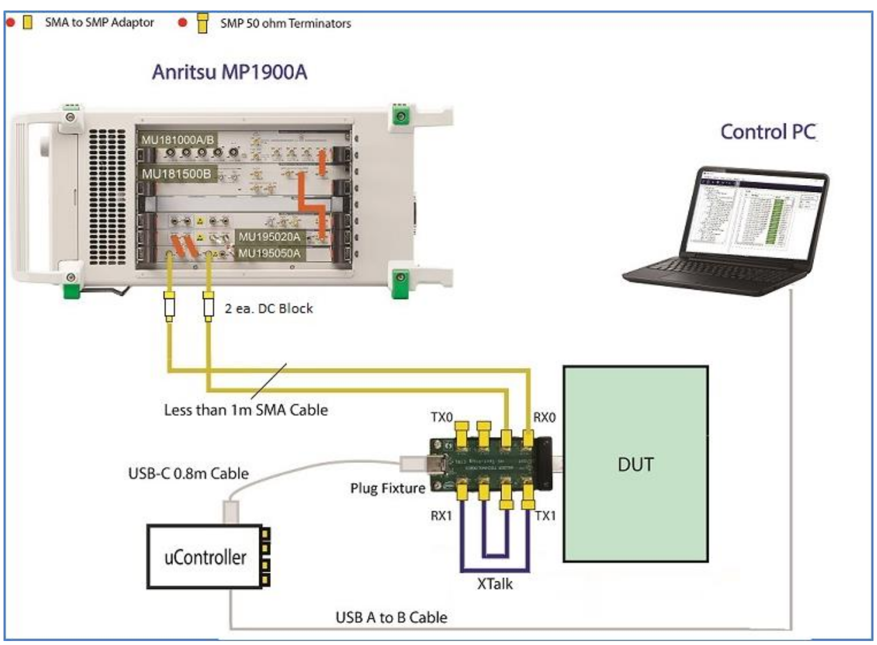



FIGURE 23. RX BER TEST SETUP AT TP3' (USING USB4 MICROCONTROLLER AND MP1900A BERT)

Connection Steps:

1. Attach the USB Type-C connector of the plug fixture to the DUT receptacle.
2. Using the MP1900A BERT TP3' (Case 1) calibration setup (Section 5.2), disconnect the MU195050A data outputs from the scope channels.
3. Connect the MU195050A data outputs through DC blocks to Rx Lane0/Lane1 of the DUT through the plug fixture.
4. Connect the USB4 microcontroller to power supply and to the controller PC.
5. Connect a 0.8M USB Type-C cable between the microcontroller and plug fixture.
6. Connect Tx Lane0/Lane1 of the plug fixture to the Rx lanes of the plug fixture that are not under test to inject crosstalk.
7. Terminate the Tx lanes of the plug fixture that are not under test with 50Ω termination.
8. Run the microcontroller test scripts to control the DUT.

### 7.1.2 BER Test Setup for TP3 (Using USB4 Microcontroller Method and MP1900A BERT)

Figure 24 shows the USB4 host/device DUT test setup diagram for TP3 (Test Point 3, Case 2) at 10G using the USB4 microcontroller method and the MP1900A BERT. The USB Type-C cable is disconnected from the calibration fixture and connected to the host/device DUT's USB Type-C receptacle connector. The microcontroller is used to directly control the host/device DUT by executing microcontroller test scripts.

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

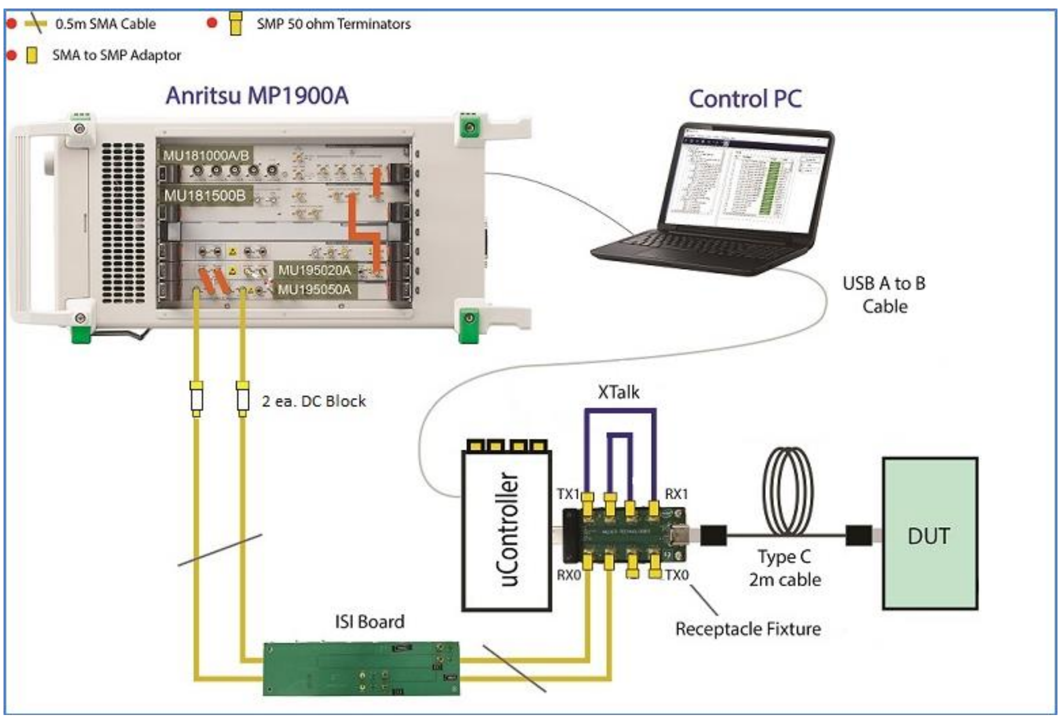



FIGURE 24. SETUP FOR TP3 RX BER TEST AT 10G OR 10.3125G (USING USB4 MICROCONTROLLER AND MP1900A BERT)

Connection Steps:

1. Using the MP1900A BERT TP3 (Case 2) calibration setup (Section 5.3), disconnect the test fixture that connects to the scope.
2. Attach the 2M USB Type-C cable to the DUT receptacle.
3. Connect the ISI channels to Rx Lane0/Lane1 of the test fixture.
4. Connect the USB4 microcontroller to power supply and to the controller PC.
5. Attach the microcontroller to the test fixture.
6. Connect Tx Lane0/Lane1 of the test fixture to the Rx lanes of the test fixture that are not under test to inject crosstalk.
7. Terminate the Tx lanes of the test fixture that are not under test with 50Ω termination.
8. Run the microcontroller test scripts to control the DUT.

Figure 25 shows the USB4 host/device DUT test setup diagram for TP3 (Test Point 3, Case 2) at 20G using the USB4 microcontroller method and the MP1900A BERT. The USB Type-C cable is disconnected from the calibration fixture and connected to the host/device DUT's USB Type-C receptacle connector. The microcontroller is used to directly control the host/device DUT by executing microcontroller test scripts.

For USB4 Gen3 speed (20Gb/s) or Thunderbolt 3 compatible Gen3 speed (20.625Gb/s), the setup uses a 0.8M USB Type-C cable.

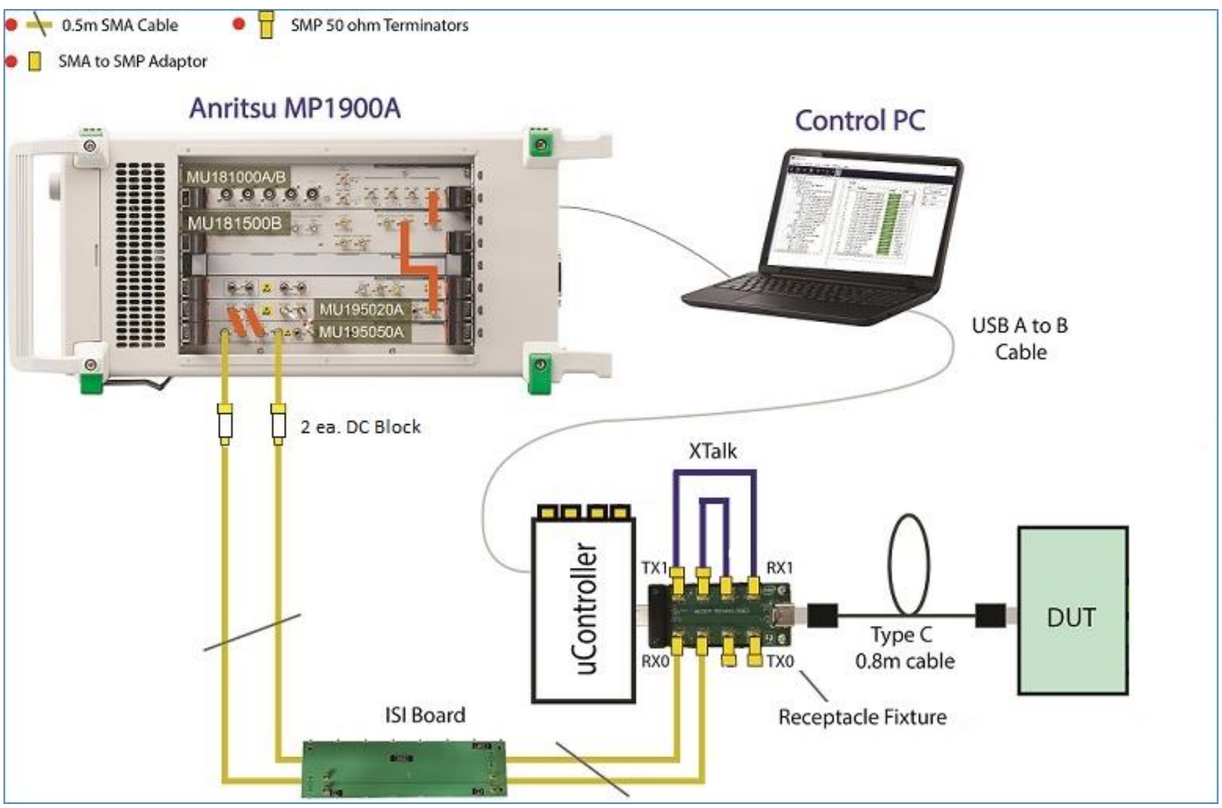



FIGURE 25. SETUP FOR TP3 RX BER TEST AT 20G OR 20.625G (USING USB4 MICROCONTROLLER AND MP1900A BERT)

Connection Steps:

1. Using the MP1900A BERT TP3 (Case 2) calibration setup (Section 5.3), disconnect the test fixture that connects to the scope.
2. Attach the 0.8M USB Type-C cable to the DUT receptacle.
3. Connect the ISI channels to Rx Lane0/Lane1 of the test fixture.
4. Connect the USB4 microcontroller to power supply and to the controller PC.
5. Attach the microcontroller to the test fixture.
6. Connect Tx Lane0/Lane1 of the test fixture to the Rx lanes of the test fixture that are not under test to inject crosstalk.
7. Terminate the Tx lanes of the test fixture that are not under test with 50Ω termination.
8. Run the microcontroller test scripts to control the DUT.

## 7.2 Select DUT Type

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

Select either a USB4 Host or Device to be tested.

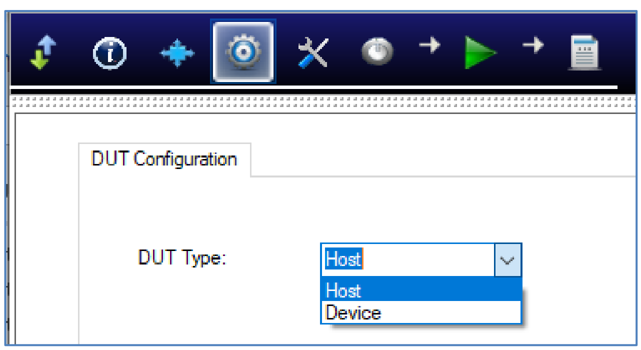



FIGURE 26. SELECT DUT TYPE

## 7.3 Select DUT Rx Tests

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

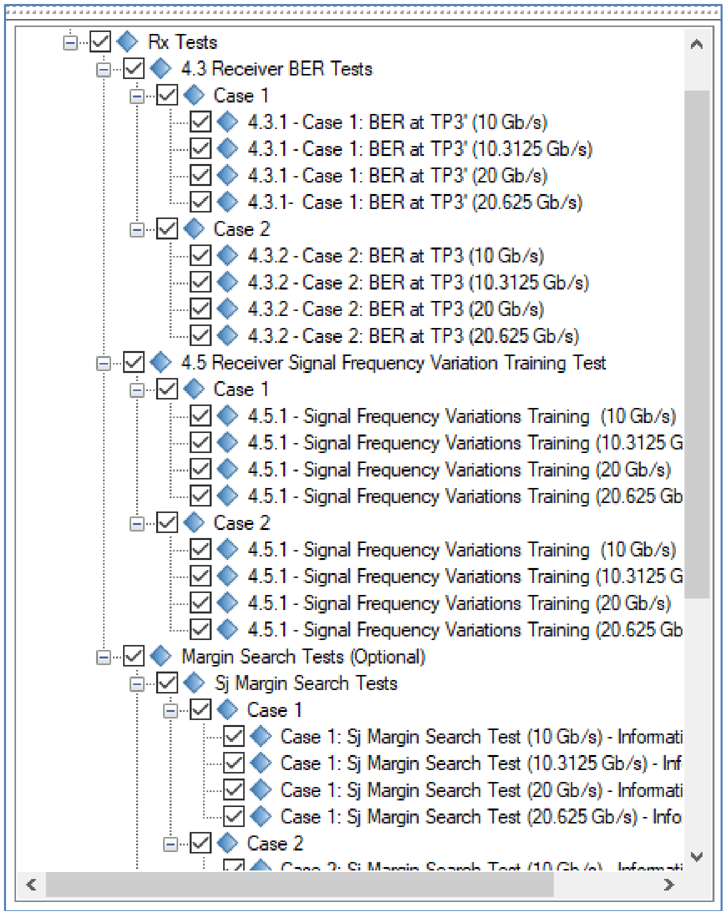



FIGURE 27. SELECT DUT RX TESTS TO BE RUN

### 7.3.1 Receiver Test Group

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

TABLE 5. SUPPORTED RX TESTS

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

| | |
|---|---|
| | only) |
| Amplitude Margin Search Tests | Runs Optional tests to search for Amplitude Margin (for information purpose only) |

## 7.4 Set Up USB4 Microcontroller Environment

Select  from the software menu to access the Configurations page.

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

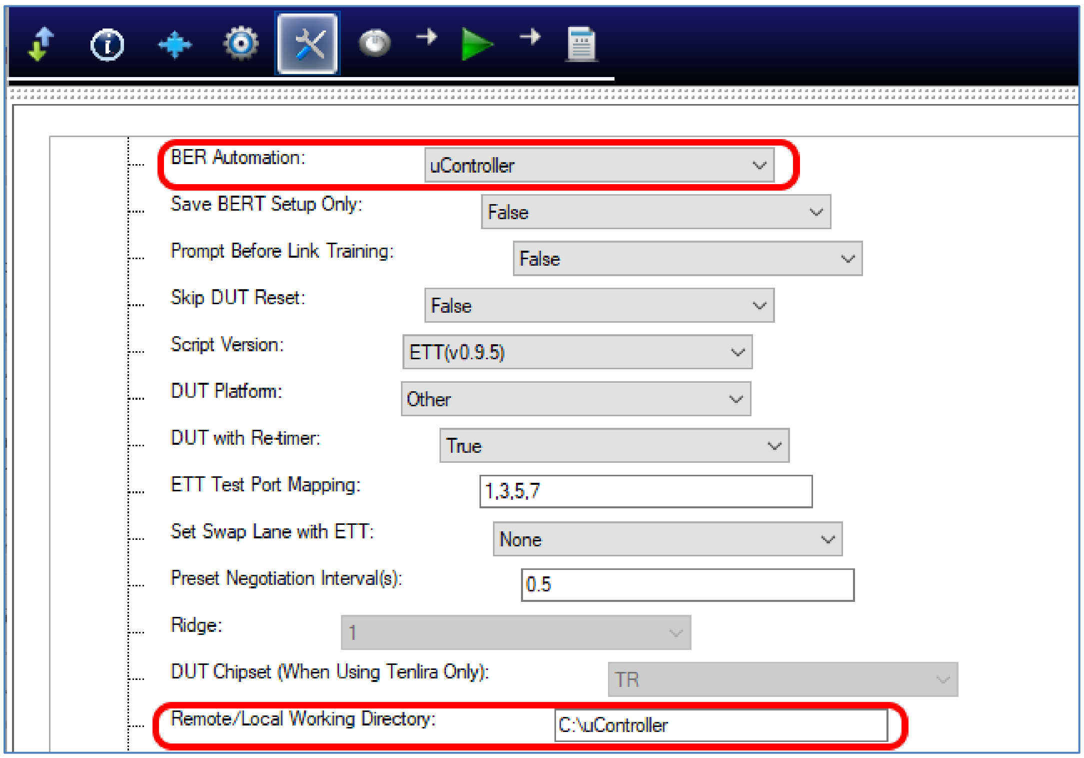



FIGURE 28. SETUP FOR USB4 MICROCONTROLLER ENVIRONMENT

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

1. Set the **BER Automation** field to "uController".
2. Set the **Remote/Local Working Directory** field to the path where the microcontroller script is installed in the controller PC.

## 7.5 Set Up Intel's TenLira Environment

Select  from the software menu to access the Configurations page.

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

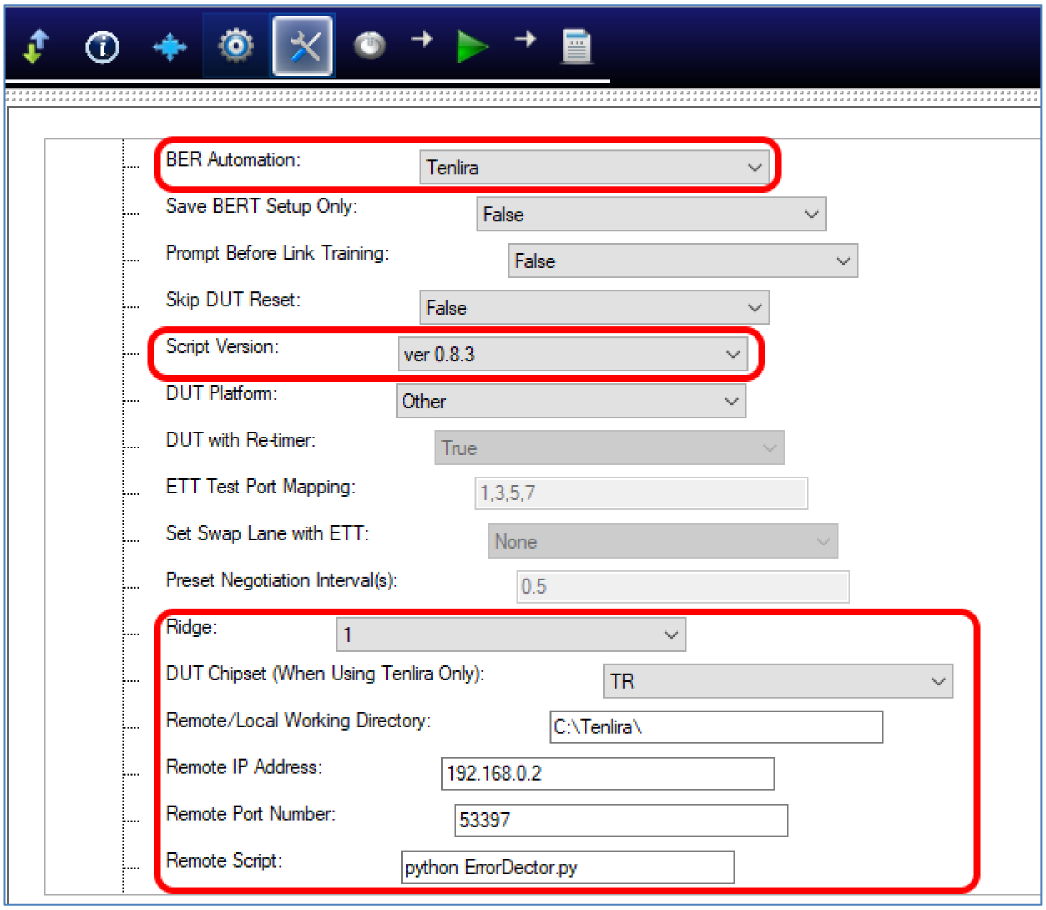



FIGURE 29. SETUP FOR TENLIRA ENVIRONMENT

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

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

## 7.6 Set Up USB4 ETT Environment

Select  from the software menu to access the Configurations page.

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

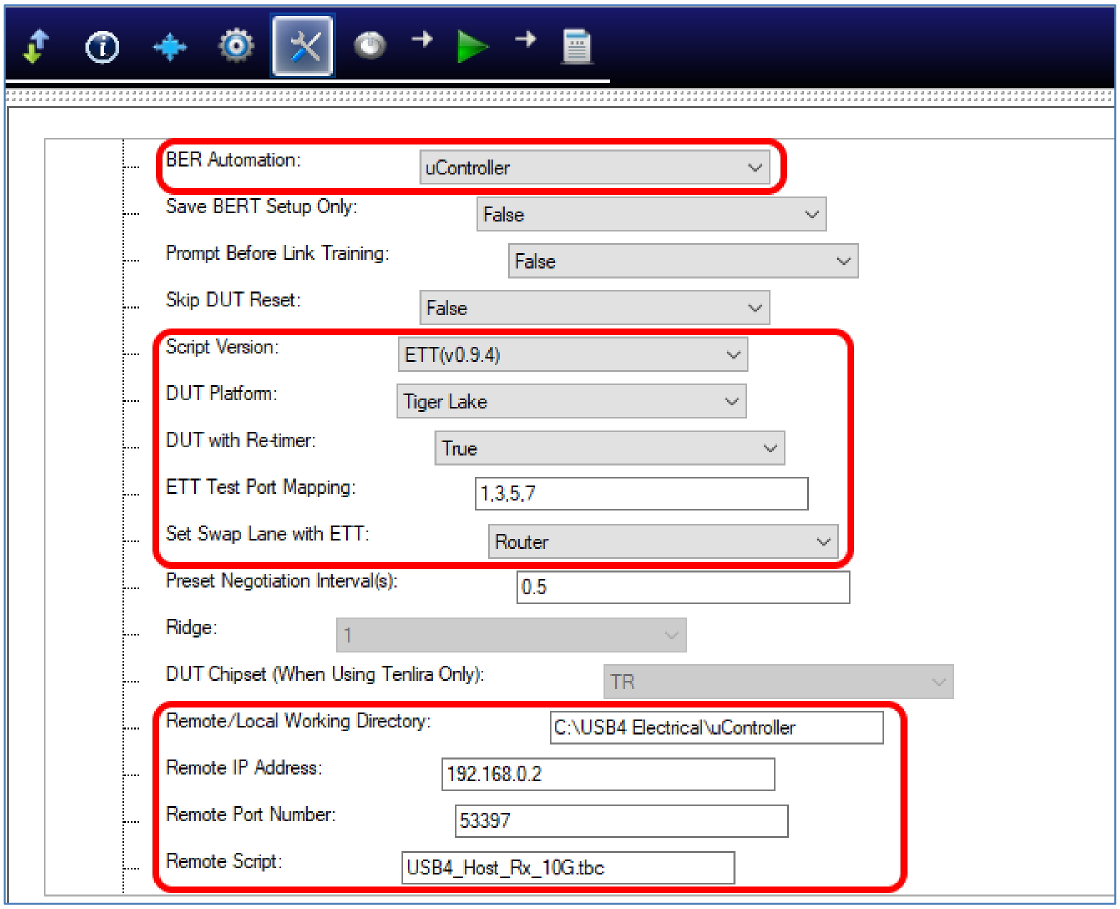


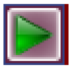

FIGURE 30. SETUP FOR ETT ENVIRONMENT

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

1. Set the **BER Automation** field to “uController”.
2. Select the **ETT Script Version** to be used.
3. Select the **DUT Platform** as supported by the DUT.
4. Select “True” if to use the **DUT with Re-timer**.
5. Specify the test connector lanes of the DUT to validate for **ETT Test Port Mapping**.
6. To perform lane switching for the DUT, select the router and/or re-timer setup in the **Set Swap Lane with ETT** field.
7. Set the **Remote/Local Working Directory** field to the path where the ETT script is installed in the host PC.

8. Provide the **Remote IP Address** and **Remote Port Number** of the remote host.
9. Enter the name of the **Remote Script** to be used.

## 7.7 Run DUT Rx Tests

Select  from the software menu to access the Run Tests page. Select the Run Option as desired before clicking the Run Tests button to start testing the DUT. *(This is similar to Section 6.6; refer for more details.)*

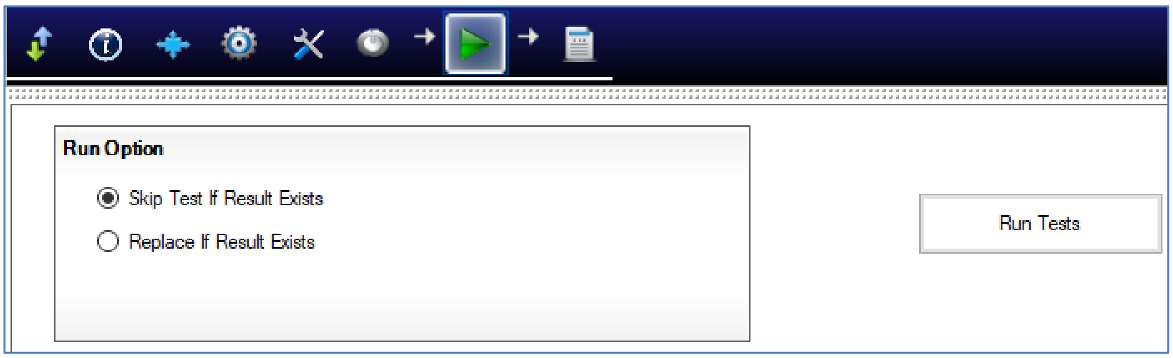



FIGURE 31. RUN TESTS

# 8 Test Results and Reports Using GRL-USB4-RXA Software

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

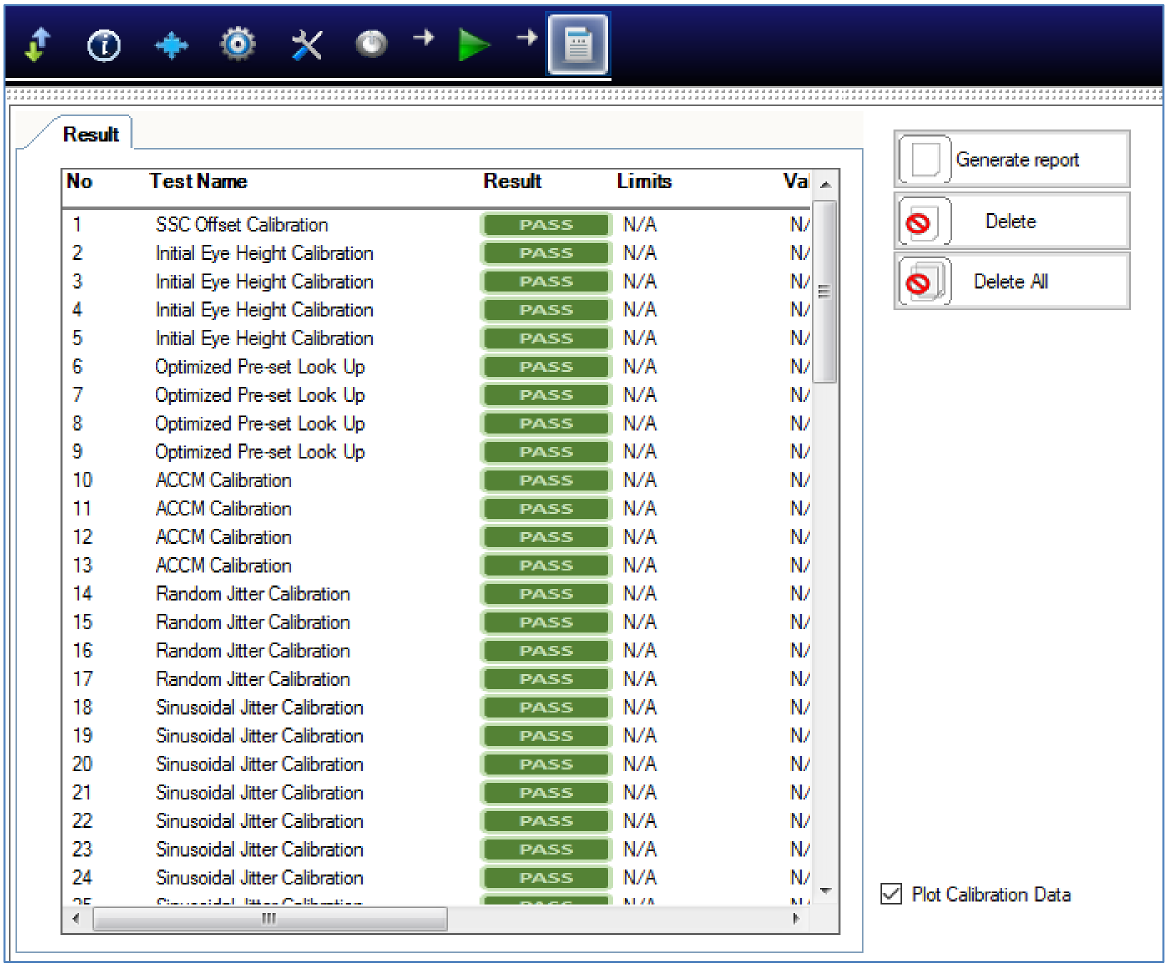



FIGURE 32. REPORT RESULTS PAGE

### 8.1.1 DUT Information

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

Anritsu USB4 Rx Test Report

**DUT Information**

| | | |
|---|---|---|
| **DUT Manufacturer** | : | GRL |
| **DUT Model Number** | : | USB4_AX001 |
| **DUT Serial Number** | : | 1000888ABC |
| **DUT Comments** | : | |

**Test Information**

| | | |
|---|---|---|
| **Test Lab** | : | Granite River Labs |
| **Test Operator** | : | John |
| **Test Date** | : | April 1, 2020 |

**Software Version**

| | | |
|---|---|---|
| **Software Revision** | : | 0.00.43 |

FIGURE 33. DUT INFORMATION

### 8.1.2 Results Summary Table

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

| No | TestName | Limits | Value | Results | Test Point | Lane | Data Rate | SJ Frequency |
|---|---|---|---|---|---|---|---|---|
| 1 | SSC Offset Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | N/A |
| 2 | SSC Offset Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | N/A |
| 3 | SSC Offset Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | N/A |
| 4 | SSC Offset Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20p625G | N/A |
| 5 | Initial Eye Height Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | N/A |
| 6 | Initial Eye Height Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | N/A |
| 7 | Initial Eye Height Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | N/A |
| 8 | Initial Eye Height Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20p625G | N/A |
| 9 | Optimized Pre-set Look Up | N/A | N/A | Pass | N/A | N/A | Rate_10G | N/A |
| 10 | Optimized Pre-set Look Up | N/A | N/A | Pass | N/A | N/A | Rate_20G | N/A |
| 11 | Optimized Pre-set Look Up | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | N/A |
| 12 | Optimized Pre-set Look Up | N/A | N/A | Pass | N/A | N/A | Rate_20p625G | N/A |
| 13 | ACCM Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | N/A |
| 14 | ACCM Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | N/A |
| 15 | ACCM Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | N/A |
| 16 | ACCM Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20p625G | N/A |
| 17 | Random Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | N/A |
| 18 | Random Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | N/A |
| 19 | Random Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | N/A |
| 20 | Random Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20p625G | N/A |
| 21 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | SJ1 |
| 22 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | SJ2 |
| 23 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | SJ3 |
| 24 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | SJ4 |
| 25 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10G | SJ5 |
| 26 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | SJ1 |
| 27 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | SJ2 |
| 28 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | SJ3 |
| 29 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | SJ4 |
| 30 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_20G | SJ5 |
| 31 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | SJ1 |
| 32 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | SJ2 |
| 33 | Periodic Jitter Calibration | N/A | N/A | Pass | N/A | N/A | Rate_10p3125G | SJ3 |

FIGURE 34. RESULTS SUMMARY TABLE EXAMPLE

### 8.1.3 Compliance Test Results

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

**Case1 10p3125G BER at TP3'**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

**Case1 20G BER at TP3'**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

**Case1 20p625G BER at TP3'**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

**Case2 10G BER at TP3**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

**Case2 10p3125G BER at TP3**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

**Case2 20G BER at TP3**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

**Case2 20p625G BER at TP3**

| Sj Frequency | SJ1 | SJ2 | SJ3 | SJ4 | SJ5 |
|---|---|---|---|---|---|
| Lane0 | - | - | - | - | - |
| Lane1 | - | - | - | - | - |
| Lane2 | - | - | - | - | - |
| Lane3 | - | - | - | - | - |

FIGURE 35. COMPLIANCE TEST RESULTS EXAMPLE

### 8.1.4 Calibration & Test Result Details

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

**102. Case 2, Eye Width Calibration [Case2,Rate_20p625G,SJ5]**

| | | |
|---|---|---|
| **Pass/Fail Stats** | : | Pass |
| **Cal Parameter** | : | Eye_Width_Rate_20p625G__Case2__SJ5 |
| **Settings Parameter** | : | SJ (p-p) |
| **Settings** | : | 120.0000 mUI(p-p) |
| **Measured Parameter** | : | Compliance TJ |
| **Measured Value** | : | 537.2145 mUI(p-p) |
| **Tj Adjust Parameter** | : | Sj |
| **Sj Frequency** | : | 100.0000 MHz |
| **Test completed time** | : | 30 September 2020 5:33:44 AM |

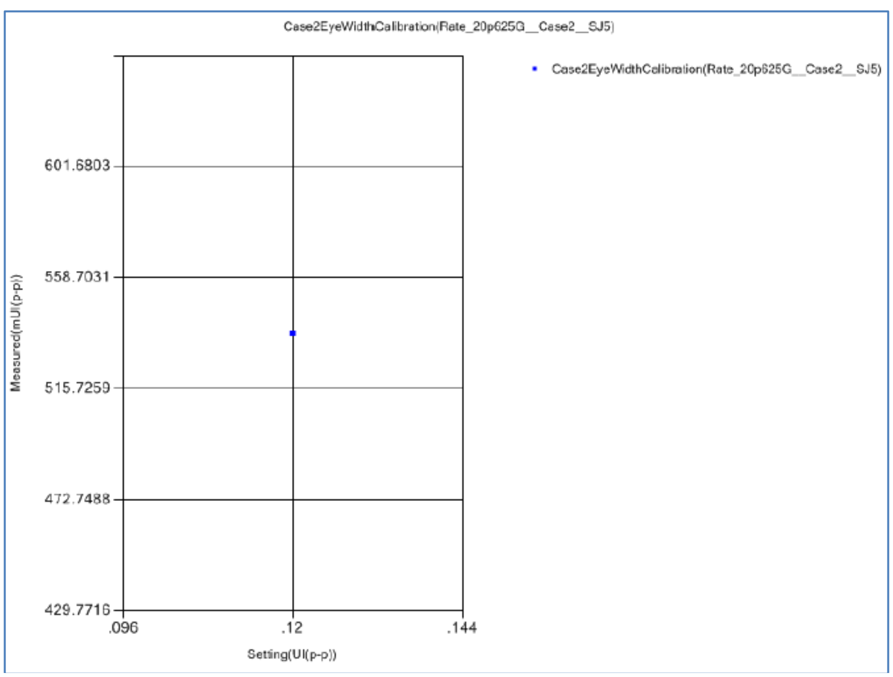




FIGURE 36. CALIBRATION/TEST RESULT DETAILS EXAMPLE

## 8.2 Delete Test Results

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

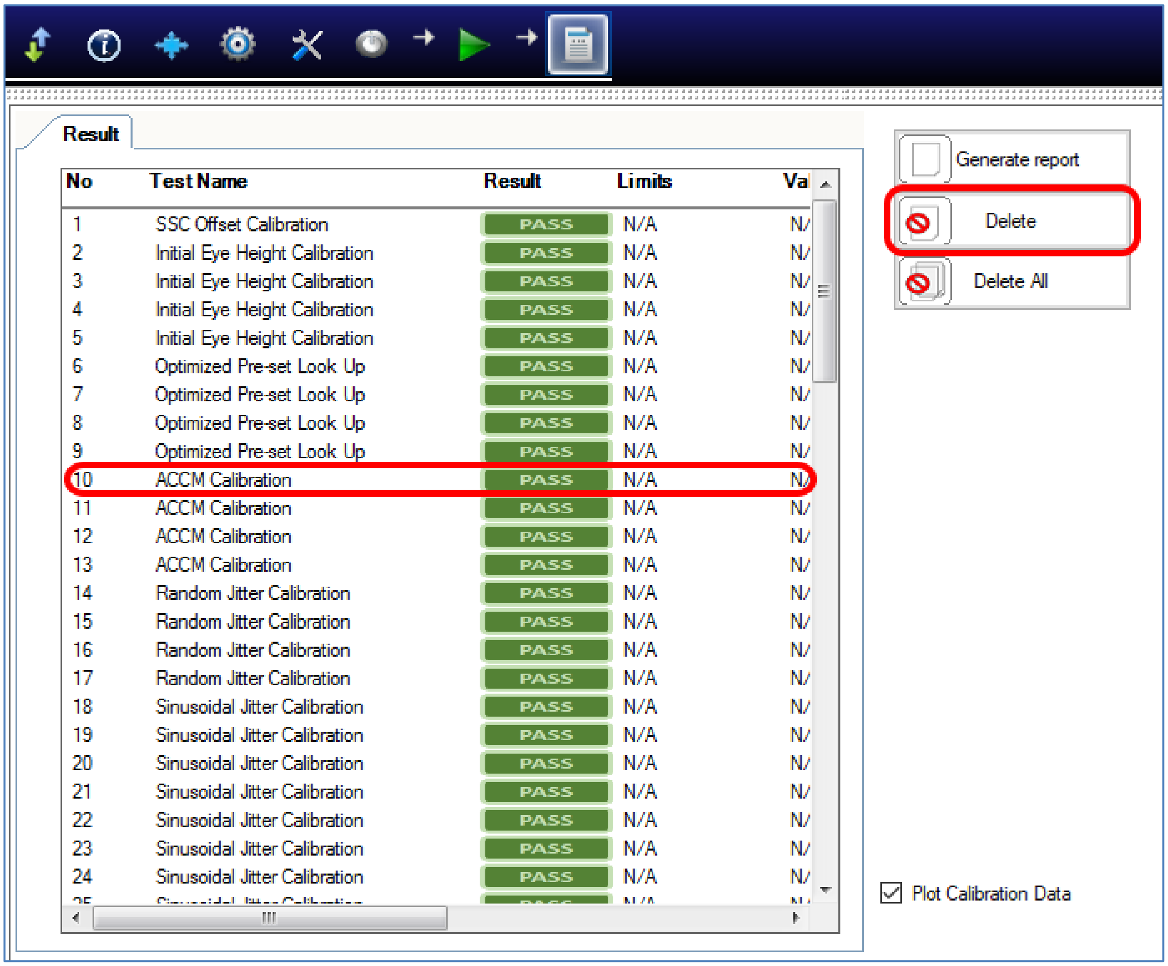



FIGURE 37. DELETE INDIVIDUAL CALIBRATION/TEST RESULTS EXAMPLE

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

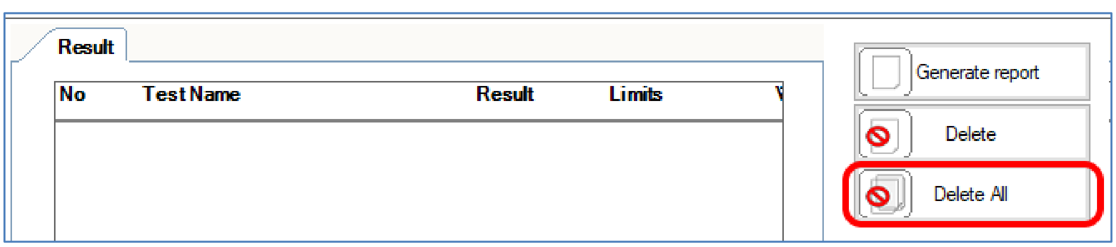



FIGURE 38. DELETE ALL RESULTS

# 9 Saving and Loading Test Sessions

The GRL-USB4-RXA software enables Calibration and Test Results to be created and maintained as a 'Live Session' in the application. This allows you to quit the application and return later to continue where you left off.

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

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

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

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

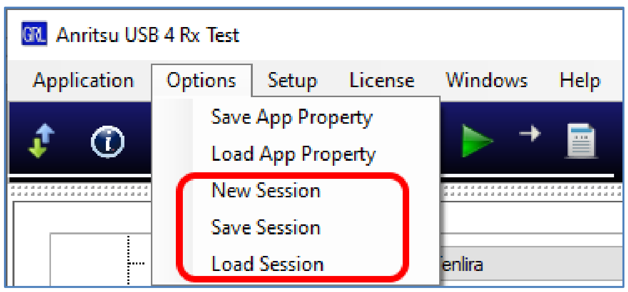



FIGURE 39. SAVING AND LOADING CALIBRATION AND TEST SESSIONS

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

# 10 Appendix A: Manual Calibration & Test Methodologies

*Note the MP1900A BERT is used in the following calibration and test methodologies.*

## 10.1 Calibrate Receiver Stressed Eye for 10Gb/s or 10.3125Gb/s Test Case 1 at TP3'

1. Set up the physical equipment connections without the ISI channel, as per Figure 10.
2. Set up the MP1900A BERT as follows:

    a) Go to Menu Bar → File → Initialize.
    b) Go to Jitter tab and set Clock Source to "Unit1:Slot2:MU181000B". See Figure 40.
    c) Go to PPG → Misc2.
    d) Set Clock Source to "Unit1:Slot4:MU181500B". See Figure 46.
    e) Set Bit Rate to 10Gbit/s or 10.3125Gbit/s. See Figure 46.
    f) Set Offset (ppm) to 300ppm for rounded rate (10G) and 400ppm for legacy rate (10.3125G). See Figure 46.
    g) Set Output Clock Rate to "Fullrate". See Figure 46.
    h) Set Test Pattern on PPG to "PRBS" and Length to "2^15-1" bits. See Figure 42.
    i) Turn on PPG Data Output.
    j) Go to PPG → Emphasis tab and turn on "Manual Setting". See Figure 43.
    k) Turn on "SSC", with settings of 32kHz (for 10G) or 36kHz (for 10.3125G) with 5600ppm (for 10G) and 5800ppm (for 10.3125G) triangle down spread. (SSC will remain on for all of the following steps.) See Figure 44.
    l) Set DATA+ amplitude to 620mV. A differential amplitude just over the 700mV EH should show as an initial value. (See the lower left in Figure 45.)
    m) Set initial CM frequency to 400MHz. See Figure 46.
    n) Turn the CM output to "Off" until the CM Calibration Step.

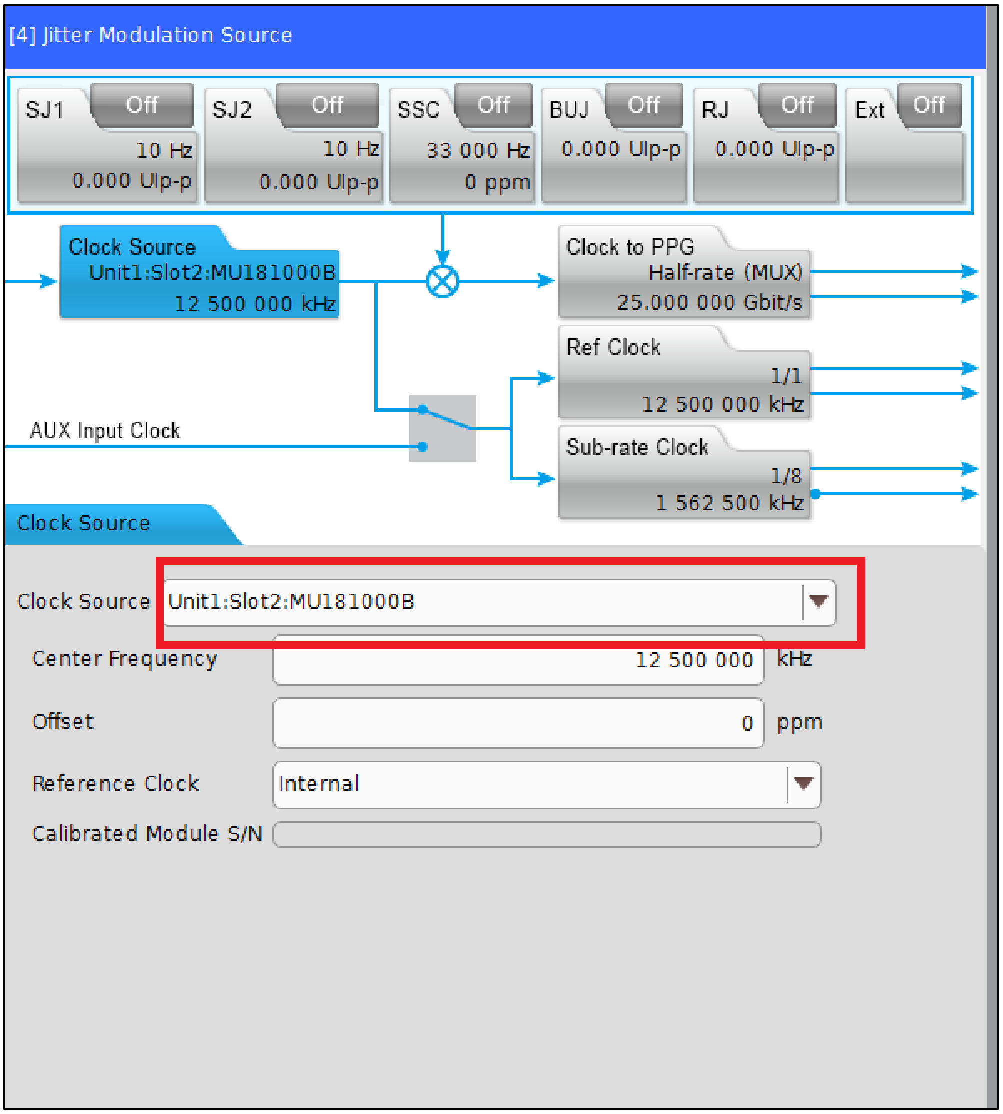



FIGURE 40. JITTER CLOCK SOURCE SETTING

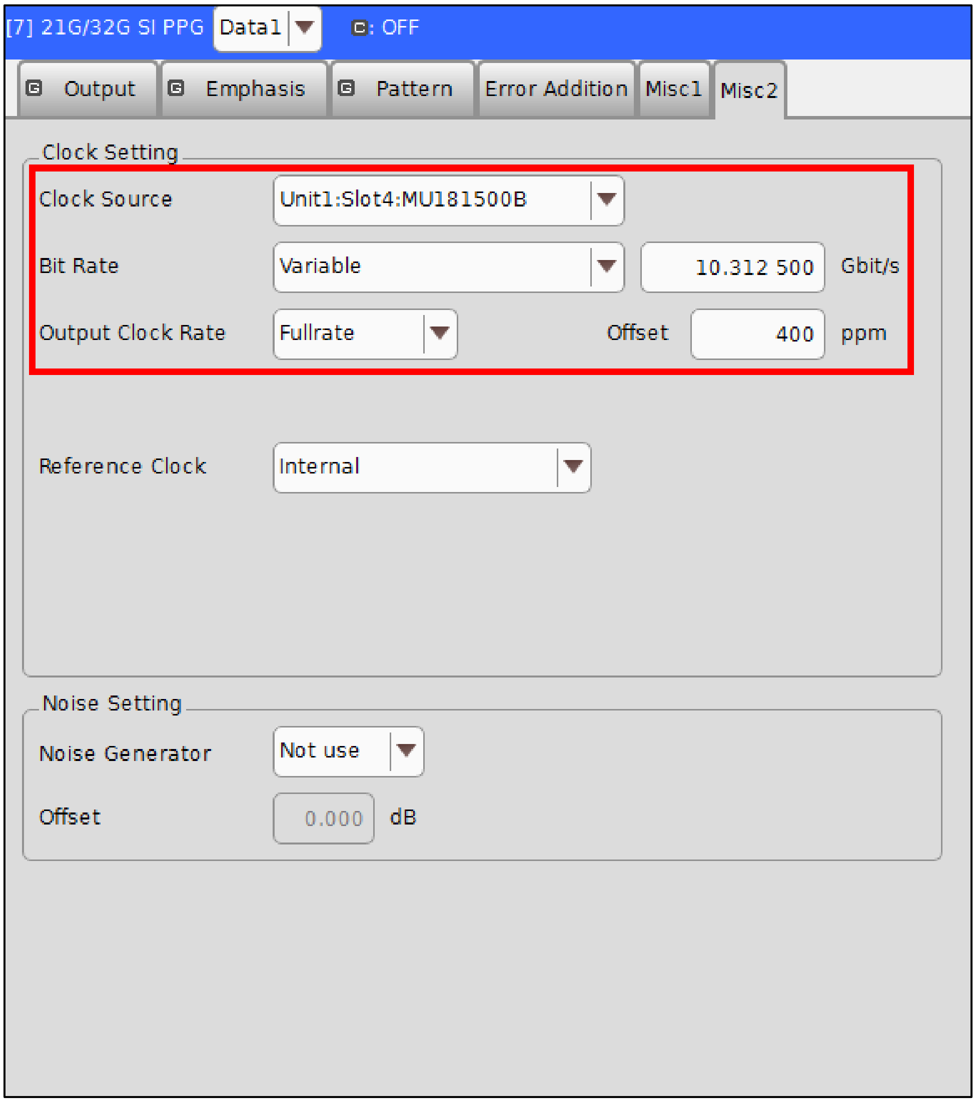



FIGURE 41. PPG MISC2 SETTINGS

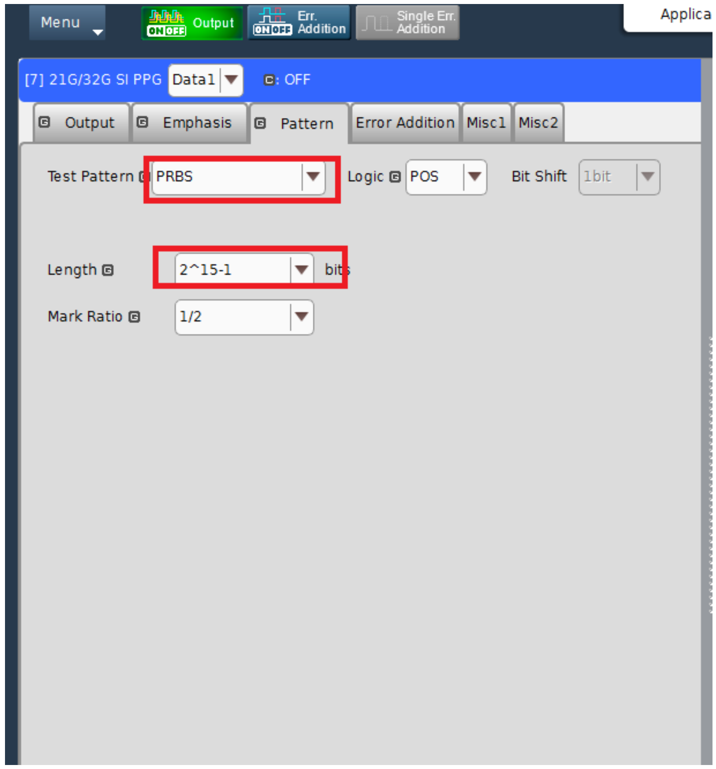



FIGURE 42. PATTERN SETTING

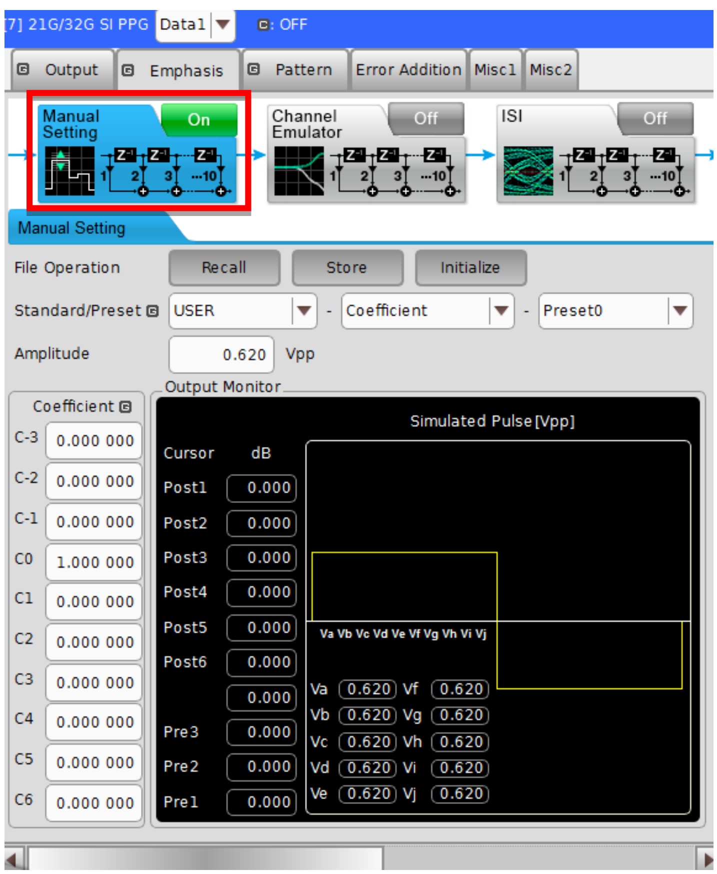


FIGURE 43. PPG EMPHASIS SETTING

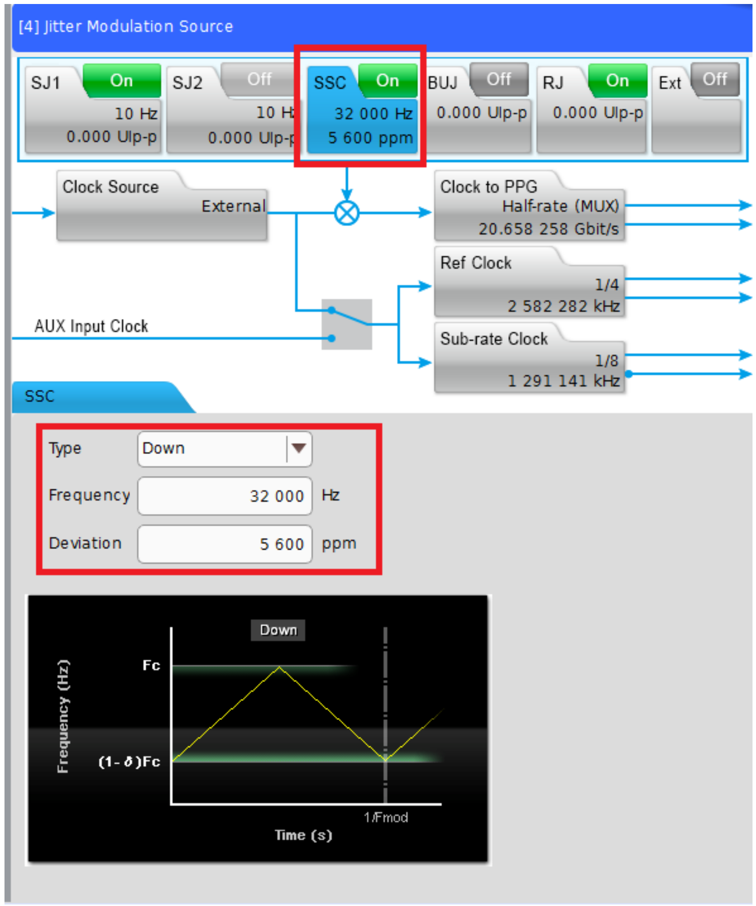



FIGURE 44. SSC SETUP


FIGURE 45. DATA+ AMPLITUDE SETTING

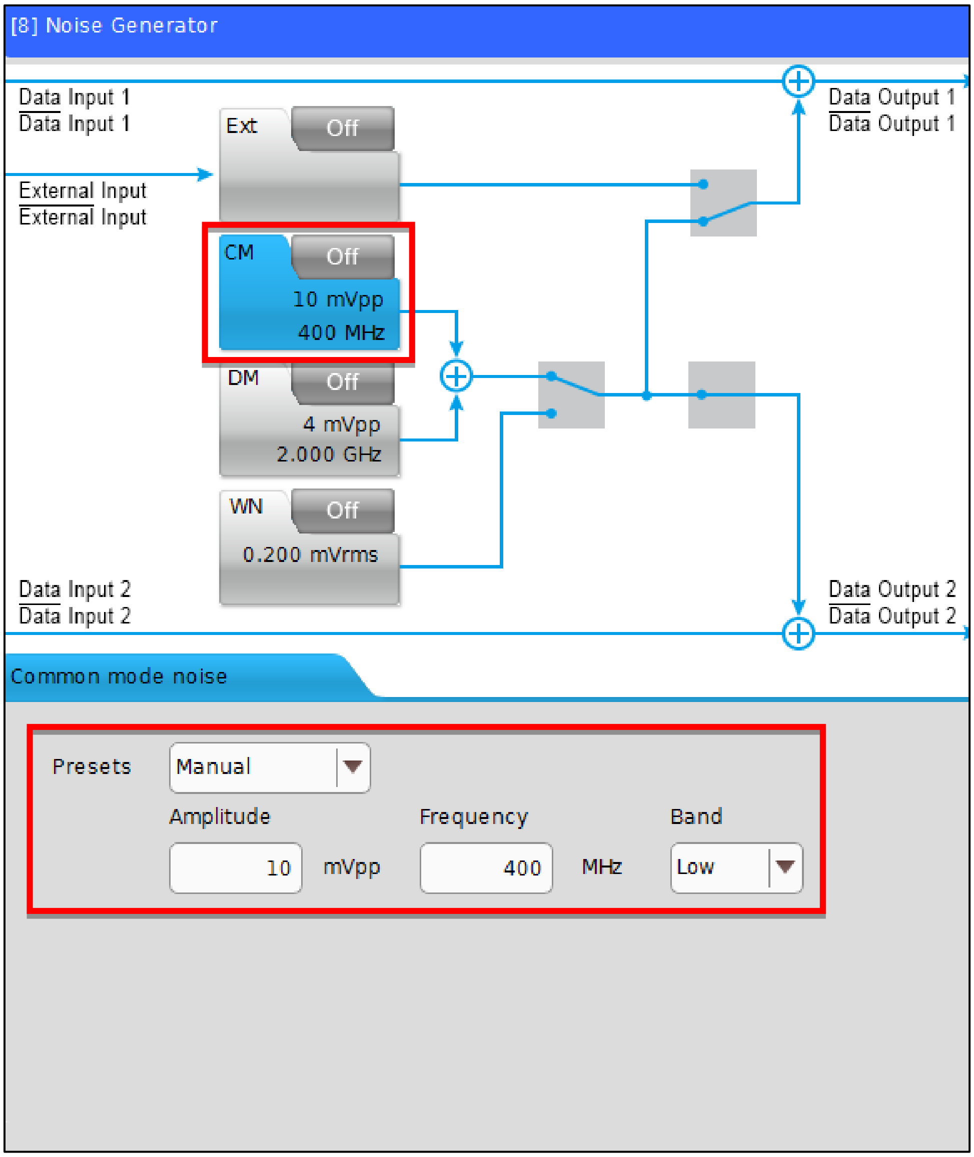



FIGURE 46. CM SETTING

### 10.1.1 Set Up Oscilloscope

#### 10.1.1.1 Oscilloscope Vertical and Horizontal Setup

Set up the Scope as listed in Table 6.

TABLE 6. OSCILLOSCOPE VERTICAL AND HORIZONTAL SETUP

| Setting | Setup |
| --- | --- |
| Vertical | Ch1-Ch3 (using the full range of the Scope's D/A) |
| Record Length | 40M in a single acquisition |
| Sample Rate | 80Gs/s |

| Setting | Setup |
|---|---|
| Averaging | OFF |
| Sample Mode | Real Time |
| Bandwidth | 16GHz (which allows for 3rd harmonic capture at 10.3125Gb/s) |
| Vertical Scale | Set to full screen without clipping |
| Sin x/x | OFF |


FIGURE 47. OSCILLOSCOPE VERTICAL AND HORIZONTAL SETUP

#### 10.1.1.2 Oscilloscope Clock Recovery Setup

Enter the Clock Recovery menu and set up the Scope as listed in Table 7.

TABLE 7. OSCILLOSCOPE CLOCK RECOVERY SETUP

| Setting | Setup |
|---|---|
| Nominal Data Rate | 10Gb/s (Rounded), 10.3125Gb/s (Thunderbolt 3 Legacy) |
| Clock Recovery Method | Second Order PLL |
| PLL Specification | OJTF<br>Loop Bandwidth: 5.000MHz<br>Damping factor: 0.94 |

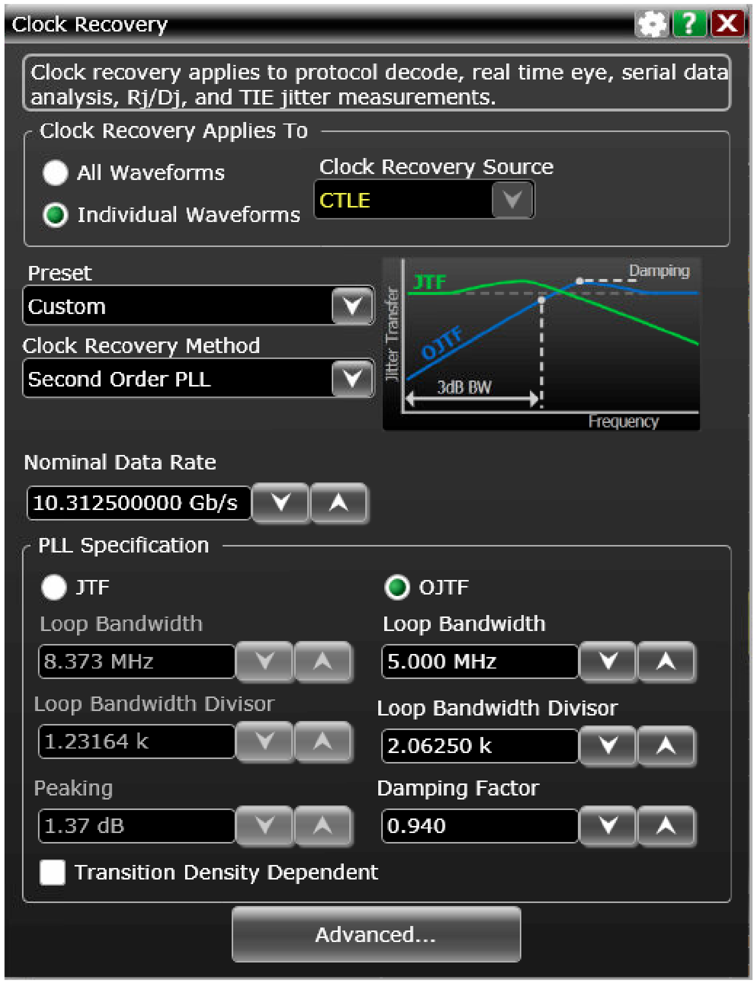



FIGURE 48. OSCILLOSCOPE CLOCK RECOVERY SETUP

#### 10.1.1.3 Oscilloscope AC Common Mode (ACCM) Setup

Set up the Scope as listed in Table 8.

TABLE 8. OSCILLOSCOPE ACCM SETUP

| Setting | Setup |
|---|---|
| Sample Rate | ≥ 80Gs/s |
| Record Length | 40Mpts per channel |
| Bandwidth | 16GHz |
| Vertical Scale | 20mV/div |
| CDR | OFF |
| Averaging | OFF |
| Sin x/x | OFF |

### 10.1.1.4 Jitter Setup

Enter the Jitter menu and set up the Scope as listed in Table 9.

TABLE 9. OSCILLOSCOPE JITTER SETUP

| **Setting** | **Setup** |
| --- | --- |
| Units | Unit Interval |
| Jitter Method | Spectral |
| Source for Jitter & Eye Diagram | Channel 1-3 |
| BER Level | 1E-12 |
| Pattern | Periodic, Repeating Pattern ($2^{15}$-1 = 32,767 bits) |

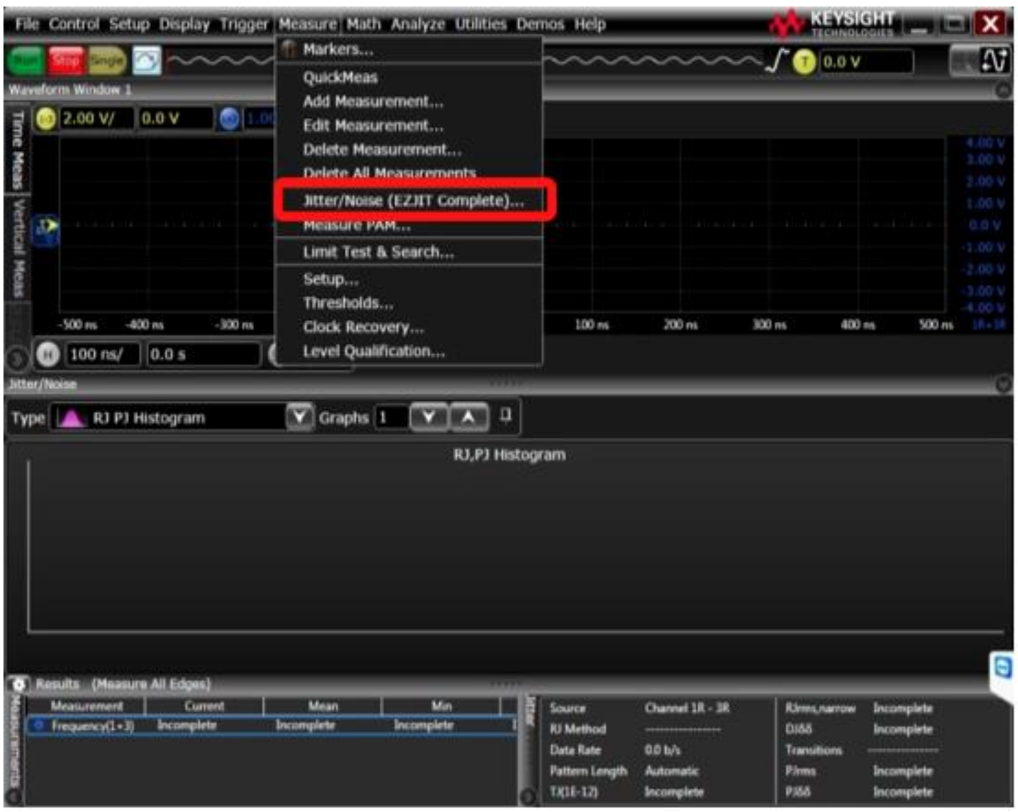


FIGURE 49. OSCILLOSCOPE JITTER SETUP

#### 10.1.1.5 Eye Diagram Vertical Setup

Set up the Scope as listed in Table 10.

TABLE 10. OSCILLOSCOPE EYE DIAGRAM VERTICAL SETUP

| Setting | Setup |
|---|---|
| Vertical Scale | 200 mV/div |
| Horizontal Scale | 2 UI's |
| Eye Mask Height | 700 mV (for final Eye Height Calibration) |
| Eye Mask Width | 650 mUI |

### 10.1.2 Record ISI Measurements

1. Step through Pre-set coefficients 0 to 14 and use a Preset which gives minimum DDJ Measurement. Although these are not calibrated values, record ISI measurement as part of the measurement table.

| Preset Number | Pre-shoot [dB] | De-emphasis [dB] | Informative Filter Coefficients | | |
|---|---|---|---|---|---|
| | | | $C_{-1}$ | $C_0$ | $C_1$ |
| 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | -1.9 | 0 | 0.90 | -0.10 |
| 2 | 0 | -3.6 | 0 | 0.83 | -0.17 |
| 3 | 0 | -5.0 | 0 | 0.78 | -0.22 |
| 4 | 0 | -8.4 | 0 | 0.69 | -0.31 |
| 5 | 0.9 | 0 | -0.05 | 0.95 | 0 |
| 6 | 1.1 | -1.9 | -0.05 | 0.86 | -0.09 |
| 7 | 1.4 | -3.8 | -0.05 | 0.79 | -0.16 |
| 8 | 1.7 | -5.8 | -0.05 | 0.73 | -0.22 |
| 9 | 2.1 | -8.0 | -0.05 | 0.68 | -0.27 |
| 10 | 1.7 | 0 | -0.09 | 0.91 | 0 |
| 11 | 2.2 | -2.2 | -0.09 | 0.82 | -0.09 |
| 12 | 2.5 | -3.6 | -0.09 | 0.77 | -0.14 |
| 13 | 3.4 | -6.7 | -0.09 | 0.69 | -0.22 |
| 14 | 3.6 | 0 | -0.17 | 0.83 | 0 |
| 15 | 1.7 | -1.7 | -0.05 | 0.55 | -0.05 |

FIGURE 50. ISI MEASUREMENT PRESET TABLE

2. In 4Tap Emphasis Ch1 Menu, create 15 Presets with coefficients which match the Table in the Thunderbolt Interconnect Specification. See Figure 51 below.

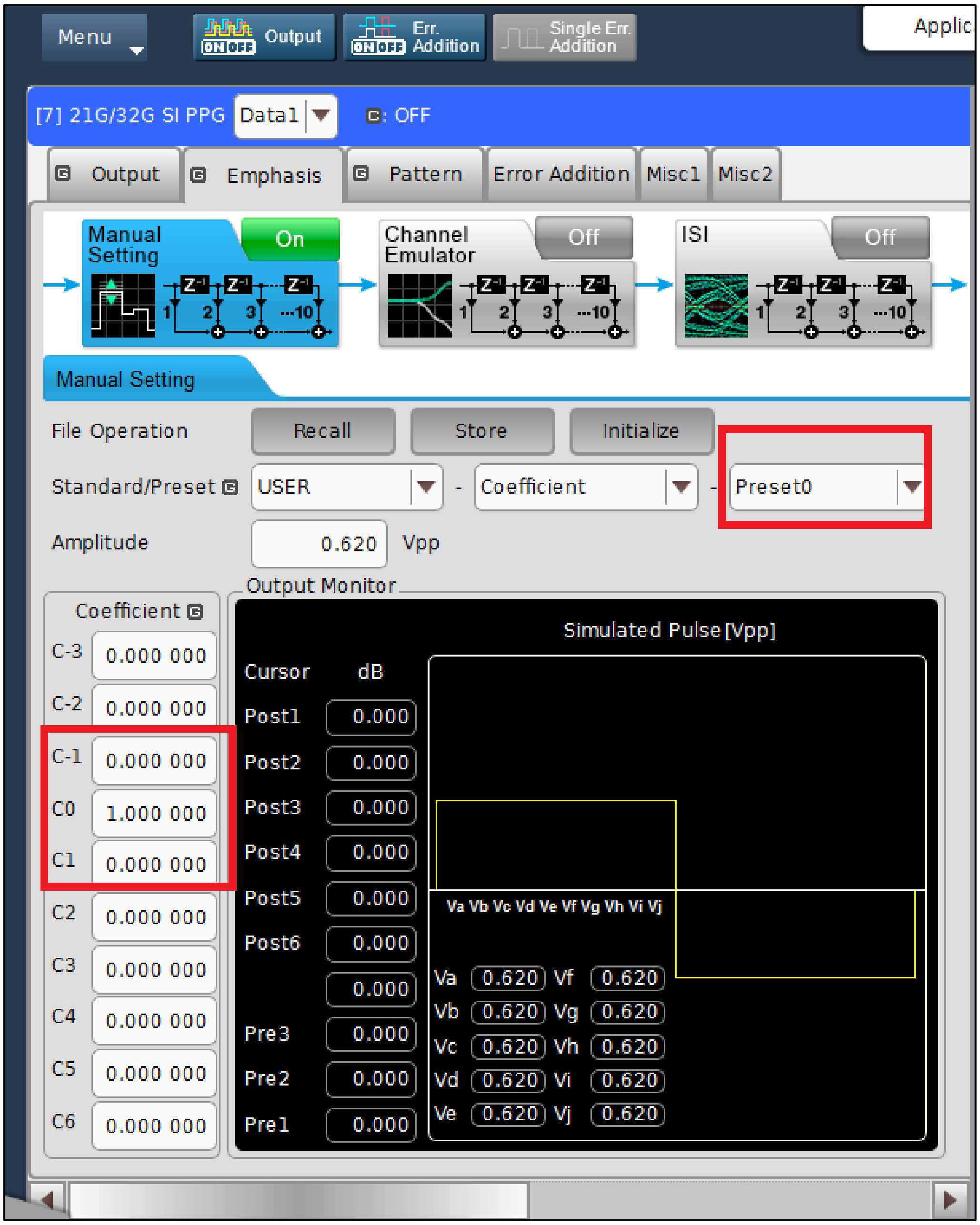
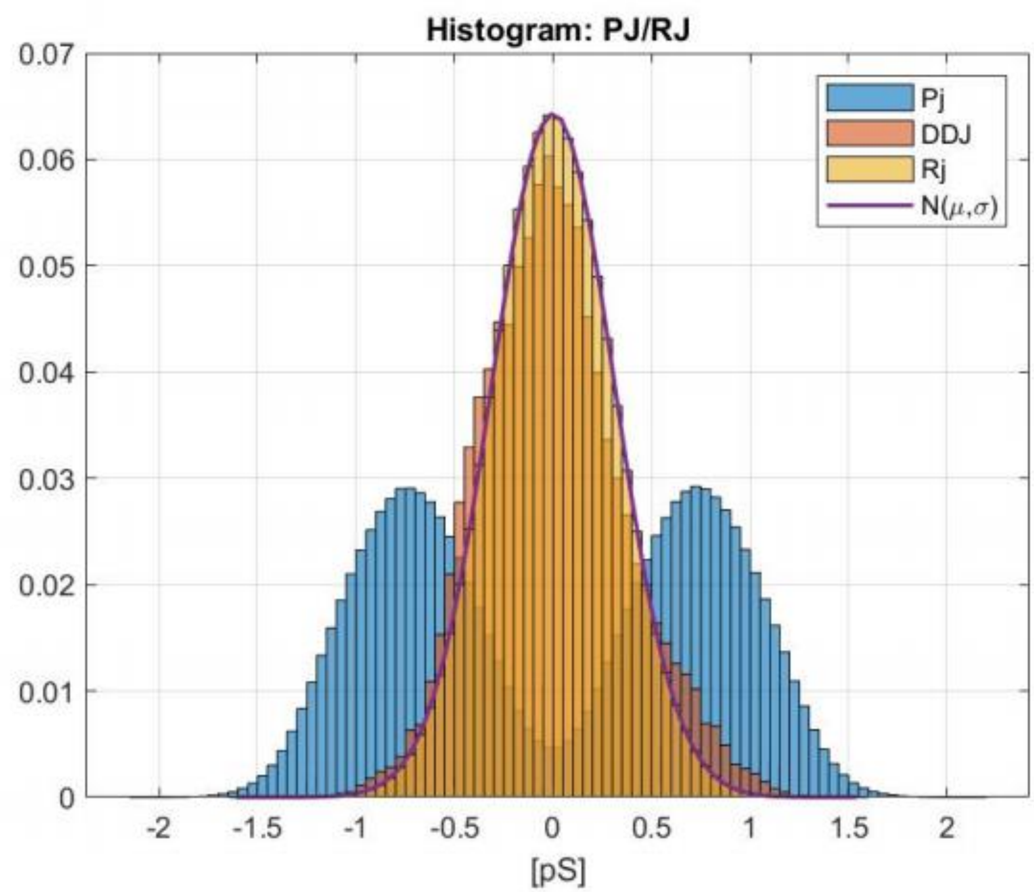



FIGURE 51. 4TAP EMPHASIS CH1 INTERFACE

3. Step through all 15 Presets. The Preset with the minimum DDJpp measurement is the optimized preset.
4. For SigTest measurement, use the following template:
   - Test Point: tp3_prime
   - CTS Test Template: jitter
5. Retrieve DDJ measurement.

| | | | | | |
|---|---|---|---|---|---|
| Electrical Compliance Test Specification for gen2_rounded | | | | | |
| Date: | 21-Oct-20 | | | | |
| DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\ | | | | | |
| File: TP3_Prime_Gen2_Rounded.bin | | | | | |
| Total Jitter (BER=1e-12) Measurement UIp-p: | Tj | 0.363443 | | | |
| PJ Jitter Measurement mUI: | PJ-rms | 58.981258 | | | |
| RJ Jitter Measurement mUI: | RJ-rms | 12.812331 | | | |
| DDJ Measurement UIp-p: | DDJ jitter UIp-p | 0.038398 | | | |
| Informative: Symbol Rate [GHz]: | NONE | Symbol Rate | 9.974974 | Drift [PPM] | -2502.56 |



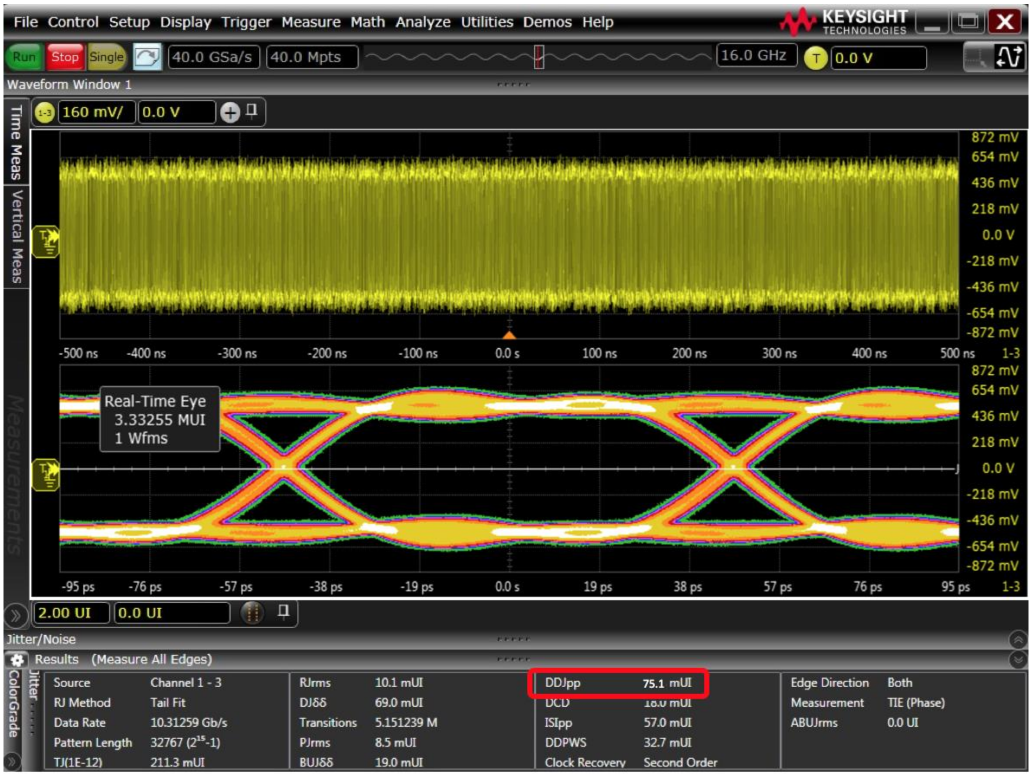



FIGURE 52. OPTIMIZED PRESET (MINIMUM DDJPP) MEASUREMENT ON KEYSIGHT SCOPE

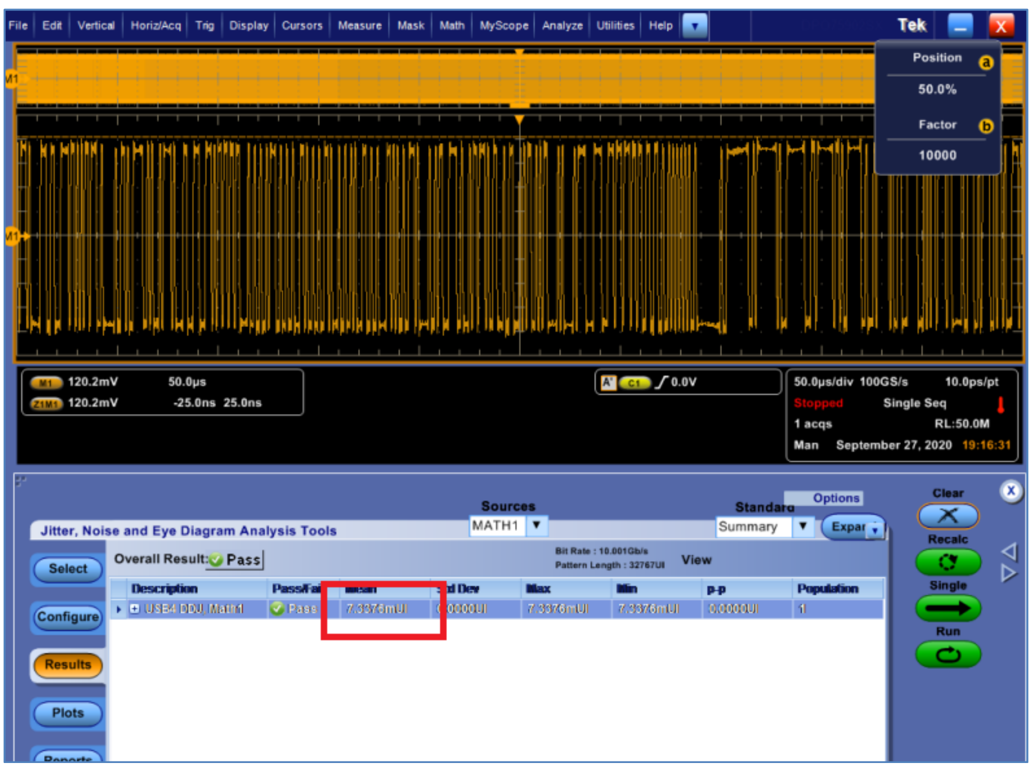



FIGURE 53. OPTIMIZED PRESET (MINIMUM DDJPP) MEASUREMENT ON TEKTRONIX SCOPE

6. Set up the scope so that Channel 1 and Channel 3 scale to 80% of screen.
7. Turn on function 1 of scope to do subtraction of Channel 1 and Channel 3.
8. Measure VPP on Function1.
9. For SigTest measurement, use the following template:
    - Test Point: tp3_prime
    - CTS Test Template: ac_common_mode
10. Retrieve AC CM measurement.

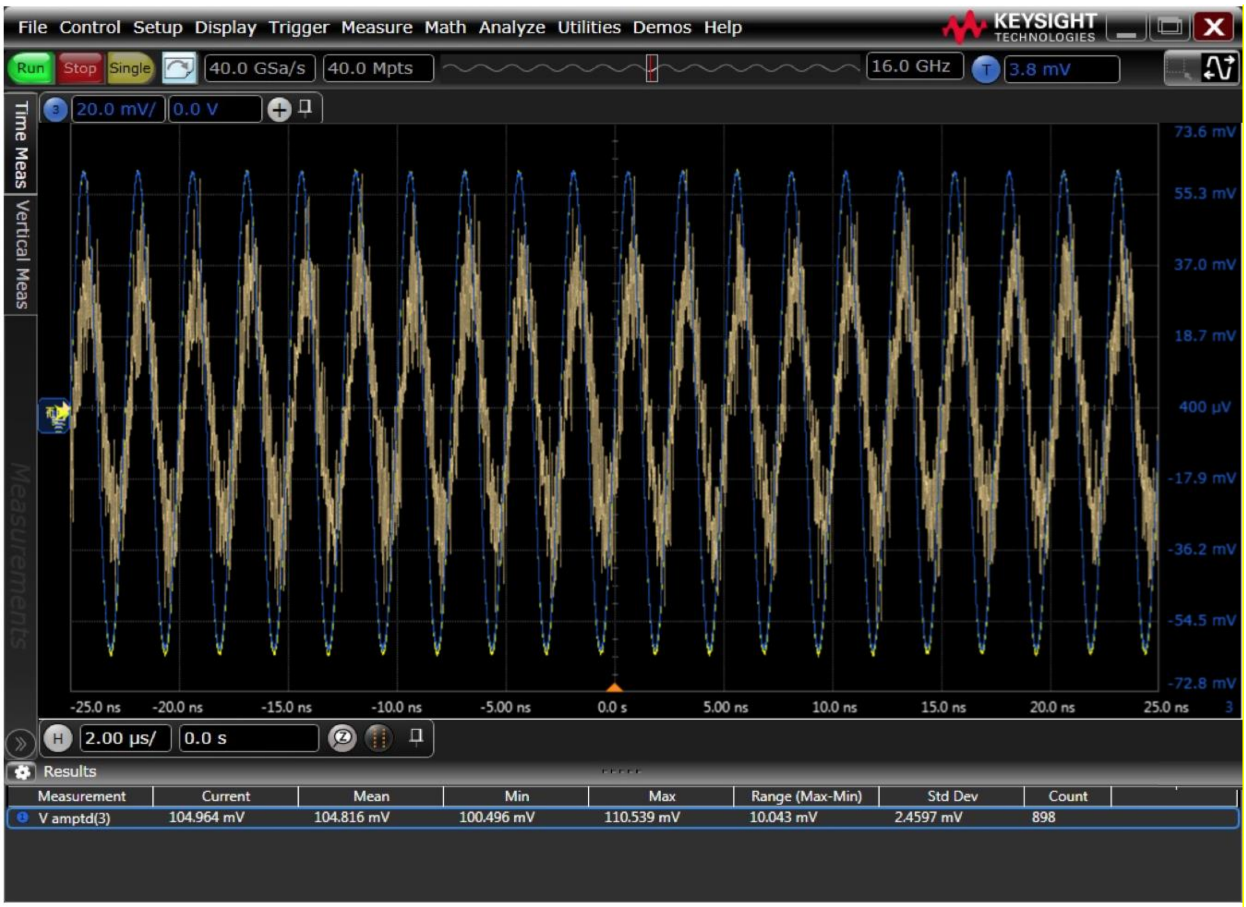



FIGURE 54. CALIBRATION TO PHASE MATCH ON KEYSIGHT SCOPE


FIGURE 55. CALIBRATION TO PHASE MATCH ON TEKTRONIX SCOPE

11. Calibrate ACCM to be 100mVpp at 400MHz Clock, using ACCM Scope Setup. Then return CM Amplitude to zero.

    a) Turn On SSC and turn Off all jitter components on the MP1900A Generator. Change the test pattern to PRBS31 and transmit the PRBS31 pattern from the MP1900A.

    b) Set the frequency to 400MHz on the MP1900A CM Generator.

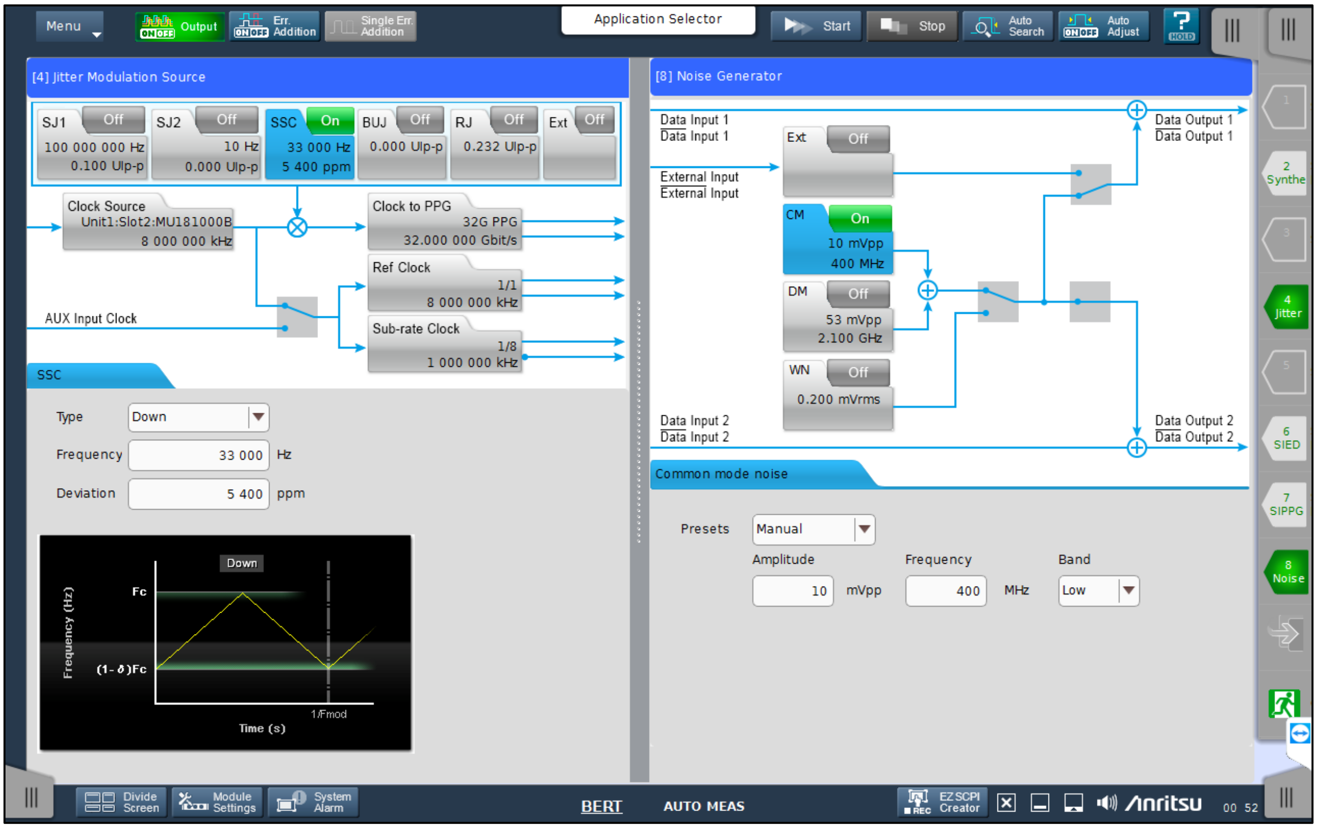



FIGURE 56. CALIBRATE ACCM

c) Measure Ch1 and Ch3 Signals on the scope to have an amplitude of a Mean Peak-to-Peak measurement of 100mVpp.

$V_{AC\text{-}CM} = (V_{TX\text{-}P} + V_{TX\text{-}N})/2$

d) Turn Off the CM output.

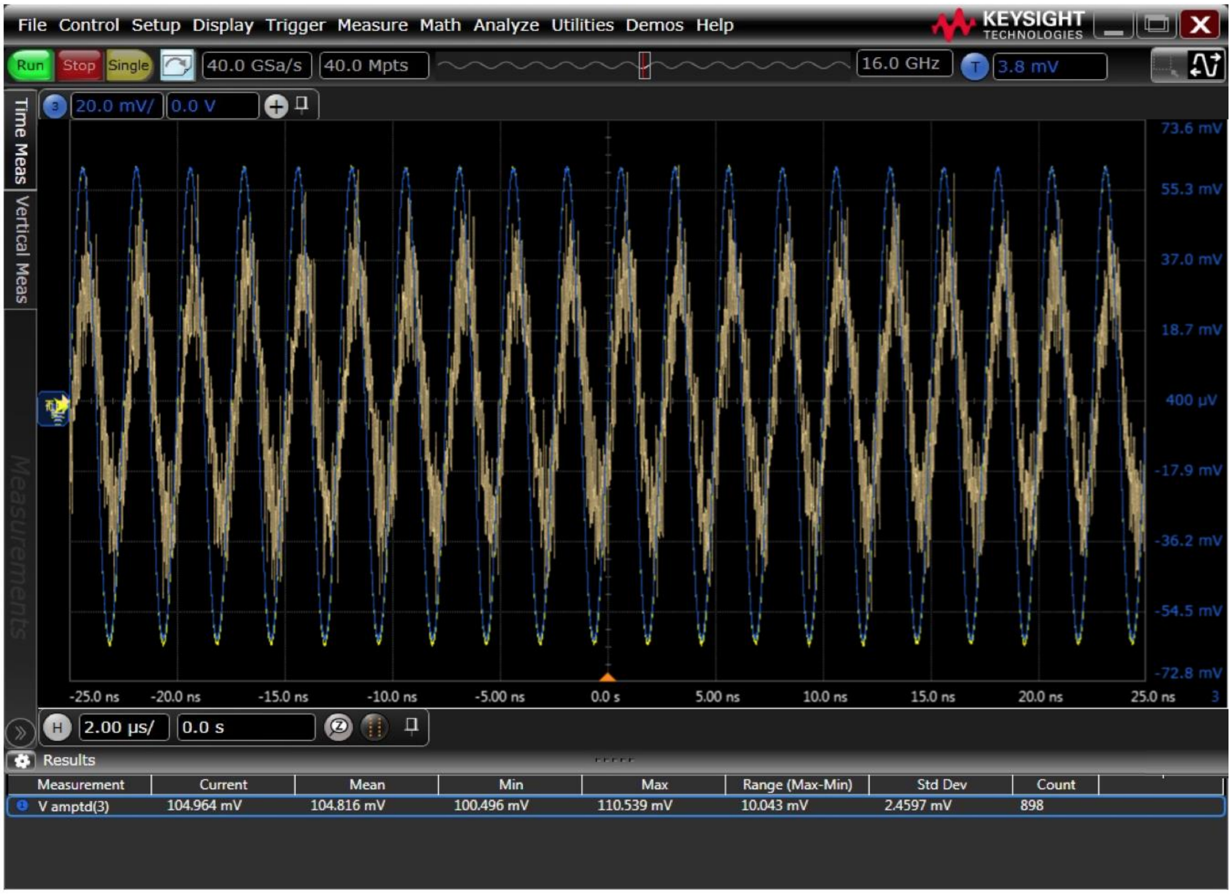



FIGURE 57. CALIBRATE ACCM PEAK-TO-PEAK AMPLITUDE

12. Turn on all remaining Jitter terms (RJ-Filtered (User); HPF (10MHz); SJ@100MHz); and set all jitter amplitudes to zero.

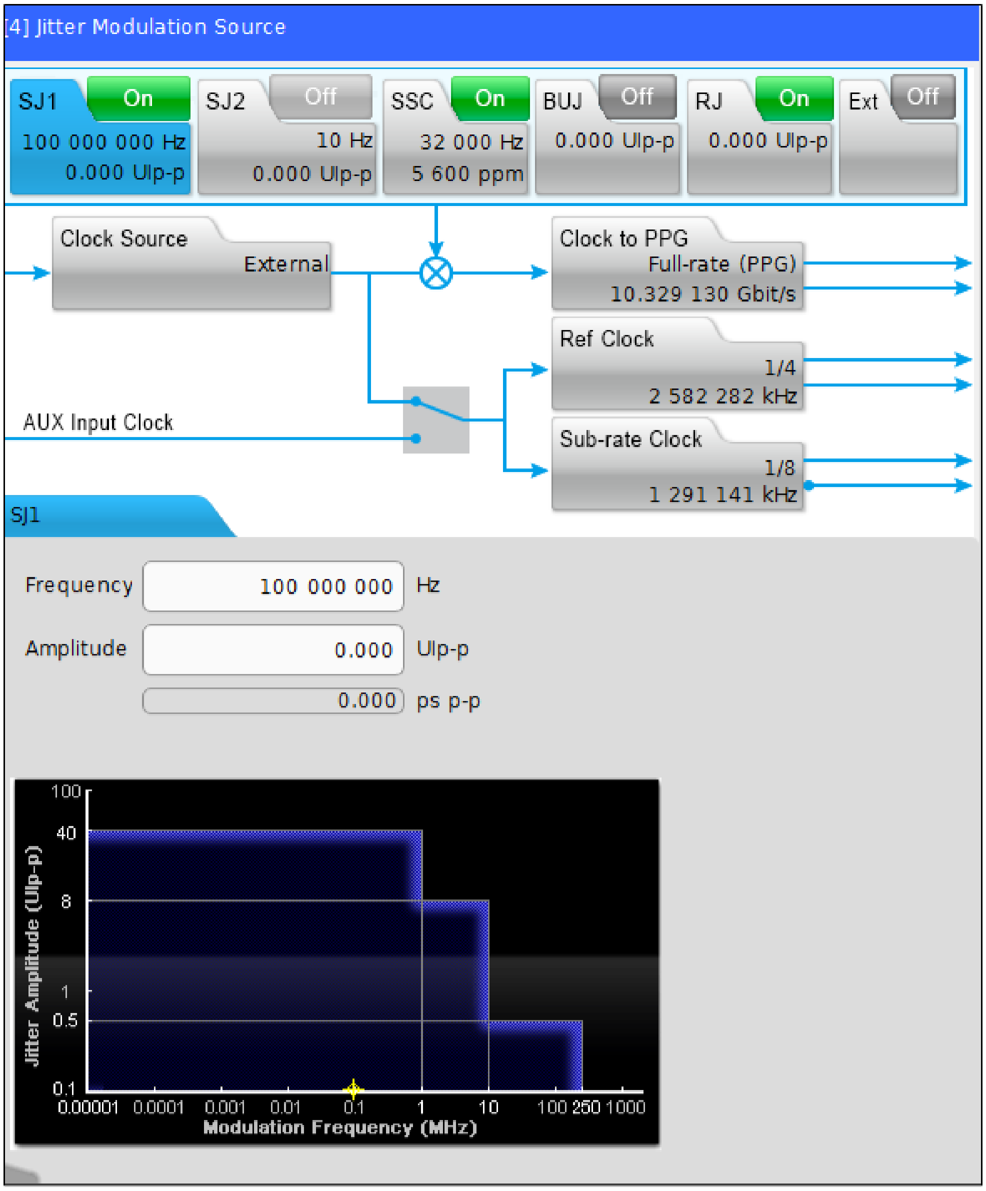



FIGURE 58. JITTER AMPLITUDES

13. Return the Scope setup to the jitter setup.
14. Set the PRBS15 pattern on the MP1900A.
15. Calibrate RJ amplitude to 140mUI peak-to-peak or 10mUI RMS.
16. For SigTest measurement, use the following template:
    - Test Point: tp3_prime
    - CTS Test Template: jitter
17. Retrieve RJ measurement.

| | | | | | |
|---|---|---|---|---|---|
| Electrical Compliance Test Specification for gen2_rounded | | | | | |
| Date: | 21-Oct-20 | | | | |
| DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\ | | | | | |
| File: TP3_Prime_Gen2_Rounded.bin | | | | | |
| Total Jitter (BER=1e-12) Measurement UIp-p: | Tj | 0.363443 | | | |
| PJ Jitter Measurement mUI: | PJ-rms | 58.981258 | | | |
| RJ Jitter Measurement mUI: | RJ-rms | 12.812331 | | | |
| DDJ Measurement UIp-p: | DDJ jitter UIp-p | 0.038398 | | | |
| Informative: Symbol Rate [GHz]: | NONE | Symbol Rate | 9.974974 | Drift [PPM] | -2502.56 |

18. Return amplitude to zero.
19. Capture a screen shot.

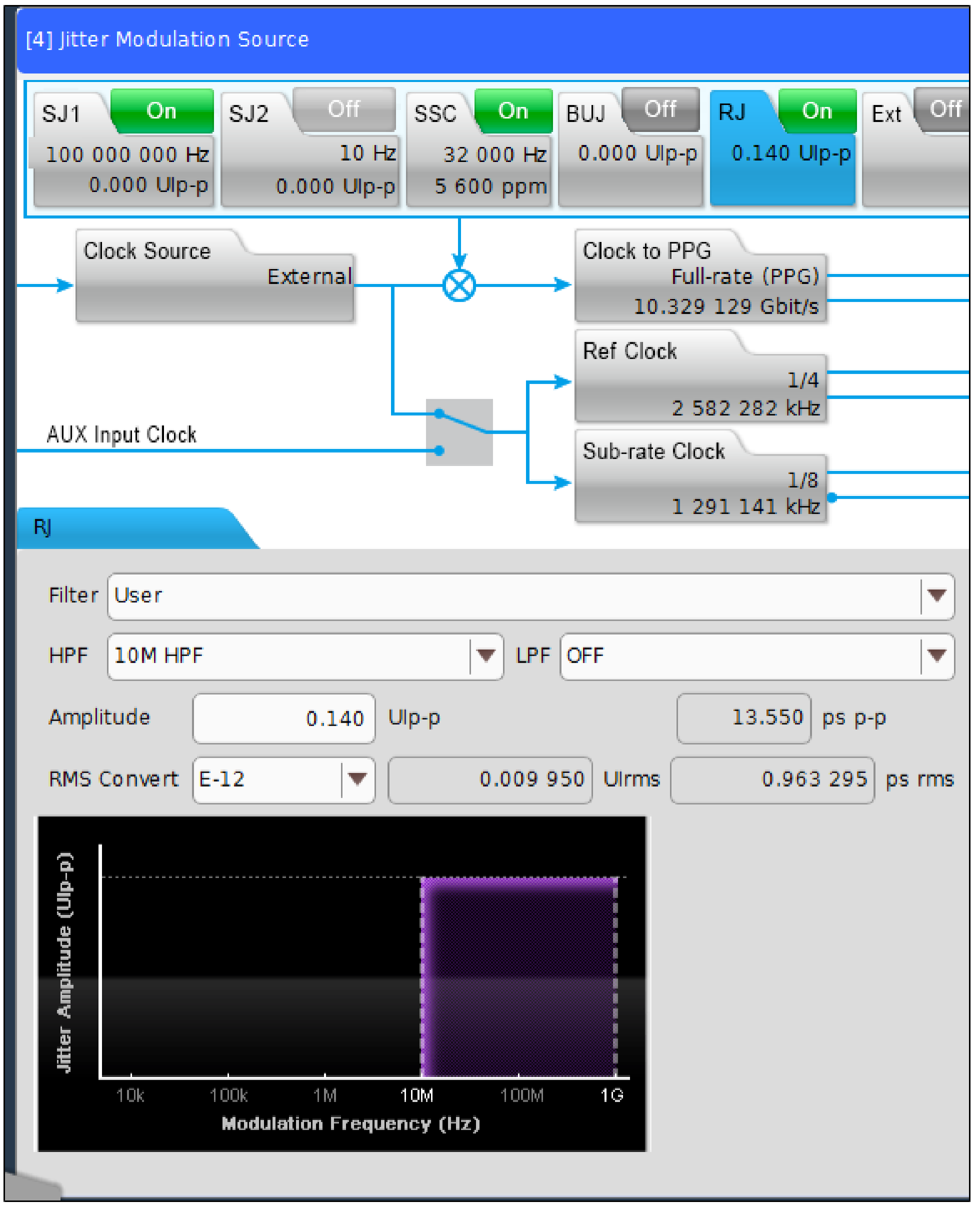



FIGURE 59. CALIBRATE RJ AMPLITUDE #1

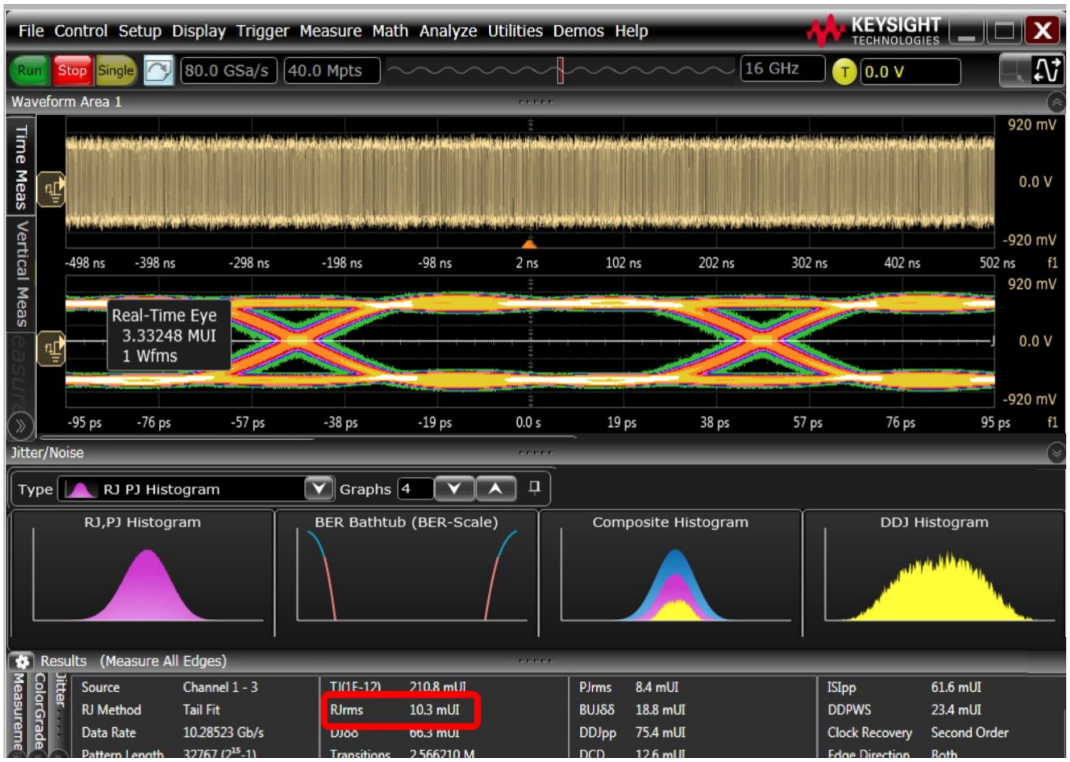



FIGURE 60. CALIBRATE RJ AMPLITUDE #2 ON KEYSIGHT SCOPE

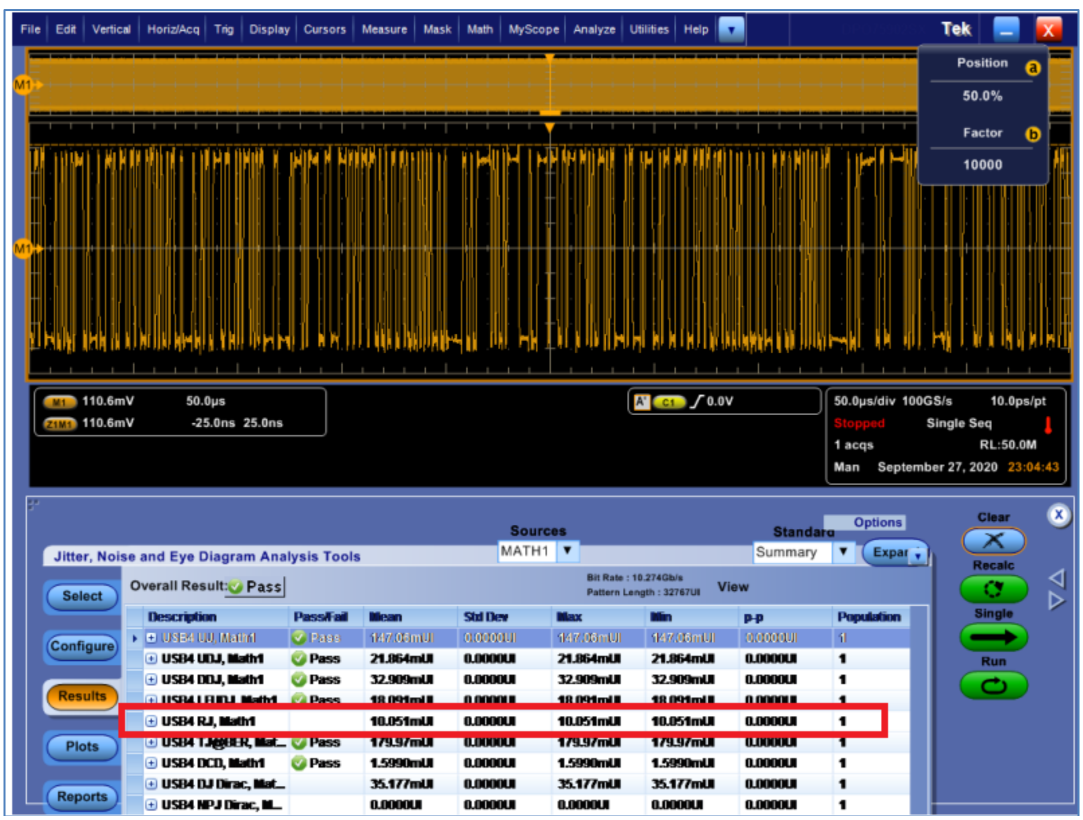



FIGURE 61. CALIBRATE RJ AMPLITUDE #2 ON TEKTRONIX SCOPE

20. Calibrate SJ amplitude to 170mUI peak-to-peak at 100MHz, where “peak-to-peak” is 170mUI.
21. For SigTest measurement, use the following template:
    - Test Point: tp3_prime
    - CTS Test Template: jitter
22. Retrieve PJ measurement in RMS. Convert to peak-to-peak by multiplying PJ-rms with a factor of 2.82.

| | | | | | |
|---|---|---|---|---|---|
| Electrical Compliance Test Specification for gen2_rounded | | | | | |
| Date: | 21-Oct-20 | | | | |
| DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\ | | | | | |
| File: TP3_Prime_Gen2_Rounded.bin | | | | | |
| Total Jitter (BER=1e-12) Measurement UIp-p: | Tj | 0.363443 | | | |
| PJ Jitter Measurement mUI: | PJ-rms | 58.981258 | | | |
| RJ Jitter Measurement mUI: | RJ-rms | 12.812331 | | | |
| DDJ Measurement UIp-p: | DDJ jitter UIp-p | 0.038398 | | | |
| Informative: Symbol Rate [GHz]: | NONE | Symbol Rate | 9.974974 | Drift [PPM] | -2502.56 |

23. Capture screen shot.

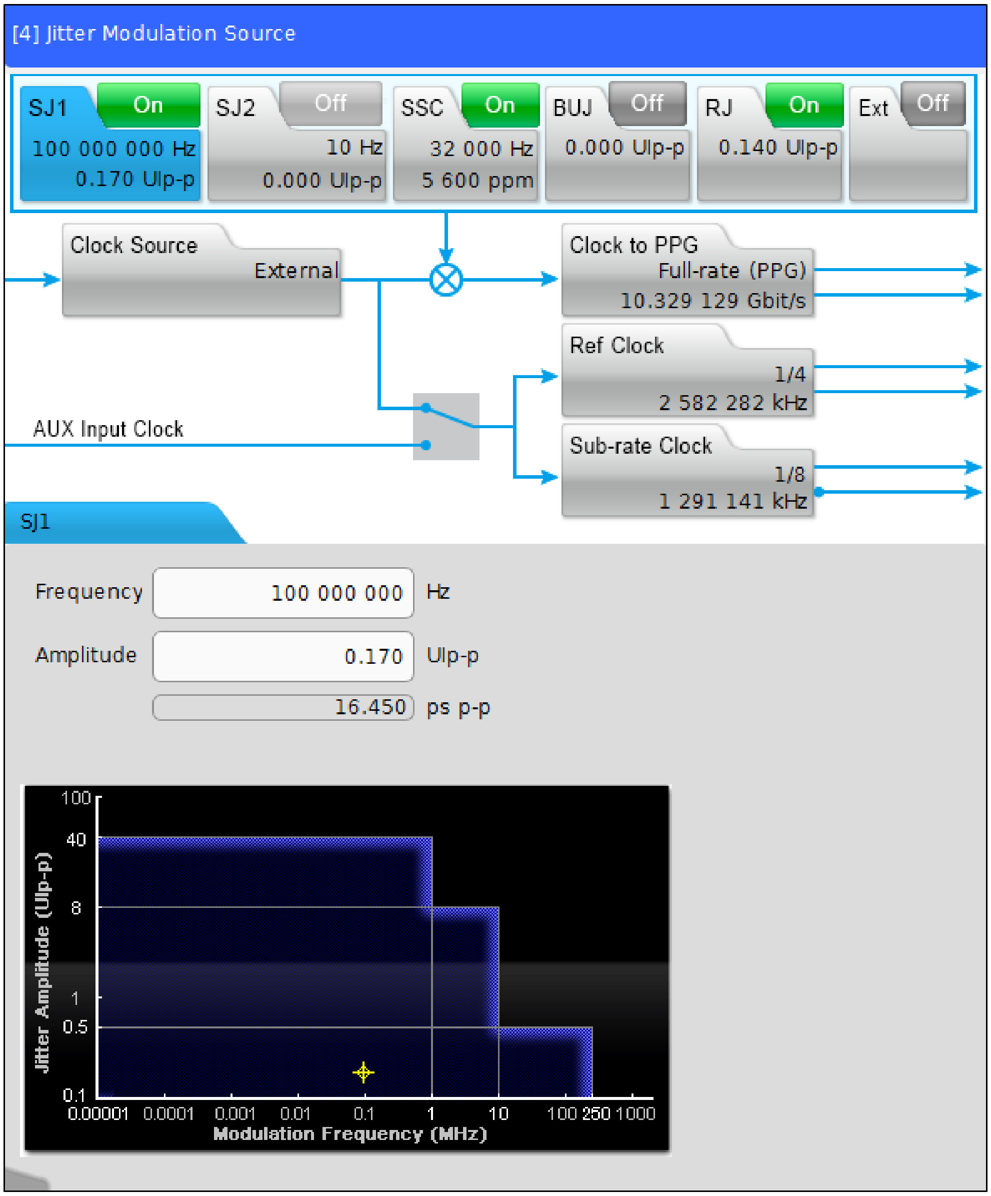



FIGURE 62. CALIBRATE SJ AMPLITUDE #1

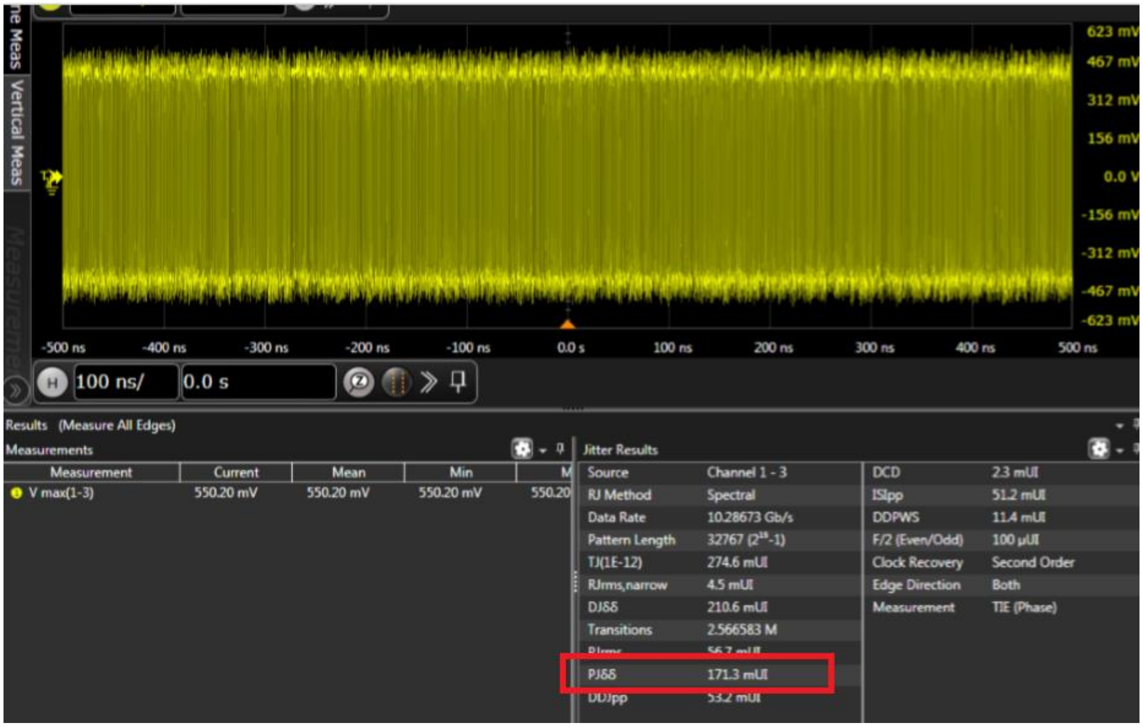


FIGURE 63. CALIBRATE SJ AMPLITUDE #2 ON KEYSIGHT SCOPE

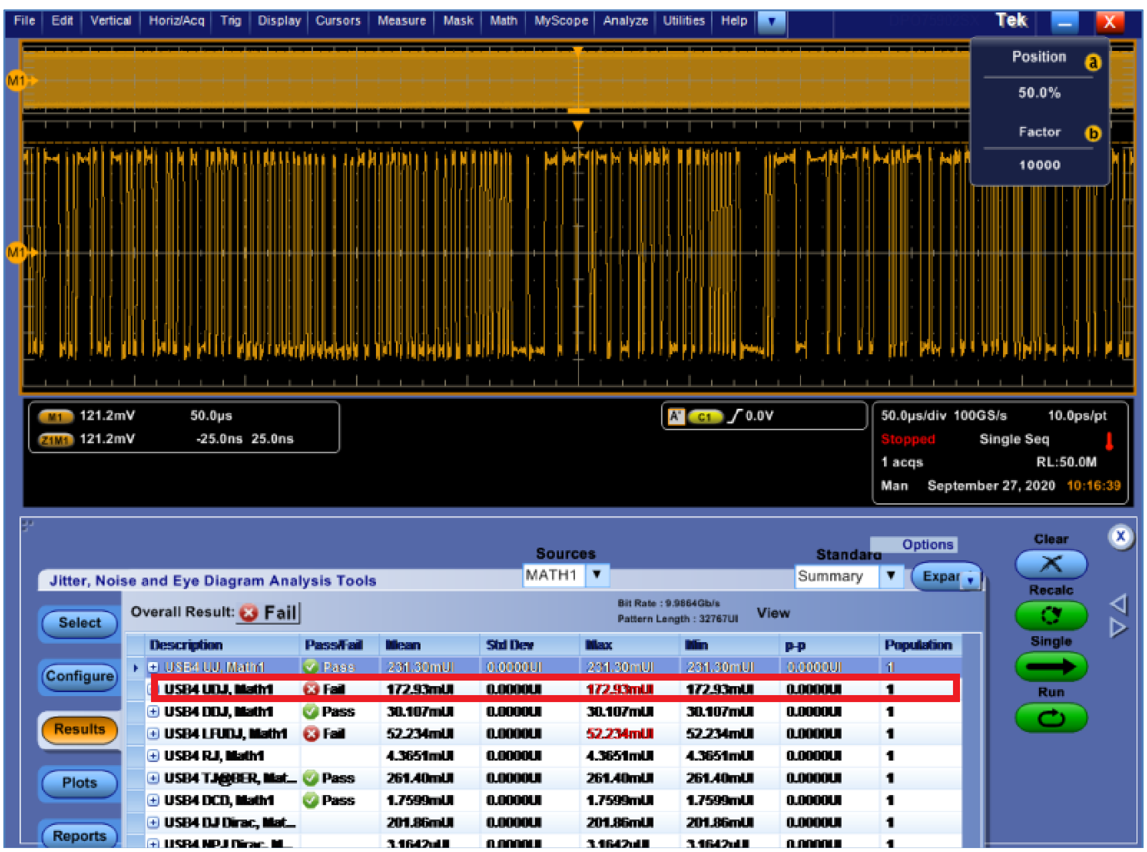


FIGURE 64. CALIBRATE SJ AMPLITUDE #2 ON TEKTRONIX SCOPE

24. Return all remaining impairment sources (CM, RJ, SJ) to their calibrated values.
25. Calibrate the TJ measurement to 350mUI ± 12.5mUI, using the SJ Amplitude control (for SJ frequency of 100MHz) and RJ Amplitude control (for SJ frequencies of less than 100MHz) as an adjustment on the BERT.
26. Capture screen shot.

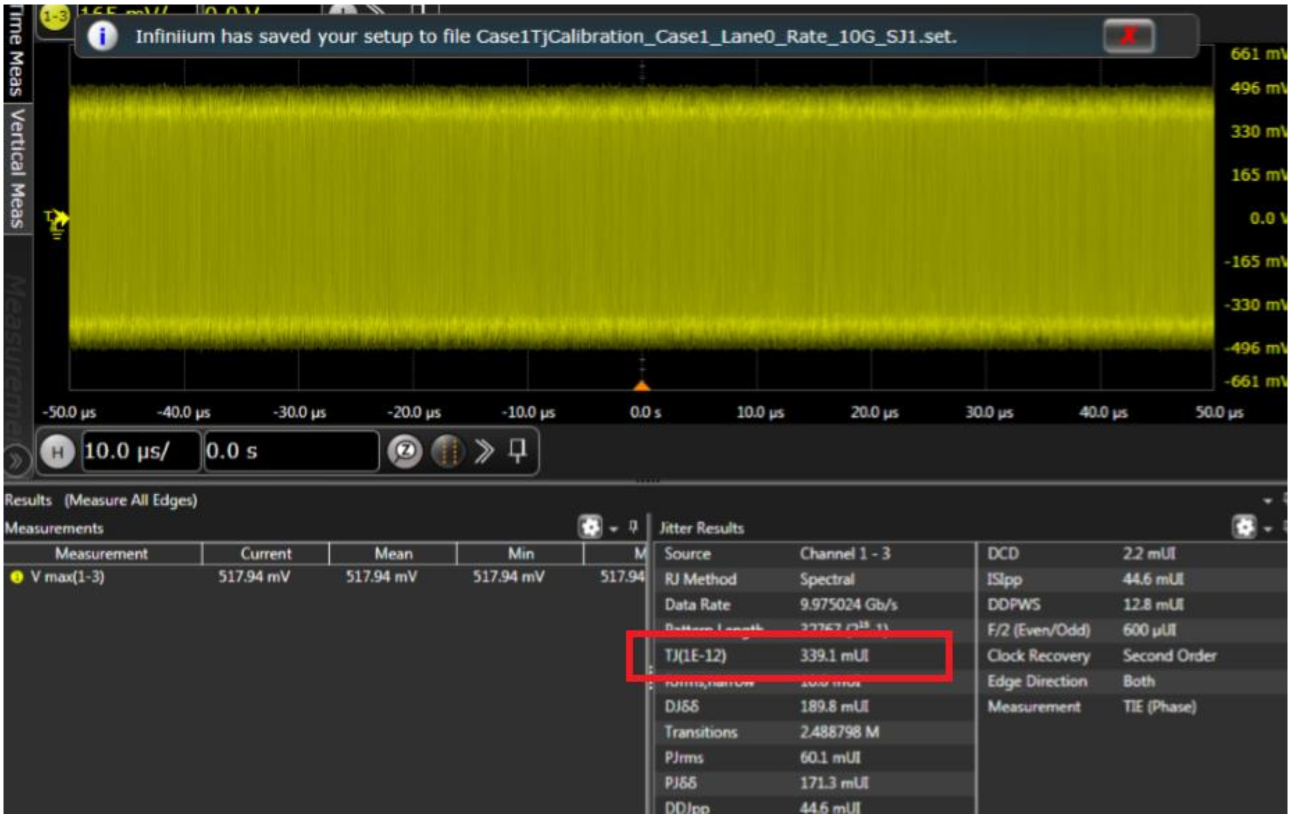



FIGURE 65. TJ MEASUREMENT ON KEYSIGHT SCOPE

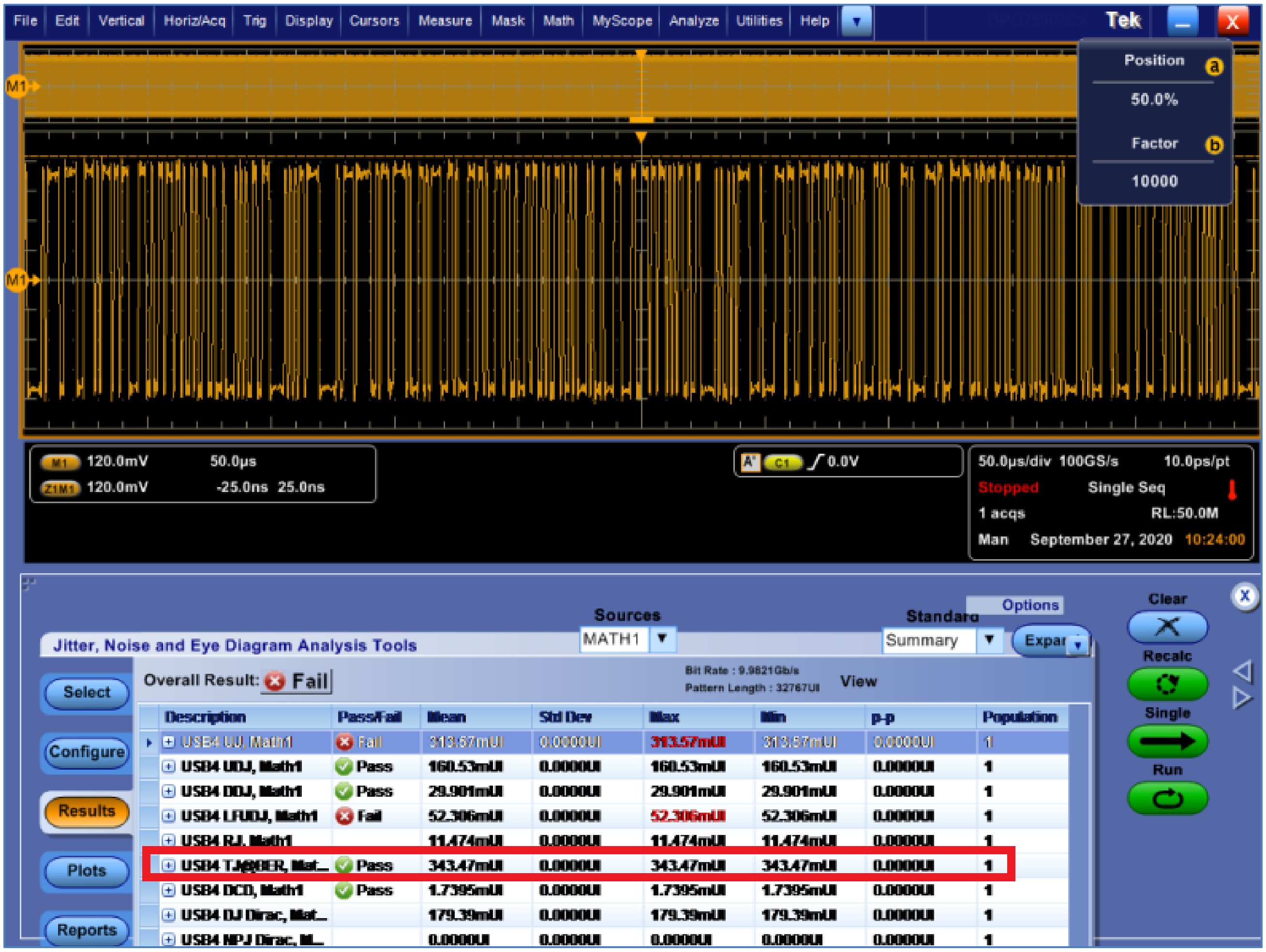


FIGURE 66. TJ MEASUREMENT ON TEKTRONIX SCOPE

27. Adjust the memory depth to capture 1,000,000 (1E6) bits.

28. Change the Pattern on the MP1900A BERT to PRBS31.

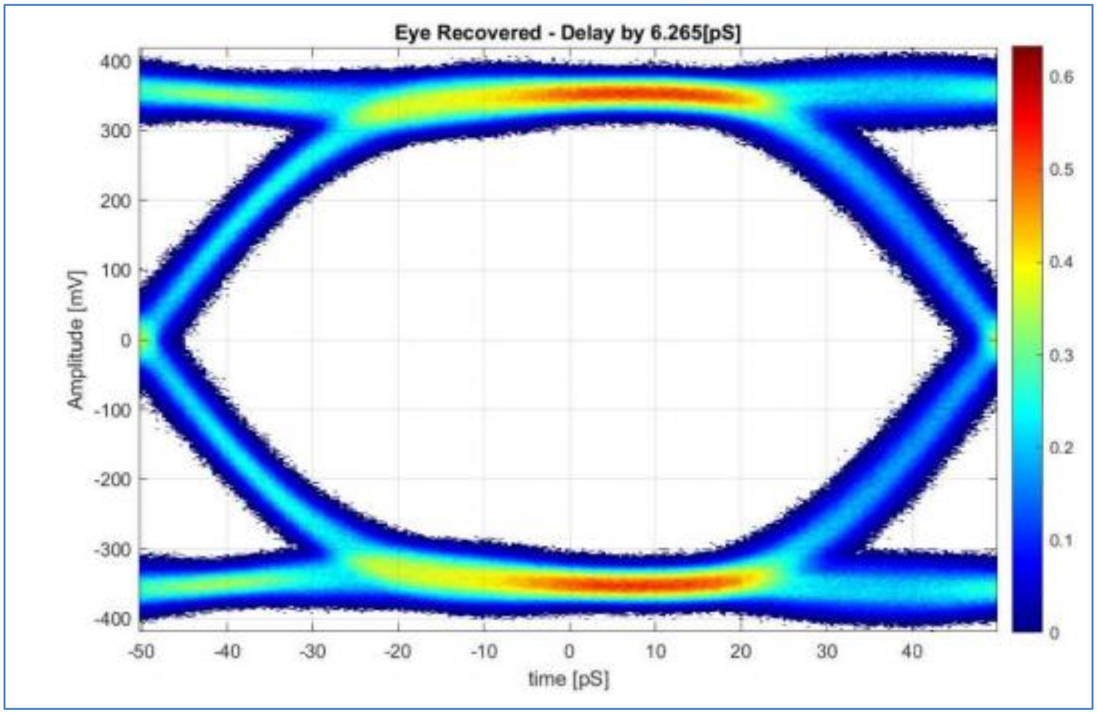
29. Calibrate Inner Eye Height to 700mV (top and bottom of the triangle eye mask are V:700mV, H:650mUI).

30. For SigTest measurement, use the following template:

    - Test Point: tp3_prime
    - CTS Test Template: ui_ssc_eye

31. Retrieve Eye Height measurement.

| | | | | | |
|---|---|---|---|---|---|
| Electrical Compliance Test Specification for gen2_rounded | | | | | |
| Date: | 21-Oct-20 | | | | |
| DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3_Prime\ | | | | | |
| File: TP3_Prime_Gen2_Rounded_prbs31.bin | | | | | |
| Eye Diagram Measurement: | EyeWidth [pS] | 89.281492 | EyeHeight[mV] | 593.984184 | |
| Informative: Symbol Rate [GHz]: | NONE | Symbol Rate | 9.975472 | Drift [PPM] | -2452.82 |




32. Capture screen shot.

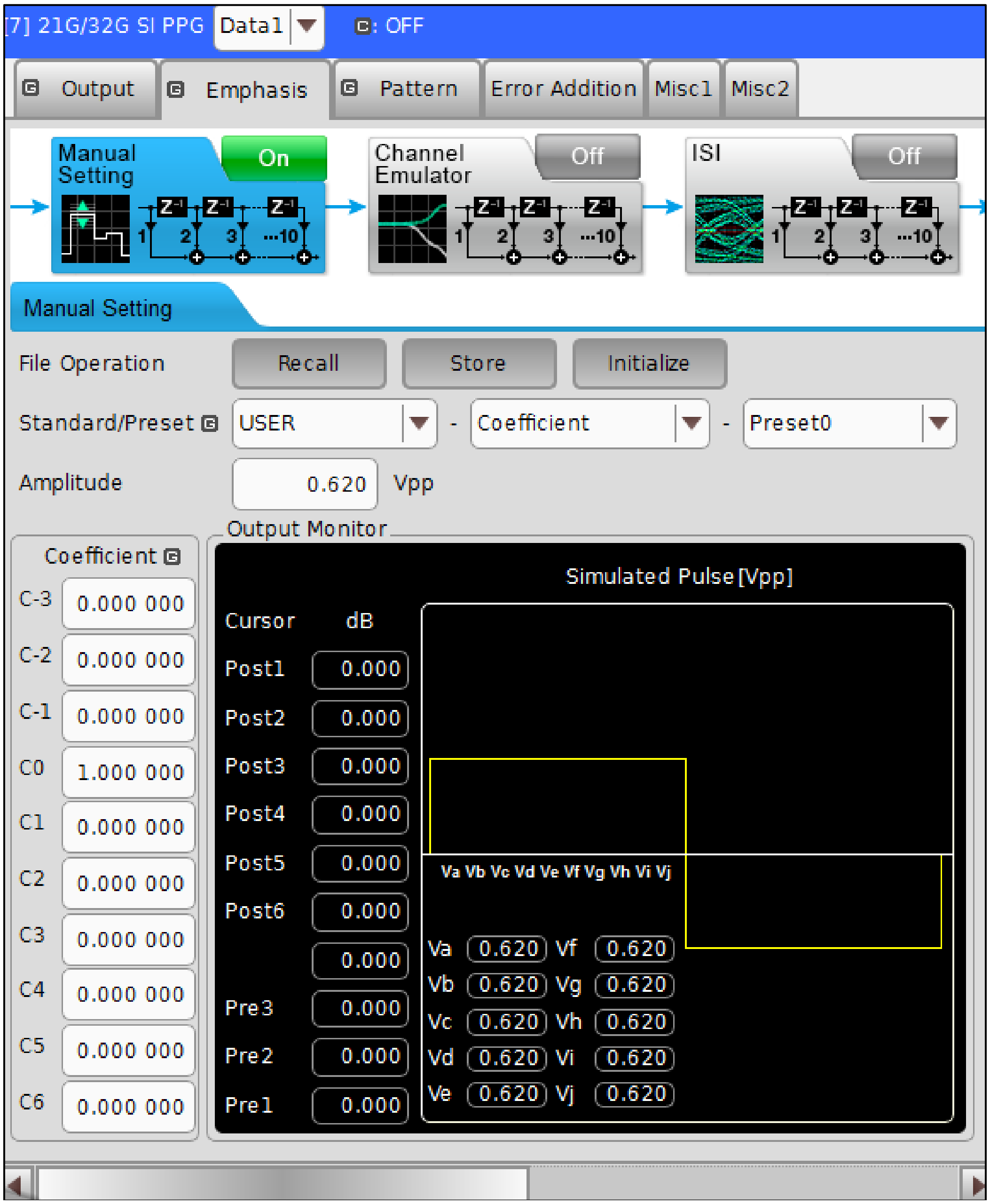



FIGURE 67. EYE AMPLITUDE

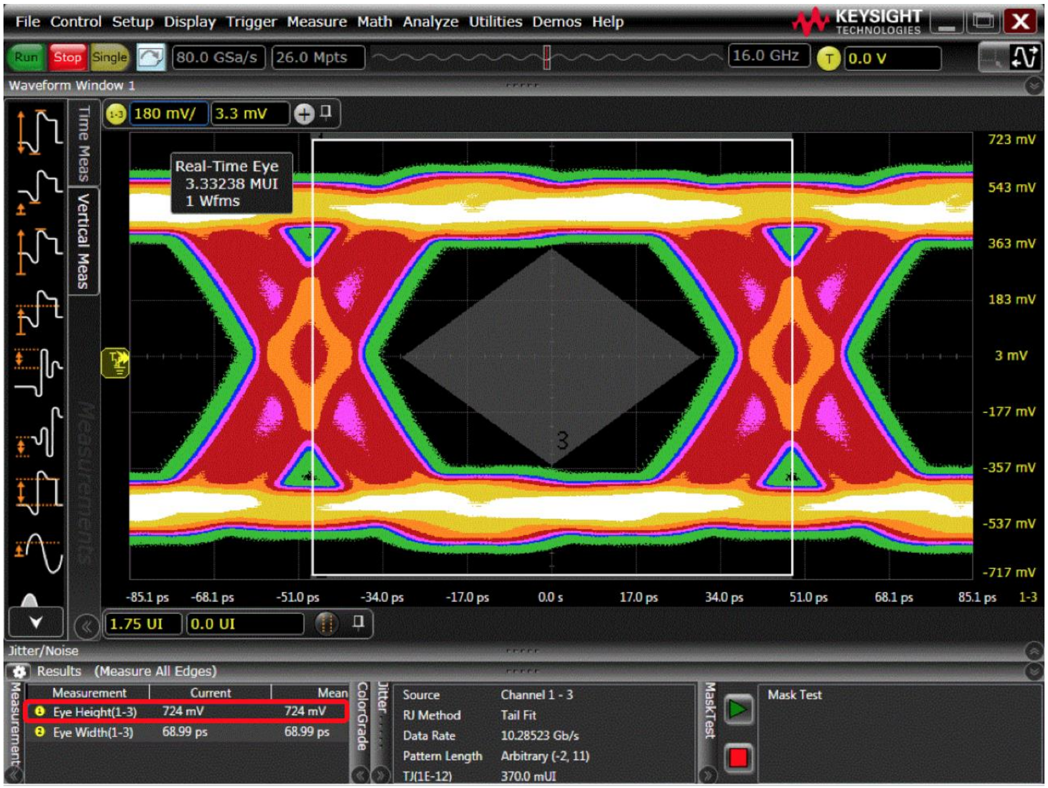



FIGURE 68. EYE MASK ON KEYSIGHT SCOPE

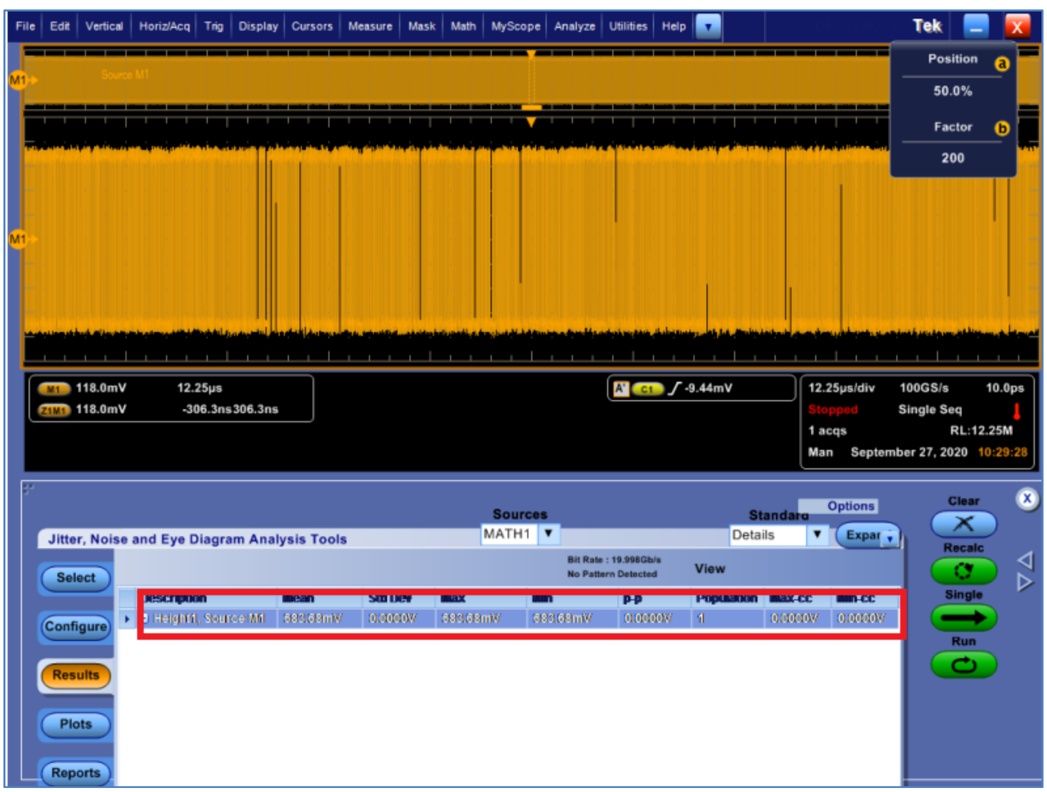



FIGURE 69. EYE MASK ON TEKTRONIX SCOPE

33. Save the BERT setup to “10G_TC1_100MHz”.
34. Return CM, RJ and PJ sources to zero amplitude.
35. Repeat step 8-21 for 1MHz, 2MHz, 10MHz and 50MHz PJ frequencies, saving the setups after each frequency as “10G_TC1_1MHz”, “10G_TC1_2MHz”, “10G_TC1_10MHz” and “10G_TC1_50MHz” respectively.

## 10.2 Test Receiver at 10Gb/s or 10.3125Gb/s for Test Case 1 at TP3’

After completing the calibration in Section 10.1, proceed to perform the test.

1. Set up the physical equipment connections, as per Figure 23.
2. Use TenLira scripts on the PC to ensure that the crosstalk generator is sending PRBS31 signals at 800mV to 10Gb/s or 10.3125Gb/s.
3. Connect the test fixture to Port A of the DUT.
4. Recall the BERT test setup for 10G_TC1_100MHz (as saved in Section 10.1.2).
5. Configure the DUT transmitter to output PRBS31 on all lanes with SSC turned ON.
6. Initiate negotiation with the preset chosen in calibration.
7. Change the preset in the BERT according to the newly acquired preset.
8. Configure the DUT for the next negotiation step with the new preset.
9. Change the preset in the BERT according to the newly requested preset.
10. Configure the DUT for the next negotiation step with the new preset.
11. If needed, change the preset in the BERT according to the newly requested preset.
12. Run the 10Gb/s or 10.3125Gb/s test script for Rx testing to determine the BER measured by the Receiver and record the error count for 10 seconds.

    Note the error checking procedure is different between Host or Device types:

    a) For Windows Host testing, TenLira scripts are run on the Host Under Test, to determine the error count. Refer to the release notes of the scripts for details on how to run the scripts.
    b) For Non-Windows Host testing, proprietary methods are used for error count.
    c) For Device testing, TenLira scripts are run on a separate controller PC that is connected to the device under test if TenLira is not installed. For details on how to run the test scripts to determine the error count, refer to the release notes of the scripts.

13. Repeat steps #4 to #12 three more times and record the error count for 10 seconds for each cycle.
14. Again, repeat steps #4 to #12 and then record the error count for 400 seconds.
15. Record the BER in the test results for 10G_TC1_100MHz.
16. If the error count equals to 0 then PASS.
17. If the error count is more than 0 then run steps #4 to #12 and then record the error count for 700 seconds.
18. If the error count is more than 1 then FAIL.

19. Repeat all the steps above for each of the four TC1 frequencies.
20. Swap Data and Crosstalk signals, applying Data to Lane1 and Crosstalk to Lane0.
21. Repeat all the steps above for Lane1 of the same port if the DUT is a 2-lane Device.
22. Repeat all the steps above on Port B if the DUT is a multi-port Device.
23. Include the Eye Diagram for 10G_TC1_100MHz in the Compliance Test Report.

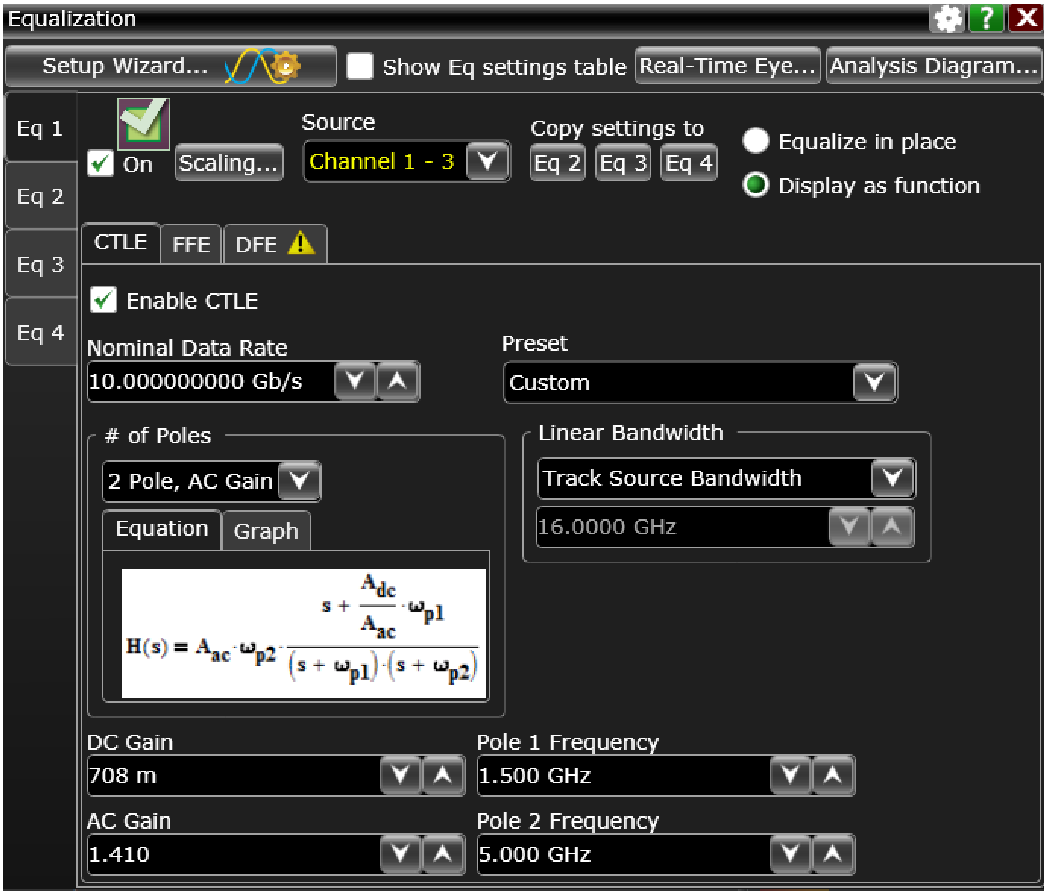
## 10.3 Calibrate and Save for 10Gb/s or 10.3125Gb/s Rx Test Case 2 at TP3

For this test case, the total ISI of a channel should be around 17.5~18.5dB @ 5GHz. The test fixture should have 1 to 1.5dB per mated pair.

1. Recall the BERT setup from 10G_TC1_100MHz.
2. Connect the physical setup with ISI Channel, as per Figure 11, as follows:
   a) Output of MU195050A connected to 40GHz K Cable
   b) -3.5dB Fixed Channel Board connected to 40GHz K Cable
   c) SMP USB Type-C Receptacle Fixture connected to -12dB Characterized 2 meter USB Type-C Cable
   d) SMP USB Type-C Receptacle Fixture connected to short 40GHz Cables into Ch1 and Ch3 of Scope
3. Search for the optimized DC Gain starting from DC Gain of 1 in Oscilloscope Equalization Setup, adjust the DC Gain to obtain the largest Eye Height with cable de-embedding. *Note: This step is not required if the SigTest method is used.*
   a) Set up the Scope as follows for CTLE:
      i) Number of Poles set to USB 3.1
      ii) DC Gain set to 1.00
      iii) AC Gain set to 1.41
      iv) Pole #1 Frequency set to 1.50 GHz
      v) Pole #2 Frequency set to 5.00 GHz
   b) Use the DC Gain Setting in Table 11 which yields the largest Eye Height.

TABLE 11. DC GAIN SETTINGS

| Index | DC Gain Setting | Index | DC Gain Setting |
|---|---|---|---|
| 0 | 1.000 | -5 | 0.562 |
| -1 | 0.891 | -6 | 0.501 |
| -2 | 0.794 | -7 | 0.446 |
| -3 | 0.708 | -8 | 0.398 |
| -4 | 0.630 | -9 | 0.354 |




$$H(s) = A_{ac} \cdot \omega_{p2} \cdot \frac{s + \frac{A_{dc}}{A_{ac}} \cdot \omega_{p1}}{(s + \omega_{p1}) \cdot (s + \omega_{p2})}$$

FIGURE 70. DC GAIN SETTING

c) Set up the DFE:

i) Set Max Tap to 50mV.

ii) Run Auto DFE.


FIGURE 71. DFE SETTING

d) Change the BERT Data pattern to PRBS31.
e) Adjust the memory depth to capture 1,000,000 (1E6) bits with 5 acquisitions (100,000 UIs per Acquisition).
f) For each acquisition, measure the Eye Width and Eye Height. Calculate the average of the five measurements and compute the Eye area via *Eye Width * Eye Height*.
g) Measure the Eye area by iterating through each CTLE gain. The CTLE gain with the biggest eye area is used for the following measurements.

4. By adjusting data amplitude, calibrate the Inner Eye Height to 120 ± 10mV diff p-p (top and bottom of the triangle eye mask) using the PRBS31 pattern.

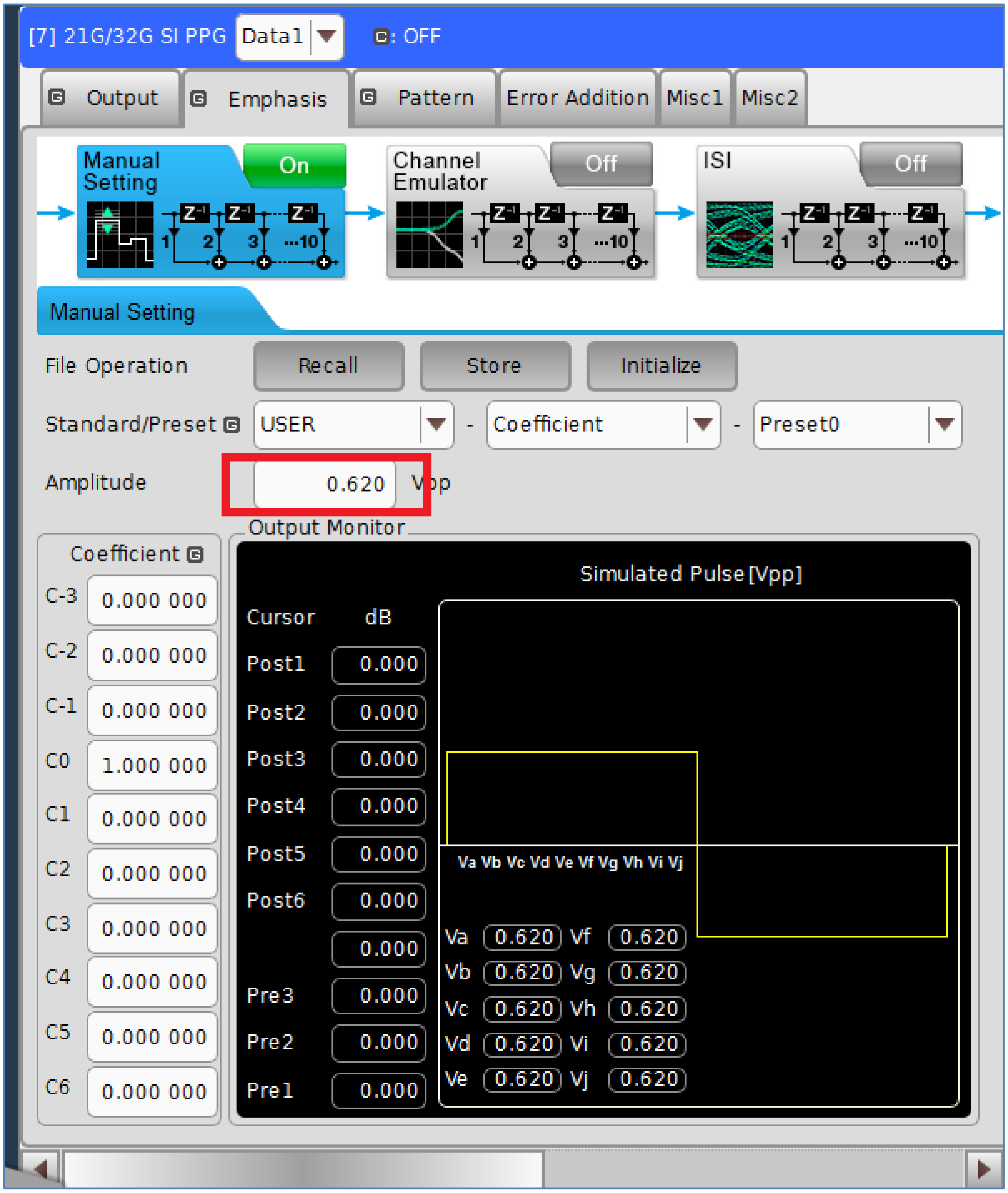
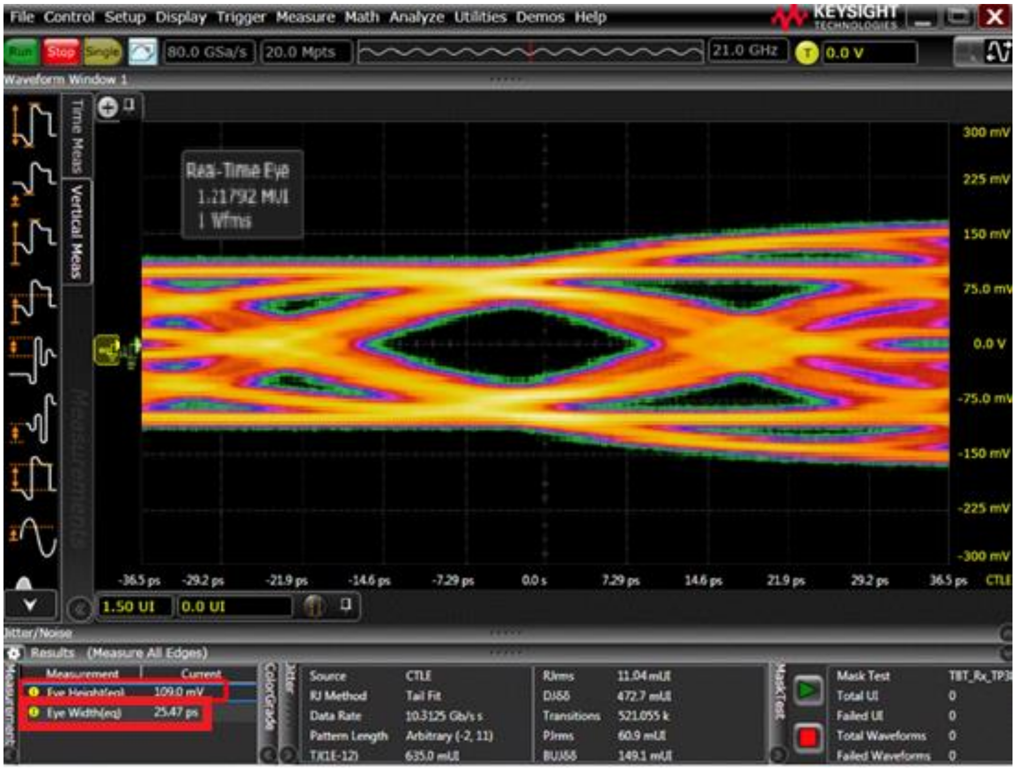
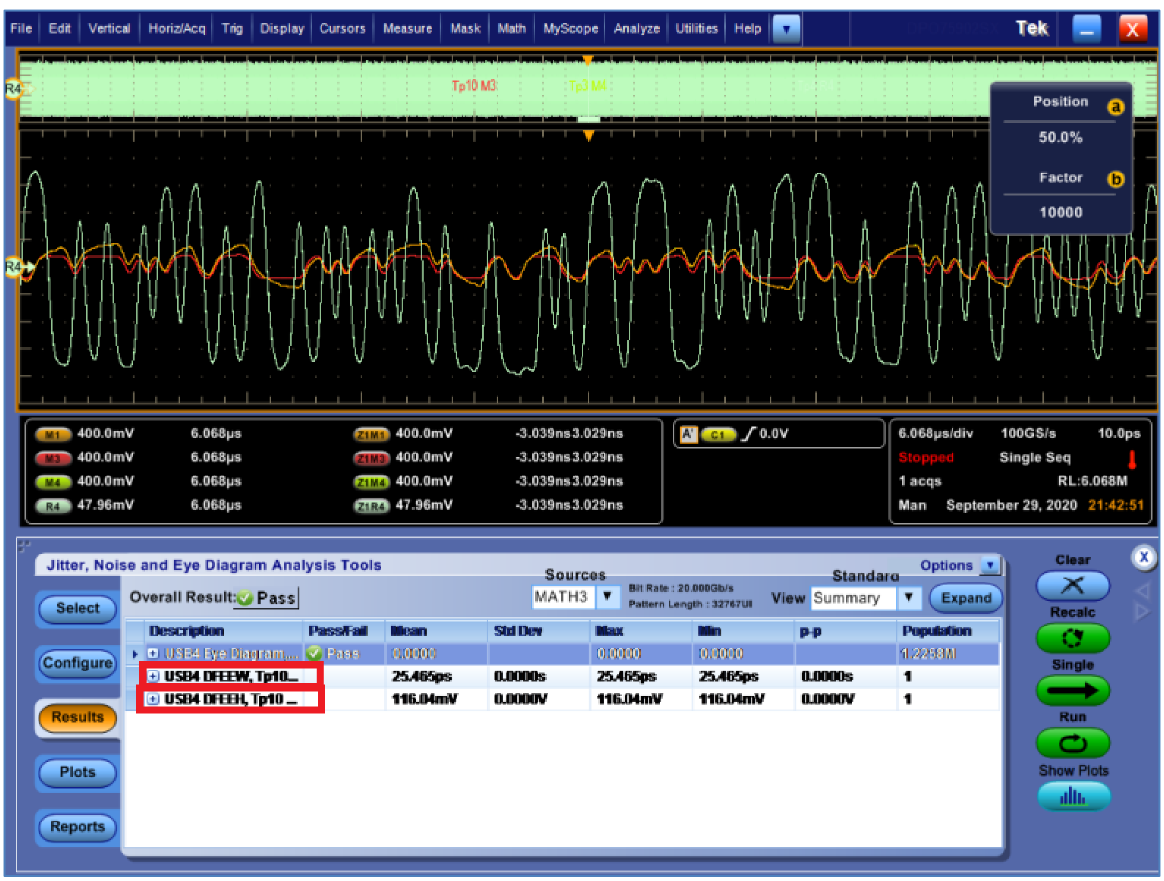



FIGURE 72. EYE AMPLITUDE


File Control Setup Display Trigger Measure Math Analyze Utilities Demos Help
KEYSIGHT TECHNOLOGIES
80.0 GSa/s
20.0 Mpts
21.0 GHz
0.0 V
Waveform Window 1
Real-Time Eye
1.21792 MUI
1 Wfms
300 mV
225 mV
150 mV
75.0 mV
0.0 V
-75.0 mV
-150 mV
-225 mV
-300 mV
1.50 UI
0.0 UI
Jitter/Noise
Results (Measure All Edges)
Measurement
Current
Eye Height(est) 109.0 mV
Eye Width(est) 25.47 ps
Source CTLE
RJ Method Tail Fit
Data Rate 10.3125 Gb/s
Pattern Length Arbitrary (-2, 11)
Mask Test
Total UI 0
Failed UI 0
Total Waveforms 0
Failed Waveforms 0


File Edit Vertical Horiz/Acq Trig Display Cursors Measure Mask Math MyScope Analyze Utilities Help
Tek
Position
50.0%
Factor
10000
6.068µs/div 100GS/s 10.0ps
Stopped Single Seq
1 acqs RL:6.068M
Man September 29, 2020 21:42:51
Jitter, Noise and Eye Diagram Analysis Tools
Select
Configure
Results
Plots
Reports
Overall Result: Pass
Sources
MATH3
Standard
View Summary
Expand
Options
Description
Pass/Fail
Mean
Std Dev
Max
Min
p-p
Population
USB4 DFEEW, Tp10...
25.465ps
0.0000s
25.465ps
25.465ps
0.0000s
1
USB4 DFEEH, Tp10...
116.04mV
0.0000V
116.04mV
116.04mV
0.0000V
1
Clear
Recalc
Single
Run
Show Plots

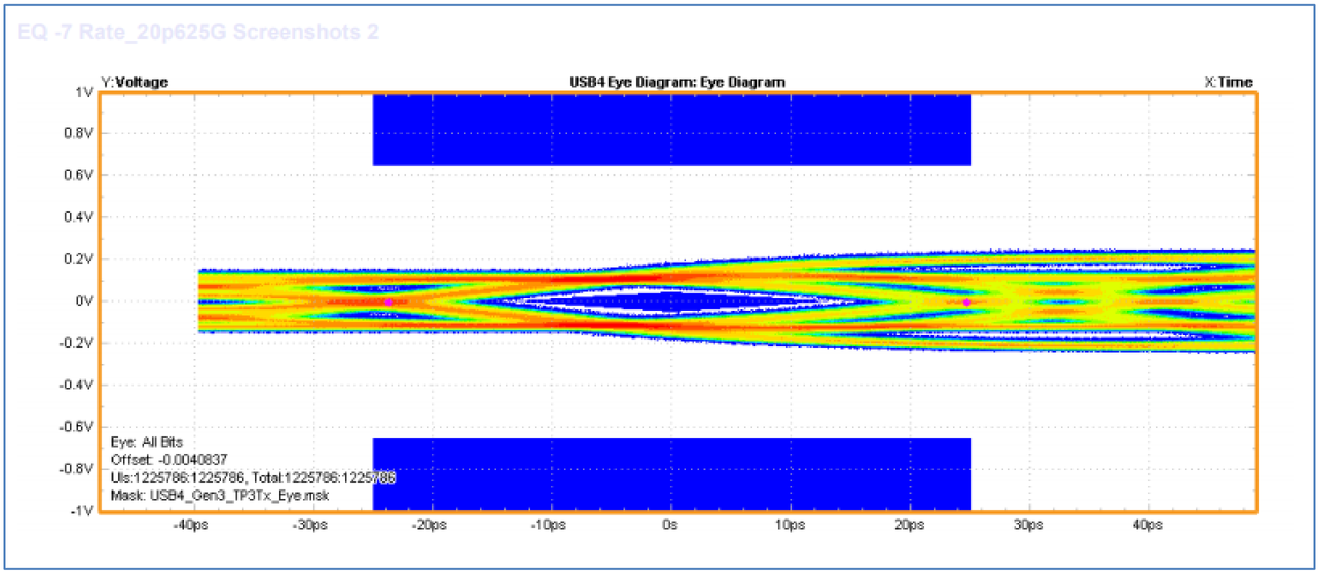
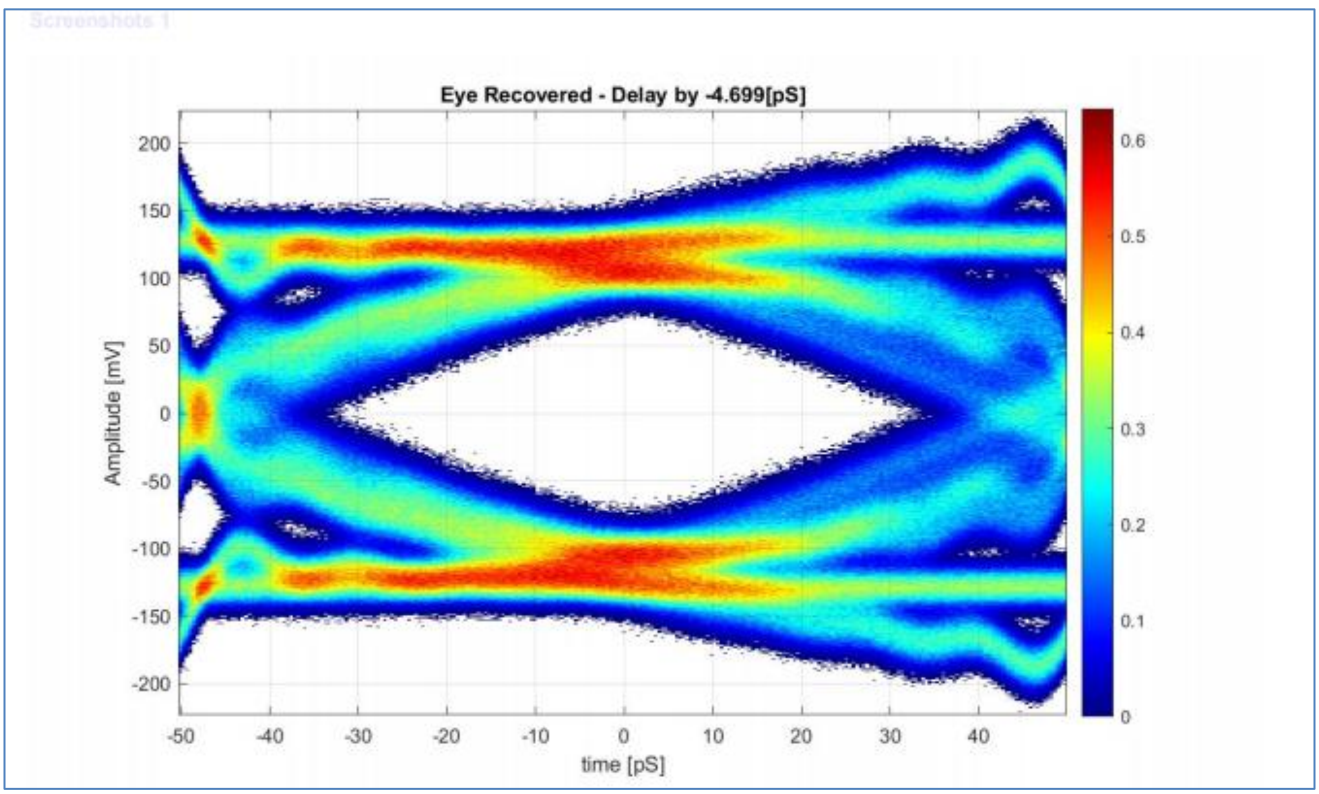



FIGURE 73. EYE AMPLITUDE MEASUREMENTS

5. For SigTest measurement, use the following template:
   - Test Point: tp3
   - CTS Test Template: tp3
6. Retrieve Eye Height measurement.



| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electrical Compliance Test Specification for gen2_rounded | | | | | | | | | | | | | | | |
| Date: | 25-Oct-20 | | | | | | | | | | | | | | |
| DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\Rx\ | | | | | | | | | | | | | | | |
| File: tp3.bin | | | | | | | | | | | | | | | |
| Eye Diagram Measurement: | EyeWidth [pS] | 81.841387 | EyeHeight[mV] | 207.027864 | | | | | | | | | | | |
| Informative: Symbol Rate [GHz]: | NONE | Symbol Rate | 9.975465 | Drift [PPM] | -2453.53 | | | | | | | | | | |
| CTLE-Adc[dB] | CTLE-DC Gain[dB] | DFE[mV] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Avg. Height[mV] | Avg. Width[pS] | Area[mV*pS] |
| 1 | 0 | 50 | 1.409 | 0.783 | 0.285 | 1.175 | 0.318 | 1.175 | 1.457 | 0.783 | 0.313 | 0.783 | 0.76 | 0.94 | 0.64 |
| 0.891 | 1 | 48.2 | 142.647 | 62.262 | 129.546 | 59.129 | 140.216 | 63.437 | 141.373 | 61.479 | 136.547 | 61.479 | 138.07 | 61.557 | 8504.51 |
| 0.794 | 2 | 42 | 170.9 | 71.269 | 162.341 | 70.877 | 172.953 | 70.485 | 172.992 | 70.485 | 168.59 | 70.485 | 169.56 | 70.72 | 11990.66 |
| 0.708 | 3 | 36.7 | 197.61 | 78.317 | 191.643 | 77.925 | 199.418 | 79.883 | 198.652 | 80.275 | 194.414 | 79.1 | 196.35 | 79.1 | 15533.05 |
| 0.631 | 4 | 32 | 208.352 | 82.233 | 205.568 | 80.667 | 206.991 | 81.058 | 208.858 | 82.233 | 205.37 | 83.016 | 207.03 | 81.841 | 16943.65 |
| 0.562 | 5 | 27.8 | 196.69 | 80.275 | 195.141 | 82.233 | 197.331 | 83.016 | 199.43 | 82.625 | 194.586 | 81.45 | 196.64 | 81.92 | 16108.95 |
| 0.501 | 6 | 24 | 185.353 | 76.751 | 182.983 | 76.359 | 185.388 | 79.883 | 185.091 | 79.492 | 181.683 | 74.01 | 184.1 | 77.299 | 14233.46 |
| 0.447 | 7 | 20.7 | 170.463 | 70.877 | 168.146 | 72.443 | 172.005 | 72.443 | 171.527 | 71.269 | 168.334 | 72.052 | 170.09 | 71.817 | 12215.35 |
| 0.398 | 8 | 17.8 | 154.847 | 66.57 | 153.365 | 67.744 | 156.741 | 67.744 | 156.386 | 67.744 | 154.618 | 67.744 | 155.19 | 67.509 | 10476.95 |
| 0.355 | 9 | 15.2 | 138.71 | 62.262 | 139.772 | 61.87 | 142.913 | 63.045 | 140.059 | 63.828 | 140.079 | 63.045 | 140.31 | 62.81 | 8813.04 |
| Optimal CTLE: 4 | | | | | | | | | | | | | | | |

7. If the Eye width is not within the 580 ± 25mUI p-p specification, tune RJ (if the SJ frequency is below 100MHz) or tune SJ (if the SJ frequency  is 100MHz) so that the eye width is within specification.
8. For SigTest measurement, use the following template:
    - Test Point: tp3
    - CTS Test Template: tp3
9. Retrieve Eye Width measurement.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electrical Compliance Test Specification for gen2_rounded | | | | | | | | | | | | | | | |
| Date: | 25-Oct-20 | | | | | | | | | | | | | | |
| DIR:C:\Desktop\SigTest_USB4_CTS\Waveforms\TP3\Rx\ | | | | | | | | | | | | | | | |
| File: tp3.bin | | | | | | | | | | | | | | | |
| Eye Diagram Measurement: | EyeWidth [pS] | 81.841387 | eHeight[mV] | 207.027864 | | | | | | | | | | | |
| Informative: Symbol Rate [GHz]: | NONE | Symbol Rate | 9.975465 | Drift [PPM] | -2453.53 | | | | | | | | | | |
| CTLE-Adc[dB] | CTLE-DC Gain[dB] | DFE[mV] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Eye Height[mV] | EYE Width[pS] | Avg. Height[mV] | Avg. Width[pS] | Area[mV*pS] |
| 1 | 0 | 50 | 1.409 | 0.783 | 0.285 | 1.175 | 0.318 | 1.175 | 1.457 | 0.783 | 0.313 | 0.783 | 0.76 | 0.94 | 0.64 |
| 0.891 | 1 | 48.2 | 142.647 | 62.262 | 129.546 | 59.129 | 140.216 | 63.437 | 141.373 | 61.479 | 136.547 | 61.479 | 138.07 | 61.557 | 8504.51 |
| 0.794 | 2 | 42 | 170.9 | 71.269 | 162.341 | 70.877 | 172.953 | 70.485 | 172.992 | 70.485 | 168.59 | 70.485 | 169.56 | 70.72 | 11990.66 |
| 0.708 | 3 | 36.7 | 197.61 | 78.317 | 191.643 | 77.925 | 199.418 | 79.883 | 198.652 | 80.275 | 194.414 | 79.1 | 196.35 | 79.1 | 15533.05 |
| 0.631 | 4 | 32 | 208.352 | 82.233 | 205.568 | 80.667 | 206.991 | 81.058 | 208.858 | 82.233 | 205.37 | 83.016 | 207.03 | 81.841 | 16943.65 |
| 0.562 | 5 | 27.8 | 196.69 | 80.275 | 195.141 | 82.233 | 197.331 | 83.016 | 199.43 | 82.625 | 194.586 | 81.45 | 196.64 | 81.92 | 16108.95 |
| 0.501 | 6 | 24 | 185.353 | 76.751 | 182.983 | 76.359 | 185.388 | 79.883 | 185.091 | 79.492 | 181.683 | 74.01 | 184.1 | 77.299 | 14233.46 |
| 0.447 | 7 | 20.7 | 170.463 | 70.877 | 168.146 | 72.443 | 172.005 | 72.443 | 171.527 | 71.269 | 168.334 | 72.052 | 170.09 | 71.817 | 12215.35 |
| 0.398 | 8 | 17.8 | 154.847 | 66.57 | 153.365 | 67.744 | 156.741 | 67.744 | 156.386 | 67.744 | 154.618 | 67.744 | 155.19 | 67.509 | 10476.95 |
| 0.355 | 9 | 15.2 | 138.71 | 62.262 | 139.772 | 61.87 | 142.913 | 63.045 | 140.059 | 63.828 | 140.079 | 63.045 | 140.31 | 62.81 | 8813.04 |
| Optimal CTLE: 4 | | | | | | | | | | | | | | | |

10. Save the BERT Setup to “10G_TC2_100MHz”.
11. Repeat steps #1 to #10 for 1MHz, 2MHz, 10MHz and 50MHz PJ frequencies, saving each setup as 10G_TC2_1MHz, 10G_TC2_2MHz, 10G_TC2_10MHz and 10G_TC2_50MHz respectively.

## 10.4 Test Receiver at 10Gb/s or 10.3125Gb/s for Test Case 2 at TP3

1. Set up the physical equipment connections, as per Figure 24.
2. Use TenLira scripts on the PC to ensure that the crosstalk generator is sending PRBS31 signals at 800mV to 10Gb/s or 10.3125Gb/s.
3. Connect the test fixture to Port A of the DUT through the 2M USB Type-C cable.
4. Recall the BERT test setup for 10G_TC2_100MHz (as saved in Section 10.3).
5. Configure the DUT transmitter to output PRBS31 on all lanes with SSC turned ON.
6. Initiate negotiation with the preset chosen in calibration.
7. Change the preset in the BERT according to the newly acquired preset.
8. Configure the DUT for the next negotiation step with the new preset.
9. Change the preset in the BERT according to the newly requested preset.
10. Configure the DUT for the next negotiation step with the new preset.
11. If needed, change the preset in the BERT according to the newly requested preset.

12. Run the 10Gb/s or 10.3125Gb/s test script for Rx testing to determine the BER measured by the Receiver and record the error count for 10 seconds.

    Note the error checking procedure is different between Host or Device types:

    a) For Windows Host testing, TenLira scripts are run on the Host Under Test, to determine the error count. Refer to the release notes of the scripts for details on how to run the scripts.
    b) For Non-Windows Host testing, proprietary methods are used for error count.
    c) For Device testing, TenLira scripts are run on a separate controller PC that is connected to the device under test if TenLira is not installed. For details on how to run the test scripts to determine the error count, refer to the release notes of the scripts.

13. Repeat steps #4 to #12 three more times and record the error count for 10 seconds for each cycle.
14. Again, repeat steps #4 to #12 and then record the error count for 400 seconds.
15. Record the BER in the test results for 10G_TC2_100MHz.
16. If the error count equals to 0 then PASS.
17. If the error count is more than 0 then run steps #4 to #12 and then record the error count for 700 seconds.
18. If the error count is more than 1 then FAIL.
19. Repeat all the steps above for each of the four TC2 frequencies.
20. Swap Data and Crosstalk signals, applying Data to Lane1 and Crosstalk to Lane0.
21. Repeat all the steps above for Lane1 of the same port if the DUT is a 2-lane Device.
22. Repeat all the steps above on Port B if the DUT is a multi-port Device.
23. Include the Eye Diagram for 10G_TC2_100MHz in the Compliance Test Report.

## 10.5 Calibrate and Save for 20Gb/s or 20.625Gb/s Rx Test Case 1 at TP3’

The initial setups for the BERT and Scope are the same as defined for the 10Gb/s or 10.3215Gb/s section above, except for the settings highlighted in **bold** below.

1. Set up the physical equipment connections without ISI Channel, as per Figure 10.
2. Set up the BERT as follows:

    a) Set the Data Rate to **20Gb/s** or **20.625Gb/s**.
    b) Set the Pattern to PRBS15.
    c) Turn on “SSC”, with settings of 32kHz (for 20G) or 36kHz (for 20.625G) with 5600ppm (for 20G) and 5800ppm (for 20.625G) triangle down spread. (SSC will remain on for all of the following steps.)
    d) Set DATA+/DATA- Launch Amplitude to 750mV. This should set the differential amplitude just above the 700mV Eye Height target value as an initial value.
    e) Set the initial CM interference amplitude to 0mV.

### 10.5.1 Set Up Oscilloscope

#### 10.5.1.1 Oscilloscope Vertical and Horizontal Setup

Set up the Scope as listed in Table 12.

TABLE 12. OSCILLOSCOPE VERTICAL AND HORIZONTAL SETUP

| Setting | Setup |
| --- | --- |
| Vertical | Ch1-Ch3 (using the full range of the Scope's D/A) |
| Horizontal | 20Gb/s or 20.625Gb/s |
| Record Length | 40M |
| Sample Rate | 80Gs/s |
| Averaging | OFF |
| Sample Mode | Real Time |
| Bandwidth | 21GHz (The Calibration Bandwidth is limited to the Bit Rate of the signal, which is 2 * 1st harmonic. This is done intentionally to be on the order of a Thunderbolt Receiver's Bandwidth. This is essentially acting as an "Electrical Reference Receiver", used for calibration. It reduces the noise measured by the Scope which a real Receiver will never perceive.) |
| Vertical Scale | Set to full screen without clipping |
| Sin x/x | OFF |

#### 10.5.1.2 Oscilloscope Clock Recovery Setup

Enter the Clock Recovery menu and set up the Scope as listed in Table 13.

TABLE 13. OSCILLOSCOPE CLOCK RECOVERY SETUP

| Setting | Setup |
| --- | --- |
| Nominal Data Rate | 20Gb/s or 20.625Gb/s |
| Clock Recovery Method | Second Order PLL |
| PLL Specification | OJTF<br>Loop Bandwidth: 5.000 MHz<br>Damping factor: 0.94 |

#### 10.5.1.3 Oscilloscope AC Common Mode (ACCM) Setup

Set up the Scope as listed in Table 14.

TABLE 14. OSCILLOSCOPE ACCM SETUP

| Setting | Setup |
|---|---|
| Sample Rate | ≥ 80Gs/s |
| Record Length | 27Mpts per channel |
| Bandwidth | 21GHz |
| Vertical Scale | 20mV/div |
| CDR | OFF |
| Averaging | OFF |
| Sin x/x | OFF |

#### 10.5.1.4 Jitter Setup

Enter the Jitter menu and set up the Scope as listed in Table 15.

TABLE 15. OSCILLOSCOPE JITTER SETUP

| Setting | Setup |
|---|---|
| Units | Unit Interval |
| Jitter Method | Spectral |
| Source for Jitter & Eye Diagram | Channel 1-3 |
| BER Level | 1E-12 |
| Pattern | Periodic, Repeating Pattern ($2^{15}$-1 = 32,767 bits) |

#### 10.5.1.5 Eye Diagram Vertical Setup

Set up the Scope as listed in Table 16.

TABLE 16. OSCILLOSCOPE EYE DIAGRAM VERTICAL SETUP

| Setting | Setup |
|---|---|
| Vertical Scale | 200 mV/div |
| Horizontal Scale | 2 UI's |
| Eye Mask Height | 700 mV (for final Eye Height Calibration) |
| Eye Mask Width | 620 mUI |

### 10.5.2 Record ISI Measurements

1. Step through the Preset Coefficients 0-15 and use the Preset which yields the minimum DDJ Measurement. Although this is not a Calibrated value, record this ISI Measurement as part of the measurements table.
2. Change the pattern on the BERT to PRBS31. Calibrate ACCM to be 100mVpp at 400MHz Clock, using the ACCM Scope Setup.
3. Return CM Amplitude to zero.
4. Turn on all remaining Jitter terms (RJ-Filtered [10MHz HPF] and SJ at 100MHz).
5. Set all jitter amplitudes to zero.
6. Return the Scope setup to the setup in Section 10.5.1.
7. Change the pattern on the BERT to PRBS15.
8. Calibrate RJ Amplitude to 140mUI peak-to-peak (10mUI RMS).
9. Return amplitude to zero.
10. Capture screen shot.
11. Calibrate SJ Amplitude to 170mUI peak-to-peak at 100MHz.
12. Capture screen shot.
13. Return all remaining impairment sources (CM, RJ, SJ) to their calibrated values.
14. Calibrate the TJ measurement to 380mUI ± 25mUI using SJ Amplitude control (for SJ Frequency of 100MHz) and RJ Amplitude control (for SJ Frequencies of less than 100 MHz) as an adjustment on the BERT.
15. Capture screen shot.
16. Change the pattern on the BERT to PRBS31.
17. Calibrate Inner Eye Height to 700mV (top and bottom of triangle eye mask, with V:700mV; H:620mUI).
18. Capture screen shot.
19. Save BERT Setup to "20G_TC1_100MHz".
20. Repeat steps #1 to #18 for 1MHz, 2MHz, 10MHz and 50MHz PJ frequencies, saving each BERT Setup as 20G_TC1_1MHz, 20G_TC1_2MHz, 20G_TC1_10MHz and 20G_TC1_50MHz.

## 10.6 Test Receiver at 20Gb/s or 20.625 Gb/s for Rx Test Case 1 at TP3'

1. Set up the physical equipment connections, as per Figure 23.
2. Use TenLira scripts on the PC to ensure that the crosstalk generator is sending PRBS31 (800mV) signals at 20Gb/s or 20.625Gb/s.
3. Connect the test fixture to Port A of the DUT.
4. Recall the BERT test setup for 20G_TC1_100MHz.
5. Configure the DUT transmitter to output PRBS31 on all lanes with SSC turned on.
6. Initiate negotiation with the preset chosen in calibration.
7. Change the preset in the BERT according to the newly acquired preset.
8. Configure the DUT for the next negotiation step with the new preset.
9. Change the preset in the BERT according to the newly requested preset.
10. Configure the DUT for the next negotiation step with the new preset.
11. If needed, change the preset in the BERT according to the newly requested preset.
12. Run the 20Gb/s or 20.625Gb/s test script for Rx testing to determine the BER measured by the Receiver and record the error count for 10 seconds.

    Note the error checking procedure is different between Host or Device types:

    a) For Windows Host testing, TenLira scripts are run on the Host Under Test, to determine the error count. Refer to the release notes of the scripts for details on how to run the scripts.
    b) For Non-Windows Host testing, proprietary methods are used for error count.
    c) For Device testing, TenLira scripts are run on a separate controller PC that is connected to the device under test if TenLira is not installed. For details on how to run the test scripts to determine the error count, refer to the release notes of the scripts.

13. Repeat steps #4 to #12 three more times and record the error count for 10 seconds for each cycle.
14. Again, repeat steps #4 to #12 and then record the error count for 200 seconds.
15. Record the BER in the test results for 20G_TC1_100MHz.
16. If the error count equals to 0 then PASS.
17. If the error count is more than 0 then run steps #4 to #12 and then record the error count for 350 seconds.
18. If the error count is more than 1 then FAIL.
19. Repeat all the steps above for each of the four TC1 frequencies.
20. Swap Data and Crosstalk signals, applying Data to Lane1 and Crosstalk to Lane0.
21. Repeat all the steps above for Lane1 of the same port if the DUT is a 2-lane Device.
22. Repeat all the steps above on Port B if the DUT is a multi-port Device.
23. Include the Eye Diagram for 20G_TC1_100MHz in the Compliance Test Report.

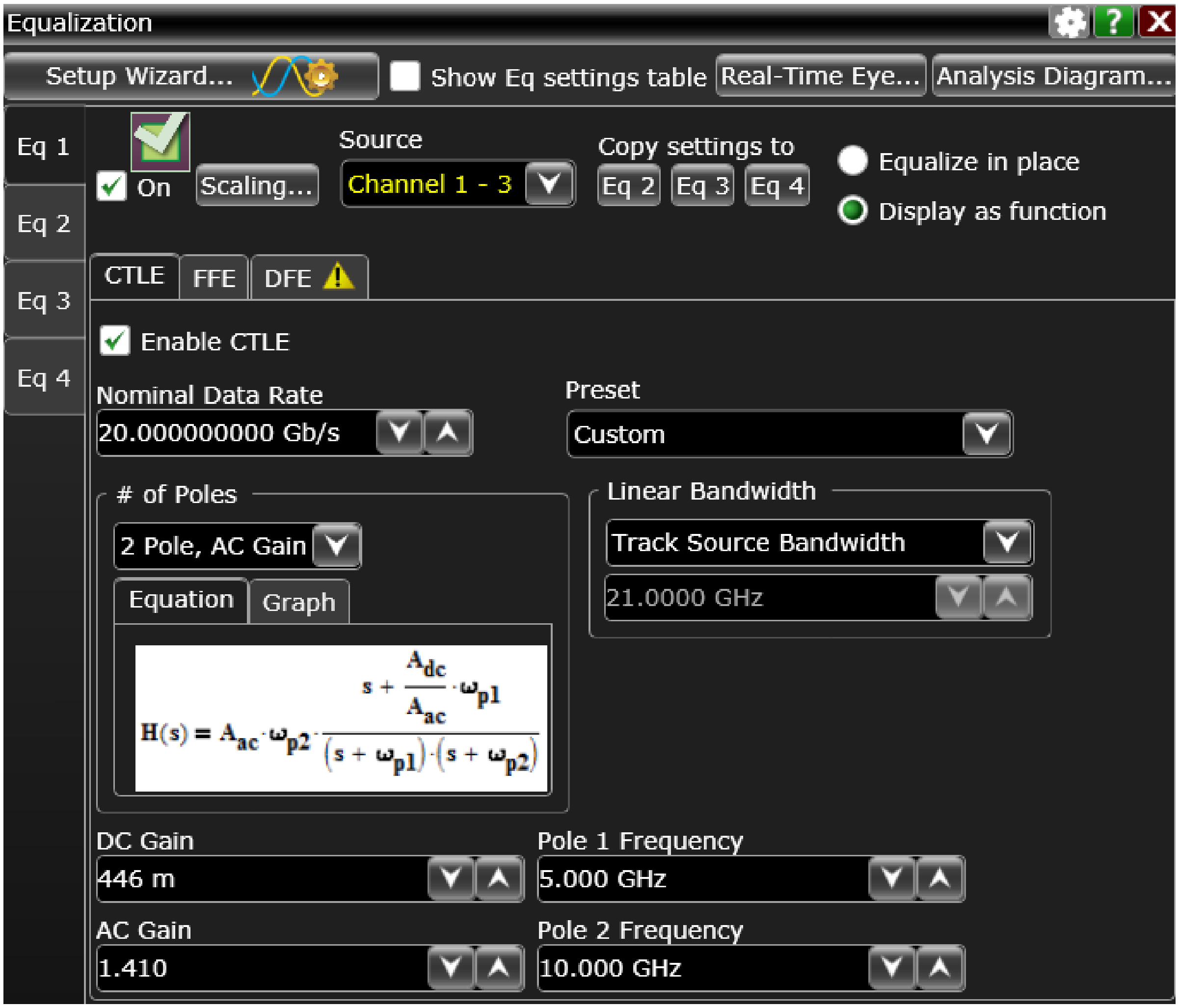
## 10.7 Calibrate and Save for 20Gb/s or 20.625Gb/s Rx Test Case 2 at TP3

For this test case, the total ISI of a channel should be around -16.5dB@10GHz. The test fixture should have 1 to 1.5dB per mated pair.

1. Recall the BERT setup from 20G_TC1_100MHz.
2. Connect the physical setup with ISI Channel, as per Figure 12, as follows:
   a) Output of MU195050A connected to 40GHz K Cable
   b) -3.5dB Fixed Channel Board connected to 40GHz K Cable
   c) SMP USB Type-C Receptacle Fixture connected to -12dB Characterized 0.8 meter USB Type-C Cable
   d) SMP USB Type-C Receptacle Fixture connected to short 40GHz Cables into Ch1 and Ch3 of Scope
3. Search for Optimized DC Gain starting from DC Gain of 1 in Oscilloscope Equalization Setup, adjust the DC Gain to obtain the largest Eye Height with cable de-embedding. *Note: This step is not required if the SigTest method is used.*
   a) Set up the Scope as follows for CTLE:
      i) Number of Poles set to USB 3.1
      ii) DC Gain set to 1.00
      iii) AC Gain set to 1.41
      iv) Pole #1 Frequency set to 5 GHz
      v) Pole #2 Frequency set to 10 GHz
   b) Use the DC Gain Setting in Table 17 which yields the largest Eye Height.

TABLE 17. DC GAIN SETTINGS

| Index | DC Gain Setting | Index | DC Gain Setting |
|---|---|---|---|
| 0 | 1.000 | -5 | 0.562 |
| -1 | 0.891 | -6 | 0.501 |
| -2 | 0.794 | -7 | 0.446 |
| -3 | 0.708 | -8 | 0.398 |
| -4 | 0.630 | -9 | 0.354 |




$$H(s) = A_{ac} \cdot \omega_{p2} \cdot \frac{s + \frac{A_{dc}}{A_{ac}} \cdot \omega_{p1}}{(s + \omega_{p1}) \cdot (s + \omega_{p2})}$$

FIGURE 74. DC GAIN SETTING

c) Set up the DFE:

i) Set Max Tap to 50mV.

ii) Run Auto DFE.

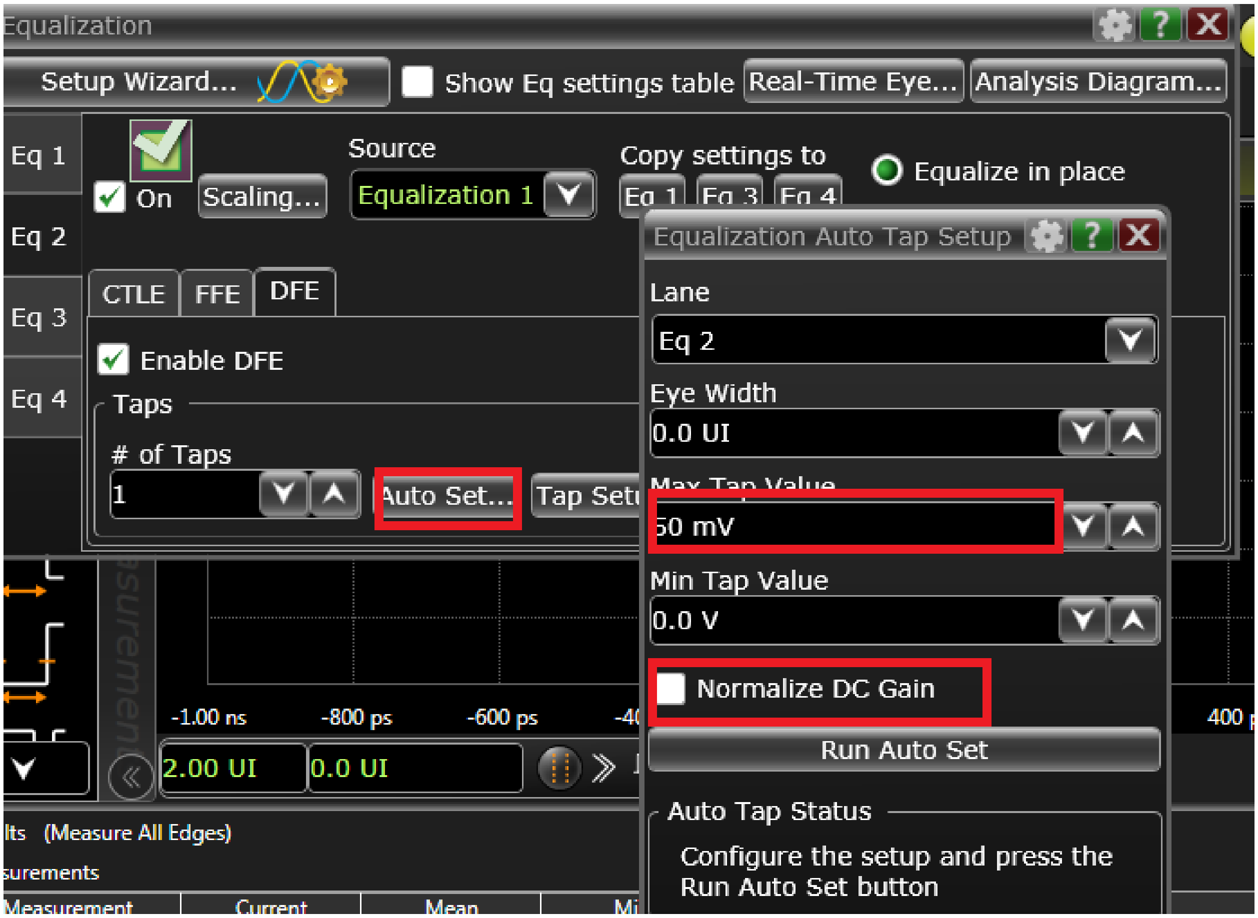



FIGURE 75. DFE SETTING

d) Adjust the memory depth to capture 1,000,000 (1E6) bits with 5 acquisitions (100,000 UI's per Acquisition).

e) For each acquisition, measure the Eye Width and Eye Height. Calculate the average of the five measurements and compute the Eye area via *Eye Width * Eye Height*.

f) Measure the Eye area by iterating through each CTLE gain. The CTLE gain with the biggest Eye area is used for the following measurements.

4. Calibrate the Inner Eye Height to 98 ± 10mV diff p-p (top and bottom of the triangle eye mask) using the PRBS31 pattern.

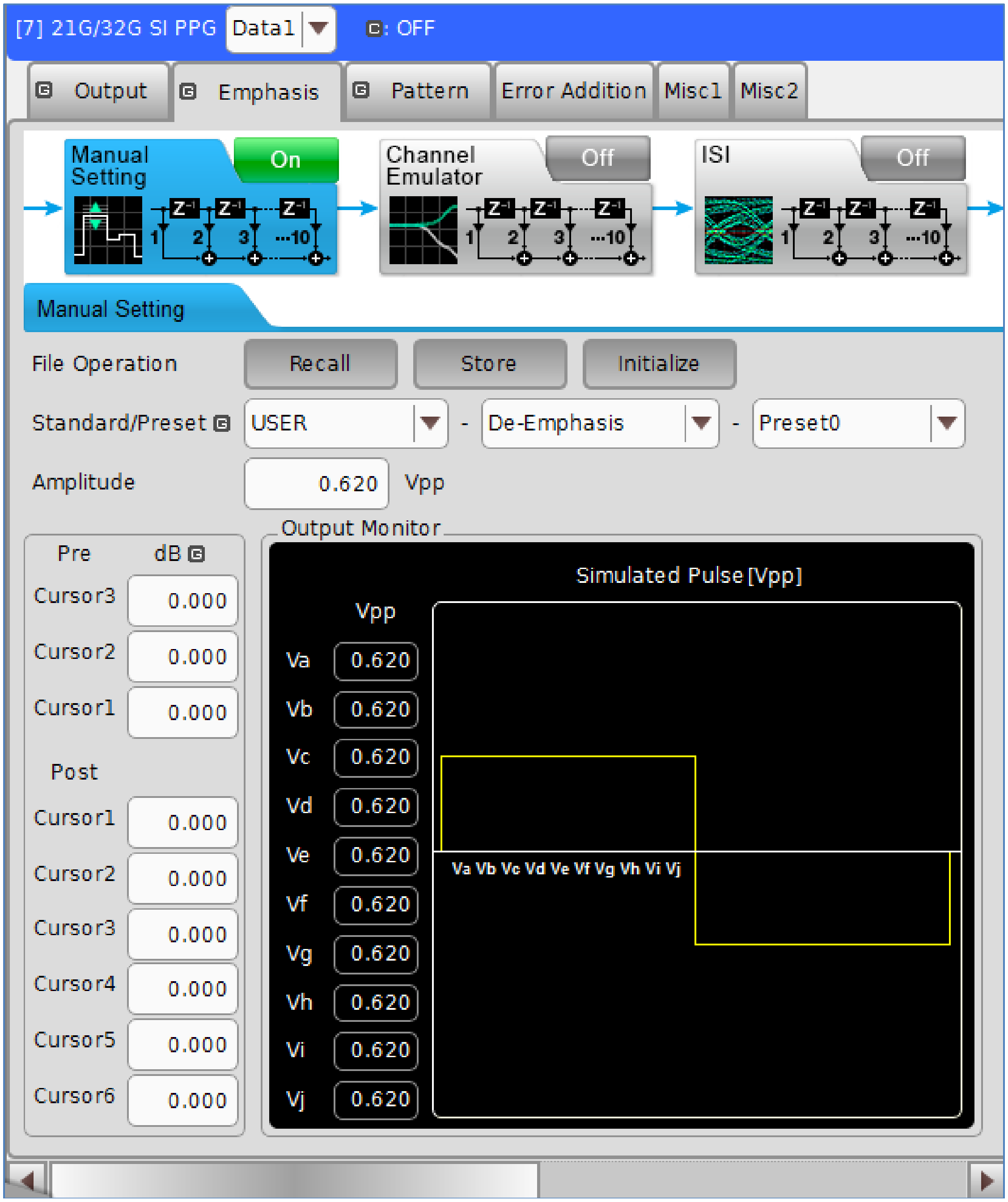
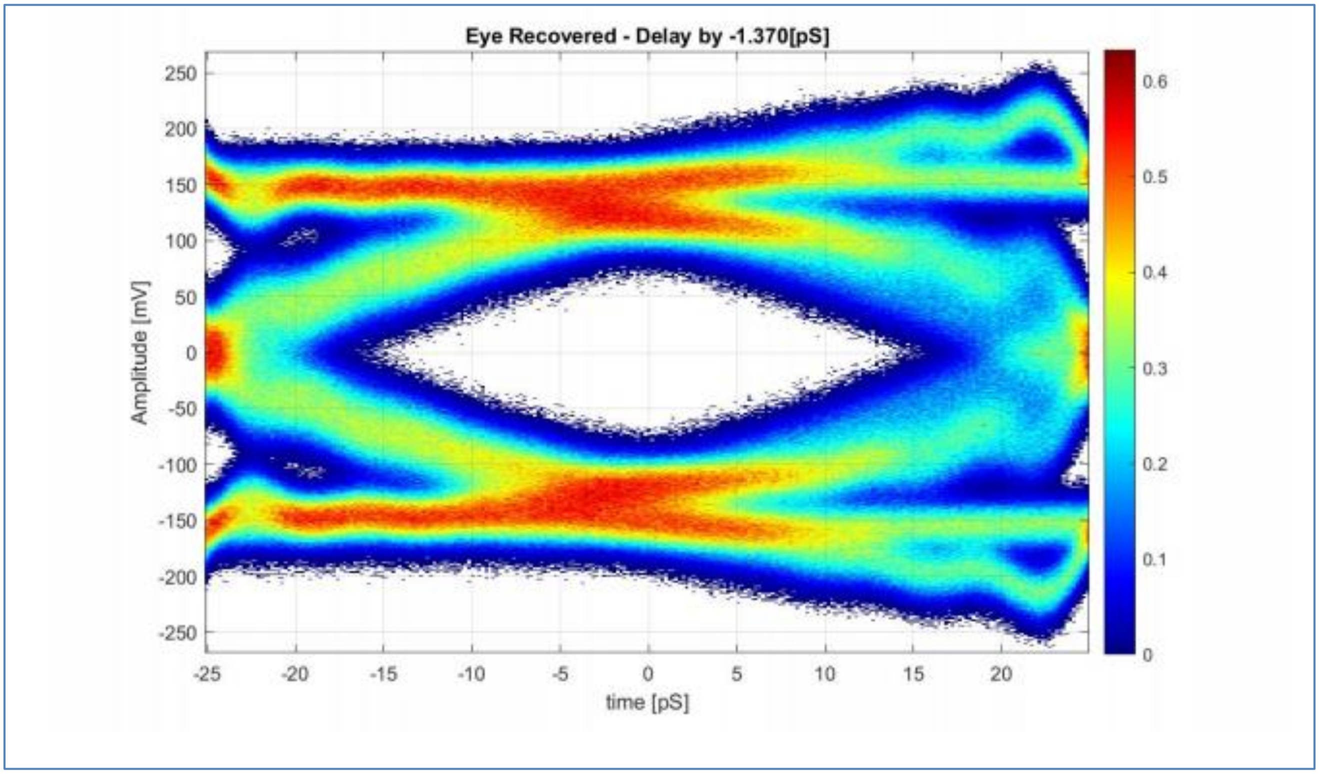



FIGURE 76. EYE AMPLITUDE


Eye Recovered - Delay by -1.370[pS]
Amplitude [mV]
time [pS]
250
200
150
100
50
0
-50
-100
-150
-200
-250
-25
-20
-15
-10
-5
0
5
10
15
20
0.6
0.5
0.4
0.3
0.2
0.1
0


File Control Setup Display Trigger Measure Math Analyze Utilities Demos Help
KEYSIGHT TECHNOLOGIES
Run Stop Single
80.0 GSa/s
20.0 Mpts
21.0 GHz
0.0 V
Waveform Window 1
Real-Time Eye
Results (Measure All Edges)
Measurement
Current
Eye Height(eq) 109.0 mV
Eye Width(eq) 25.47 ps
Source CTLE
RJ Method Tail Fit
Data Rate 10.3125 Gb/s
Pattern Length Arbitrary (-2, 11)
RJrms 11.04 mUI
DJδδ 472.7 mUI
Transitions 521.055 k
PJrms 60.9 mUI
BUJδδ 149.1 mUI
Mask Test
Total UI 0
Failed UI 0
Total Waveforms 0
Failed Waveforms 0

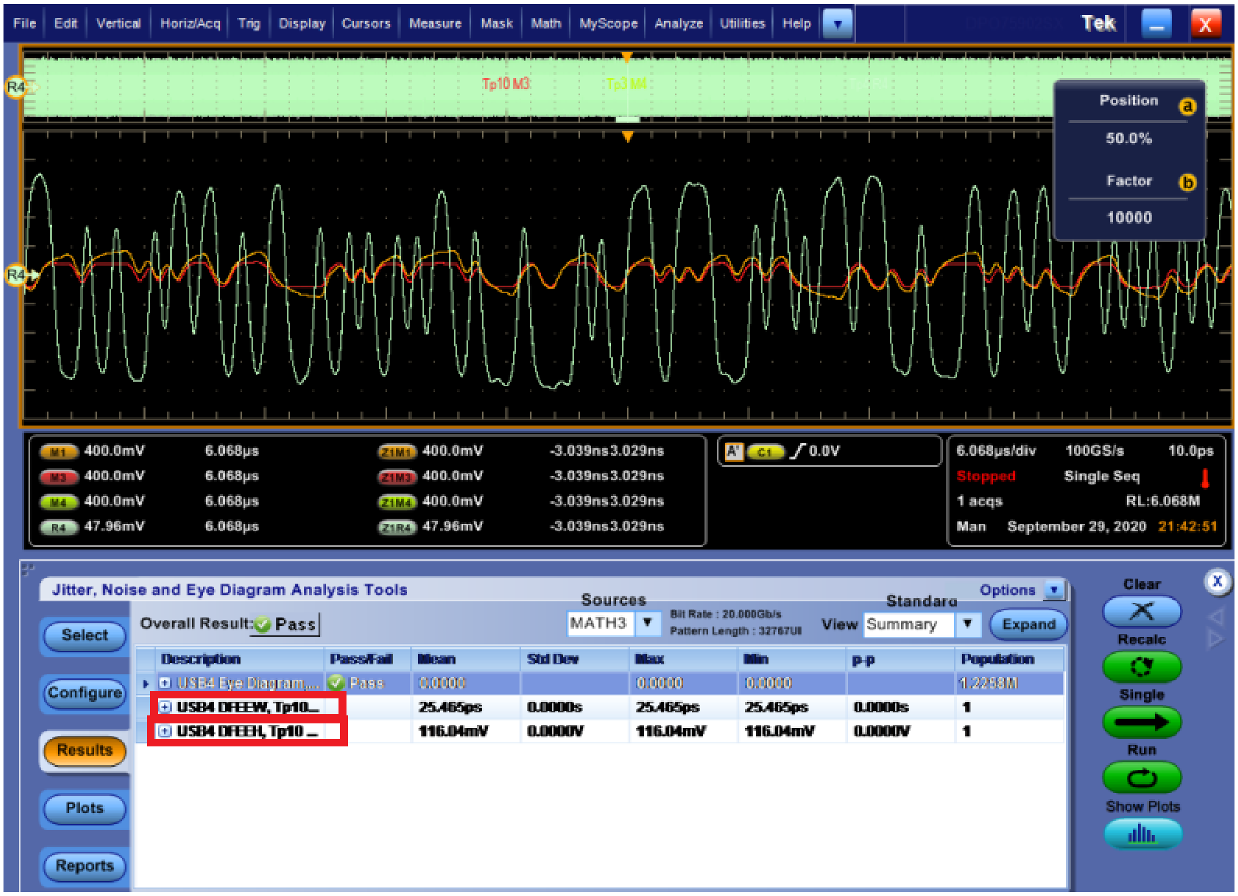



FIGURE 77. EYE AMPLITUDE MEASUREMENTS

5. For SigTest measurement, use the following template:
    - Test Point: tp3
    - CTS Test Template: tp3
6. Retrieve Eye Height measurement.
7. If the Eye Width is not within the 540 ± 50mUI p-p specification, tune RJ (if the SJ frequency is below 100MHz) or tune SJ (if the SJ frequency is 100MHz) so that the Eye Width is within specification.
8. For SigTest measurement, use the following template:
    - Test Point: tp3
    - CTS Test Template: tp3
9. Retrieve Eye Width measurement.
10. Capture screen shot.
11. Save BERT Setup to “20G_TC2_100MHz”.
12. Repeat steps #1 to #11 for 1MHz, 2MHz, 10MHz and 50MHz PJ frequencies, saving each setup as 20G_TC2_1MHz, 20G_TC2_2MHz, 20G_TC2_10MHz and 20G_TC2_50MHz respectively.

## 10.8 Test Receiver at 20Gb/s or 20.625Gb/s for Test Case 2 at TP3

1. Set up the physical equipment connections, as per Figure 25.
2. Use TenLira scripts on the PC to ensure that the crosstalk generator is sending PRBS31 signals at 800mV to 20Gb/s or 20.625Gb/s.
3. Connect the test fixture to Port A of the DUT through the 0.8M USB Type-C cable.
4. Recall the BERT test setup for 20G_TC2_100MHz (as saved in Section 10.7).
5. Configure the DUT transmitter to output PRBS31 on all lanes with SSC turned ON.
6. Initiate negotiation with the preset chosen in calibration.
7. Change the preset in the BERT according to the newly acquired preset.
8. Configure the DUT for the next negotiation step with the new preset.
9. Change the preset in the BERT according to the newly requested preset.
10. Configure the DUT for the next negotiation step with the new preset.
11. If needed, change the preset in the BERT according to the newly requested preset.
12. Run the 20Gb/s or 20.625Gb/s test script for Rx testing to determine the BER measured by the Receiver and record the error count for 10 seconds.

    Note the error checking procedure is different between Host or Device types:

    a) For Windows Host testing, TenLira scripts are run on the Host Under Test, to determine the error count. Refer to the release notes of the scripts for details on how to run the scripts.
    b) For Non-Windows Host testing, proprietary methods are used for error count.
    c) For Device testing, TenLira scripts are run on a separate controller PC that is connected to the device under test if TenLira is not installed. For details on how to run the test scripts to determine the error count, refer to the release notes of the scripts.

13. Repeat steps #4 to #12 three more times and record the error count for 10 seconds for each cycle.
14. Again, repeat steps #4 to #12 and then record the error count for 200 seconds.
15. Record the BER in the test results for 20G_TC2_100MHz.
16. If the error count equals to 0 then PASS.
17. If the error count is more than 0 then run steps #4 to #12 and then record the error count for 350 seconds.
18. If the error count is more than 1 then FAIL.
19. Repeat all the steps above for each of the four TC2 frequencies.
20. Swap Data and Crosstalk signals, applying Data to Lane1 and Crosstalk to Lane0.
21. Repeat all the steps above for Lane1 of the same port if the DUT is a 2-lane Device.
22. Repeat all the steps above on Port B if the DUT is a multi-port Device.
23. Include the Eye Diagram for 20G_TC2_100MHz in the Compliance Test Report.

## 10.9 Test for Signal Frequency Variation Training (10Gb/s or 10.3125Gb/s)

1. Recall the BERT Test Setup for 10G_TC2_1MHz. Turn Off SSC.
2. Set SJ Frequency to 400 kHz.
3. Set SJ Amplitude to 22.4UI.
4. Configure the DUT transmitter to output PRBS15 on all lanes with SSC turned ON.
5. Initiate negotiation with the preset chosen in calibration.
6. Change the preset in the BERT according to the newly acquired preset.
7. Configure the DUT for the next negotiation step with the new preset.
8. Change the preset in the BERT according to the newly requested preset.
9. Configure the DUT for the next negotiation step with the new preset.
10. If needed, change the preset in the BERT according to the newly requested preset.
11. Run the 10Gb/s or 10.3125Gb/s test script for Rx testing to determine the BER measured by the Receiver and record the error count for 10 seconds.

    Note the error checking procedure is different between Host or Device types:

    a) For Windows Host testing, TenLira scripts are run on the Host Under Test, to determine the error count. Refer to the release notes of the scripts for details on how to run the scripts.
    b) For Non-Windows Host testing, proprietary methods are used for error count.
    c) For Device testing, TenLira scripts are run on a separate controller PC that is connected to the device under test if TenLira is not installed. For details on how to run the test scripts to determine the error count, refer to the release notes of the scripts.

12. If the BER is ≤ 1E-6, the test is considered passed, otherwise the test has failed.
13. Repeat all the above steps 20 times for each lane.

## 10.10 Test for Signal Frequency Variation Training (20Gb/s or 20.625Gb/s)

1. Recall the BERT Test Setup for 20G_TC2_1MHz. Turn Off SSC.
2. Set SJ Frequency to 400 kHz.
3. Set SJ Amplitude to 44.8UI.
4. Configure the DUT transmitter to output PRBS15 on all lanes with SSC turned ON.
5. Initiate negotiation with the preset chosen in calibration.
6. Change the preset in the BERT according to the newly acquired preset.
7. Configure the DUT for the next negotiation step with the new preset.
8. Change the preset in the BERT according to the newly requested preset.
9. Configure the DUT for the next negotiation step with the new preset.
10. If needed, change the preset in the BERT according to the newly requested preset.
11. Run the 20Gb/s or 20.625Gb/s test script for Rx testing to determine the BER measured by the Receiver and record the error count for 10 seconds.

    Note the error checking procedure is different between Host or Device types:

a) For Windows Host testing, TenLira scripts are run on the Host Under Test, to determine the error count. Refer to the release notes of the scripts for details on how to run the scripts.
b) For Non-Windows Host testing, proprietary methods are used for error count.
c) For Device testing, TenLira scripts are run on a separate controller PC that is connected to the device under test if TenLira is not installed. For details on how to run the test scripts to determine the error count, refer to the release notes of the scripts.

12. If the BER is ≤ 1E-6, the test is considered passed, otherwise the test has failed.
13. Repeat all the above steps 20 times for each lane.

# 11 Appendix B: Receiver Stressed Eye Calibration Using SigTest

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

*Note: When using SigTest, apply the same procedure for receiver stressed eye calibration (for all USB4 data rates) as described in Appendix A, but replace the Scope measurements with the SigTest results.*

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

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

## 11.1 Install and Run SigTest

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

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

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

## 11.2 Set Up Scope for Saving Waveforms

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

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

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

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

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

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

# 12 Appendix C: Connecting Keysight Oscilloscope to PC

If using a Keysight oscilloscope, refer to the following procedure on how to connect the Scope to be used with a controller PC. The Keysight Scope can be connected to 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 the controller PC.
2. When installed successfully, the IO icon (  ) will appear in the taskbar notification area of the controller PC.
3. Select the IO icon to launch the **Keysight Connection Expert**.
4. Click Rescan.

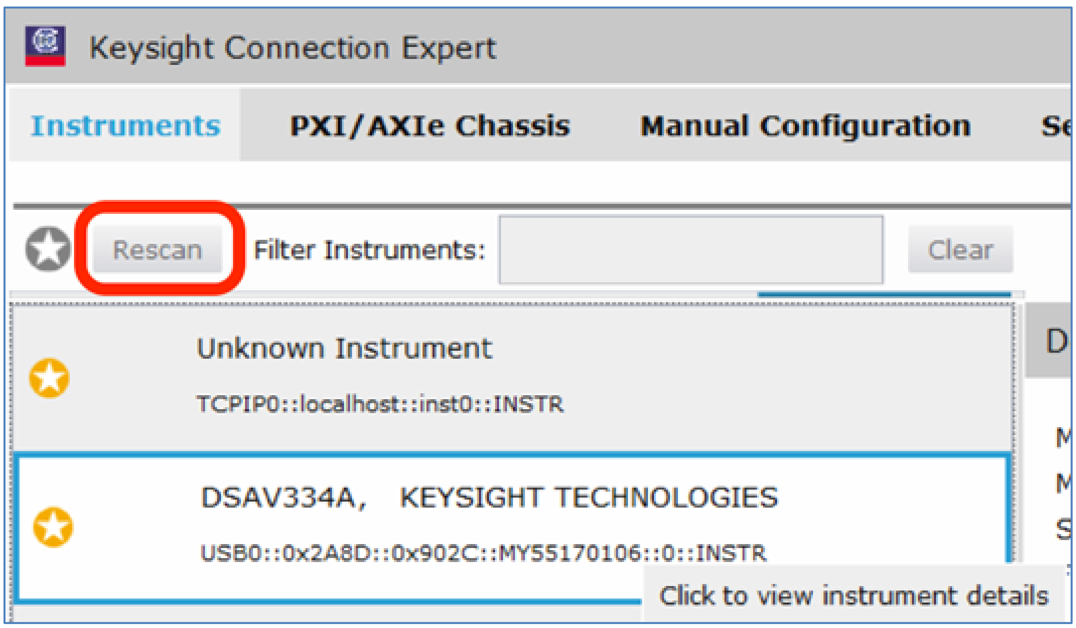



FIGURE 78. KEYSIGHT CONNECTION EXPERT

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

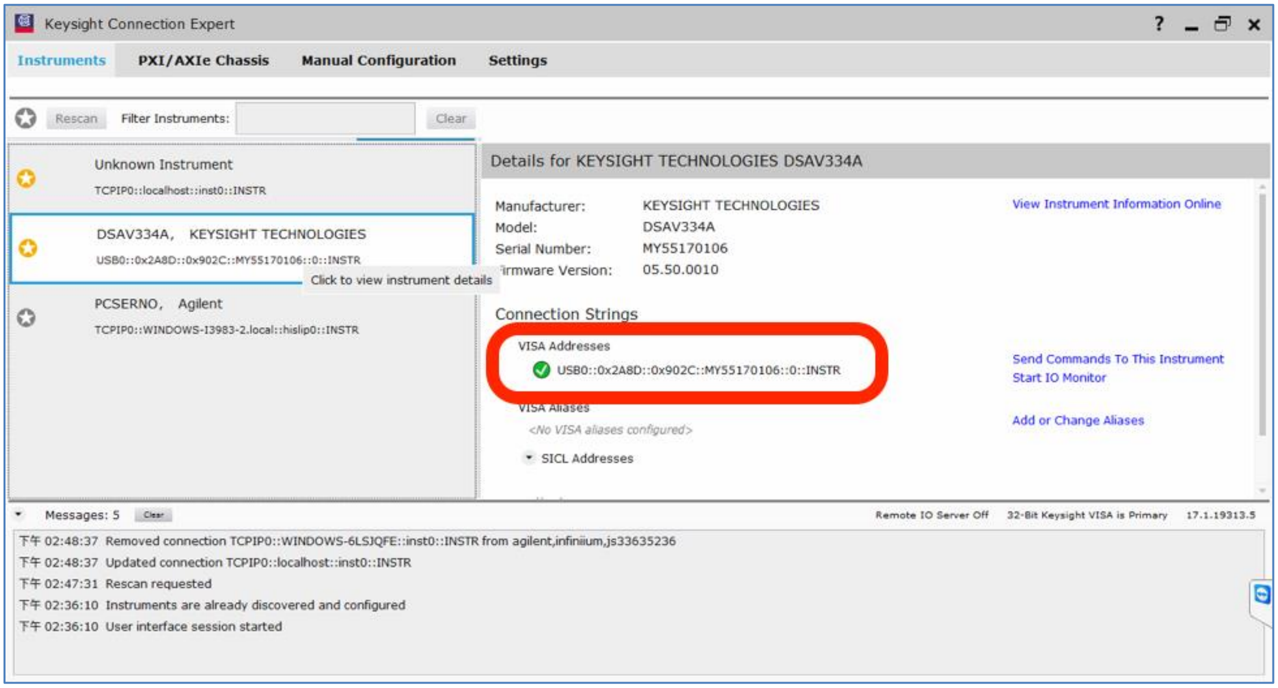



FIGURE 79. OSCILLOSCOPE'S VISA ADDRESS

6. When connecting the Keysight Scope to the PC through GPIB/USB, type in the VISA address into the 'Address' field on the Equipment Setup page of the GRL-Anritsu USB4 Rx Test Application. If the GRL-Anritsu USB4 Rx Test Application is installed on the Keysight Scope, type in the Scope IP address, for example "TCPIP0::127.0.0.1::inst0::INSTR". If the GRL software is installed on the 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".

# 13 Appendix D: Connecting Tektronix Oscilloscope to PC

If using a Tektronix DPOJET Series oscilloscope, refer to the following procedure on how to connect the Scope to be used with a controller PC. The Tektronix Scope can be connected to 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 controller PC.
2. When installed successfully, open the OpenChoice Instrument Manager application.

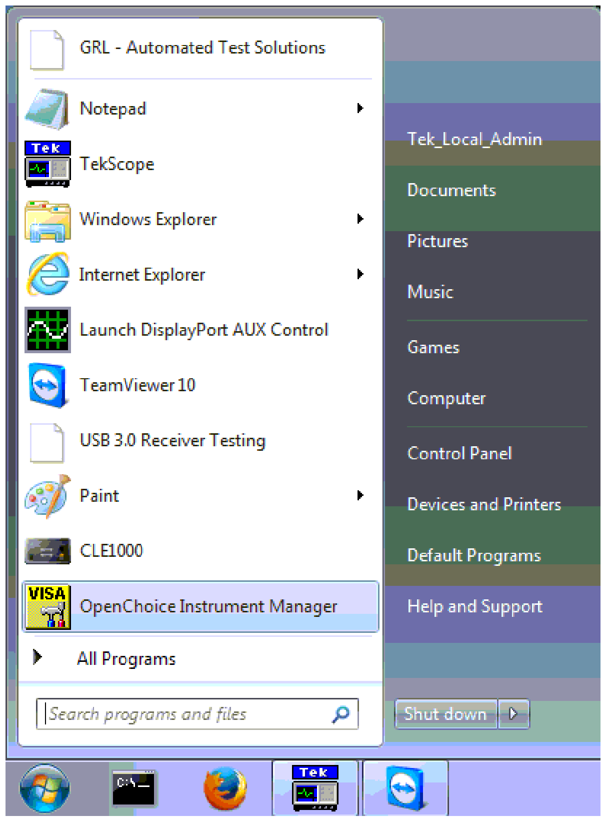



FIGURE 80. OPENCHOICE INSTRUMENT MANAGER IN START MENU

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 controller 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.

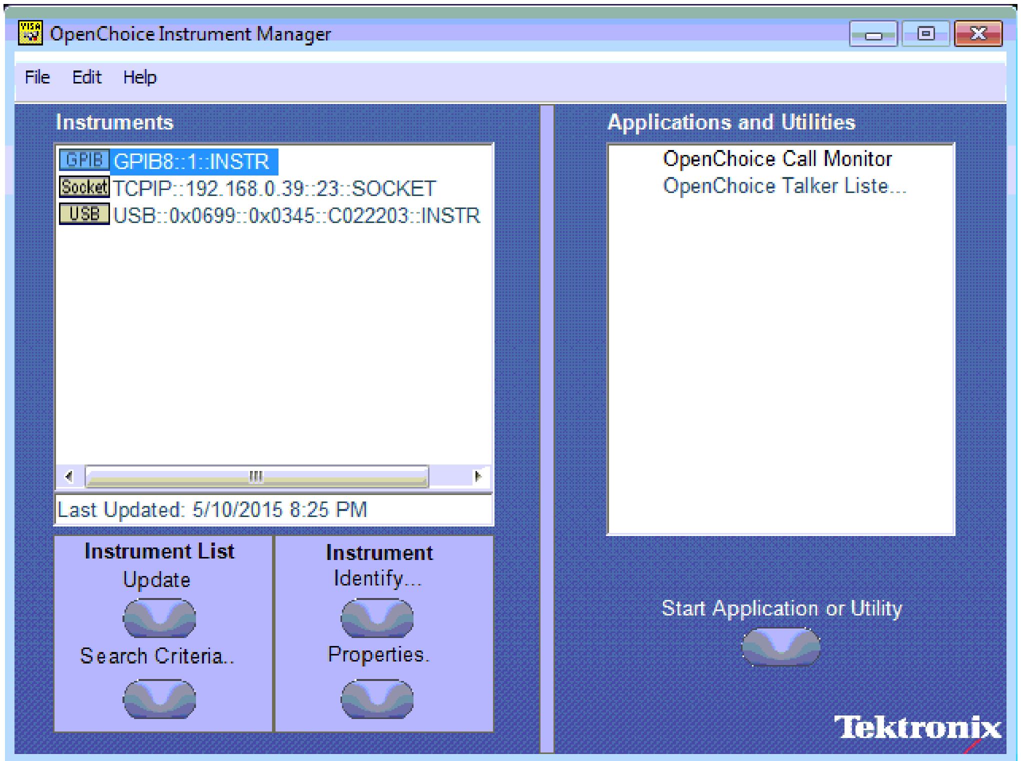



FIGURE 81. OPENCHOICE INSTRUMENT MANAGER MENU

4. If connecting the Tektronix Scope to the controller 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 controller 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-Anritsu USB4 Rx Test Application, type in the Scope address into the 'Address' field. If the GRL-Anritsu USB4 Rx Test Application is installed on the Tektronix Scope, ensure the Scope is connected via GPIB and type in the GPIB network address, for example "GPIB8::1::INSTR". If the GRL software is installed on the controller 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.

# 14 Appendix E: Connecting Teledyne LeCroy Oscilloscope to PC

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

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

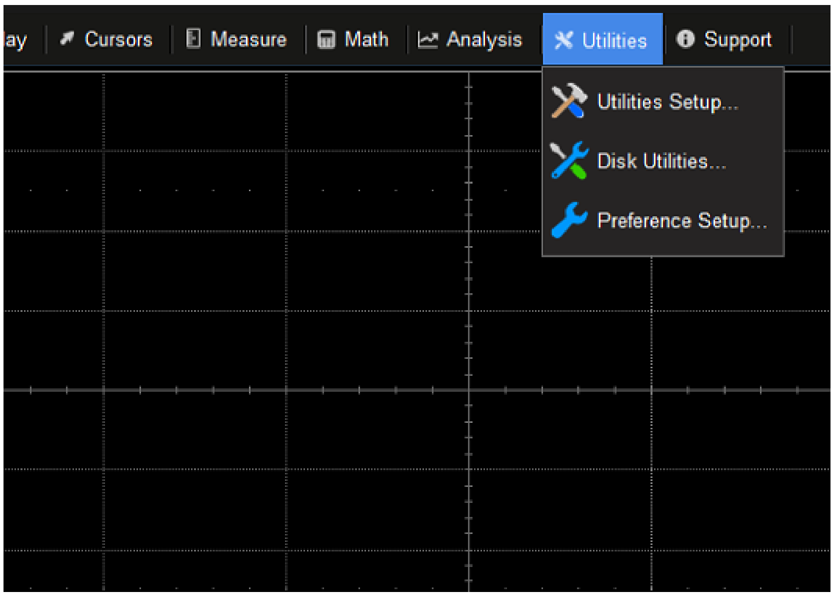



FIGURE 82. UTILITIES SETUP MENU

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

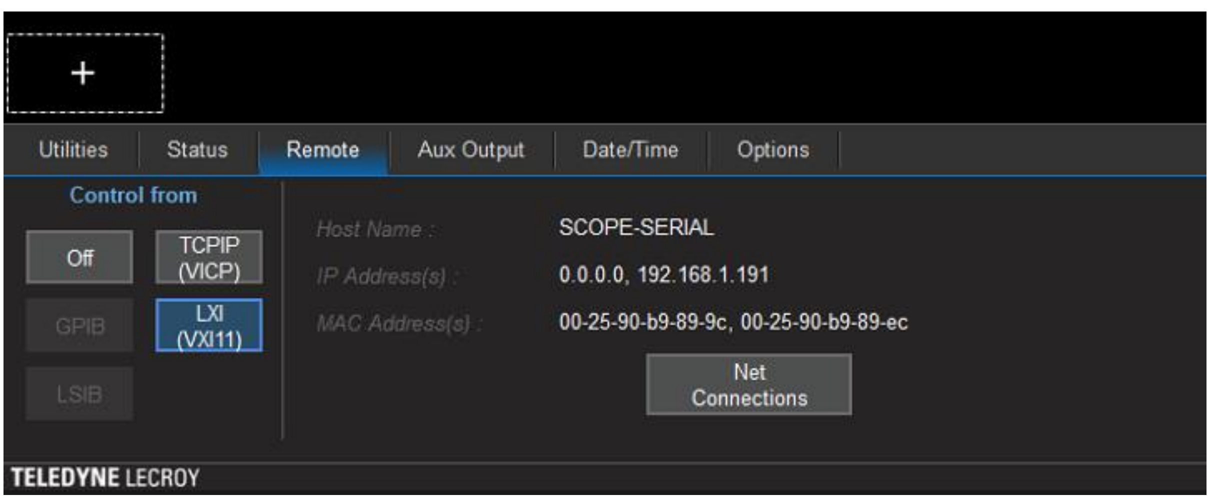



FIGURE 83. OSCILLOSCOPE'S IP ADDRESS

3. On the Equipment Setup page of the GRL Anritsu USB-4 Rx Test Application, type in the Scope IP address into the 'Address' field.

# 15 Appendix F: 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.

## 15.1 Set Up Transfer Function for the Keysight Scope

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

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

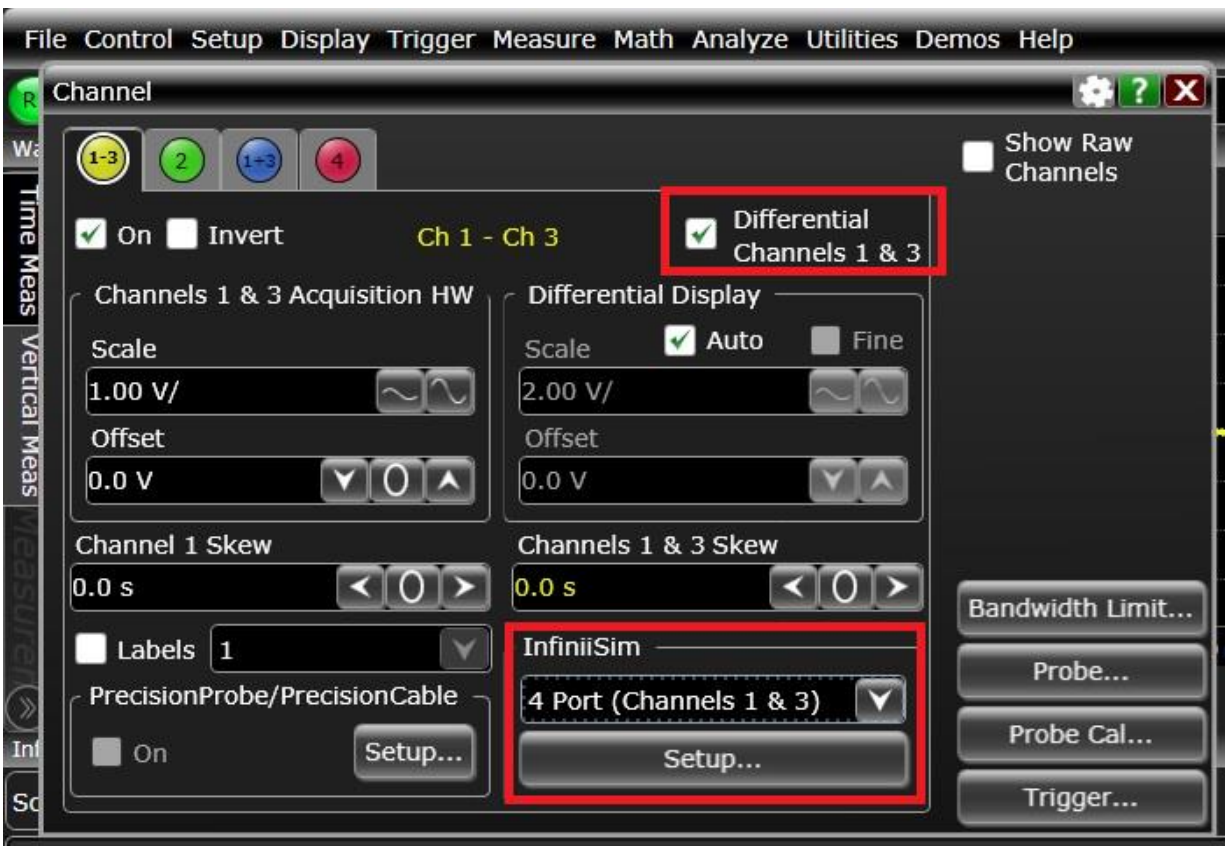




FIGURE 84. SMA CABLE TRANSFER FUNCTION– SET UP SCOPE CHANNELS 1 & 3

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


FIGURE 85. SMA CABLE TRANSFER FUNCTION– SELECT SETUP WIZARD ON SCOPE

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

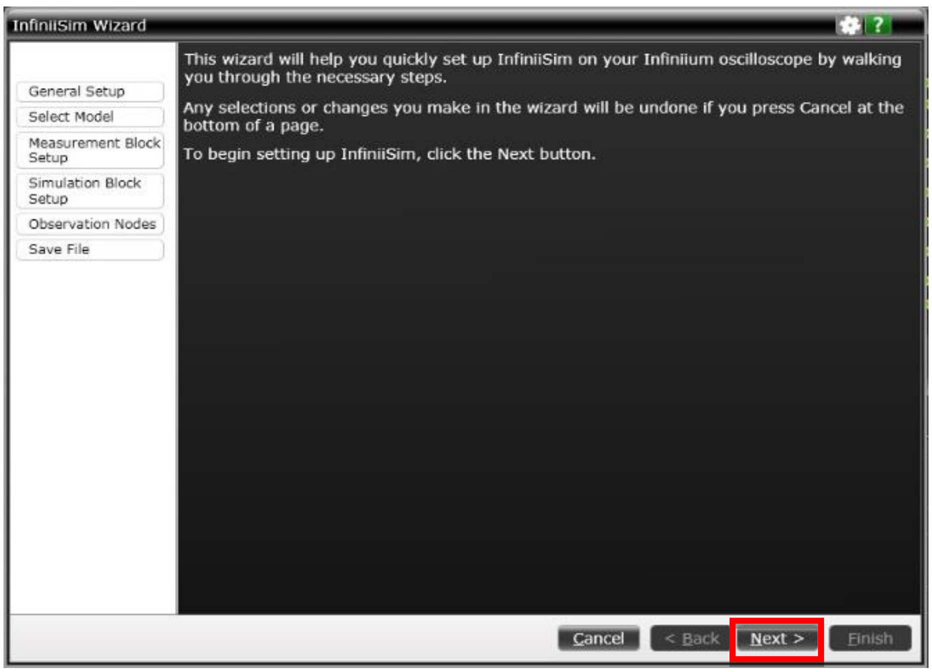



FIGURE 86. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #1

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

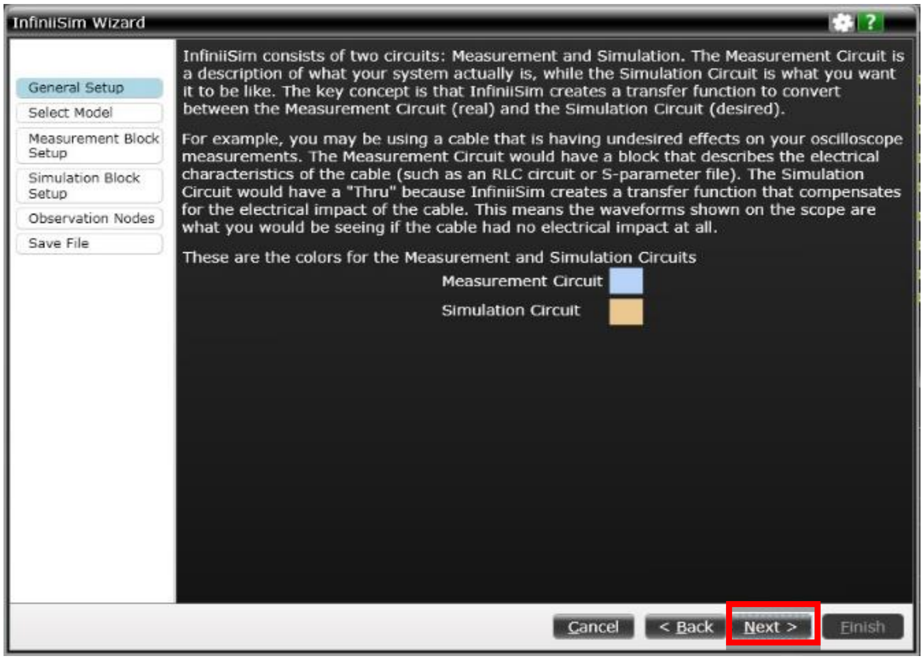



FIGURE 87. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #2

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

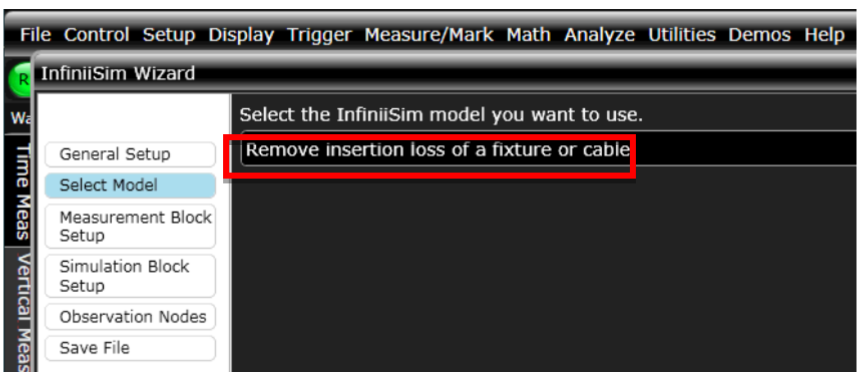



FIGURE 88. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #3

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

   Select **Next** to proceed.

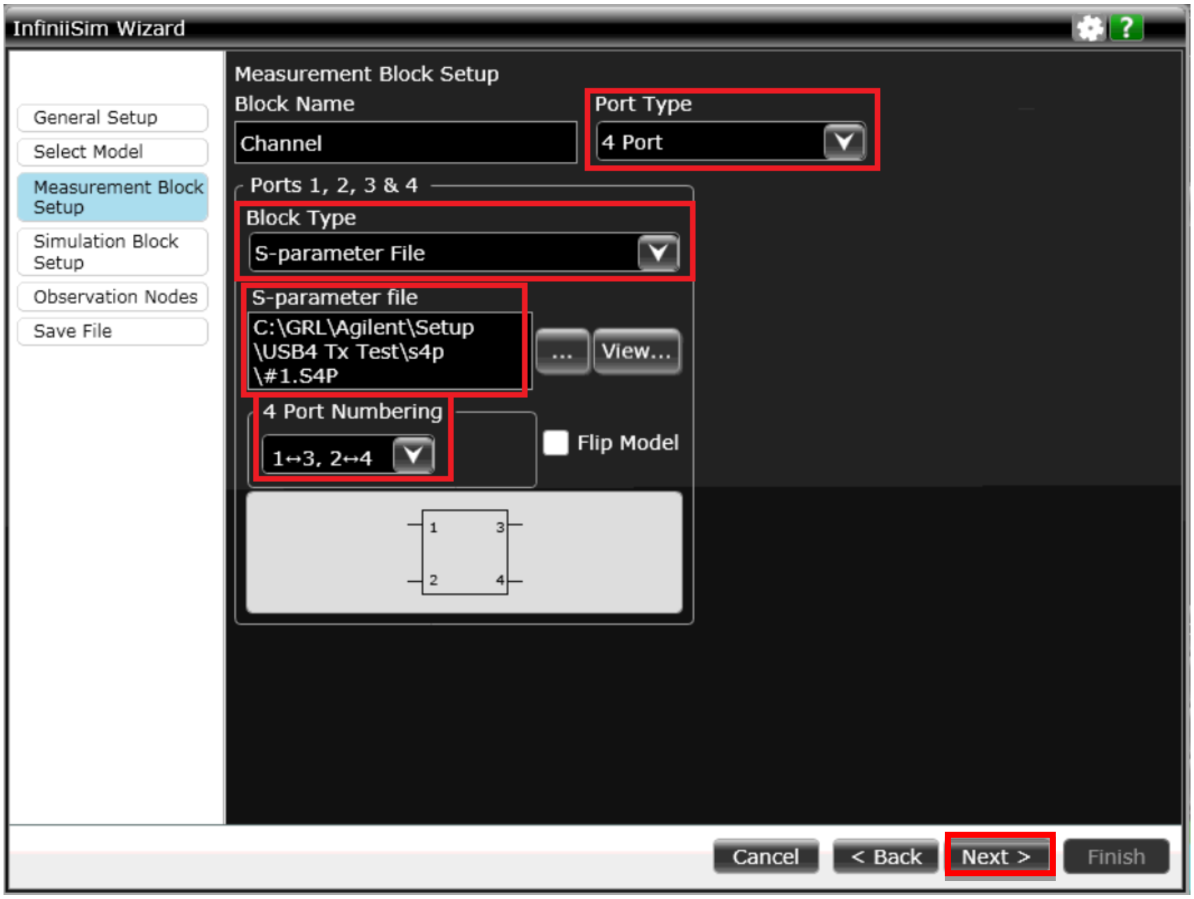
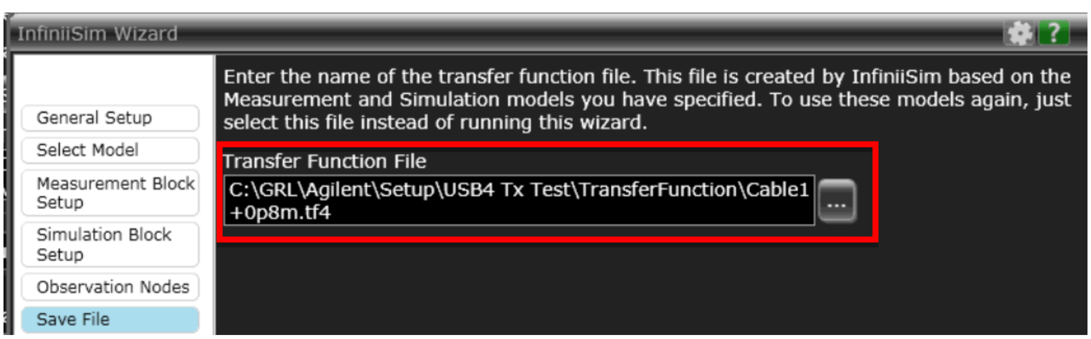



FIGURE 89. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE #4

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



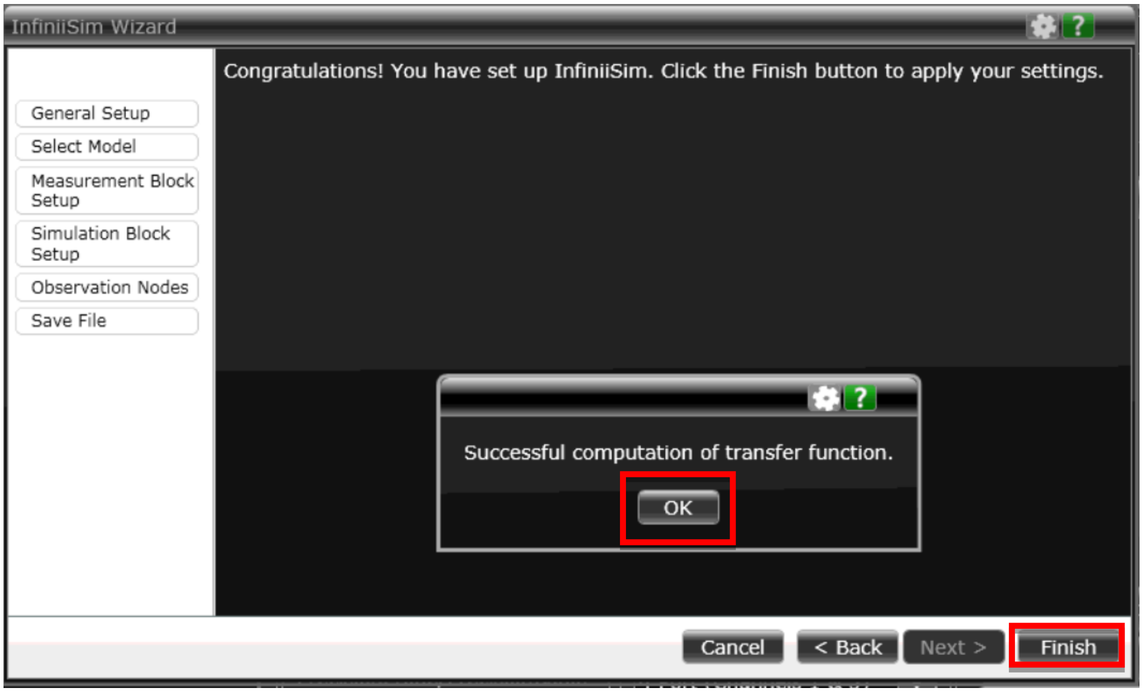
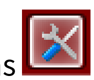
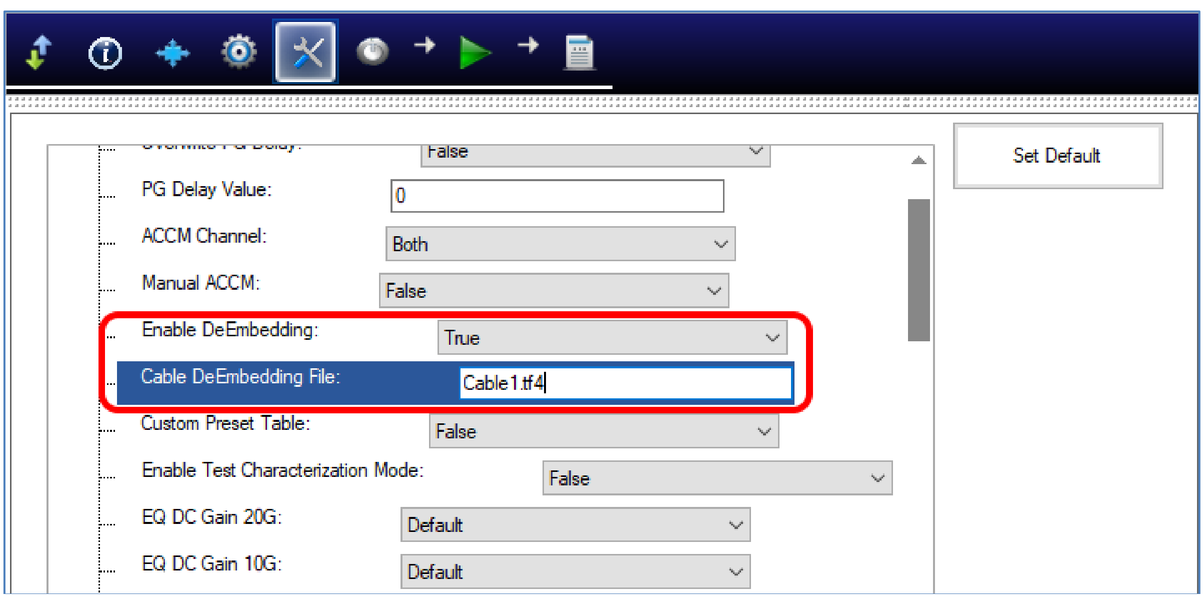



FIGURE 90. SMA CABLE TRANSFER FUNCTION– SET UP INFINIISIM ON SCOPE COMPLETED

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




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

## 15.2 Create Filter Files for the Tektronix Scope

### 15.2.1 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**:

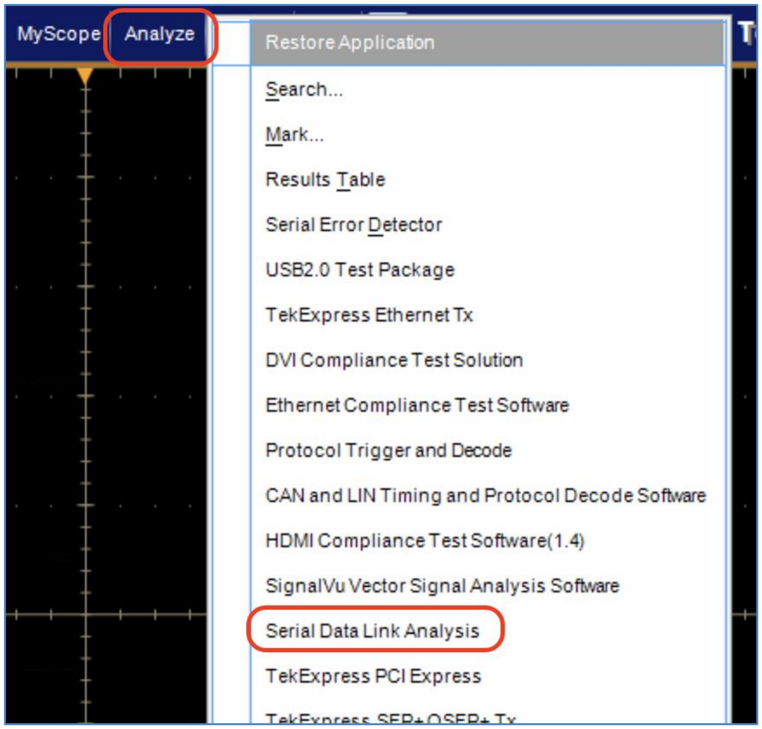



FIGURE 91. SELECT AND OPEN SERIAL DATA LINK ANALYSIS ON TEKTRONIX SCOPE

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.

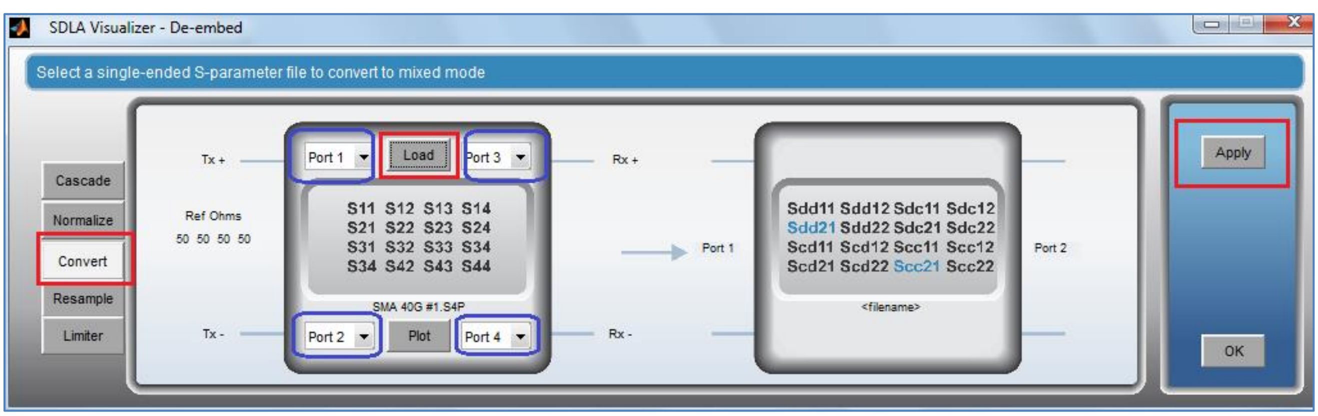



FIGURE 92. CONVERT TO MIXED MODE S-PARAMETERS

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

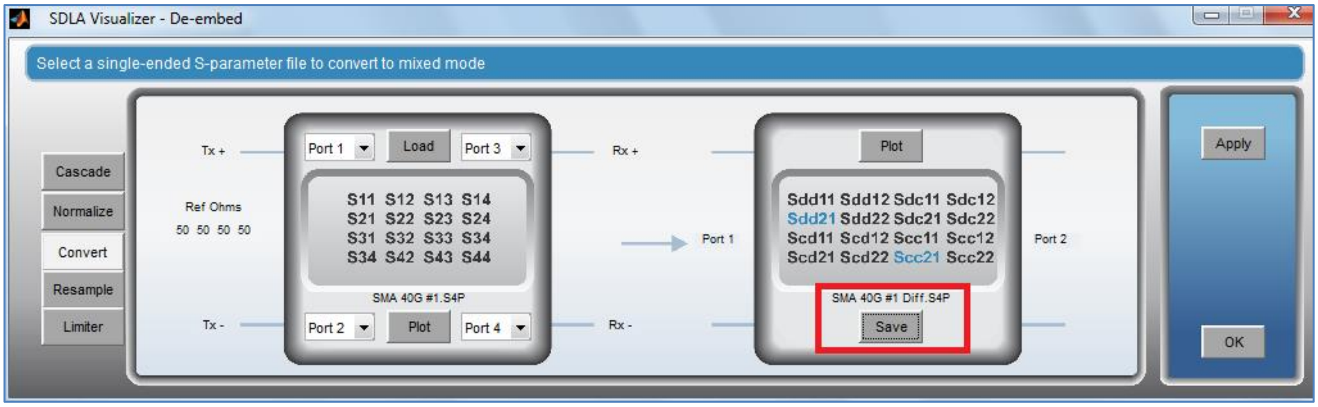



FIGURE 93. SAVE CONVERTED MIXED MODE S-PARAMETERS

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

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

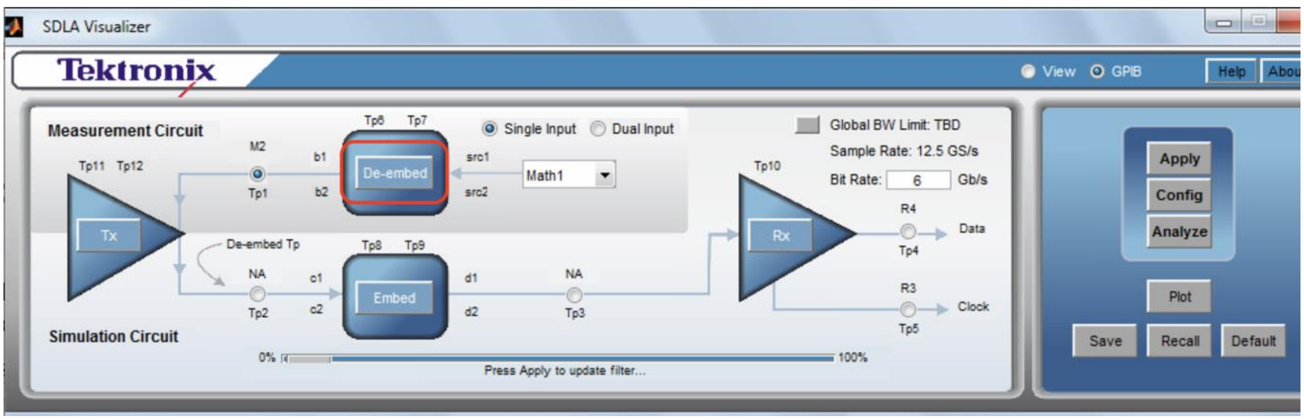



FIGURE 94. CREATE SMA CABLE DE-EMBEDDING FILES – #1

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

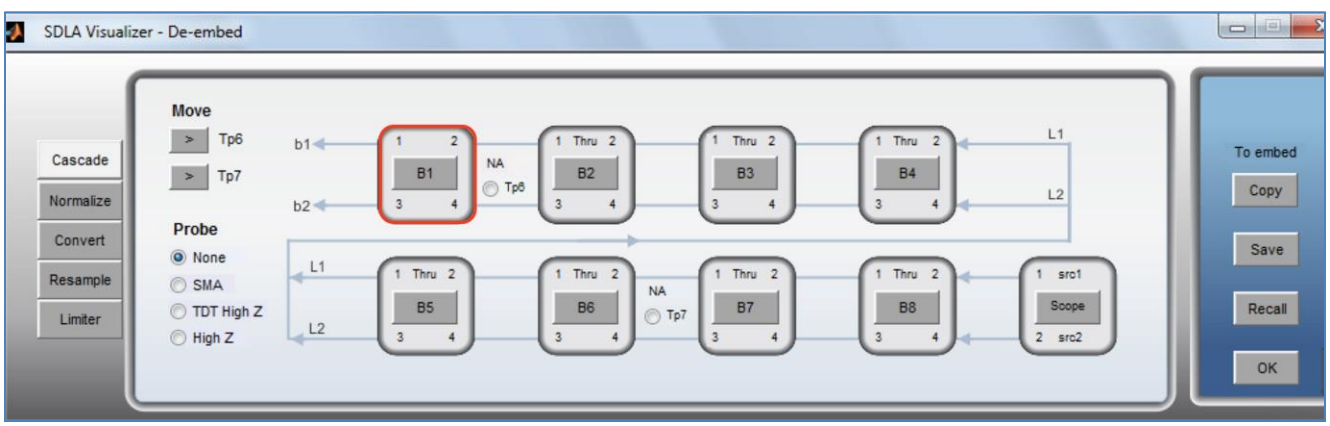



FIGURE 95. CREATE SMA CABLE DE-EMBEDDING FILES – #2

3. Click on the **Browse** button to load the mixed mode S-parameter file that has been created from Section 15.2.1. Then click **OK**.

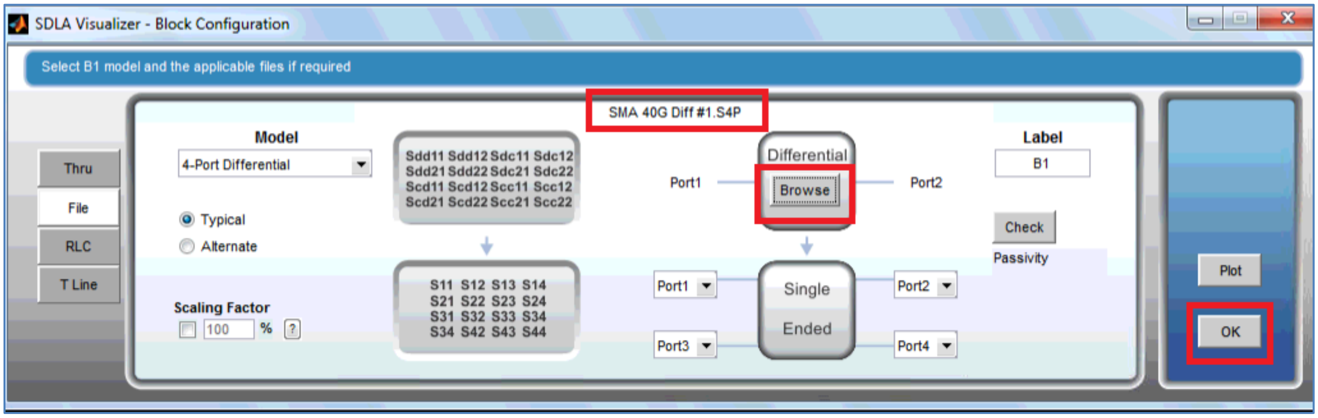


FIGURE 96. CREATE SMA CABLE DE-EMBEDDING FILES – #3

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

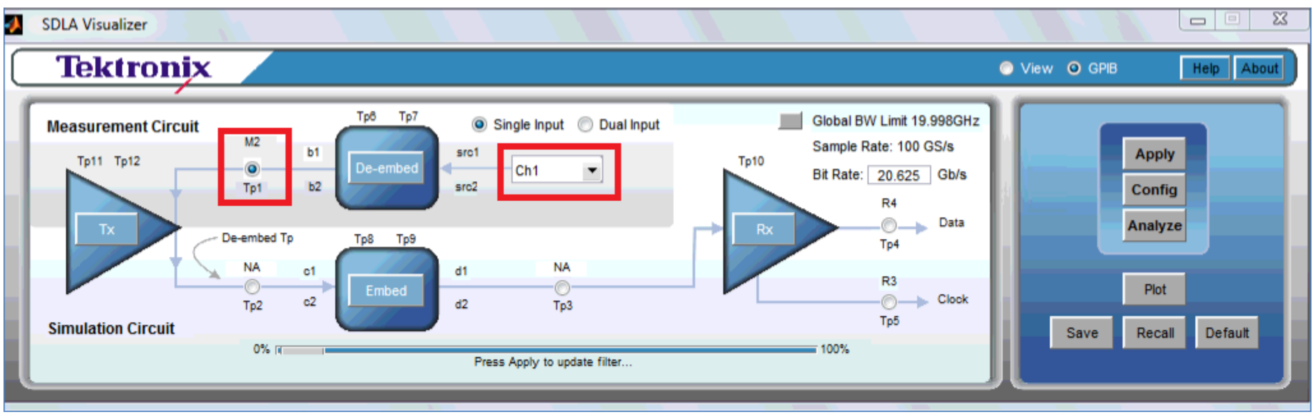


FIGURE 97. CREATE SMA CABLE DE-EMBEDDING FILES – #4

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

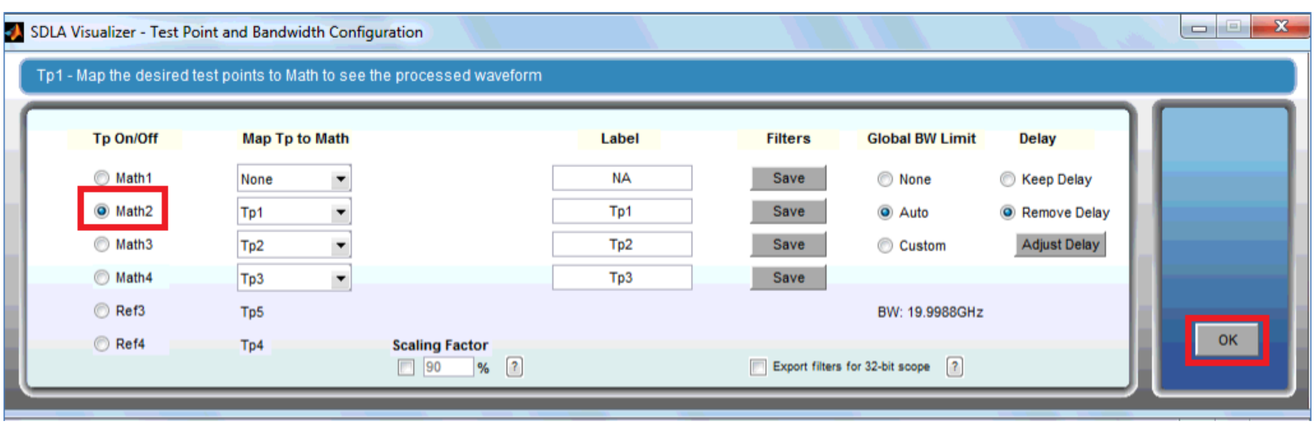


FIGURE 98. CREATE SMA CABLE DE-EMBEDDING FILES – #5

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

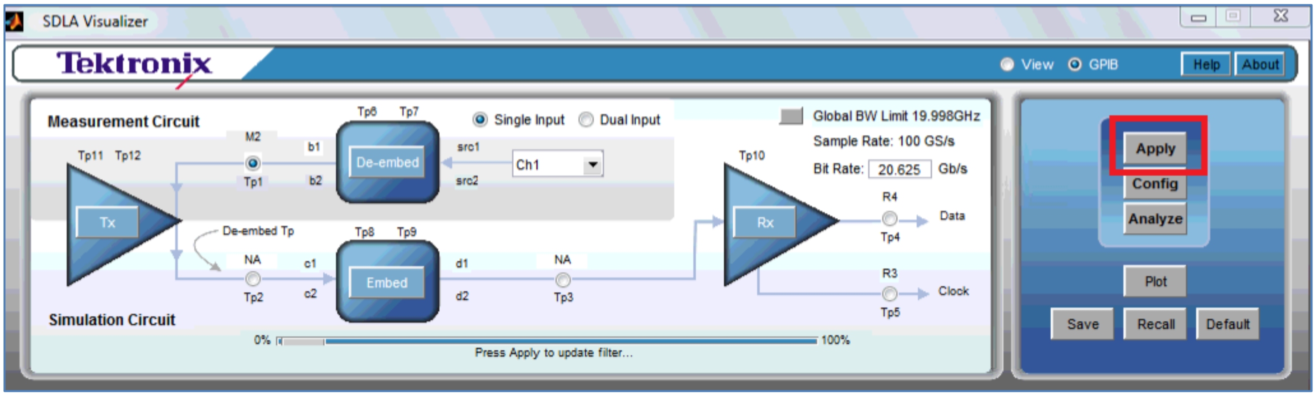
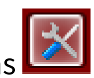
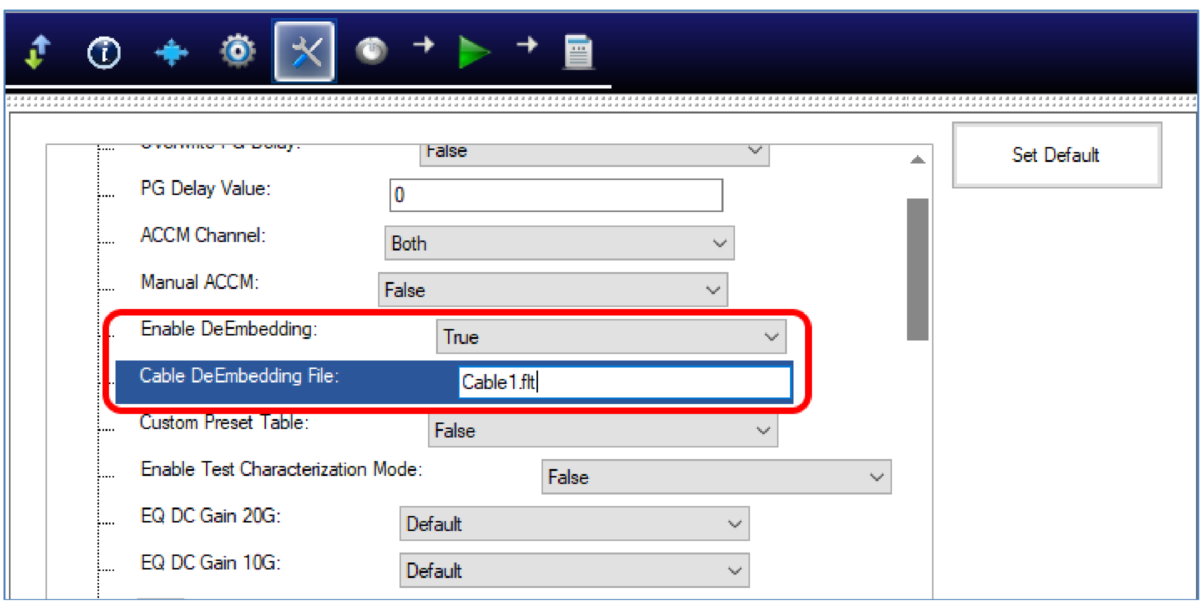



FIGURE 99. CREATE SMA CABLE DE-EMBEDDING FILES – #6

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\ Anritsu USB4 Rx Test\TransferFunction"*** directory on the Tektronix scope and rename the file for de-embedding of channels 1 & 3.

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

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