



GRL Platform Solutions

**IEEE 802.3ck 400 GbE 53-Gbaud PAM4
Backplane/Cable Interface Receiver Compliance Test
Automation Solution User Guide & MOI
Using GRL-8023CK-CRKR-RXA Automation Test
Software,
Anritsu MP1900A BERT,
and
Keysight N1000A + N1060A DCA-X Sampling
Oscilloscope**

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1 Introduction

This user manual provides information using the GRL-8023CK-CRKR-RXA test automation solution to set up and test the receiver (Rx) of 53-Gbaud PAM4 cable and backplane interfaces to meet IEEE 802.3ck standards compliance for up to 400GBASE-CR4 or 400GBASE-KR4.

The main body of this documentation first describes how to configure the GRL-8023CK-CRKR-RXA test software to calibrate the receiver interference and jitter tolerance of the CR/KR interface. This includes calibration of the BERT with a victim signal, FEXT signal and noise signal source and jitter amplitude. The GRL Platform Solutions software will automate these calibration along with Channel Operating Margin (COM) calculation of the noise amplitude to be added.

After completing calibration, the GRL-8023CK-CRKR-RXA software will automate compliance testing for the CR/KR interface receiver using a BER of $<2.4 \times 10^{-4}$ and FEC error ratio of $<10^{-3}$ as a metric. Testing of the DUT includes Rx equalizer optimization, Rx interference tolerance and jitter tolerance for respective channel test cases.

The GRL-8023CK-CRKR-RXA software performs calibration & test automation according to IEEE 802.3ck-approved Methods of Implementation (MOI's) with the Anritsu BERT and the Keysight DCA-X sampling oscilloscope. The GRL Platform Solutions software is run from the computer or oscilloscope to provide automation control to test the DUT for IEEE 802.3ck Rx electrical compliance. When combined with a satisfactory level of interoperability testing, these tests provide a reasonable level of confidence that the DUT's will function properly in most IEEE 802.3ck environments.

Note: For manual test methodology, refer to Appendix of this documentation or IEEE 802.3ck for approved Method of Implementation (MOI's) as technical reference.

2 Resource Requirements

Note: Equipment requirements may vary according to the lab setup and DUT. Below are the recommended lists of equipment for the typical test setup.

2.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – SYSTEMS AND ACCESSORIES

System & Accessory	Qty.	Description/Key Spec Requirement
Oscilloscope	1	Keysight N1000A + N1060A DCA-X Sampling Oscilloscope with N1091CKCA Tx test application software [Note: Ensure that all oscilloscope channels are calibrated before running tests]
BERT	1	Anritsu MP1900A Signal Quality Analyzer-R, with following modules: - MU196020A PAM4 Pulse Pattern Generator (Slot 1, 2 & 3) ^[a] - MU181500B Jitter Modulation Source (Slot 5-6) - MU181000B 4-Port Synthesizer (Slot 7-8)
Vector Network Analyzer	1	Anritsu MS4647B Vector Network Analyzer > 50 GHz
Signal Generator	1	Anritsu MG3692C Signal Generator use 7.25 GHz fixed
Noise Generator (<i>alternative noise source</i>)	1	Noisecom UFX7000B Series Programmable Noise Generator or equivalent
Frequency Dependent Attenuator	2 2	Anritsu Devices AN44168B 30 GHz Bessel Filter ^[b] and Anritsu J1790A cable ^[b]
Pick-off Tee	2	Anritsu J1793A Pick-off Tee
V(f) - V(f) Adapter	2	Anritsu 34VFVF50A Adapter
V(f) - K(m) Adapter	2	Anritsu 34VFKM50A Adapter
Terminator	2	Anritsu J1632A SMA-connector 50-ohm terminator

System & Accessory	Qty.	Description/Key Spec Requirement
Fixed Attenuator	2	Anritsu 41V-10 10-dB Fixed Attenuator
Miniature Circuit Breaker ^[c]	2	For CR test
Cable Assembly (11 dB) ^[c]	1	For Test 1 case in CR test
Cable Assembly (19.75 dB) ^[c]	1	For Test 2 case in CR test
Computer (laptop or desktop)	1	Windows 7+ OS For automation control

^[a] With Option 002 (58 Gbaud) and Option 011 (4 Tap Emphasis).

^[b] 5.4 dB for Test 2 case in CR test.

^[c] DUT connector type dependent.

TABLE 2. EQUIPMENT REQUIREMENTS – CABLES

Cable ^[a]	Qty.
Anritsu J1789A V-type coaxial cable (40 cm)	6
Anritsu J1790A V-type coaxial cable (80 cm)	4
Anritsu J1625A SMA-type coaxial cable (1 m)	1

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

2.2 Software Requirements

TABLE 3. SOFTWARE REQUIREMENTS

Software	Description/Source
GRL-8023CK-CRKR-RXA	GRL Platform Solutions IEEE 802.3ck (400 GbE) 53-Gbaud PAM4 Backplane/Cable Interface Automated Receiver Calibration and Compliance Test Solution – www.grlps.com
VISA (Virtual Instrument Software Architecture) API Software	VISA Software is required to be installed on the controller PC running GRL-8023CK-CRKR-RXA software. GRL Platform Solutions' software framework has been tested to work with all three versions of VISA available on the Market: 1. NI-VISA: http://www.ni.com/download/ni-visa-17.0/6646/en/ 2. Keysight IO Libraries: www.keysight.com (Search on IO Libraries) 3. Tektronix TekVISA: www.tek.com (Downloads > Software > TekVisa)
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 MP1900A BERT.

3 Set Up GRL-8023CK-CRKR-RXA Automation Software

This section provides the procedures to start up and pre-configure the GRL-8023CK-CRKR-RXA automation software before running tests. It also helps users familiarize themselves with the basic operation of the software.

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

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

3.1 Download GRL-8023CK-CRKR-RXA Software

Download and install the GRL-8023CK-CRKR-RXA software as follows:

1. If the GRL Platform Solutions software is to be installed on a PC (where it is referred to as 'control PC'), install VISA (Virtual Instrument Software Architecture) on to the PC where GRL-8023CK-CRKR-RXA is to be used (see Section 2.2).
2. Download the software ZIP file package from the GRL Platform Solutions support site.
3. The ZIP file contains:
 - **IEEE8023ck_Rx_PatternFilesInstallationxxxxxxxxxxSetup.exe** – Run this on the Anritsu MP1900A BERT to install the pattern setup files.
 - **IEEE8023ck_RxTestApplicationxxxxxxxxxxSetup.exe** – Run this on the PC or on the oscilloscope to install the application.
 - **IEEE8023ck_Rx_ScopeSetupFilesInstallationxxxxxxxxxxSetup.exe** – Run this on the oscilloscope to install the scope setup files.

3.2 Launch and Set Up GRL-8023CK-CRKR-RXA Software

1. Once the GRL-8023CK-CRKR-RXA software is installed, open the GRL folder from the Windows Start menu. Click on **GRL – Automated Test Solutions** within the GRL folder to launch the GRL Platform Solutions software framework.

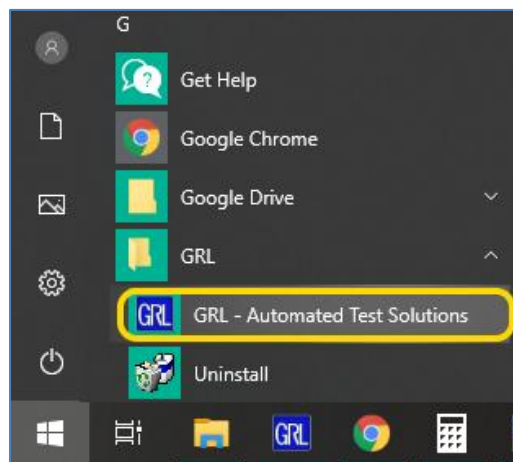


FIGURE 1. SELECT AND LAUNCH GRL PLATFORM SOLUTIONS FRAMEWORK

2. From the **Application → Rx Test Solution** drop-down menu, select '**Anritsu IEEE802.3ck Rx Test**' to start the IEEE802.3ck PAM4 CR/KR Rx Test Application. If the selection is grayed out, it means that your license has expired.

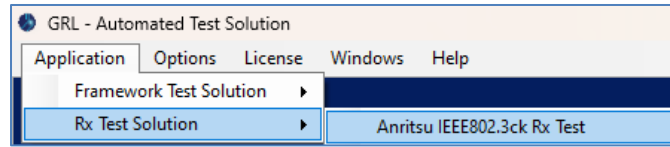


FIGURE 2. START IEEE802.3CK PAM4 CR/KR RX TEST APPLICATION

3. To enable license, go to **License → License Info**.

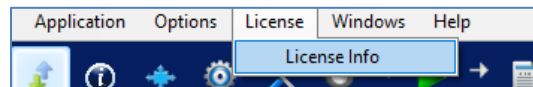


FIGURE 3. SEE LICENSE DETAILS

- a) Check the license status for the installed application.

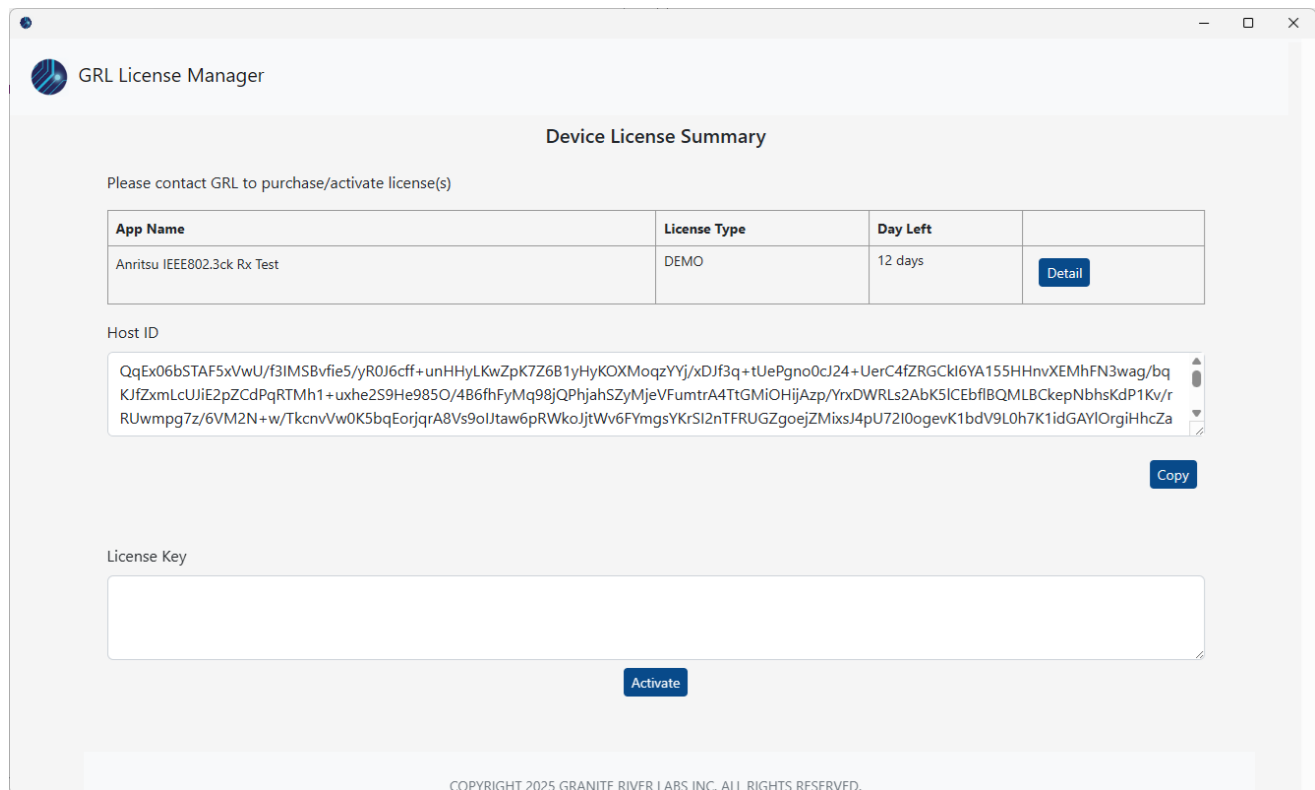


FIGURE 4. CHECK LICENSE FOR INSTALLED APPLICATION

- b) Activate a License:

- If you have an Activation Key, enter it in the **License Key** field provided and select **Activate**. The installed application is ready for use upon successful activation.
- If you do not have an Activation Key, close the above window to use a demo version of the application over a free 12-day trial period.

Note: Once the 12-day trial period ends, you will need to request an Activation Key to continue using the application on the same computer by contacting support@grlps.com.

4. Select the Equipment Setup icon  on the Anritsu IEEE802.3ck Rx Test Application menu.
5. Connect the Anritsu MP1900A BERT via LAN to the GRL Platform Solutions 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.

6. On the Scope or control PC, obtain the network addresses for all the connected instruments from the device settings. Note these addresses as they will be used to connect the instruments to the GRL Platform Solutions automation software.
7. On the Equipment Setup page of the Anritsu IEEE802.3ck Rx Test Application, type in the address of each connected instrument into the ‘Address’ field.
(Note: If the GRL Platform Solutions software is installed on the **Keysight Scope**, type in the Scope IP address, for example “TCPIP0::127.0.0.1::inst0::INSTR”.)

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

If the GRL Platform Solutions 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.

8. 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.

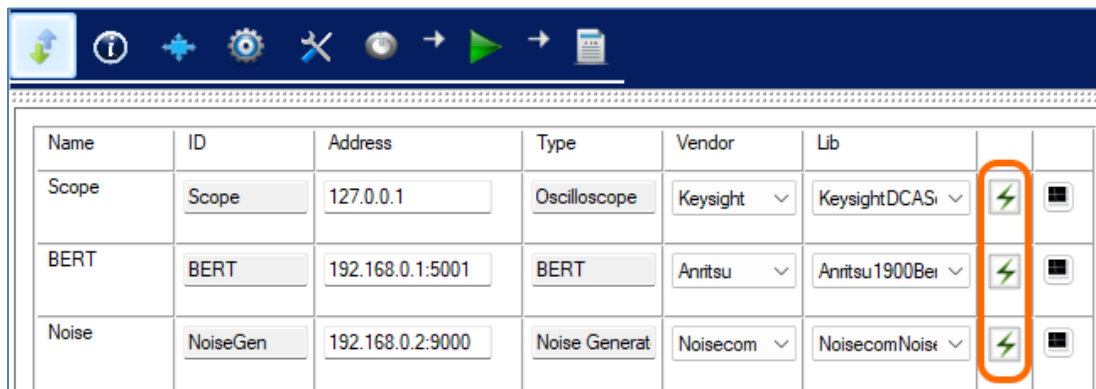


FIGURE 5. GRL PLATFORM SOLUTIONS SOFTWARE INSTRUMENT CONNECTION SETUP

Note: Additional information for connecting the Keysight oscilloscope to the PC is provided in the Appendix of this document.

3.3 Set Up Remote File Server

1. The **GRLRemoteServer.exe** will also be installed along with the **IEEE8023ck_Rx_ScopeSetupFilesInstallationxxxxxxxxSetup.exe** on the Scope. The GRLRemoteServer.exe is installed under the “C:\GRL\GRLRemoteProxyServer” directory.

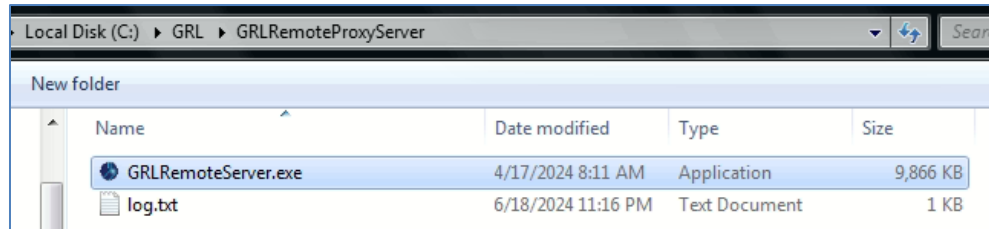


FIGURE 6. INSTALLED GRLREMOTESERVER.EXE FILE DIRECTORY

2. Double-click on **GRLRemoteServer.exe**. When the icon appears on the system tray, right-click on the icon and then select **GRL Remote Server**.

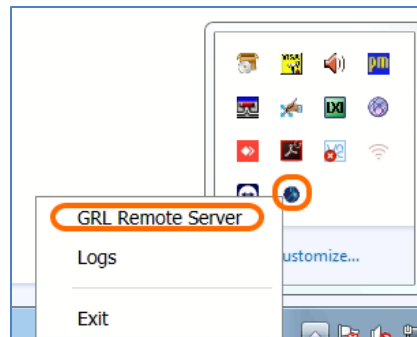


FIGURE 7. START GRL REMOTE SERVER

3. The **GRL Proxy Server** dialog will appear displaying the remote server’s IP address and port number.

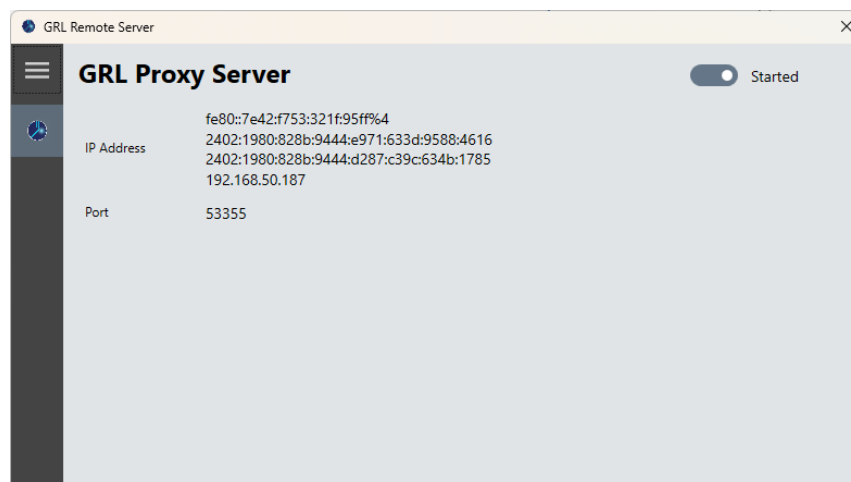


FIGURE 8. RUNNING GRL REMOTE SERVER

4. If the GRL Platform Solutions software is installed on the PC to control the Scope, the GRLRemoteServer.exe must be run on the Scope to move large waveform files back to the control PC for post-processing.

5. When running the GRLRemoteServer.exe, make sure that the control PC and Scope are connected to the same network, using IP addresses as in following example:
 - Control PC IP address: 192.168.50.187
 - Scope IP address: 192.168.50.35

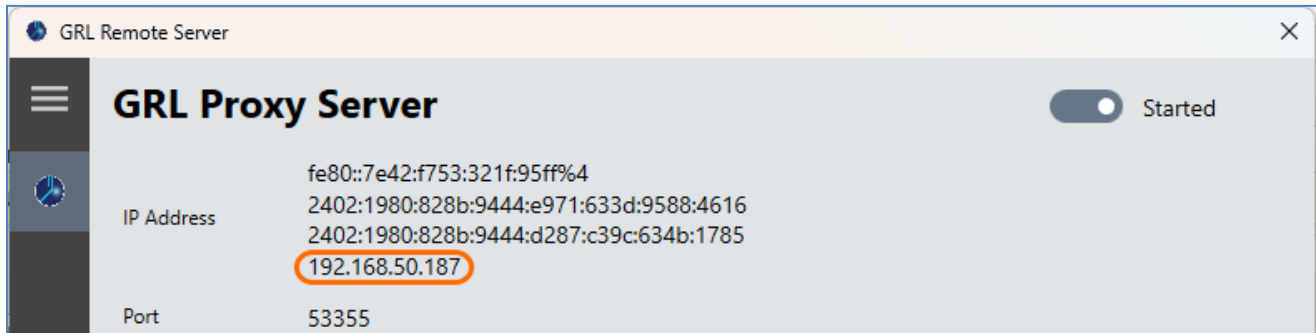


FIGURE 9. VERIFY REMOTE SERVER CONNECTION FOR CONTROL PC AND SCOPE

6. On the GRL Platform Solutions IEEE802.3ck Rx Test Application, go to the Configurations  page. Select “True” for the “Enable Remote Server” field. Then, configure the “Remote Server IP” and “Remote Server Port” parameters to match the network settings of the GRL Remote Server as shown in the example below:

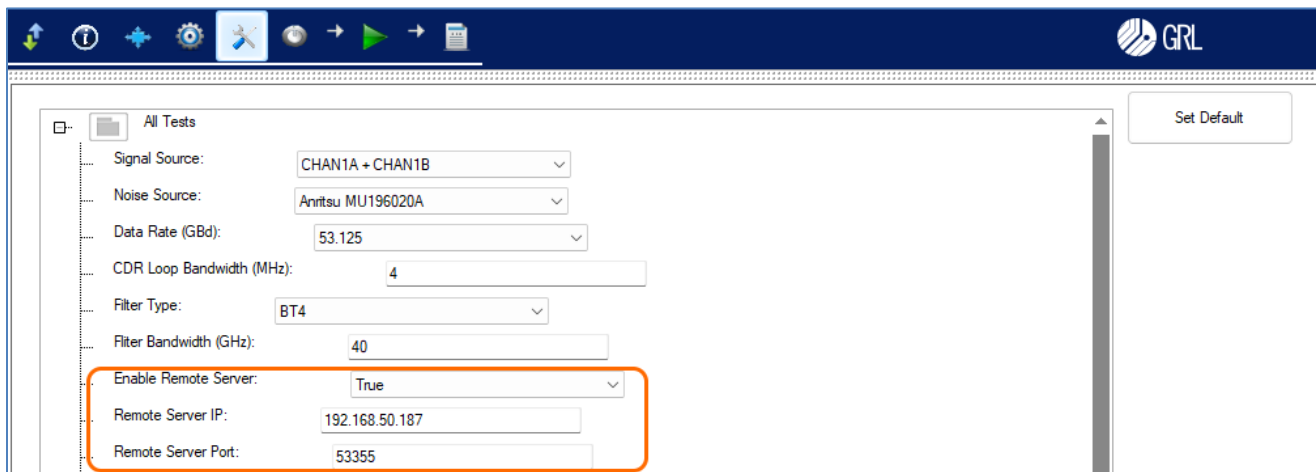


FIGURE 10. CONFIGURE REMOTE SERVER NETWORK SETTINGS ON GRL PLATFORM SOLUTIONS SOFTWARE

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

3.4 Pre-Configure Software Before Calibration/Testing

Once all equipment is successfully connected from the previous section, proceed to set up the preliminary settings before going to the advanced measurement setup.

3.4.1 Enter Calibration/Test Session Information

Select  from the 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.

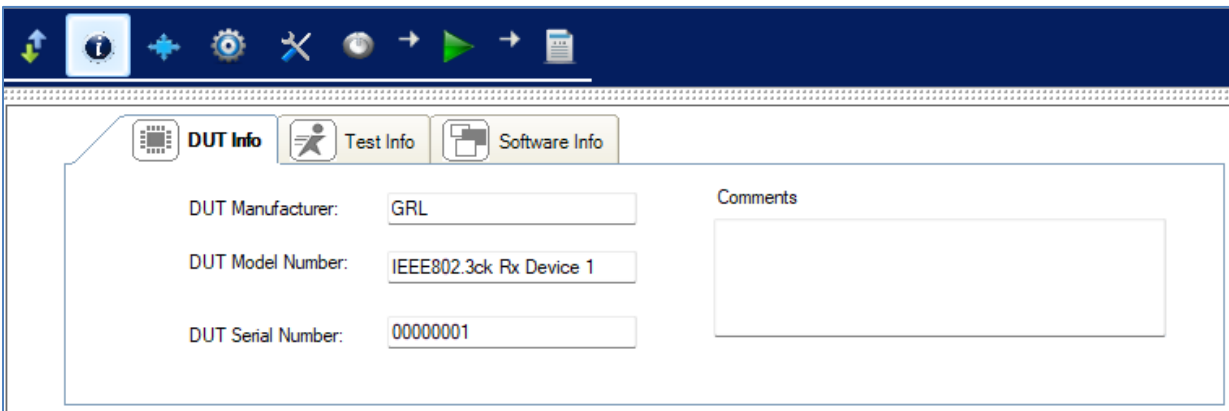


FIGURE 11. ENTER CALIBRATION/TEST SESSION INFORMATION

4 Receiver Calibration Setups

The GRL-8023CK-CRKR-RXA test solution supports automated Rx interference and jitter tolerance calibration for the PAM4 CR/KR interfaces. To perform calibration, the GRL-8023CK-CRKR-RXA software is run from the PC or oscilloscope to enable automation control for each step of calibration.

When calibration is completed, the GRL-8023CK-CRKR-RXA software will generate a test report detailing all results obtained from the calibration.

The following sections show the setup connection diagrams for the Anritsu MP1900A BERT calibration.

4.1 Connection Setup for Anritsu MP1900A BERT Generator Set

Figure 12 shows the connection setup between each module of the Anritsu MP1900A BERT Generator Set and the MG3692C Signal Generator.

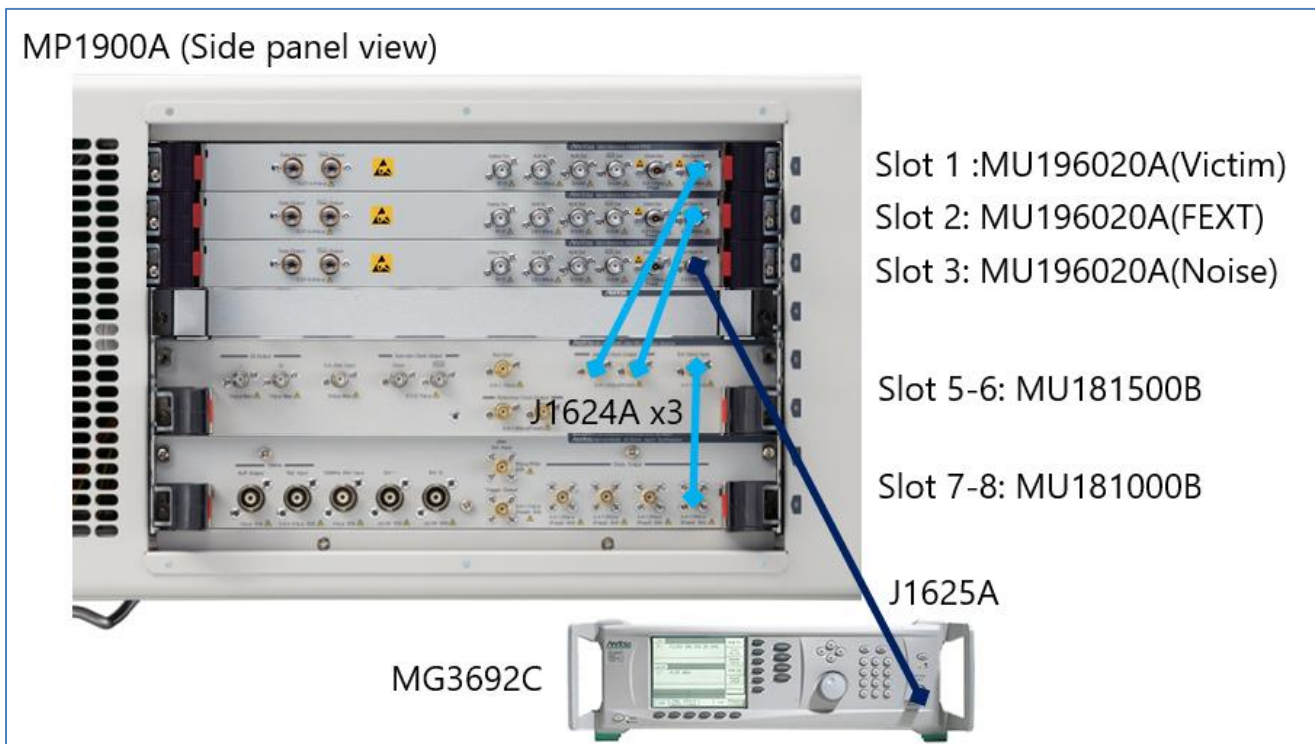


FIGURE 12. CONNECTION SETUP FOR MP1900A BERT GENERATOR SET MODULES AND MG3692C SIGNAL GENERATOR

Connection Steps:

1. Using the J1624A cable, connect the Jittered Clock Out of the MU181500B Jitter Modulator to the Ext Clock In of the MU196020A Pulse Pattern Generator (at Slot 1- used as the Victim signal source).
2. Using the J1624A cable, connect the other Jittered Clock Out of the MU181500B Jitter Modulator to the Ext Clock In of the MU196020A Pulse Pattern Generator (at Slot 2- used as the FEXT signal source).

3. Using the J1625A cable, connect the MG3692C output to the Ext Clock In of the MU196020A Pulse Pattern Generator (at Slot 3- used as the Noise signal source).
4. Using the J1624A cable, connect the MU181000B Clock Out to the MU181500B Ext Clock In.

4.2 Connection Setup for Victim Signal Calibration (CR Interface)

Figure 13 shows the calibration setup diagram for victim signal evaluation of the CR interface using the Anritsu MP1900A BERT and the Keysight N1000A + N1060A DCA-X sampling oscilloscope.

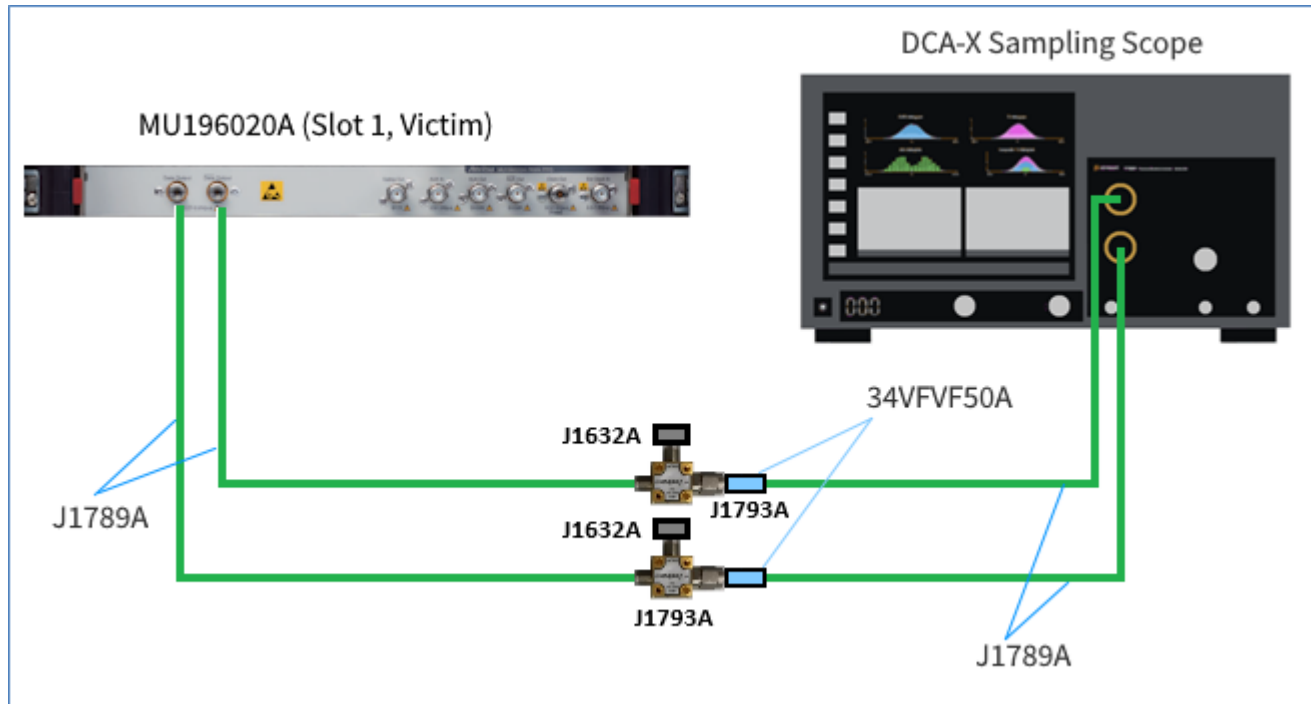


FIGURE 13. SETUP FOR VICTIM SIGNAL CALIBRATION (CR INTERFACE)

Connection Steps:

1. Using the MP1900A BERT setup connections (Section 4.1), connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to the J1793A pick-off tees and then to CHAN1A and CHAN1B of the Keysight N1000A + N1060A DCA-X sampling oscilloscope through the 34VFVF50A V(f) - V(f) adapters using the J1789A coaxial cables.
2. Connect the pick-off routes of the J1793A to the J1632A 50-ohm terminators.

4.3 Connection Setup for Victim Signal Calibration (KR Interface)

Figure 14 shows the calibration setup diagram for victim signal evaluation of the KR interface using the Anritsu MP1900A BERT and the Keysight N1000A + N1060A DCA-X sampling oscilloscope.

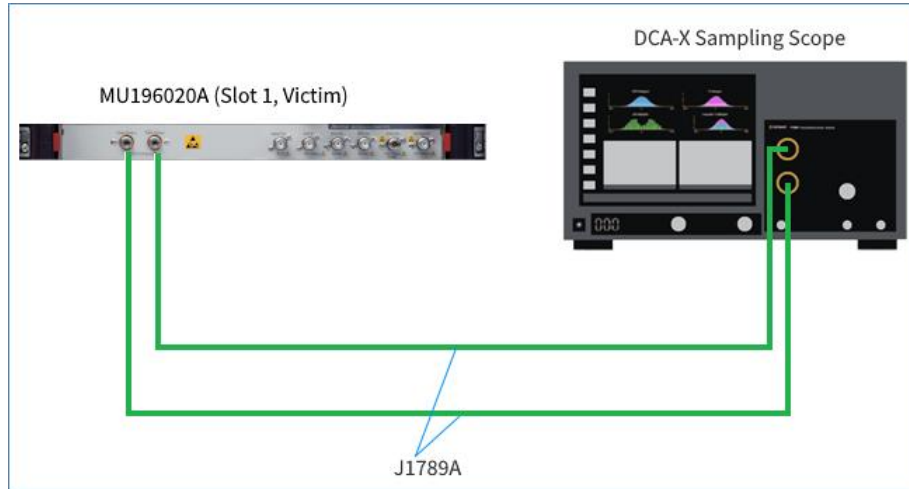


FIGURE 14. SETUP FOR VICTIM SIGNAL CALIBRATION (KR INTERFACE)

Connection Steps:

Using the MP1900A BERT setup connections (Section 4.1), connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to CHAN1A and CHAN1B of the Keysight N1000A + N1060A DCA-X sampling oscilloscope using the J1789A coaxial cables.

4.4 Connection Setup for FEXT Signal Calibration (CR/KR Interface)

Figure 15 shows the calibration setup diagram to check the amplitude of the MU196020A PAM4 Pulse Pattern Generator (Slot 2) used as the FEXT signal for the CR/KR interface using the Anritsu MP1900A BERT and the Keysight N1000A + N1060A DCA-X sampling oscilloscope.

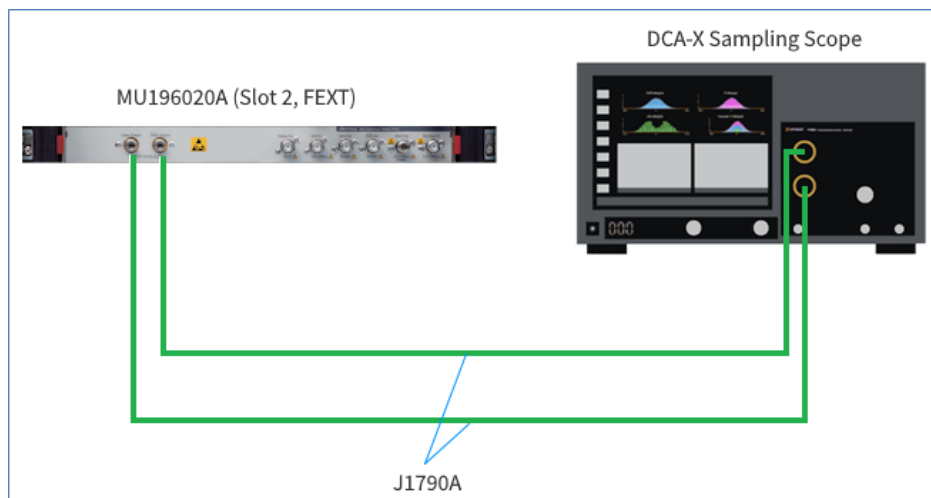


FIGURE 15. SETUP FOR FEXT SIGNAL CALIBRATION (CR/KR INTERFACE)

Connection Steps:

Using the MP1900A BERT setup connections (Section 4.1), connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to CHAN1A and CHAN1B of the Keysight N1000A + N1060A DCA-X sampling oscilloscope using the J1790A coaxial cables.

4.5 Connection Setup for Noise Signal Calibration (CR/KR Interface)

Figure 16 shows the calibration setup diagram to check the performance of the MU196020A PAM4 Pulse Pattern Generator (Slot 3) used as the Noise signal for the CR/KR interface using the Anritsu MP1900A BERT and the Keysight N1000A + N1060A DCA-X sampling oscilloscope.

Note: The Noisecom noise generator can be used as the noise source alternative to the BERT MU196020A PPG. Replace the MU196020A PPG with the Noisecom noise generator and connect the data outputs to the oscilloscope channels through the Anritsu 34VFKF50A coaxial adapters using the Anritsu J1551A coaxial cables.

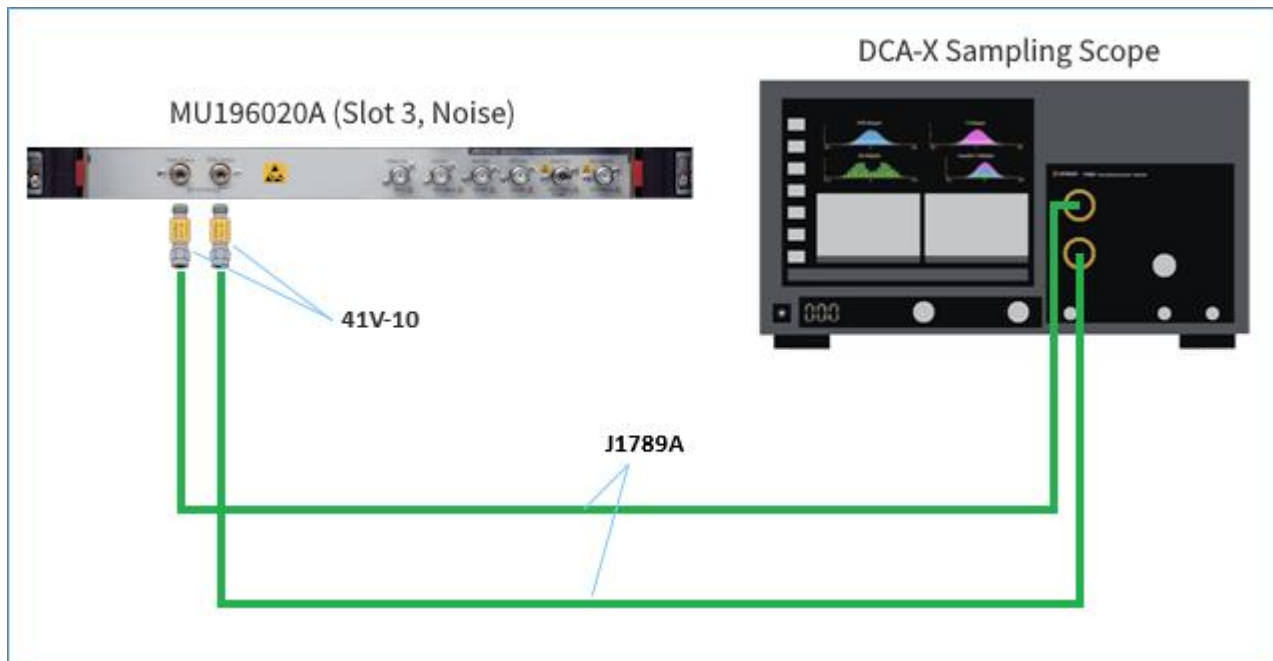


FIGURE 16. SETUP FOR NOISE SIGNAL CALIBRATION (CR/KR INTERFACE)

Connection Steps:

1. Using the MP1900A BERT setup connections (Section 4.1), connect the MU196020A (at Slot 3- Noise Signal Source) data outputs through the 41V-10 fixed attenuators to CHAN1A and CHAN1B of the Keysight N1000A + N1060A DCA-X sampling oscilloscope using the J1789A coaxial cables.

4.6 Connection Setup for Jitter Amplitude Calibration (CR Interface)

Figure 17 shows the calibration setup diagram to check the jitter amplitude of the MU196020A PAM4 Pulse Pattern Generator (Slot 1) used as the Victim signal for the CR interface using the Anritsu MP1900A BERT and the Keysight N1000A + N1060A DCA-X sampling oscilloscope.

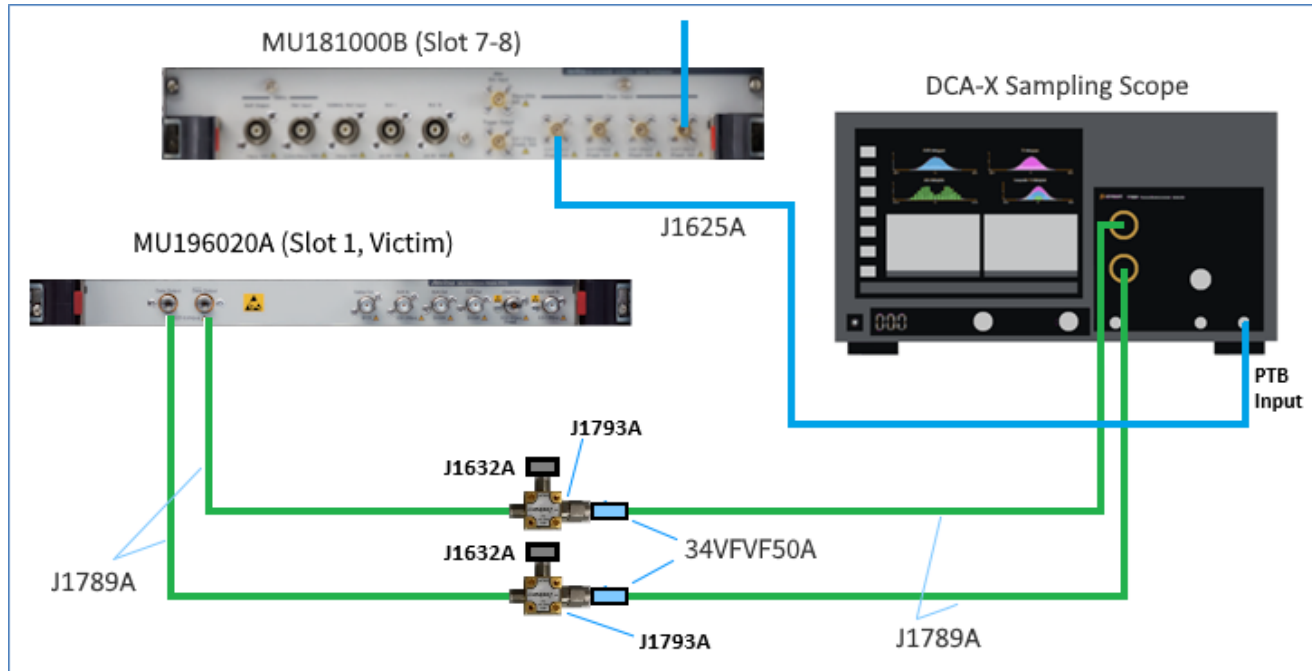


FIGURE 17. SETUP FOR JITTER AMPLITUDE CALIBRATION (CR INTERFACE)

Connection Steps:

1. Using the MP1900A BERT setup connections (Section 4.1), connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to the J1793A pick-off tees and then to CHAN1A and CHAN1B of the Keysight N1000A + N1060A DCA-X sampling oscilloscope through the 34VFVF50A V(f) - V(f) adapters using the J1789A coaxial cables.
2. Connect the pick-off routes of the J1793A to the J1632A 50-ohm terminators.
3. Using the J1625A coaxial cable, connect one of the Clock outputs of the MU181000B Synthesizer (Slot 7-8) to the Precision Timebase (PTB) input of the N1060A module.

4.7 Connection Setup for Jitter Amplitude Calibration (KR Interface)

Figure 18 shows the calibration setup diagram to check the jitter amplitude of the MU196020A PAM4 Pulse Pattern Generator (Slot 1) used as the Victim signal for the KR interface using the Anritsu MP1900A BERT and the Keysight N1000A + N1060A DCA-X sampling oscilloscope.

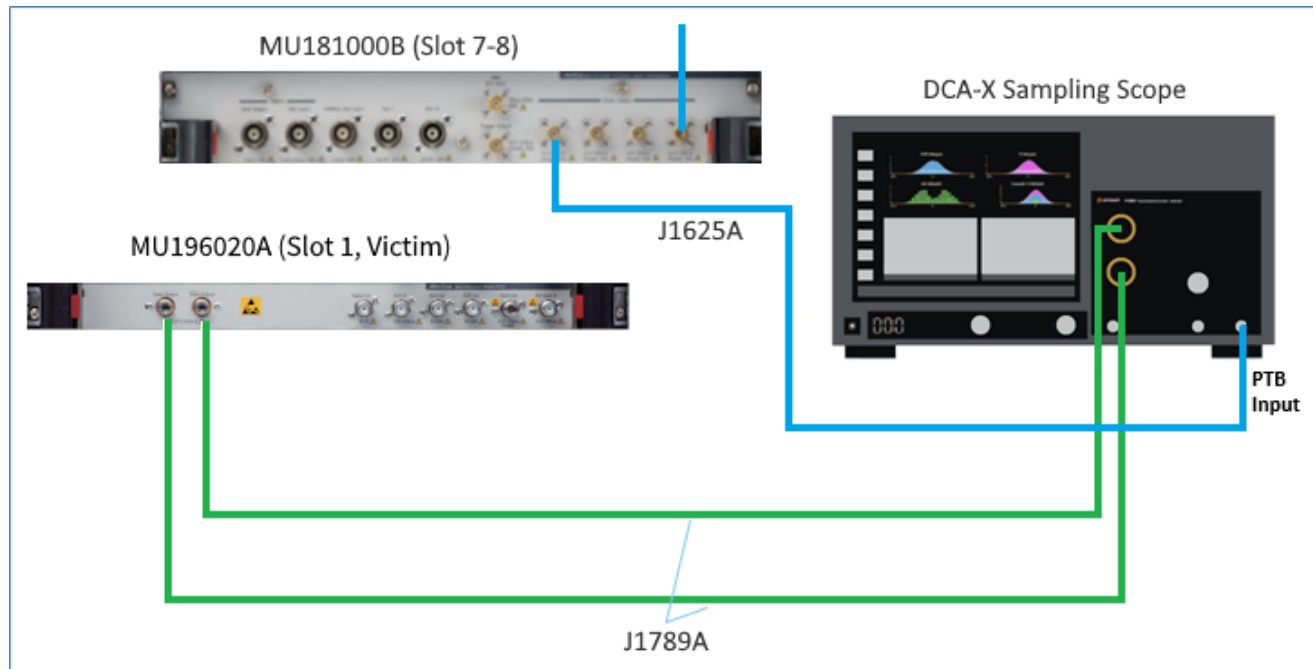


FIGURE 18. SETUP FOR JITTER AMPLITUDE CALIBRATION (KR INTERFACE)

Connection Steps:

1. Using the MP1900A BERT setup connections (Section 4.1), connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to CHAN1A and CHAN1B of the Keysight N1000A + N1060A DCA-X sampling oscilloscope using the J1789A coaxial cables.
2. Using the J1625A coaxial cable, connect one of the Clock outputs of the MU181000B Synthesizer (Slot 7-8) to the Precision Timebase (PTB) input of the N1060A module.

5 Calibrating Using GRL-8023CK-CRKR-RXA Software

5.1 Set Measurement Conditions

Select  from the software menu to access the **Conditions** page to set the conditions for calibration and testing. The GRL Platform Solutions software will perform calibration and testing for the selected defined SJ frequencies and test channel cases.

Recommended procedure:

- *Step 1:* When calibrating, select all conditions that may be used for testing, and perform the calibration.
 - *Step 2:* Once calibration is completed and ready for testing, re-select the necessary test conditions. For example, if required to test for a single SJ frequency, then select only the required SJ frequency for testing.
1. Select the **Test Channel** case(s). [Note: Test 1 is a test case that corresponds to low-loss channels while Test 2 is a test case that corresponds to high-loss channels.]

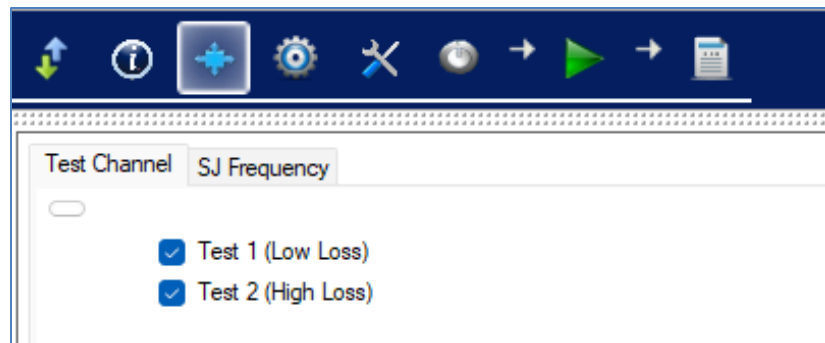


FIGURE 19. SELECT TEST CHANNEL CASE(S)

2. Select the **SJ Frequency**(s).

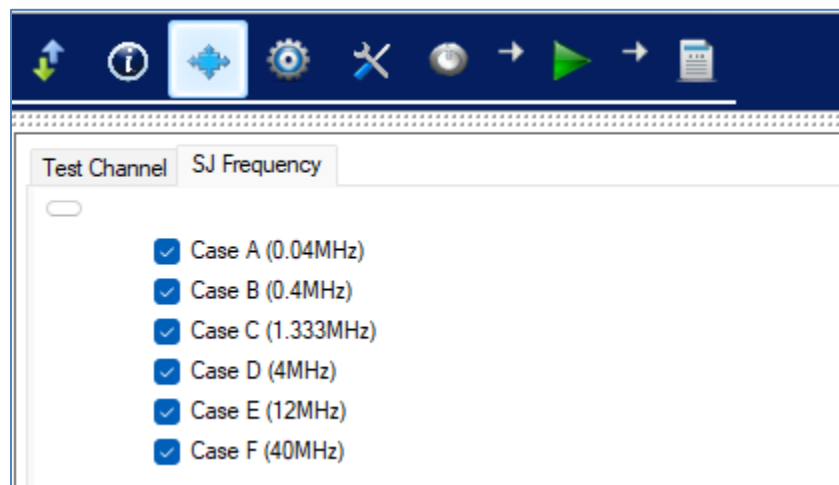


FIGURE 20. SELECT SJ FREQUENCY(S)

5.2 Set Calibration Requirements

Select  from the software menu to access the **Setup Configuration** page to configure the calibration setup requirements.

5.2.1 Test Setup Tab

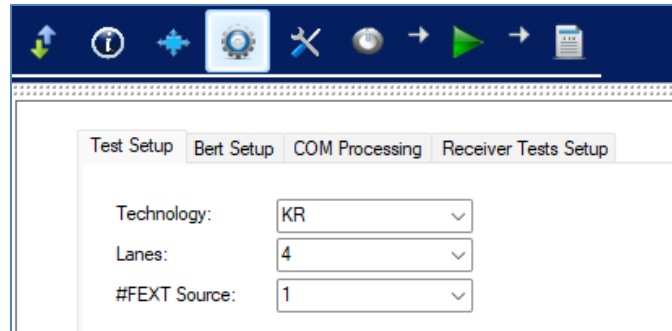


FIGURE 21. TEST SETUP CONFIGURATION

- Technology:** Select the cable (**CR**) interface (100GBASE-CR1 / 200GBASE-CR2 / 400GBASE-CR4) or backplane (**KR**) interface (100GBASE-KR1 / 200GBASE-KR2 / 400GBASE-KR4) as the DUT.
- Lanes:** Select the DUT lanes to be tested according to the supported interface.
- #FEXT Source:** Select the FEXT crosstalk measurement lanes using the BERT PAM4 PPG as the FEXT signal source.

5.2.2 BERT Setup Tab

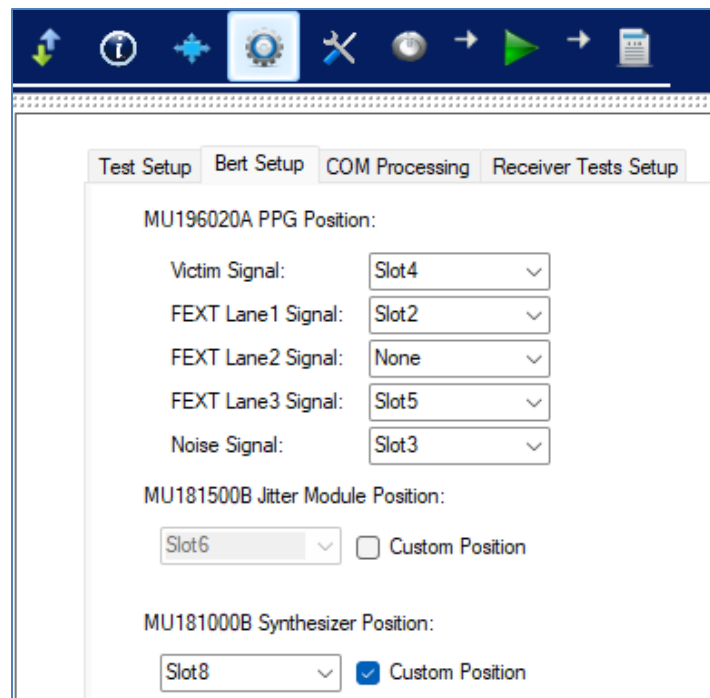


FIGURE 22. BERT SETUP CONFIGURATION

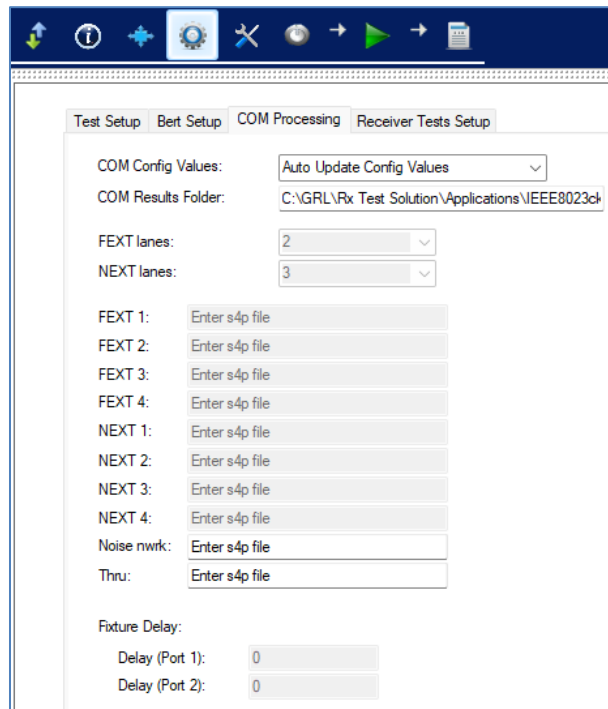
MU196020A PPG Position:

- Victim Signal:** Select the BERT PAM4 PPG Slot to be used as the victim signal source.
- FEXT Lane1 Signal:** If “#FEXT Source” is selected other than “None” in the “Test Setup” tab, select the BERT PAM4 PPG Slot to be used as the signal source for FEXT crosstalk measurement lane 1.
- FEXT Lane2 Signal:** If “#FEXT Source” is selected as “2” or “3” in the “Test Setup” tab, select the BERT PAM4 PPG Slot to be used as the signal source for FEXT crosstalk measurement lane 2.
- FEXT Lane3 Signal:** If “#FEXT Source” is selected as “3” in the “Test Setup” tab, select the BERT PAM4 PPG Slot to be used as the signal source for FEXT crosstalk measurement lane 3.
- Noise Signal:** If the BERT PAM4 PPG is used as the noise signal source, select the slot placement of the noise module in the BERT.

MU181500B Jitter Module Position: Select the slot placement of the MU181500B Jitter Modulator module in the BERT by selecting the “Custom Position” checkbox.

MU181000B Synthesizer Position: Select the slot placement of the MU181000B Synthesizer module in the BERT by selecting the “Custom Position” checkbox.

5.2.3 COM Processing Tab



The screenshot shows the 'COM Processing' tab of a software configuration window. The window has a title bar with standard icons and a menu bar with 'Test Setup', 'Bert Setup', 'COM Processing', and 'Receiver Tests Setup'. The 'COM Processing' tab is active. It contains the following fields and controls:

- COM Config Values:** A dropdown menu set to 'Auto Update Config Values'.
- COM Results Folder:** A text field containing 'C:\GRL\Rx Test Solution\Applications\IEEE8023ck'.
- FEXT lanes:** A dropdown menu set to '2'.
- NEXT lanes:** A dropdown menu set to '3'.
- FEXT 1:** A text field with placeholder 'Enter s4p file'.
- FEXT 2:** A text field with placeholder 'Enter s4p file'.
- FEXT 3:** A text field with placeholder 'Enter s4p file'.
- FEXT 4:** A text field with placeholder 'Enter s4p file'.
- NEXT 1:** A text field with placeholder 'Enter s4p file'.
- NEXT 2:** A text field with placeholder 'Enter s4p file'.
- NEXT 3:** A text field with placeholder 'Enter s4p file'.
- NEXT 4:** A text field with placeholder 'Enter s4p file'.
- Noise nrwk:** A text field with placeholder 'Enter s4p file'.
- Thru:** A text field with placeholder 'Enter s4p file'.
- Fixture Delay:**
 - Delay (Port 1):** A text field with value '0'.
 - Delay (Port 2):** A text field with value '0'.

FIGURE 23. COM PROCESSING CONFIGURATION

- COM Config Values:** Select whether to automatically update or use IEEE 802.3ck default values for the COM parameters.
- COM Results Folder:** Set the folder path for storing the COM calculation results.

- c) **FEXT Lanes:** Select the number of FEXT channels (number of lanes depending on the BERT PAM4 PPG's FEXT setup).
- d) **NEXT Lanes:** Select the number of NEXT channels (number of lanes depending on the DUT Tx).
- e) **FEXT 1/2/3/4:** Specify the FEXT S-parameter measurement result .s4p file for the number of FEXT lanes selected.
- f) **NEXT 1/2/3/4:** Specify the NEXT S-parameter measurement result .s4p file for the number of NEXT lanes selected.
- g) **Noise nwrk:** Specify the S-parameter measurement result .s4p file for the noise channel lane.
- h) **Thru:** Specify the S-parameter measurement result .s4p file for the input thru channel response lane.
- i) **Delay (Port 1/Port2):** Set the delay time to be measured using the VNA's Time Domain function at the specific Port for the measured test lane (Thru) and cross talk (FEXT, NEXT) lanes.

5.3 Select Calibration

The test selection panel on the left of the software screen 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-8023CK-CRKR-RXA software automatically runs the selected calibration when initiated. See Section 5.6 on running the calibration. Select the check box(s) of the desired Rx calibration.

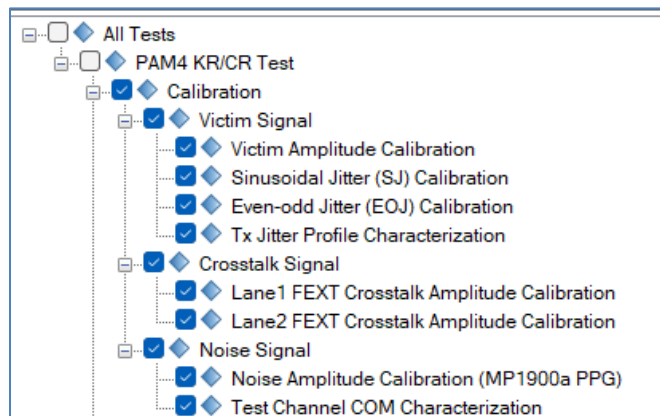


FIGURE 24. SELECT RX CALIBRATION

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

5.4 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, click on the “Set Default” button.

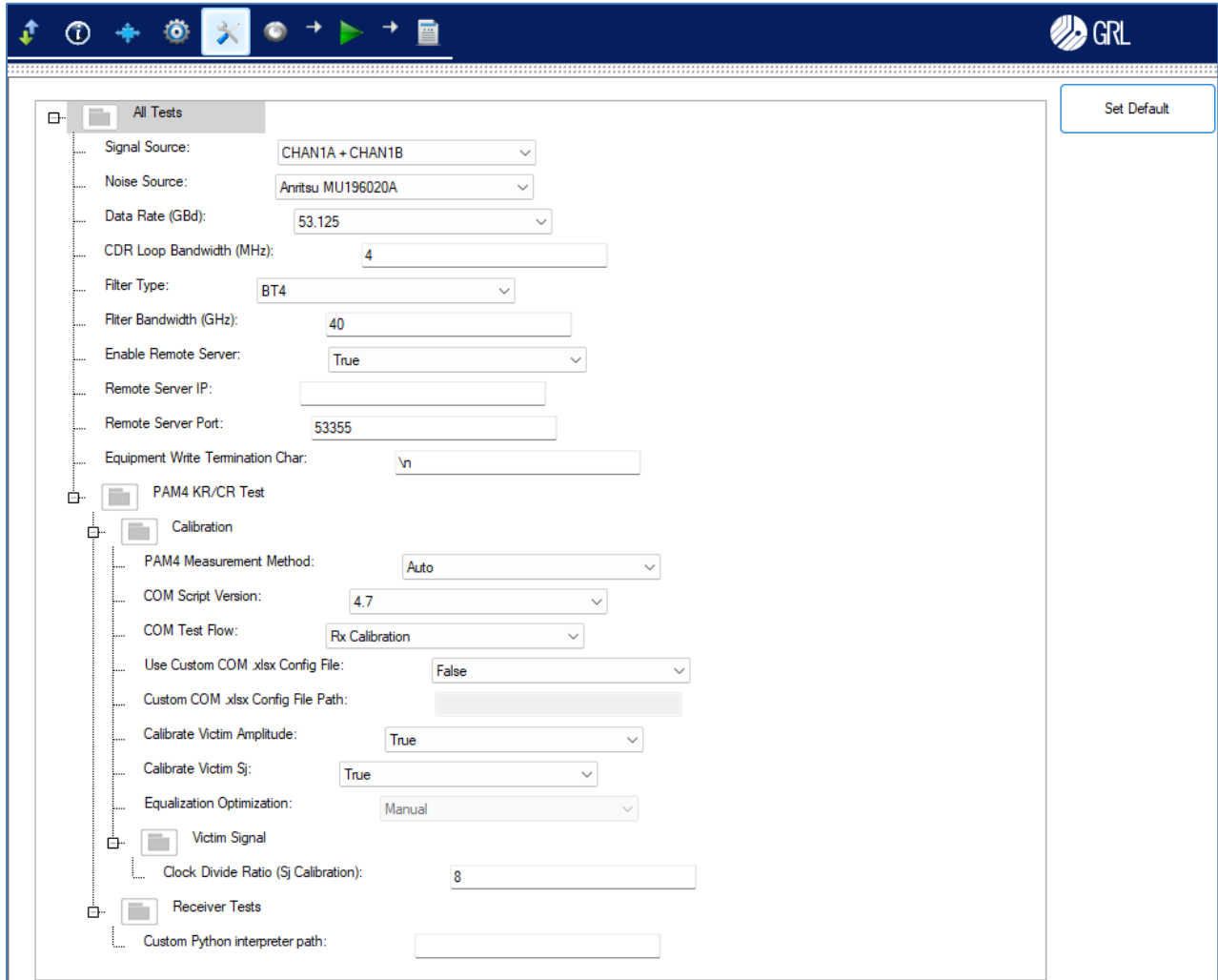


FIGURE 25. CONFIGURE CALIBRATION/TEST PARAMETERS

TABLE 4. CALIBRATION PARAMETERS DESCRIPTION

Parameter	Description
Signal Source	Select the channels on the Keysight N1000A sampling oscilloscope for signal measurements.
Noise Source	Select either the Anritsu BERT MU196020A PAM4 PPG or the Noisecom noise generator to be used as the noise signal source.
Data Rate (GBd)	Select the data rate (currently only 53-Gbaud is supported in the GRL Platform Solutions software).

CDR Loop Bandwidth (MHz)	Set the clock and data recovery (CDR) loop bandwidth to be used for clock recovery.
Filter Type	Select the 4th order Bessel-Thomson filter (“BT4”) or the brick wall filter to be used with the sampling scope for waveform measurement. Select “None” if not using a filter.
Filter Bandwidth (GHz)	If a filter is selected under “Filter Type”, specify the bandwidth of the filter.
Enable Remote Server	Select ‘True’ to enable the GRL Remote Server on the scope for file processing if the GRL Platform Solutions software is installed on the PC to control the scope. See Section 3.3 on how to set up the remote server.
Remote Server IP	If the GRL Remote Server is enabled, enter the IP address for the GRL Remote Server. See Section 3.3 on how to set up the remote server.
Remote Server Port	If the GRL Remote Server is enabled, enter the port number to match the network setting of the GRL Remote Server. See Section 3.3 on how to set up the remote server.
Equipment Write Termination Char	Enter the termination character to terminate the communication/connection with the test equipment.
PAM4 Measurement Method	Select the automation (“Auto”) mode using the GRL Platform Solutions software or the vendor scope application to be used as the method of measurement.
COM Script Version	Select the version of the COM tool or a manual COM calculation method to be used.
COM Test Flow	Select to apply the COM calculation when performing Rx calibration or Tx test standard conformance.
Use Custom COM .xlsx Config File	“False” is usually the case. Select “True” to use a custom COM parameter EXCEL sheet from the COM tool.
Custom COM .xlsx Config File Path	If using a custom COM parameter file, specify the location of the file.
Calibrate Victim Amplitude	“True” is usually the case. Select “False” to skip calibration of the victim signal amplitude.
Calibrate Victim SJ	“True” is usually the case. Select “False” to skip calibration of the victim signal SJ frequencies.
Equalization Optimization	Select the method through which the receiver can configure the transmitter to optimize performance.
Clock Divide Ratio (SJ Calibration)	Specify the divide ratio of a clock divider for the reference clock.
Custom Python Interpreter Path	Specify the path to the Python Interpreter executable in the Python script to be used for DUT Rx compliance testing.

5.5 Configure Calibration Target Values

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

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

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

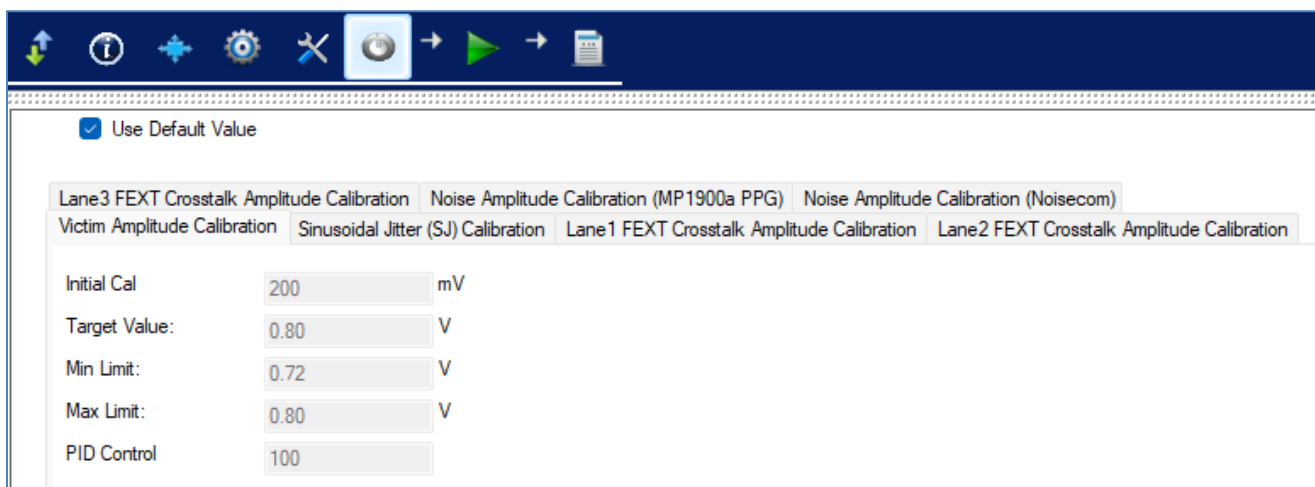


FIGURE 26. CALIBRATION TARGET OVERWRITE PAGE

5.6 Run Automation Calibration

Once calibration have been selected and set up from the previous sections, they are now ready to be run.

Select  from the menu to access the Run Tests page. The GRL-8023CK-CRKR-RXA software automatically runs the selected calibration when initiated.

Before running the calibration, select the option to to:

- **Skip Test if Result Exists** – If results from previous calibration exist, the software will *skip* those calibration.
- **Replace if Result Exists** – If results from previous calibration exist, the software will *replace* those calibration with new results.

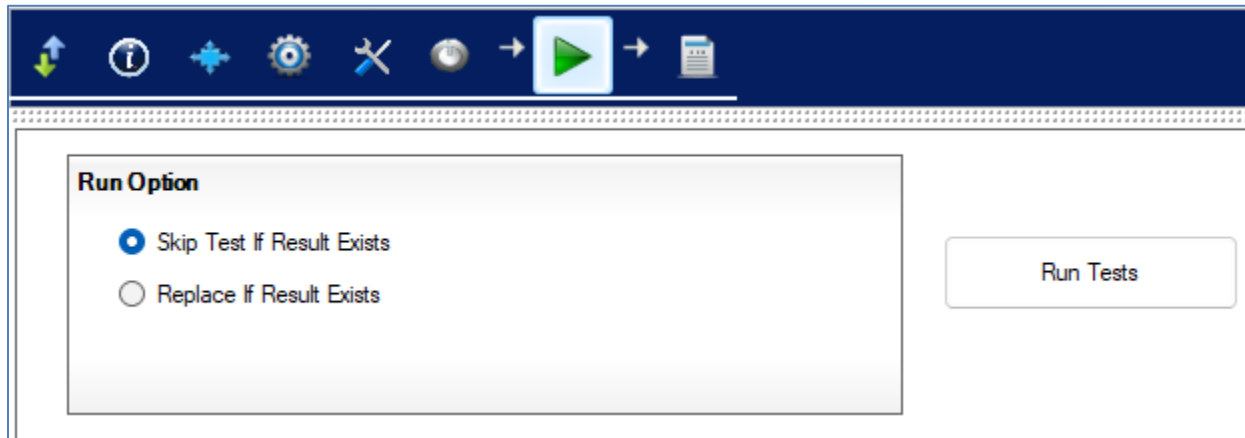


FIGURE 27. RUN TESTS PAGE

Select the **Run Tests** button to start running the selected calibration. The connection diagram for the calibration being run will initially appear to allow the user to make sure that the calibration environment has been properly set up before calibration can proceed. Below shows an example of the connection diagram pop-up.

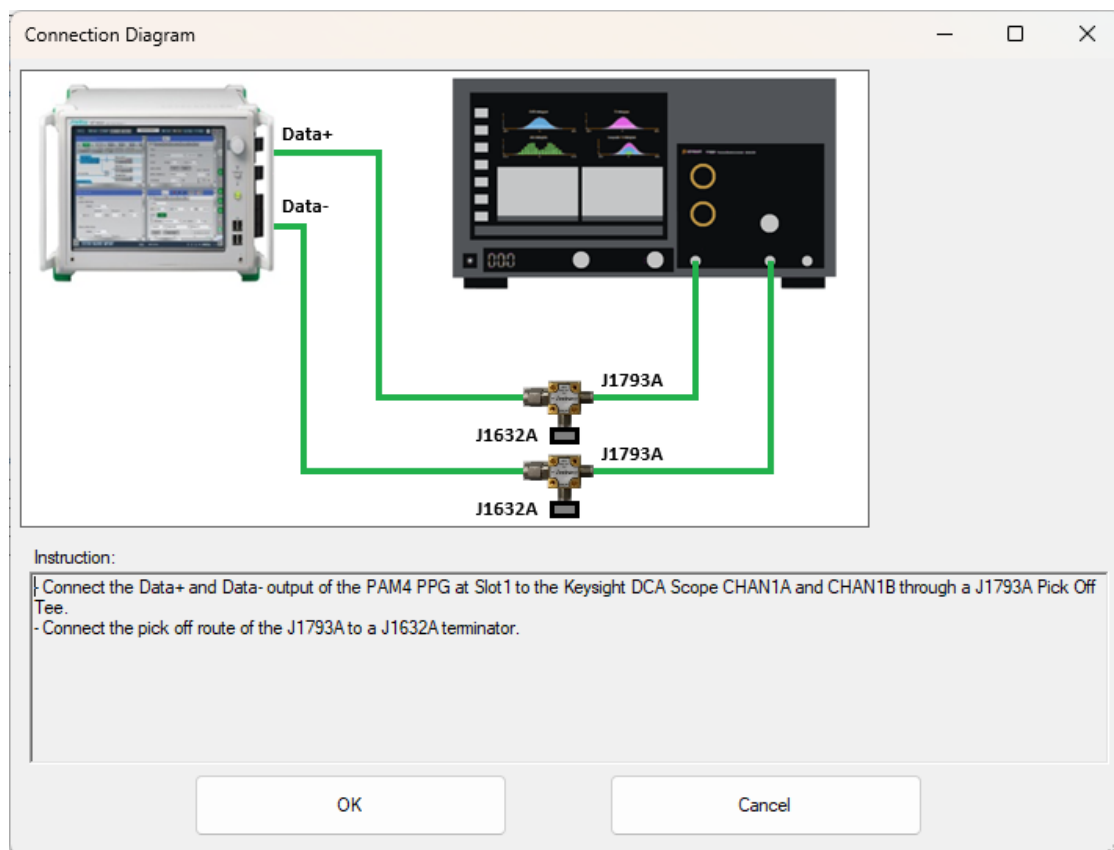


FIGURE 28. EXAMPLE CONNECTION POP-UP DIAGRAM FOR CALIBRATION

6 Compliance Testing Using GRL-8023CK-CRKR-RXA Software

After calibration has completed successfully, receiver BER (Bit Error Rate) compliance testing can then be performed on the PAM4 CR/KR interface device under test (DUT). The GRL-8023CK-CRKR-RXA software automates the receiver interference and jitter tolerance compliance tests for BER measurement, at the spec-defined or user-defined jitter frequency steps.

The interference tolerance test is performed for two test cases (Test 1 for low loss channels and Test 2 for high-loss channels). The jitter tolerance test is performed for the Test 2 case only.

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

6.1 Connection Setup for Interference Tolerance Test (CR Interface)

6.1.1 Test 1 Case

Figure 29 shows the Test 1 case setup diagram for the CR interface receiver interference tolerance test using the MP1900A BERT, 11 dB cable assembly and MCB's.

Note: The Noisecom noise generator can be used as the noise source alternative to the BERT MU196020A PPG. Replace the MU196020A PPG with the Noisecom noise generator and connect the data outputs directly to the J1793A pick-off tees using the Anritsu J1551A coaxial cables.

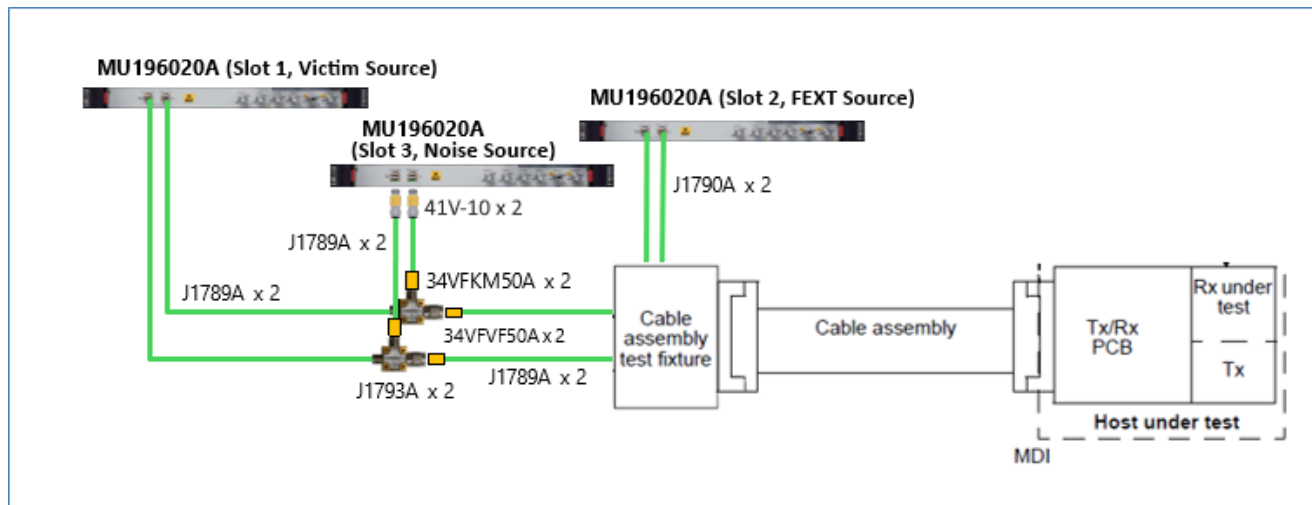


FIGURE 29. TEST 1 CASE SETUP FOR DUT RX INTERFERENCE TOLERANCE TEST (CR INTERFACE)

Connection Steps:

1. Connect the MCB's to the cable assembly test fixture and the DUT using an 11 dB cable assembly.
2. Using the victim signal calibration setup (Section 4.2), FEXT signal calibration setup (Section 4.4) and noise signal calibration setup (Section 4.5), disconnect the scope channels from the these setups. Connect the MU196020A (at Slot 3- Noise Signal

Source) data outputs through the 41V-10 fixed attenuators to the J1793A pick-off tees through the 34VFKM50A adapters.

3. Connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to the cable assembly test fixture using the J1790A coaxial cables.

6.1.2 Test 2 Case

Figure 30 shows the Test 2 case setup diagram for the CR interface receiver interference tolerance test using the MP1900A BERT, 19.75 dB cable assembly and MCB's.

Note: The Noisecom noise generator can be used as the noise source alternative to the BERT MU196020A PPG. Replace the MU196020A PPG with the Noisecom noise generator and connect the data outputs directly to the J1793A pick-off tees using the Anritsu J1551A coaxial cables.

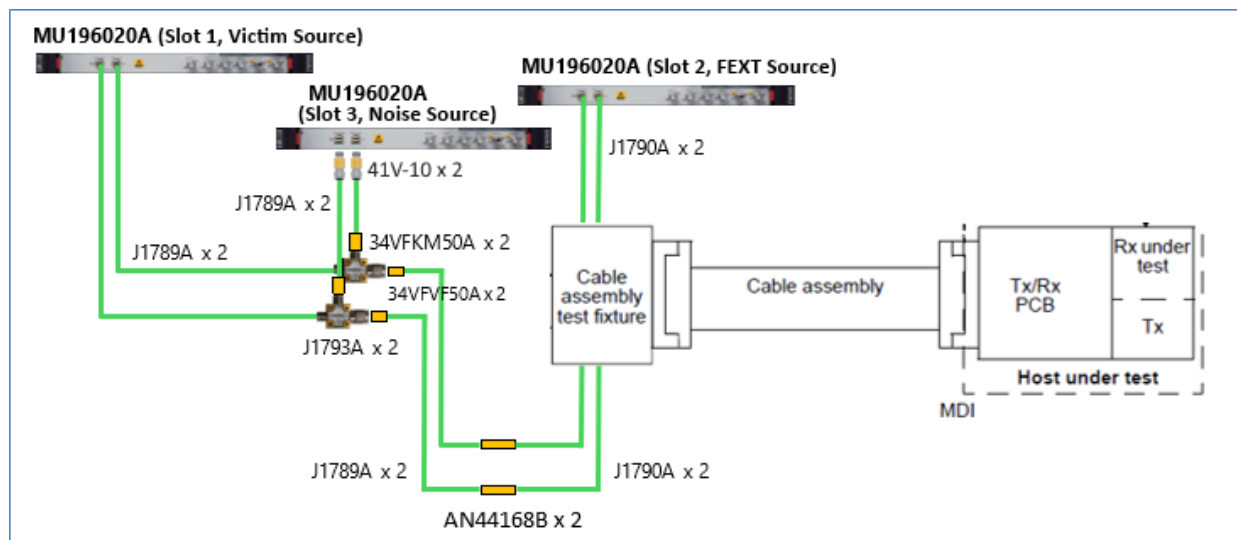


FIGURE 30. TEST 2 CASE SETUP FOR DUT RX INTERFERENCE TOLERANCE TEST (CR INTERFACE)

Connection Steps:

1. Connect the MCB's to the cable assembly test fixture and the DUT using a 19.75 dB cable assembly.
2. Using the victim signal calibration setup (Section 4.2), FEXT signal calibration setup (Section 4.4) and noise signal calibration setup (Section 4.5), disconnect the scope channels from the these setups. Connect the MU196020A (at Slot 3- Noise Signal Source) data outputs through the 41V-10 fixed attenuators to the J1793A pick-off tees through the 34VFKM50A adapters.
3. Connect one end of the AN44168B 30 GHz Bessel filters with the 34VFKM50A V(f) - V(f) adapters using the J1789A coaxial cables.
4. Connect the other end of the AN44168B 30 GHz Bessel filters with the cable assembly test fixture using the J1790A coaxial cables.
5. Connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to the cable assembly test fixture using the J1790A coaxial cables.

6.2 Connection Setup for Interference Tolerance Test (KR Interface)

6.2.1 Test 1 Case

Figure 31 shows the Test 1 case setup diagram for the KR interface receiver interference tolerance test using the MP1900A BERT, an ISI channel with an insertion loss of 14.5 dB and a TP5v to TP5 replica fixture.

Note: The Noisecom noise generator can be used as the noise source alternative to the BERT MU196020A PPG. Replace the MU196020A PPG with the Noisecom noise generator and connect the data outputs directly to the J1793A pick-off tees using the Anritsu J1551A coaxial cables.

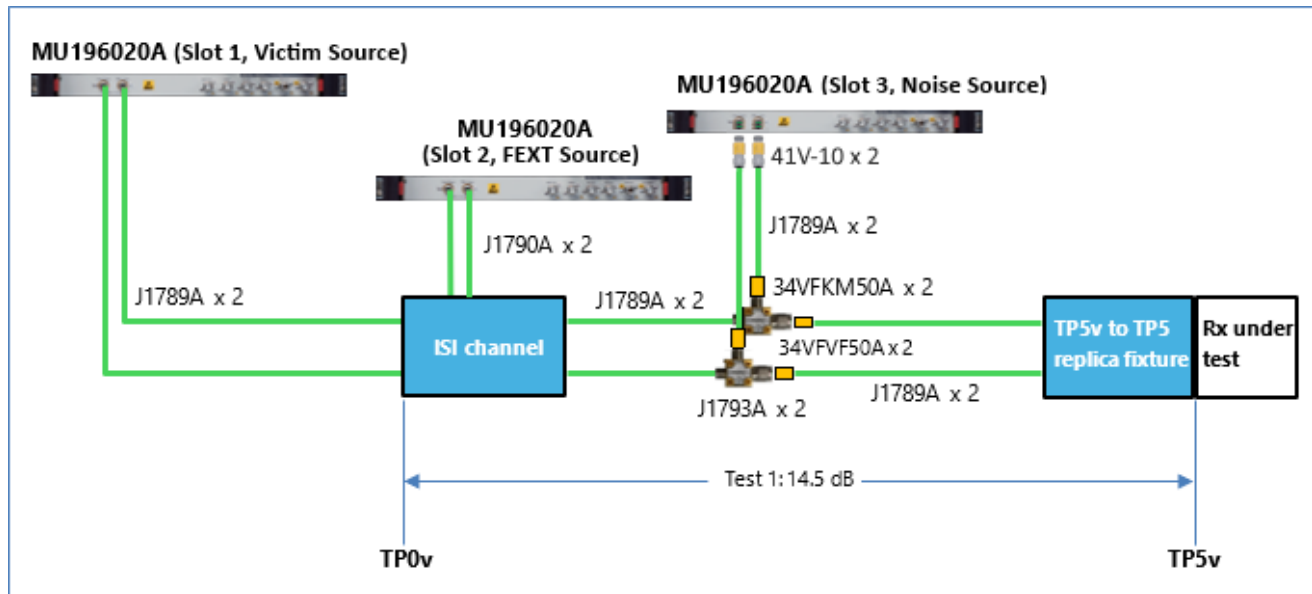


FIGURE 31. TEST 1 CASE SETUP FOR DUT RX INTERFERENCE TOLERANCE TEST (KR INTERFACE)

Connection Steps:

1. Attach the DUT to a TP5v to TP5 replica fixture.
2. Using the victim signal calibration setup (Section 4.2), FEXT signal calibration setup (Section 4.4) and noise signal calibration setup (Section 4.5), disconnect the scope channels from the these setups. Connect the MU196020A (at Slot 3- Noise Signal Source) data outputs through the 41V-10 fixed attenuators to the J1793A pick-off tees through the 34VFKM50A adapters.
3. Connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to the ISI channel (with an insertion loss of 14.5 dB) using the J1789A coaxial cables.
4. Connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to the ISI channel using the J1790A coaxial cables.
5. Connect the ISI channel to the J1793A pick-off tees using the J1789A coaxial cables.
6. Connect the other end of the J1793A pick-off tees to the TP5v to TP5 replica fixture through the 34VFVF50A V(f) - V(f) adapters using the J1789A coaxial cables.

6.2.2 Test 2 Case

Figure 32 shows the Test 2 case setup diagram for the KR interface receiver interference tolerance test using the MP1900A BERT, an ISI channel with an insertion loss of 28.5 dB and a TP5v to TP5 replica fixture.

Note: The Noisecom noise generator can be used as the noise source alternative to the BERT MU196020A PPG. Replace the MU196020A PPG with the Noisecom noise generator and connect the data outputs directly to the J1793A pick-off tees using the Anritsu J1551A coaxial cables.

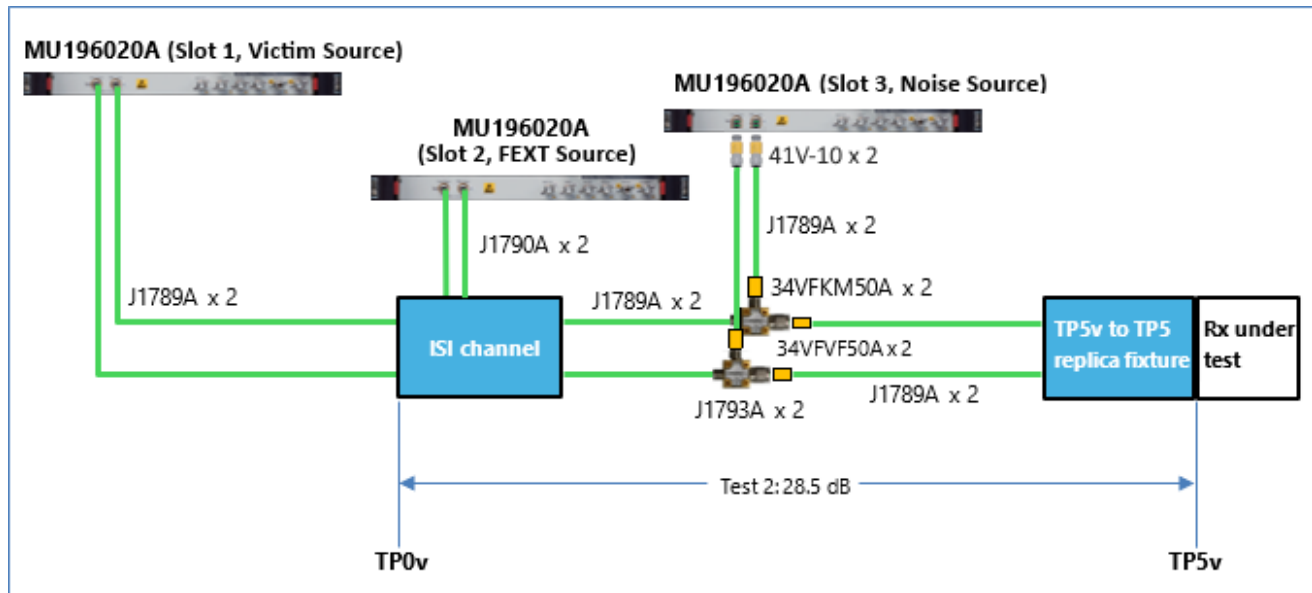


FIGURE 32. TEST 2 CASE SETUP FOR DUT RX INTERFERENCE TOLERANCE TEST (KR INTERFACE)

Connection Steps:

1. Attach the DUT to a TP5v to TP5 replica fixture.
2. Using the victim signal calibration setup (Section 4.2), FEXT signal calibration setup (Section 4.4) and noise signal calibration setup (Section 4.5), disconnect the scope channels from these setups. Connect the MU196020A (at Slot 3- Noise Signal Source) data outputs through the 41V-10 fixed attenuators to the J1793A pick-off tees through the 34VFKM50A adapters.
3. Connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to the ISI channel (with an insertion loss of 28.5 dB) using the J1789A coaxial cables.
4. Connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to the ISI channel using the J1790A coaxial cables.
5. Connect the ISI channel to the J1793A pick-off tees using the J1789A coaxial cables.
6. Connect the other end of the J1793A pick-off tees to the TP5v to TP5 replica fixture through the 34VFVF50A V(f) - V(f) adapters using the J1789A coaxial cables.

6.3 Connection Setup for Jitter Tolerance Test (CR Interface)

Note: The jitter tolerance test is performed for the Test 2 case only.

Figure 33 shows the Test 2 case setup diagram for the CR interface receiver jitter tolerance test using the MP1900A BERT, 19.75 dB cable assembly and MCB's.

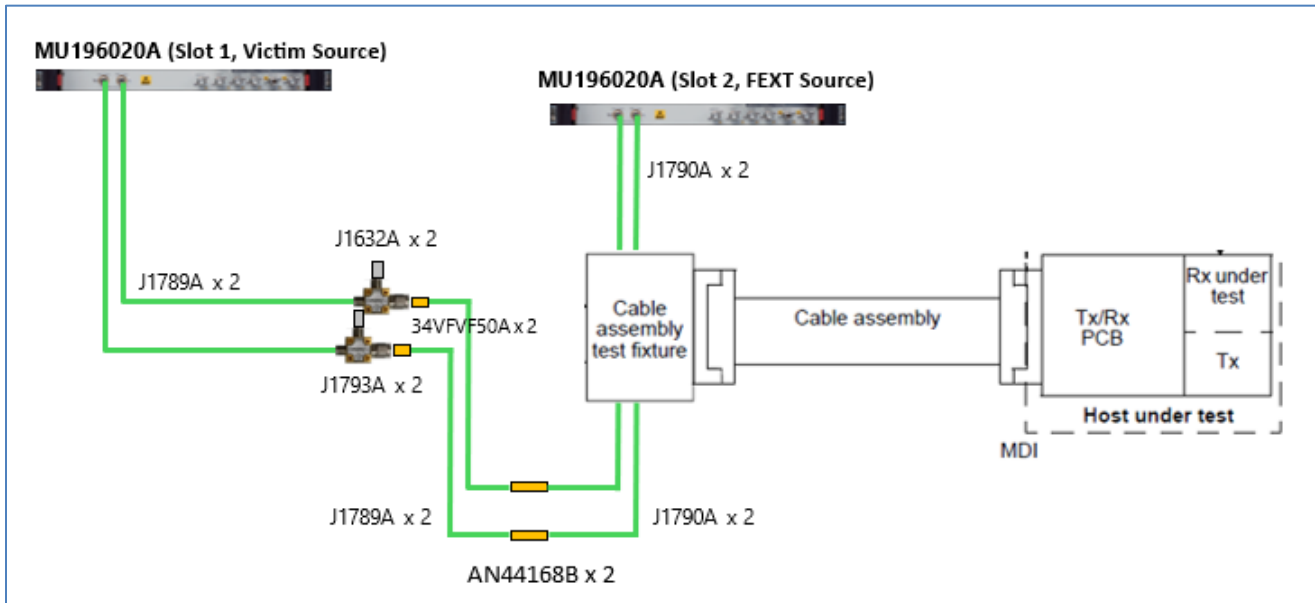


FIGURE 33. TEST 2 CASE SETUP FOR DUT RX JITTER TOLERANCE TEST (CR INTERFACE)

Connection Steps:

1. Connect the MCB's to the cable assembly test fixture and the DUT using a 19.75 dB cable assembly.
2. Using the victim signal calibration setup (Section 4.6) and FEXT signal calibration setup (Section 4.4), disconnect the scope channels from these setups.
3. Connect one end of the AN44168B 30 GHz Bessel filters with the 34VVF50A V(f) - V(f) adapters using the J1789A coaxial cables.
4. Connect the other end of the AN44168B 30 GHz Bessel filters with the cable assembly test fixture using the J1790A coaxial cables.
5. Connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to the cable assembly test fixture using the J1790A coaxial cables.

6.4 Connection Setup for Jitter Tolerance Test (KR Interface)

Note: The jitter tolerance test is performed for the Test 2 case only.

Figure 34 shows the Test 2 case setup diagram for the KR interface receiver jitter tolerance test using the MP1900A BERT, an ISI channel with an insertion loss of 28.5 dB and a TP5v to TP5 replica fixture.

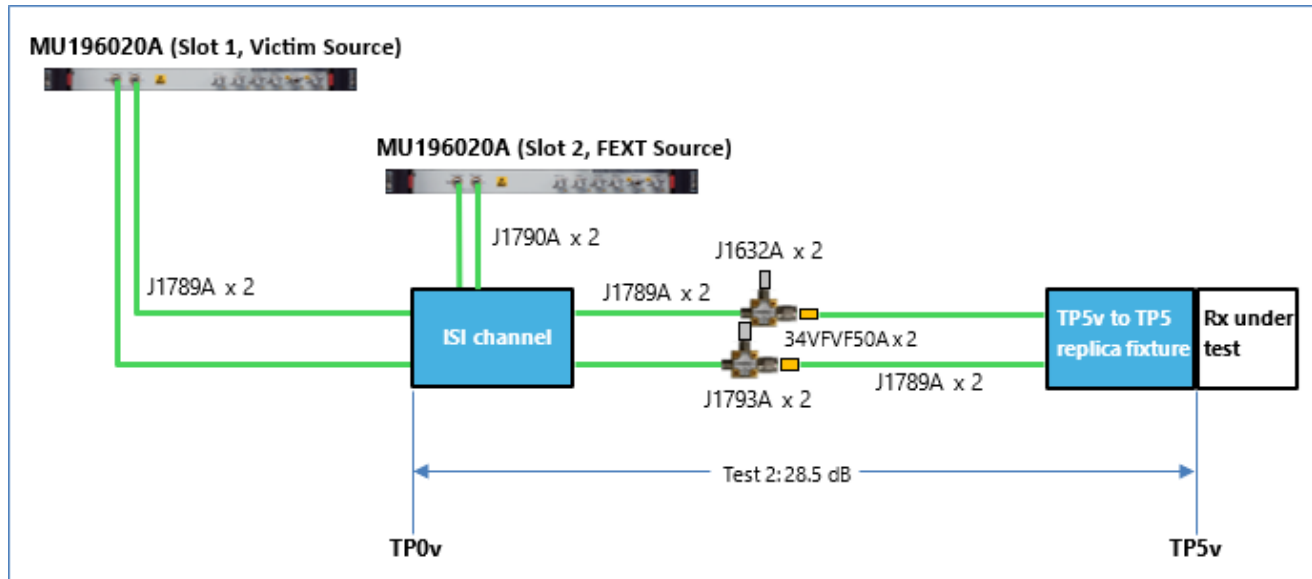


FIGURE 34. TEST 2 CASE SETUP FOR DUT RX JITTER TOLERANCE TEST (KR INTERFACE)

Connection Steps:

1. Attach the DUT to a TP5v to TP5 replica fixture.
2. Using the victim signal calibration setup (Section 4.6) and FEXT signal calibration setup (Section 4.4), disconnect the scope channels from these setups.
3. Connect the MU196020A (at Slot 1- Victim Signal Source) data outputs to the ISI channel (with an insertion loss of 28.5 dB) using the J1789A coaxial cables.
4. Connect the MU196020A (at Slot 2- FEXT Signal Source) data outputs to the ISI channel using the J1790A coaxial cables.
5. Connect the ISI channel to the J1793A pick-off tees using the J1789A coaxial cables. Connect the pick-off routes of the J1793A to the J1632A 50-ohm terminators.
6. Connect the other end of the J1793A pick-off tees to the TP5v to TP5 replica fixture through the 34VVFV50A V(f) - V(f) adapters using the J1789A coaxial cables.

6.5 Set Up Test Requirements

After setting up the physical equipment, select  from the software menu to access the Setup Configuration page to configure the DUT Rx test setup requirements.

6.5.1 Receiver Tests Setup Tab

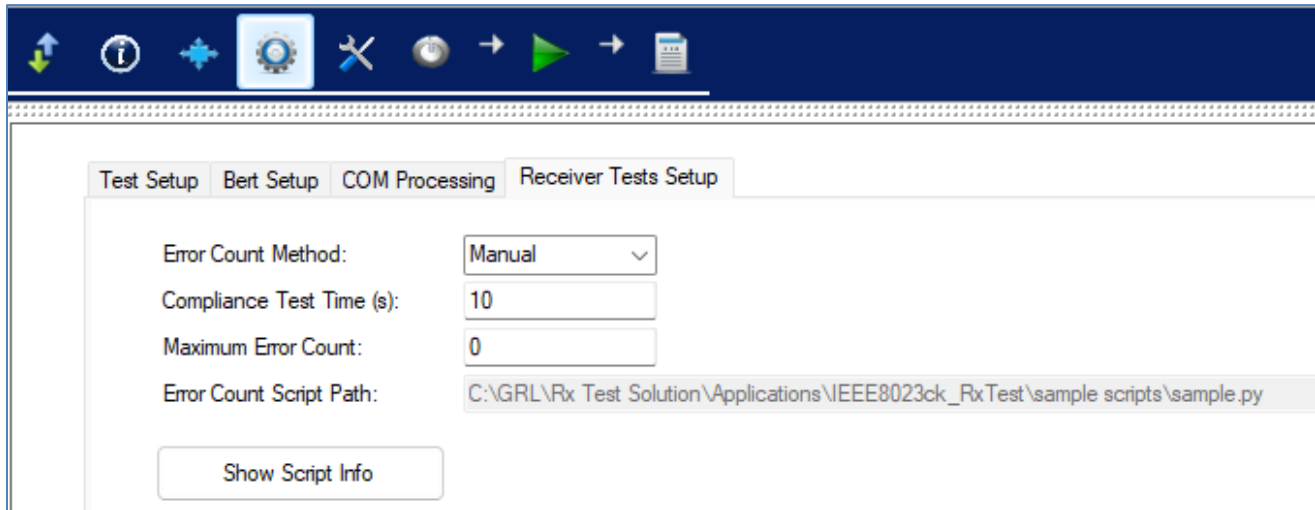


FIGURE 35. SET UP ERROR COUNT

- a) **Error Count Method:** Select to perform the error count manually or using a Python Script or using the BERT Error Detector.
 - **Manual:** User will be prompted to key in the number of errors detected.
 - **Python Script:** The GRL-8023CK-CRKR-RXA software will execute an error counter Python script uploaded by the user for the DUT.
 - **Error Detector:** The GRL-8023CK-CRKR-RXA software will utilize the Error Detector of the BERT to be used with the DUT.
- b) **Compliance Test Time:** Specify the duration for the BER test run.
- c) **Maximum Error Count:** Specify the maximum error limits to be tested for compliance.
- d) **Error Count Script Path:** If the Python script is selected as the “Error Count Method”, set the working directory to the path where the Python script is installed in the host PC. The user can view the script configuration by clicking on the **Show Script Info** button.

6.6 Select DUT Rx Compliance Tests

After setting up the DUT Rx test requirements, access the test selection panel on the left of the software screen to select the Rx compliance tests to be run. Select the check box(s) for the required Rx tests.

Note: When running tests for the first time or changing anything in the setup, it is suggested to perform calibration first. If calibration is not completed, attempting to run the Rx tests will throw errors.

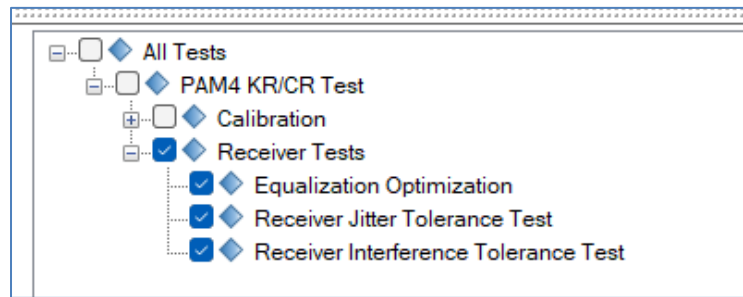


FIGURE 36. SELECT RX TESTS

6.7 Run Automation Tests

Once tests have been selected and set up from the previous sections, the tests are now ready to be run.

Select  from the software menu to access the Run Tests page. The GRL-8023CK-CRKR-RXA software automatically runs the selected tests when initiated.

Before running the tests, select the option to:

- **Skip Test if Result Exists** – If results from previous tests exist, the software will *skip* those tests.
- **Replace if Result Exists** – If results from previous tests exist, the software will *replace* those tests with new results.



FIGURE 37. RUN TESTS PAGE

Select the **Run Tests** button to start running the selected tests. The connection diagram for the test being run will initially appear to allow the user to make sure that the test environment has been properly set up before testing can proceed.

7 Interpreting GRL-8023CK-CRKR-RXA Test Report

When all calibration and test runs have completed from the previous section, the GRL-8023CK-CRKR-RXA software will automatically display the results on the **Report** page.

Select  from the menu to access the Report page for a quick view of all results.

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

For detailed test report, select the **Generate report** button to generate a PDF report. To have the calibration data plotted in the report, select the **Plot Calibration Data** checkbox.

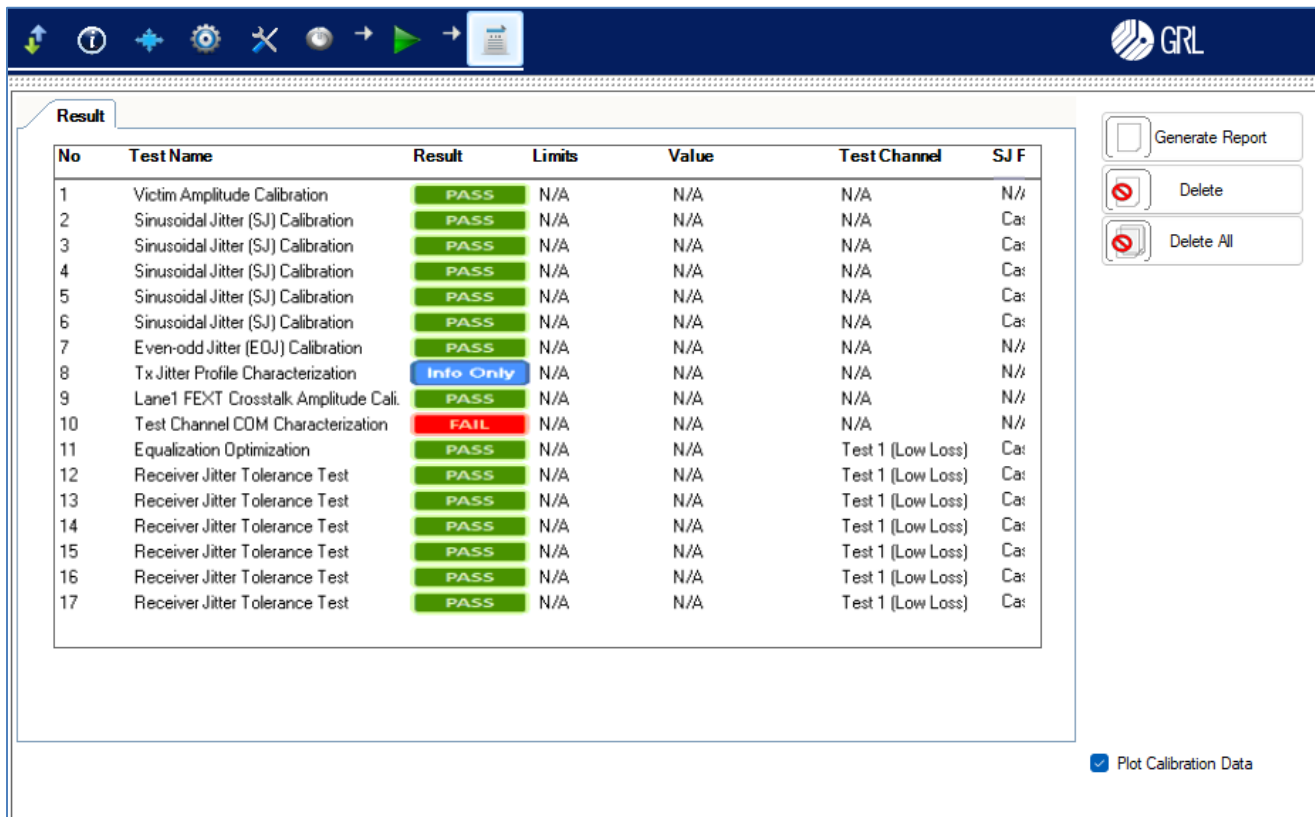


FIGURE 38. TEST REPORT PAGE

7.1 Understand Test Report Information

This section gives a general overview of the test report to help users familiarize themselves with the format. Select the **Generate report** button to generate the test report.

7.1.1 Test Session Information

This portion displays the information previously entered on the **Session Info** page.

Anritsu IEEE802.3ck Rx Test Report

DUT Information

DUT Manufacturer : GRL

DUT Model Number : IEEE802.3ck Rx Device 1

DUT Serial Number : 00000001

DUT Comments :

Test Information

Test Lab : Granite River Labs

Test Operator : David

Test Date : 24 May 2024

Software Version

Software Revision : 0.99.1

FIGURE 39. TEST SESSION INFORMATION EXAMPLE

7.1.2 Test Summary Table

This table provides an overall view of all the calibration and tests performed along with their conditions and results.

Anritsu IEEE802.3ck Rx Test Report						
No	TestName	Limits	Value	Results	Test Channel	SJ Frequency
1	Victim Amplitude Calibration	N/A	N/A	Pass		
2	Sinusoidal Jitter (SJ) Calibration	N/A	N/A	Pass	N/A	Case C (1.333MHz)
3	Sinusoidal Jitter (SJ) Calibration	N/A	N/A	Pass	N/A	Case D (4MHz)
4	Sinusoidal Jitter (SJ) Calibration	N/A	N/A	Pass	N/A	Case E (12MHz)
5	Sinusoidal Jitter (SJ) Calibration	N/A	N/A	Pass	N/A	Case F (40MHz)
6	Sinusoidal Jitter (SJ) Calibration	N/A	N/A	Pass	N/A	Case B (0.4MHz)
7	Even-odd Jitter (EOJ) Calibration	N/A	N/A	Pass		
8	Tx Jitter Profile Characterization	N/A	N/A	InfoOnly		
9	Lane1 FEXT Crosstalk Amplitude Calibration	N/A	N/A	Pass		
10	Test Channel COM Characterization	N/A	N/A	Fail		
11	Equalization Optimization	N/A	N/A	Pass	Test 1 (Low Loss)	Case B (0.4MHz)
12	Receiver Jitter Tolerance Test	N/A	N/A	Pass	Test 1 (Low Loss)	Case A (0.04MHz)
13	Receiver Jitter Tolerance Test	N/A	N/A	Pass	Test 1 (Low Loss)	Case C (1.333MHz)
14	Receiver Jitter Tolerance Test	N/A	N/A	Pass	Test 1 (Low Loss)	Case D (4MHz)
15	Receiver Jitter Tolerance Test	N/A	N/A	Pass	Test 1 (Low Loss)	Case E (12MHz)
16	Receiver Jitter Tolerance Test	N/A	N/A	Pass	Test 1 (Low Loss)	Case F (40MHz)
17	Receiver Jitter Tolerance Test	N/A	N/A	Pass	Test 1 (Low Loss)	Case B (0.4MHz)

FIGURE 40. TEST SUMMARY TABLE EXAMPLE

7.1.3 Test Results

This portion displays the results in detail along with supporting data points and/or screenshots for each calibration/test run.

9. Lane1 FEXT Crosstalk Amplitude Calibration

Pass/Fail Stats : Pass
Cal Parameter : Crosstalk Amplitude Lane1
CrosstalkLane1AmplitudeCal Settings : 524.0000 mV
Measured Value : 799.8500 mV
Test completed time : 26 4 2024 22:24:22

CrosstalkLane1AmplitudeCal Plot

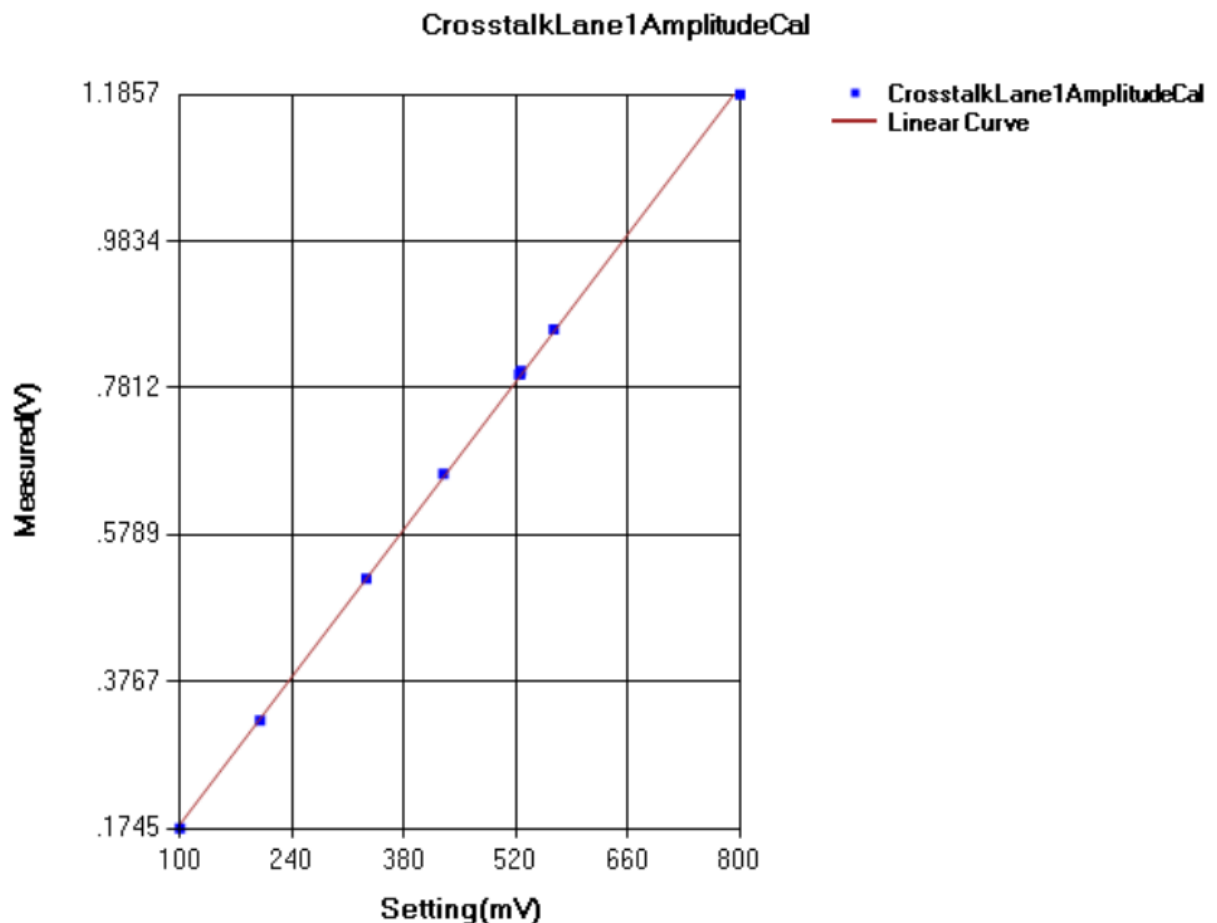


FIGURE 41. TEST RESULTS EXAMPLE

7.2 Delete Test Results

To individually delete any unwanted calibration/test results, select the corresponding result row and **Delete** button.

To entirely remove all existing calibration/test results, select the **Delete All** button.

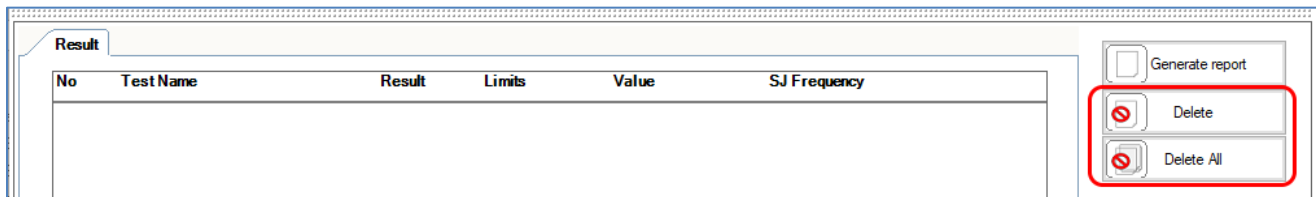


FIGURE 42. DELETE TEST RESULTS

8 Saving and Loading GRL-8023CK-CRKR-RXA Test Sessions

The usage model for the GRL-8023CK-CRKR-RXA software is that the test results are created and maintained as a 'Live Session' in the application. This allows the user to quit the application and return later to continue where the user left off.

Save and Load Sessions are used to save a test session that the user may want to recall later. The user can 'switch' between different sessions by saving and loading them when needed.

- To **save a test session**, with all of the test parameter information, test results, and any waveforms, select the Options drop-down menu and then select 'Save Session'.
- To **load a test session** back into the application, including the saved test parameter settings, select Options → 'Load Session'.
- To **create a new test session** and return the application back to the default configuration, select Options → 'New Session'.

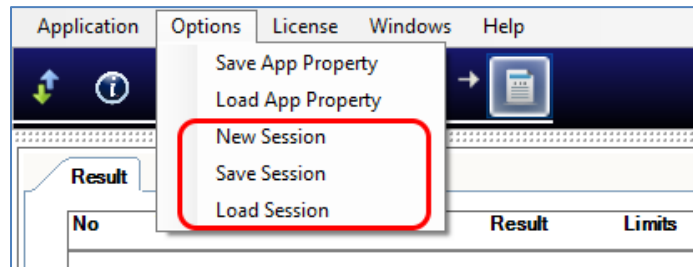


FIGURE 43. SAVE/LOAD/CREATE TEST SESSIONS

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

9 Appendix A: Method of Implementation (MOI) for Manual IEEE 802.3ck PAM4 CR/KR Interface Receiver Measurements

This section describes how to manually perform IEEE 802.3ck 53-Gbaud PAM4 CR/KR Interface Rx calibration and DUT compliance testing using the Anritsu MP1900A BERT and Keysight N1000A + N1060A sampling oscilloscope.

The following steps give a general overview for calibrating & testing the PAM4 CR/KR interface receiver.

- i) Calibrate for the following components:
 - Interference Tolerance for the CR/KR interface:
 - Measure the characteristics of Test channels and Test 1 & Test 2 cases to verify that the results meet the target insertion losses.
 - Verify the performance of the MU196020A PAM4 PPG modules used as the Victim signal, FEXT signal and noise signal source respectively.
 - Calculate the noise amplitude to be added using the COM tool.
 - Jitter Tolerance for the CR/KR interface:
 - Verify the jitter amplitude of the MU196020A PAM4 PPG (Slot 1) used as the Victim signal source.
- ii) Test for DUT Rx compliance to target specifications for the following components:
 - Interference Tolerance for the CR/KR interface for the Test 1 & Test 2 cases:
 - Configure MU196020A PAM4 PPG Victim signal, FEXT signal & noise signal settings and the value calculated by the COM tool.
 - Determine the Emphasis setting of the MU196020A (Slot 1) and the Equalizer setting of the DUT Rx.
 - Measure the BER to target $<2.4 \times 10^{-4}$ and FEC error ratio to target $<10^{-3}$.
 - Jitter Tolerance for the CR/KR interface for the Test 2 case only:
 - Configure MU196020A PAM4 PPG Victim signal and FEXT signal settings and the value calculated by the COM tool.
 - Determine the Emphasis setting of the MU196020A (Slot 1) and the Equalizer setting of the DUT Rx.
 - Set the jitter amplitude and measure the BER to target $<2.4 \times 10^{-4}$ and FEC error ratio to target $<10^{-3}$ for each jitter frequency.

9.1 Perform Rx Interference Tolerance Calibration (for CR Interface)

9.1.1 Measure the characteristics of Test channels and Test 1 & Test 2 cases to verify that the results meet the target insertion losses

Note: The following procedure applies for the 400GBASE-CR4 interface (4-lane cable).

1. Based on the following connections as shown in Figure 44 below, measure the characteristics of each test channel lane using a vector network analyzer.

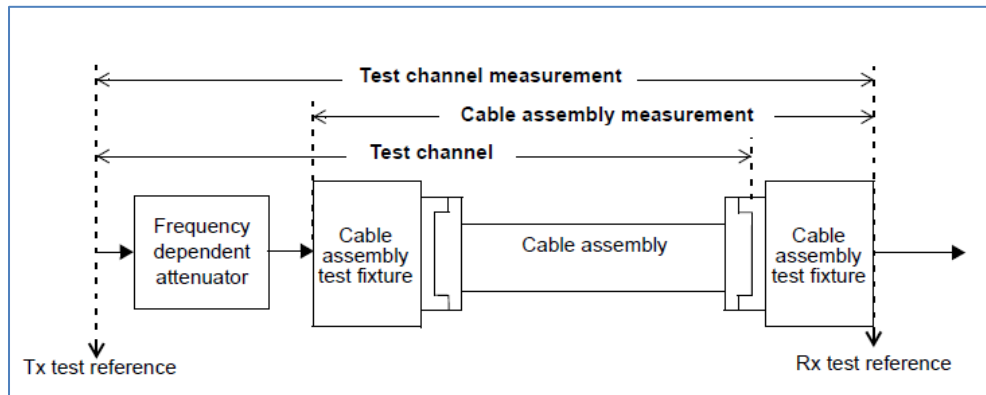


FIGURE 44. TEST CHANNEL CALIBRATION CONNECTION DIAGRAM (AS REFERENCED FROM IEEE802.3CK STANDARD FIGURE 110-3B)

2. Based on Figure 45 below, measure the FEXT and NEXT crosstalk characteristics according to the characteristics of the measurement lane and the crosstalk environment during testing. Measure each S-parameter and save the results as a S4P file for each test channel and Test 1 & Test 2 cases.

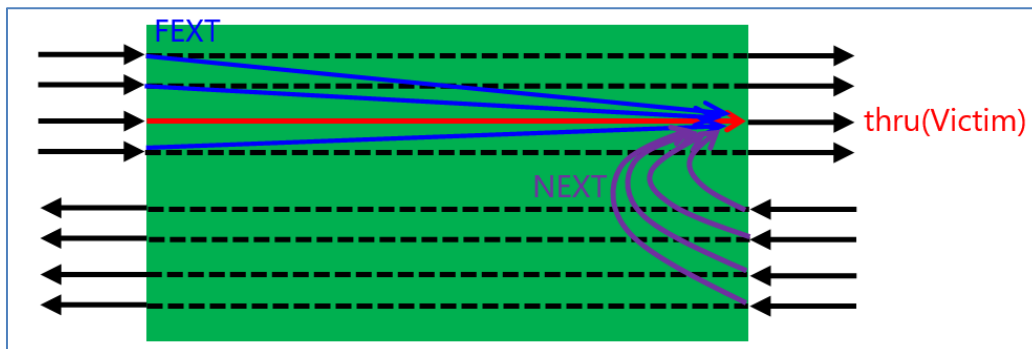


FIGURE 45. THRU TEST LANE AND FEXT & NEXT CROSSTALK LANES

3. Use the Time Domain function of the vector network analyzer to measure the delay time for the measured lanes and enter the results in the .xlsx sheet for COM calculation. Refer to Section 9.1.5 for details.

The procedure in the following sections uses one signal from the MU196020A PAM4 PPG (Slot 2) as FEXT and the Tx lanes of the DUT as NEXT.

9.1.2 Verify the performance of the MU196020A PAM4 PPG (Slot 1) used as the victim signal

1. Set up the connections for the Anritsu MP1900A BERT modules and victim signal calibration setup as shown in Figure 12 and Figure 13 respectively.
2. Turn on the MP1900A BERT and the N1000A sampling oscilloscope and warm up for approximately 30 minutes. Initialize the settings on both the BERT and scope. It is also a prerequisite to perform calibration on the input port of the N1060A module prior to calibration/testing.
3. Set the reference clock for the MU196020A PAM4 PPG as follows:
 - a) On the MU1815000B Settings screen as shown below, select the **Clock Source** setting as **MU181000B**.

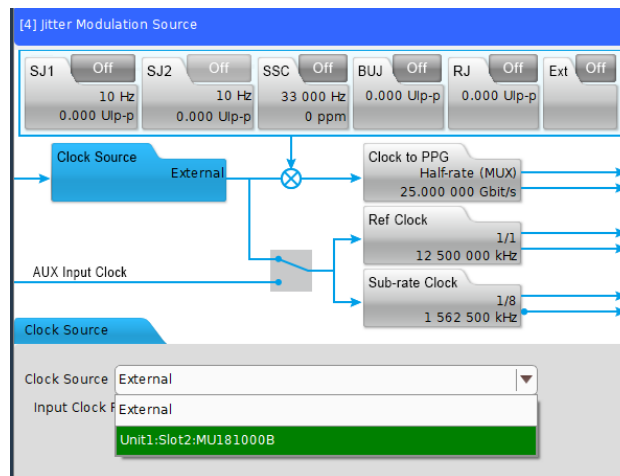


FIGURE 46. MU181500B CLOCK SOURCE SETTING

- b) On the MU196020A Misc2 Settings screen as shown below, select the **Clock Source** setting as **MU181500B**.

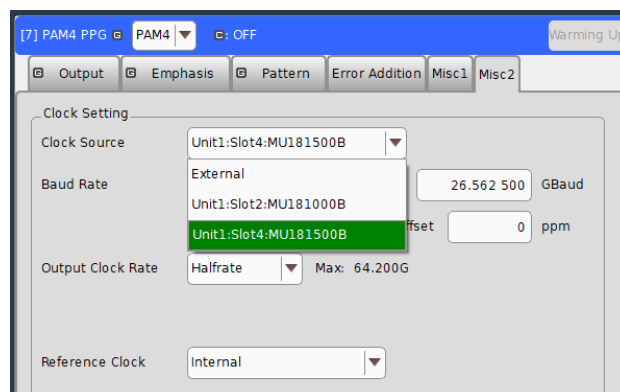


FIGURE 47. MU196020A Misc2 CLOCK SOURCE SETTING

4. On the MU196020A Output setting screen, set the following:
 - Baud Rate: **53.125 GBaud**

- Ext ATT Factor: **2.1 dB** (typ. loss in J1793A)
- Total Amplitude: **0.509 Vpp** (amplitude set to **0.4 Vpp** after passing J1793A)
- Offset: **0.509 V** (offset set to **0.4 V** after passing J1793A)

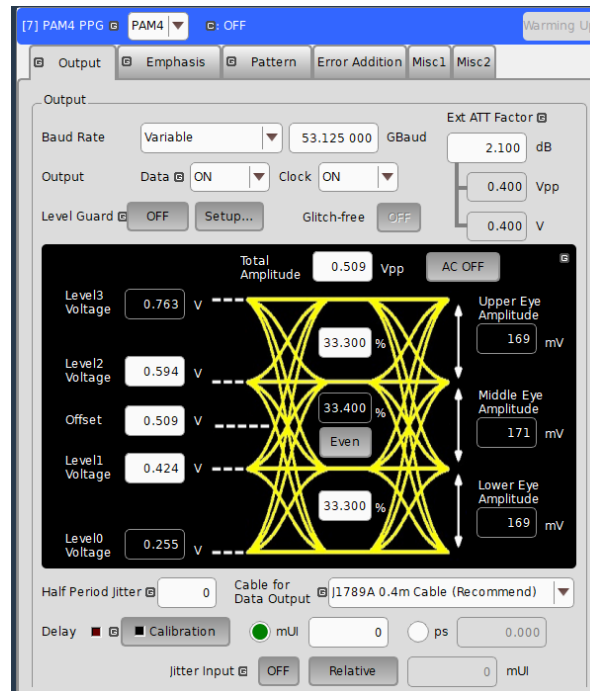


FIGURE 48. MU196020A (VICTIM) OUTPUT SETTINGS

- On the MU196020A Pattern setting screen, select the **Test Pattern** as **PRBS13Q**.

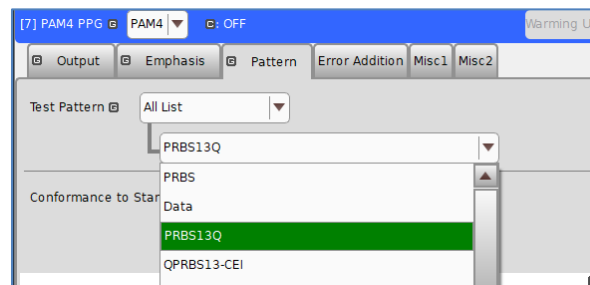


FIGURE 49. MU196020A (VICTIM) PATTERN SETTINGS

- On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output the signal.



FIGURE 50. MP1900A BERT OUTPUT ON

- Launch the N1091CKCA IEEE802.3Tx Test Application on the N1000A sampling oscilloscope and verify that the Even-odd jitter, J3u, Jrms, and SNDR meet the Tx standard using the following steps:

[Starting from Default Setting:]

- a) From the N1091CKCA IEEE802.3Tx Test Application, select **Test Standard 400GBase-CR4/200GBase-CR2/100GBase-CR TP2**.
- b) Perform **Differential Skew Adjust**.
- c) Adjust the MU196020A prior to performing measurements by selecting **Even-odd jitter** in the Test Item screen and measure the Even-odd jitter performance against the Half Period Jitter setting of the MU196020A. Repeat the Even-odd jitter measurement while adjusting the Half Period Jitter in the range of -1.5~+1.5 (step 0.2) to determine the Half Period Jitter setting value at which the Even-odd jitter is the maximum value below 0.025 UI.

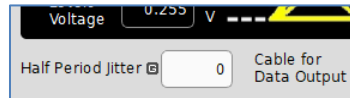


FIGURE 51. HALF PERIOD JITTER SETTING

- d) After adjusting the Even-odd jitter, select **J3u**, **Jrms**, **Even-odd jitter** and **SNDR** as Test Items and proceed to run measurements.
- e) Ensure that the measurement report file is saved.
- f) Once measurements have completed, turn **OFF** the **Output** button on the upper left corner of the MP1900A BERT screen.



9.1.3 Verify the amplitude of the MU196020A PAM4 PPG (Slot 2) used as the FEXT signal

1. Set up the connections for the FEXT signal calibration setup as shown in Figure 15.
2. Set the reference clock for the MU196020A PAM4 PPG (Slot 2) as follows:
 - a) On the MU196020A (Slot 2) **Misc2** settings screen, select the **Clock Source** setting as **External**. Select the **Operation Baud Rate** setting as **32.10-64.20**.

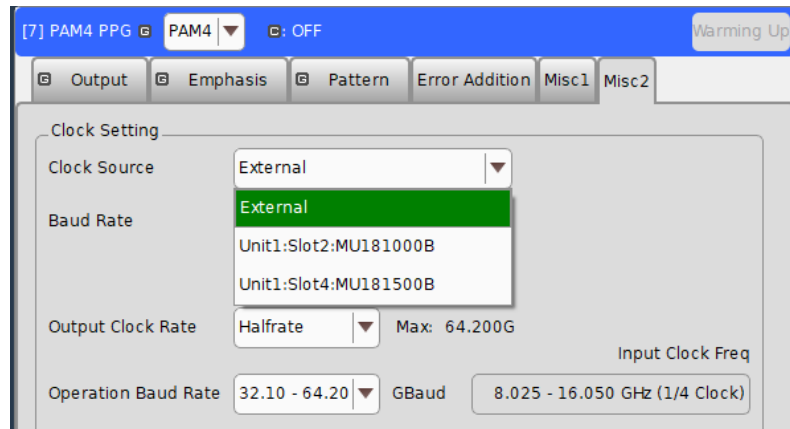


FIGURE 52. CLOCK SOURCE SETTING FOR MU196020A (SLOT 2, FEXT)

- b) On the MU196020A (Slot 2) **Output** screen, check that the **Baud Rate** is displayed as **53.125 Gbaud**.
3. Set the Output and Pattern settings for the MU196020A PAM4 PPG (Slot 2) as follows:
 - a) Output setting:
 - Total Amplitude: **0.325 Vpp**
 - Cable for Data Output: **J1790A 0.8m Cable**

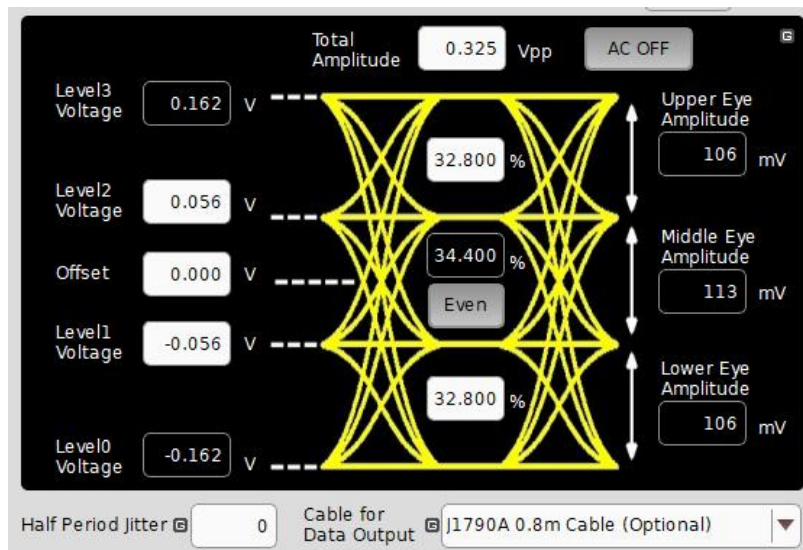


FIGURE 53. OUTPUT SETTING FOR MU196020A (SLOT 2, FEXT)

- b) Pattern setting:
 - Test Pattern: **PRBS13Q**

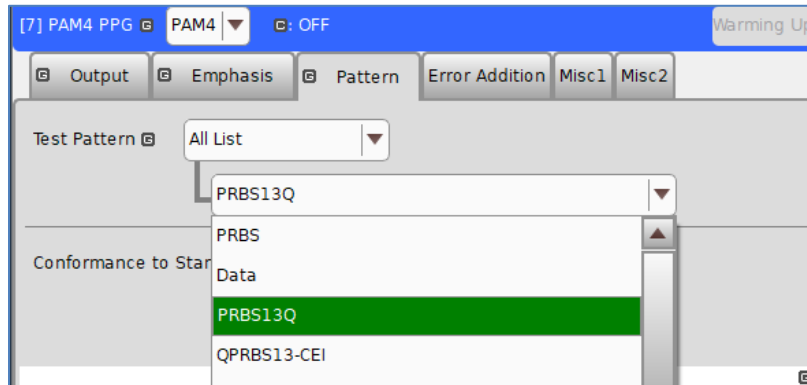


FIGURE 54. PATTERN SETTING FOR MU196020A (SLOT 2, FEXT)

4. Measure the data output of the MU196020A PAM4 PPG (Slot 2) with the N1000A sampling oscilloscope and verify that the differential amplitude is ≤ 0.8 Vpp.

If the amplitude exceeds 0.8 Vpp, reduce the value of the MU196020A total amplitude setting to cause the amplitude to be lower than 0.8 Vpp.

The following shows an example of a typical test result by adjusting the FEXT peak-to-peak amplitude with a target of 0.8 Vpp.



FIGURE 55. FEXT PEAK-TO-PEAK AMPLITUDE TEST RESULT EXAMPLE

The following procedure describes how to measure the FEXT amplitude with the N1000A sampling scope:

- i) From the “Setup” menu, select **Default Setup**.
- ii) From the “Setup” menu, select **Modules** → **Precision Waveform Analyzer**.

- iii) On the “Channels 1A&1B” tab, click on **Diff**, select **SIRC** and set the “Bandwidth” setting to **40 GHz**.
- iv) On the “Clock Recovery” tab, select the “Input symbol rate” as **53.125G** and click on the **Clock Recovery lock**.
- v) On the “Channels 1A&1B” tab, click on **Advanced setup** → **Auto differential deskew 1a&1b**.
- vi) On the “Precision Timebase” tab, select **Enable Precision Timebase**.
- vii) Close the “Precision Waveform Analyzer” setting window.
- viii) Run **Autoscale**.
- ix) From the “Measure” menu, select **Oscilloscope** → **Amplitude** → **peak-peak amplitude**.
- x) Read the “peak-peak amplitude” result.
- xi) Adjust the MP1900A amplitude setting and read the result.

9.1.4 Verify the performance of the MU196020A PAM4 PPG (Slot 3) used as the noise signal

1. Set up the connections for the noise signal calibration setup as shown in Figure 16.
2. Set the reference clock for the MU196020A PAM4 PPG (Slot 3) as follows:
 - a) On the MU196020A (Slot 3) **Misc2** settings screen, select the **Clock Source** setting as **External**. Select the **Operation Baud Rate** setting as **50.00-64.20**.

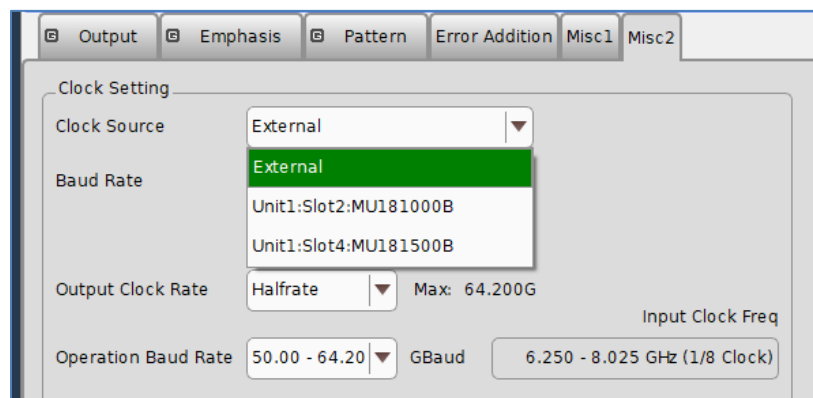


FIGURE 56. CLOCK SOURCE SETTING FOR MU196020A (SLOT 3, NOISE)

3. Input the MG3692C frequency of **7.25 GHz** and Output Power of **0 dBm** to the External Clock Input of the MU196020A (Slot 2).
4. On the MU196020A (Slot 3) **Output** screen, check that the **Baud Rate** is displayed as **58.0 Gbaud**.
5. Set the Output, Emphasis and Pattern settings for the MU196020A (Slot 2) as follows:
 - a) Output setting:
 - Cable for Data Output: **J1789A 0.4m Cable**
 - b) Emphasis settings:

- Manual Setting: **On**
- Pre-Cursor 1: **4 dB**
- Post-Cursor 1: **-4 dB**

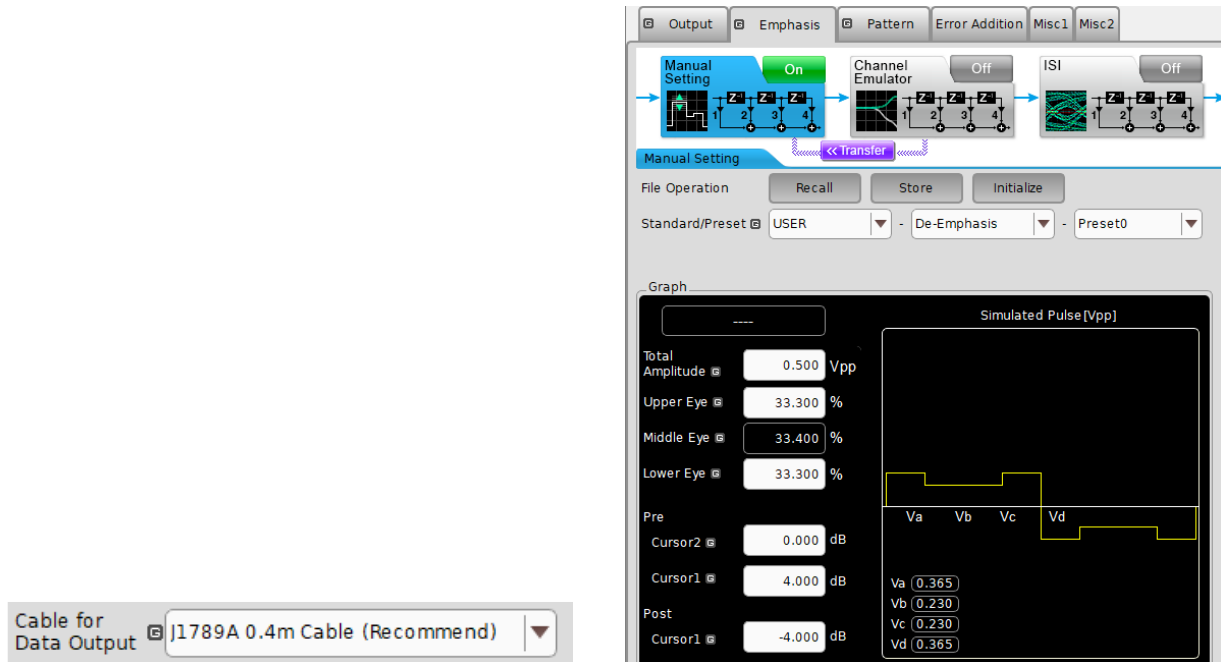


FIGURE 57. OUTPUT AND EMPHASIS SETTINGS FOR MU196020A (SLOT 3, NOISE)

c) Pattern setting:

- Test Pattern: **PRBS**
- PRBS Length: **$2^{31}-1$**

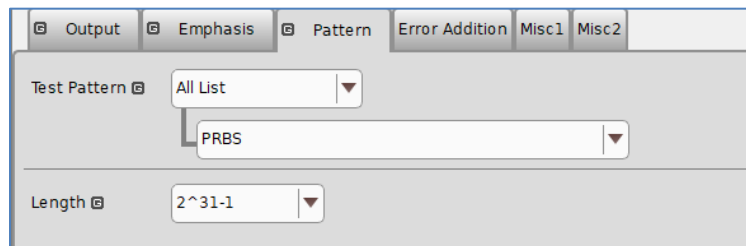


FIGURE 58. PATTERN SETTING FOR MU196020A (SLOT 3, NOISE)

- On the MP1900A BERT Output screen, turn **On** the **Output** button and measure the amplitude on the N1000A sampling scope while adjusting the Total Amplitude setting on the MU196020A (Slot 3).

For each Total Amplitude setting, measure the Peak-to-Peak amplitude for **0.2, 0.3, 0.4, 0.5, 0.6, 0.7** and **0.8 V**. The resultant amplitude measured should be around **12 to 47 mV (rms)**.

The following procedure describes how to measure the Noise amplitude with the N1000A sampling scope:

- From the “Setup” menu, select **Default Setup**.

- ii) From the “Setup” menu, select **Trigger Setup**.
- iii) For the “General Trigger Setup”, check out **Automatic** and select **Free Run**.
- iv) Close the setup window.
- v) From the “Setup” menu, select **Modules** → **Precision Waveform Analyzer**.
- vi) On the “Channels 1A&1B” tab, click on **Diff**, set the “Scale” to **4 mV** and set the “Bandwidth” to **50 GHz**.
- vii) Close the setting window.
- viii) From the “Setup” menu, select **Timebase Setup**.
- ix) Set the “Scale” to **2 ns** and close the setup window.
- x) From the “Measure” menu, select **Oscilloscope** → **Amplitude** → **peak-peak amplitude**.
- xi) Read the “peak-peak amplitude” result.
- xii) Adjust the MP1900A amplitude setting and read the result.

9.1.5 Calculate the noise amplitude to be added using the COM tool

Note: Refer to Section 10, Appendix B on how to use the COM tool.

1. Open the COM parameter EXCEL sheet (“**config_com_ieee8023_93a=3ck_d3p1_CR_CA_11_30_21.xlsx**”) and go to column “**G28**”. Enter the delay time for the Cable Assembly test fixture.
2. Run “**com_ieee8023_93a_470.exe**”.
3. The calculation results will be stored in the “**Results←100GEL_CR_CA_XXXXX**” folder. Check the following results and reflect them in the settings for the next test.

Note: References will vary depending on the test case (Test 1 or Test 2).

- For Test 1: CA_eval_yyyy_test case1_results.csv
 - For Test 2: CA_eval_yyyy_test case2_results.csv
- a) For “**channel_operating_margin_dB**”, verify that the result is > 3 dB.
 - b) For “**ERL**”, verify that the result is > 7.3 dB.
 - c) If COM and ERL do not meet the above requirements, check the performance, connectivity, etc. of the test channel.
 - d) Verify the value of “**sigma_bn**”.
 - e) Select the output setting for the MU196020A (Slot 3) that provides this value.
 - f) Verify the value of “**TXLE_taps**” which is the reference value for the MU196020A (Slot 1, Victim) Emphasis setting.
4. Measure the S-parameter of the noise path using the following setup:

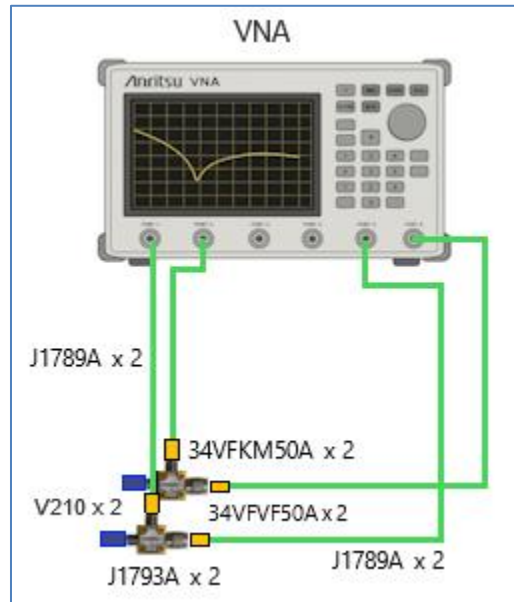


FIGURE 59. SETUP FOR S-PARAMETER MEASUREMENT OF NOISE PATH

- Using the J1789A coaxial cables, connect one pair of the VNA channels to the J1793A pick-off tees through the 34VFKM50A adapters.
- Using the J1789A coaxial cables, connect another pair of the VNA channels to the J1793A pick-off tees through the 34VFVF50A adapters.
- Connect the pick-off routes of the J1793A to the V210 50-ohm terminators.

9.2 Perform Rx Interference Tolerance Calibration (for KR Interface)

9.2.1 Measure the characteristics of Test channels and Test 1 & Test 2 cases to verify that the results meet the target insertion losses

Note: The following procedure applies for the 400GBASE-KR4 interface (4-lane connector).

1. Based on the following connections as shown in Figure 44 below, measure the characteristics of each test channel lane using a vector network analyzer.

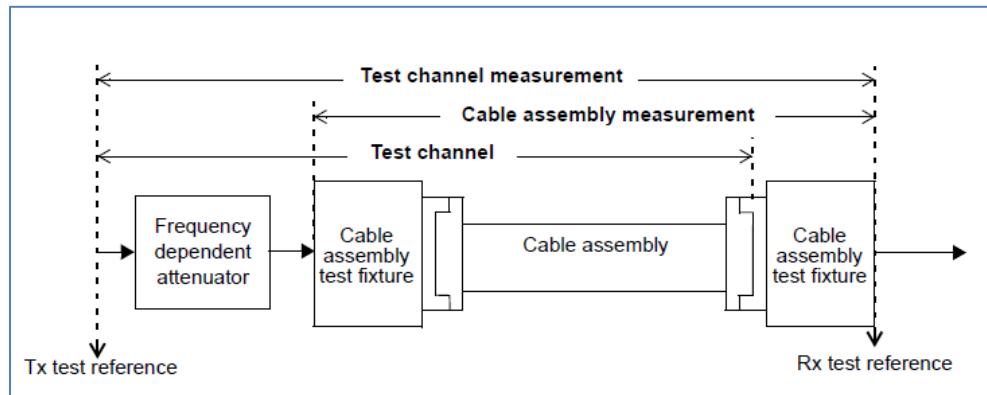


FIGURE 60. TEST CHANNEL CALIBRATION CONNECTION DIAGRAM (AS REFERENCED FROM IEEE802.3 STANDARD FIGURE 110-3B)

2. Based on Figure 45 below, measure the FEXT and NEXT crosstalk characteristics according to the characteristics of the measurement lane and the crosstalk environment during testing. Measure each S-parameter and save the results as a S4P file for each test channel and Test 1 & Test 2 cases.

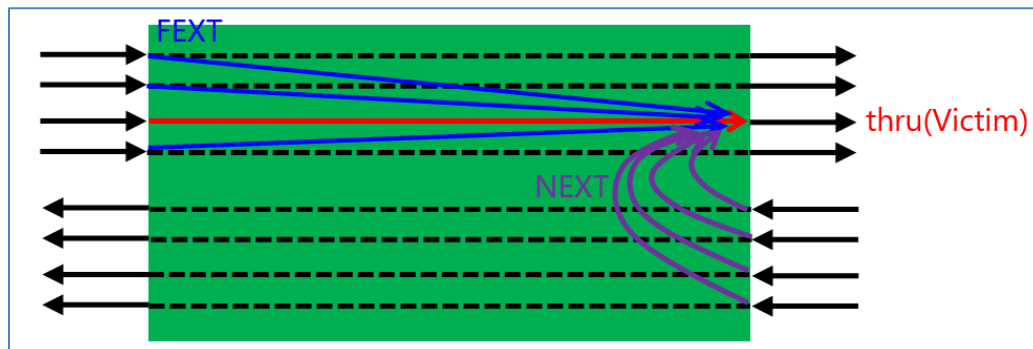


FIGURE 61. THRU TEST LANE AND FEXT & NEXT CROSSTALK LANES

3. Use the Time Domain function of the vector network analyzer to measure the delay time for the measured lanes and enter the results in the .xlsx sheet for COM calculation. Refer to Section 9.2.5 for details.

The procedure in the following sections uses one signal from the MU196020A PAM4 PPG (Slot 2) as FEXT and the Tx lanes of the DUT as NEXT.

9.2.2 Verify the performance of the MU196020A PAM4 PPG (Slot 1) used as the victim signal

1. Set up the connections for the Anritsu MP1900A BERT modules and victim signal calibration setup as shown in Figure 12 and Figure 14 respectively.
2. Turn on the MP1900A BERT and the N1000A sampling oscilloscope and warm up for approximately 30 minutes. Initialize the settings on both the BERT and scope. It is also a prerequisite to perform calibration on the input port of the N1060A module prior to calibration/testing.
3. Set the reference clock for the MU196020A PAM4 PPG as follows:
 - a) On the MU1815000B Settings screen as shown below, select the **Clock Source** setting as **MU181000B**.

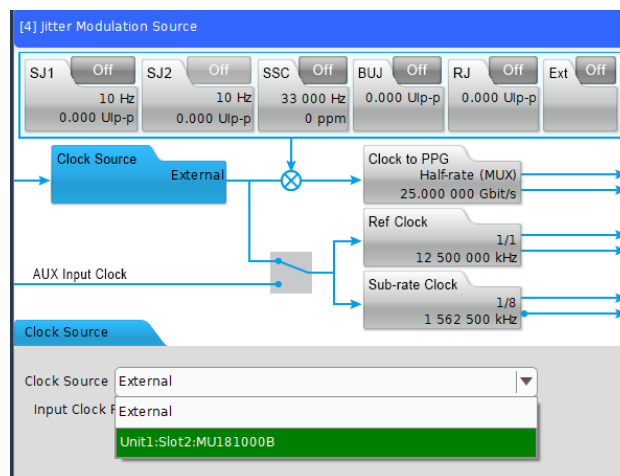


FIGURE 62. MU181500B CLOCK SOURCE SETTING

- b) On the MU196020A Misc2 Settings screen as shown below, select the **Clock Source** setting as **MU181500B**.

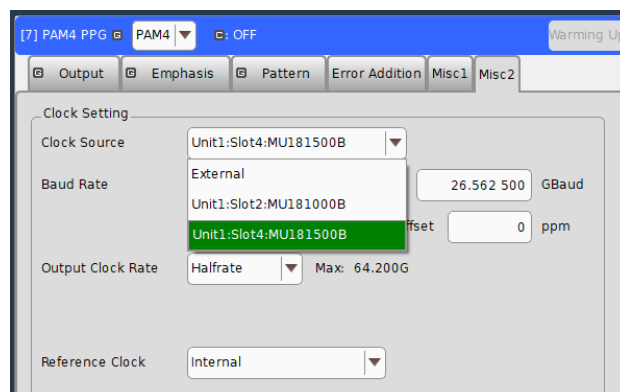


FIGURE 63. MU196020A Misc2 CLOCK SOURCE SETTING

4. On the MU196020A Output setting screen, set the following:
 - Baud Rate: **53.125 GBaud**

- Total Amplitude: **0.4 Vpp**
- Offset: **0.4 V**

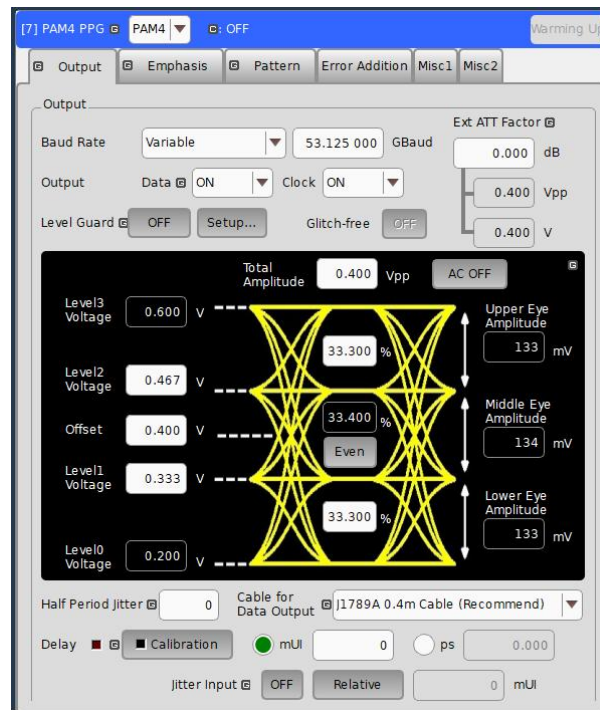


FIGURE 64. MU196020A (VICTIM) OUTPUT SETTINGS

- On the MU196020A Pattern setting screen, select the **Test Pattern** as **PRBS13Q**.

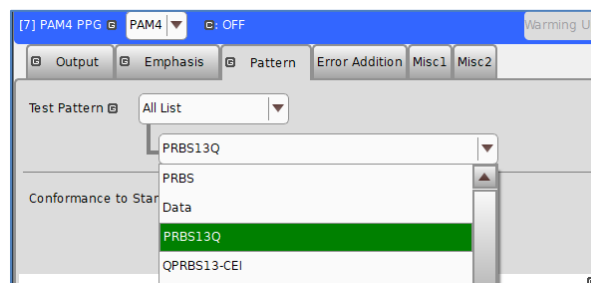


FIGURE 65. MU196020A (VICTIM) PATTERN SETTINGS

- On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output the signal.



FIGURE 66. MP1900A BERT OUTPUT ON

- Launch the N1091CKCA IEEE802.3Tx Test Application on the N1000A sampling oscilloscope and verify that the Even-odd jitter, J3u, Jrms, and SNDR meet the Tx standard using the following steps:

[Starting from Default Setting:]

- a) From the N1091CKCA IEEE802.3Tx Test Application, select **400GBase-KR4/200GBase-KR2/100GBase-KR TP0v**.
- b) Perform **Differential Skew Adjust**.
- c) Adjust the MU196020A prior to performing measurements by selecting **Even-odd jitter** in the Test Item screen and measure the Even-odd jitter performance against the Half Period Jitter setting of the MU196020A. Repeat the Even-odd jitter measurement while adjusting the Half Period Jitter in the range of -1.5~+1.5 (step 0.2) to determine the Half Period Jitter setting value at which the Even-odd jitter is the maximum value below 0.025 UI.

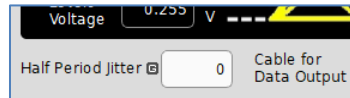


FIGURE 67. HALF PERIOD JITTER SETTING

- d) After adjusting the Even-odd jitter, select **J3u, Jrms, Even-odd jitter** and **SNDR** as Test Items and proceed to run measurements.
- e) Ensure that the measurement report file is saved.
- f) Once measurements have completed, turn **OFF** the **Output** button on the upper left corner of the MP1900A BERT screen.

9.2.3 Verify the amplitude of the MU196020A PAM4 PPG (Slot 2) used as the FEXT signal

1. Set up the connections for the FEXT signal calibration setup as shown in Figure 15.
2. Set the reference clock for the MU196020A PAM4 PPG (Slot 2) as follows:
 - a) On the MU196020A (Slot 2) **Misc2** settings screen, select the **Clock Source** setting as **External**. Select the **Operation Baud Rate** setting as **32.10-64.20**.

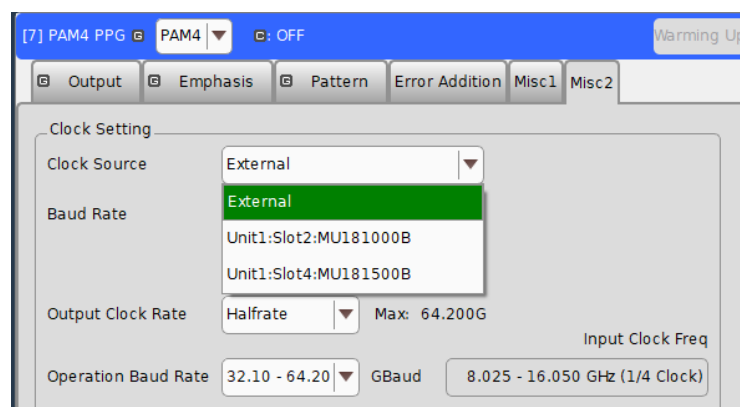


FIGURE 68. CLOCK SOURCE SETTING FOR MU196020A (SLOT 2, FEXT)

- b) On the MU196020A (Slot 2) **Output** screen, check that the **Baud Rate** is displayed as **53.125 Gbaud**.
3. Set the Output and Pattern settings for the MU196020A PAM4 PPG (Slot 2) as follows:
 - a) Output setting:
 - Total Amplitude: **0.325 Vpp**

- Cable for Data Output: **J1790A 0.8m Cable**

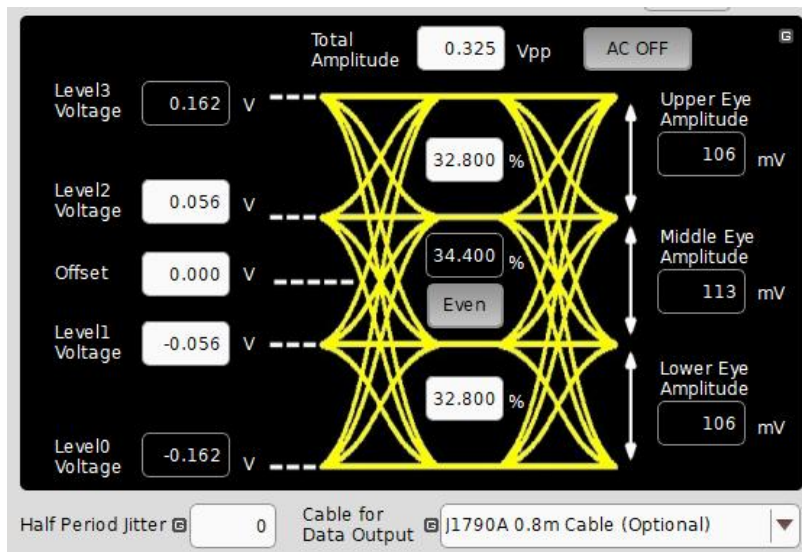


FIGURE 69. OUTPUT SETTING FOR MU196020A (SLOT 2, FEXT)

b) Pattern setting:

- Test Pattern: **PRBS13Q**

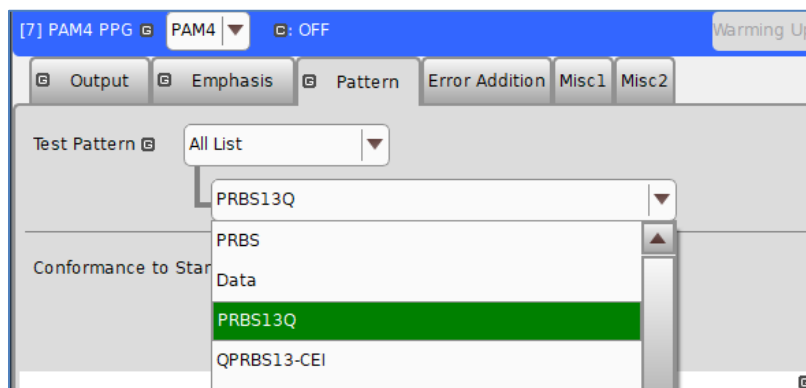


FIGURE 70. PATTERN SETTING FOR MU196020A (SLOT 2, FEXT)

4. Measure the data output of the MU196020A PAM4 PPG (Slot 2) with the N1000A sampling oscilloscope and verify that the differential amplitude is ≤ 0.8 Vpp.

If the amplitude exceeds 0.8 Vpp, reduce the value of the MU196020A total amplitude setting to cause the amplitude to be lower than 0.8 Vpp.

The following shows an example of a typical test result by adjusting the FEXT peak-to-peak amplitude with a target of 0.8 Vpp.



FIGURE 71. FEXT PEAK-TO-PEAK AMPLITUDE TEST RESULT EXAMPLE

The following procedure describes how to measure the FEXT amplitude with the N1000A sampling scope:

- i) From the “Setup” menu, select **Default Setup**.
- ii) From the “Setup” menu, select **Modules** → **Precision Waveform Analyzer**.
- iii) On the “Channels 1A&1B” tab, click on **Diff**, select **SIRC** and set the “Bandwidth” setting to **40 GHz**.
- iv) On the “Clock Recovery” tab, select the “Input symbol rate” as **53.125G** and click on the **Clock Recovery lock**.
- v) On the “Channels 1A&1B” tab, click on **Advanced setup** → **Auto differential deskew 1a&1b**.
- vi) On the “Precision Timebase” tab, select **Enable Precision Timebase**.
- vii) Close the “Precision Waveform Analyzer” setting window.
- viii) Run **Autoscale**.
- ix) From the “Measure” menu, select **Oscilloscope** → **Amplitude** → **peak-peak amplitude**.
- x) Read the “peak-peak amplitude” result.
- xi) Adjust the MP1900A amplitude setting and read the result.

9.2.4 Verify the performance of the MU196020A PAM4 PPG (Slot 3) used as the noise signal

1. Set up the connections for the noise signal calibration setup as shown in Figure 16.
2. Set the reference clock for the MU196020A PAM4 PPG (Slot 3) as follows:
 - a) On the MU196020A (Slot 3) **Misc2** settings screen, select the **Clock Source** setting as **External**. Select the **Operation Baud Rate** setting as **50.00-64.20**.

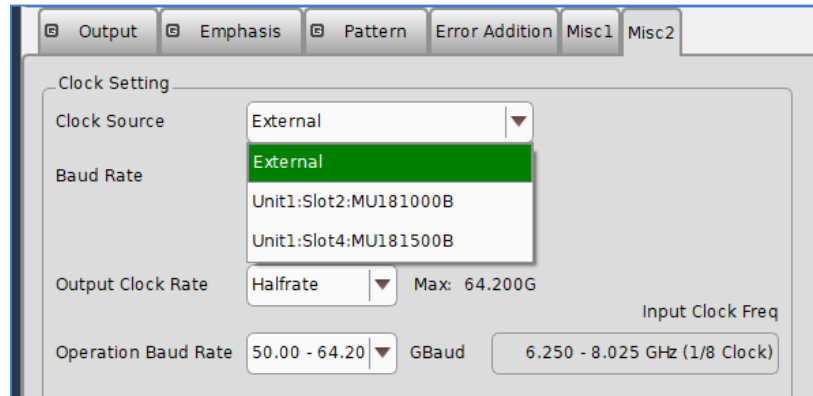


FIGURE 72. CLOCK SOURCE SETTING FOR MU196020A (SLOT 3, NOISE)

3. Input the MG3692C frequency of **7.25 GHz** and Output Power of **0 dBm** to the External Clock Input of the MU196020A (Slot 2).
4. On the MU196020A (Slot 3) **Output** screen, check that the **Baud Rate** is displayed as **58.0 GBaud**.
5. Set the Output, Emphasis and Pattern settings for the MU196020A (Slot 2) as follows:
 - a) Output setting:
 - Cable for Data Output: **J1789A 0.4 m Cable**
 - b) Emphasis settings:
 - Manual Setting: **On**
 - Pre-Cursor 1: **4 dB**
 - Post-Cursor 1: **-4 dB**

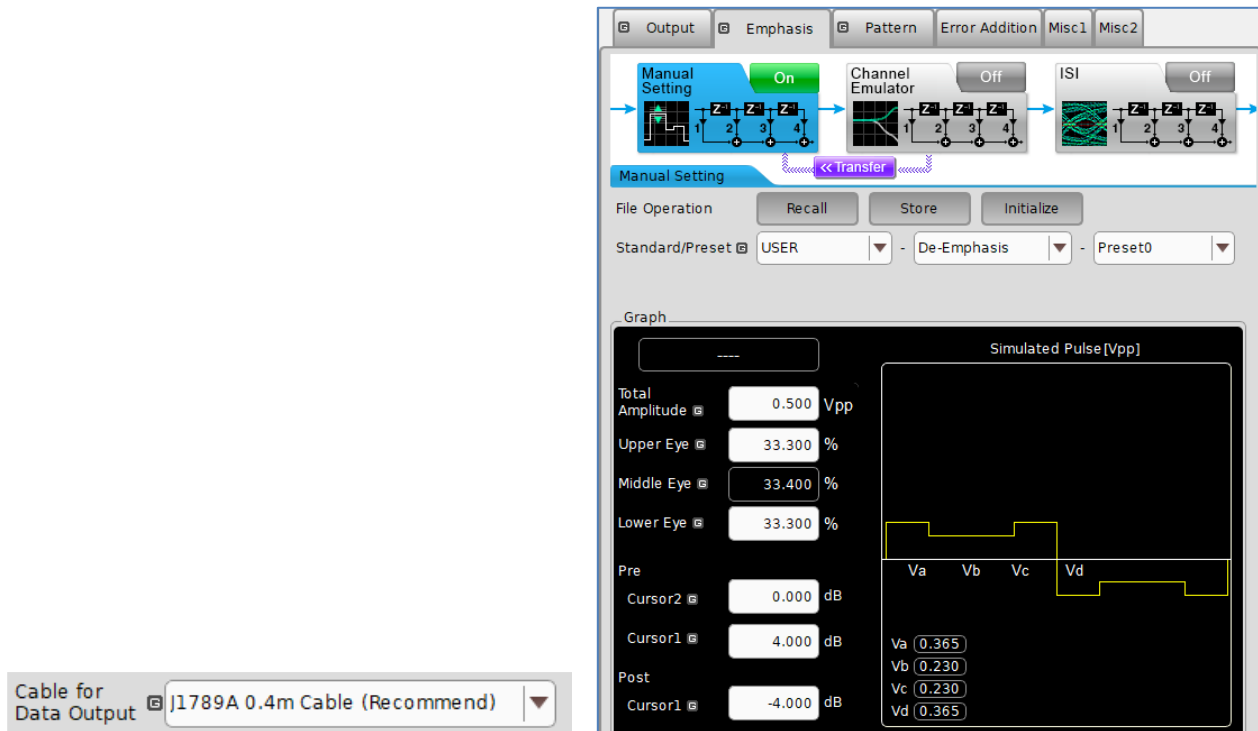


FIGURE 73. OUTPUT AND EMPHASIS SETTINGS FOR MU196020A (SLOT 3, NOISE)

c) Pattern setting:

- Test Pattern: **PRBS**
- PRBS Length: **2³¹-1**

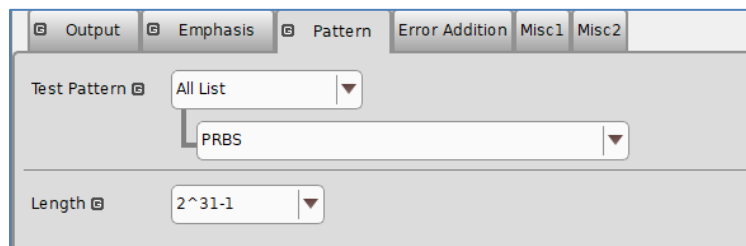


FIGURE 74. PATTERN SETTING FOR MU196020A (SLOT 3, NOISE)

- On the MP1900A BERT Output screen, turn **On** the **Output** button and measure the amplitude on the N1000A sampling scope while adjusting the Total Amplitude setting on the MU196020A (Slot 3).

For each Total Amplitude setting, measure the Peak-to-Peak amplitude for **0.2, 0.3, 0.4, 0.5, 0.6, 0.7** and **0.8 V**. The resultant amplitude measured should be around **12 to 47 mV (rms)**.

The following procedure describes how to measure the Noise amplitude with the N1000A sampling scope:

- i) From the “Setup” menu, select **Default Setup**.
- ii) From the “Setup” menu, select **Trigger Setup**.
- iii) For the “General Trigger Setup”, check out **Automatic** and select **Free Run**.
- iv) Close the setup window.
- v) From the “Setup” menu, select **Modules** → **Precision Waveform Analyzer**.
- vi) On the “Channels 1A&1B” tab, click on **Diff**, set the “Scale” to **4 mV** and set the “Bandwidth” to **50 GHz**.
- vii) Close the setting window.
- viii) From the “Setup” menu, select **Timebase Setup**.
- ix) Set the “Scale” to **2 ns** and close the setup window.
- x) From the “Measure” menu, select **Oscilloscope** → **Amplitude** → **peak-peak amplitude**.
- xi) Read the “peak-peak amplitude” result.
- xii) Adjust the MP1900A amplitude setting and read the result.

9.2.5 Calculate the noise amplitude to be added using the COM tool

Note: Refer to Section 10, Appendix B on how to use the COM tool.

1. Open the COM parameter EXCEL sheet (“**config_com_ieee8023_93a=3ck_d3p1_KR_11_30_21.xlsx**”).
2. Run “**com_ieee8023_93a_470.exe**”.
3. The calculation results will be stored in the “**Results←100GEL_KR_XXXXX**” folder. Check the following results and reflect them in the settings for the next test.

Note: References will vary depending on the test case (Test 1 or Test 2).

- For Test 1: KR_eval_yyyy_test case1_results.csv
 - For Test 2: KR_eval_yyyy_test case2_results.csv
- a) For “**channel_operating_margin_dB**”, verify that the result is > 3 dB.
 - b) For “**ERL**”, verify that the result is > 9.7 dB.
 - c) If COM and ERL do not meet the above requirements, check the performance, connectivity, etc. of the test channel.
 - d) Verify the value of “**sigma_bn**”.
 - e) Select the output setting for the MU196020A (Slot 3) that provides this value.
 - f) Verify the value of “**TXLE_taps**” which is the reference value for the MU196020A (Slot 1, Victim) Emphasis setting.
4. Measure the S-parameter of the noise path using the following setup:

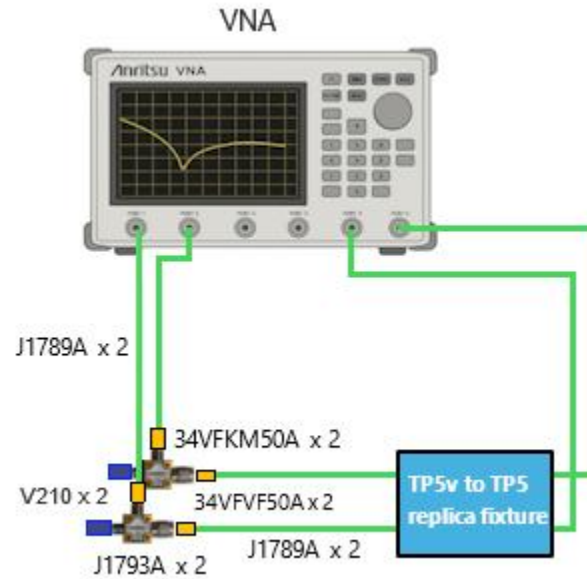


FIGURE 75. SETUP FOR S-PARAMETER MEASUREMENT OF NOISE PATH

- Using the J1789A coaxial cables, connect one pair of the VNA channels to the J1793A pick-off tees through the 34VFKM50A adapters.
- Connect the other end of the J1793A pick-off tees to the TP5v to TP5 replica fixture through the 34VFVF50A V(f) - V(f) adapters using the J1789A coaxial cables.
- Connect another pair of the VNA channels to the TP5v to TP5 replica fixture.
- Connect the pick-off routes of the J1793A to the V210 50-ohm terminators.

9.3 Perform Rx Jitter Tolerance Calibration (for CR Interface)

9.3.1 Verify the jitter amplitude of the MU196020A PAM4 PPG (Slot 1) used as the Victim signal

Note: The Noise signal from the Interference Tolerance calibration will not be used in the following jitter tolerance calibration.

1. Set up the connections for the Anritsu MP1900A BERT modules and jitter amplitude calibration setup as shown in Figure 12 and Figure 17 respectively.
2. Turn on the MP1900A BERT and the N1000A sampling oscilloscope and warm up for approximately 30 minutes. Initialize the settings on both the BERT and scope. It is also a prerequisite to perform calibration on the input port of the N1060A module prior to calibration/testing.
3. Set the reference clock for the MU196020A PAM4 PPG (Slot 1) as follows:
 - a) On the MU1815000B Settings screen as shown below, select the **Clock Source** setting as **MU181000B**.

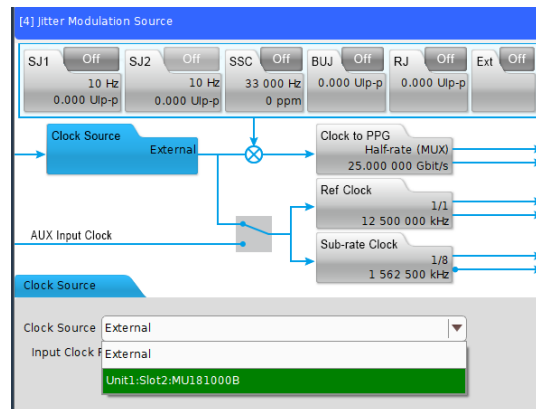


FIGURE 76. MU181500B CLOCK SOURCE SETTING

- b) On the MU196020A Misc2 Settings screen as shown below, select the **Clock Source** setting as **MU181500B**.

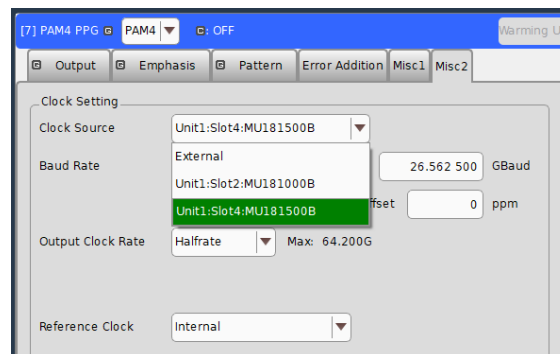


FIGURE 77. MU196020A Misc2 CLOCK SOURCE SETTING

4. On the MU196020A Output setting screen, set the following:
 - Baud Rate: **53.125 Gbaud**
 - Ext ATT Factor: **2.1 dB** (typ. loss in J1793A)

- Total Amplitude: **0.509 Vpp** (amplitude set to **0.4 Vpp** after passing J1793A)

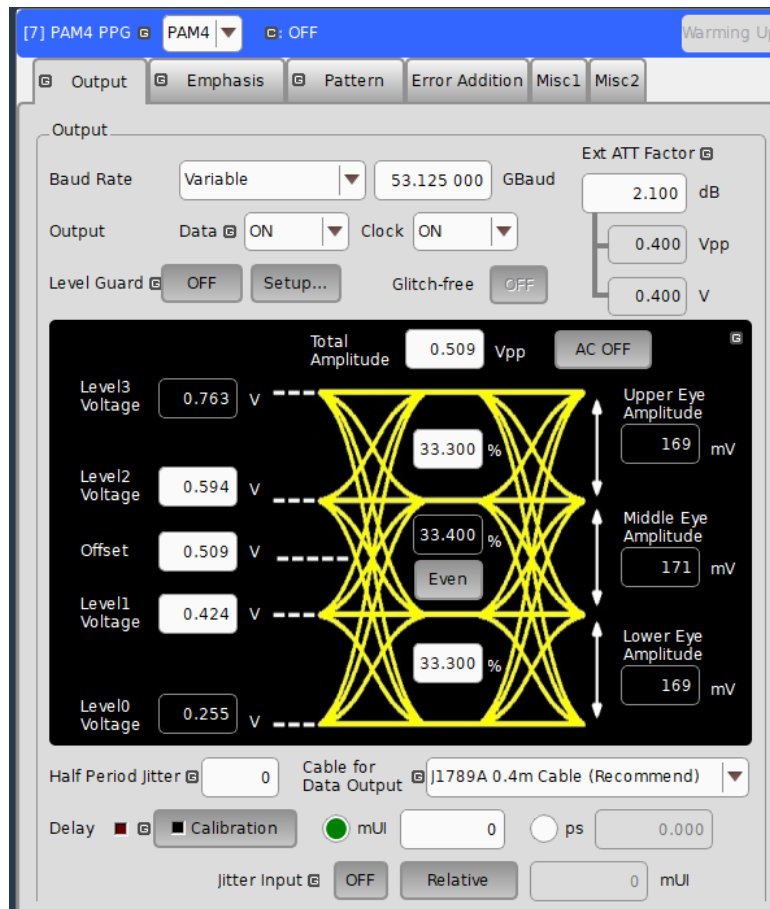


FIGURE 78. MU196020A (VICTIM) OUTPUT SETTINGS

5. On the MU196020A Emphasis setting screen, turn **Off** the **Manual Setting**.

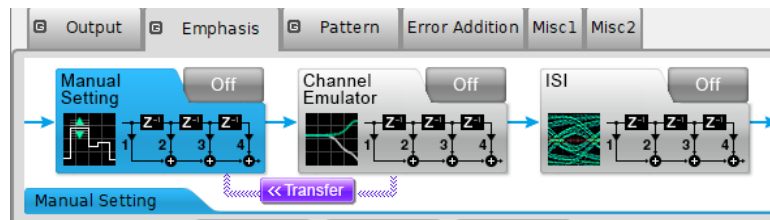


FIGURE 79. MU196020A (VICTIM) EMPHASIS SETTINGS

6. On the MU196020A Pattern setting screen, select the **Test Pattern** as **JP03A**.

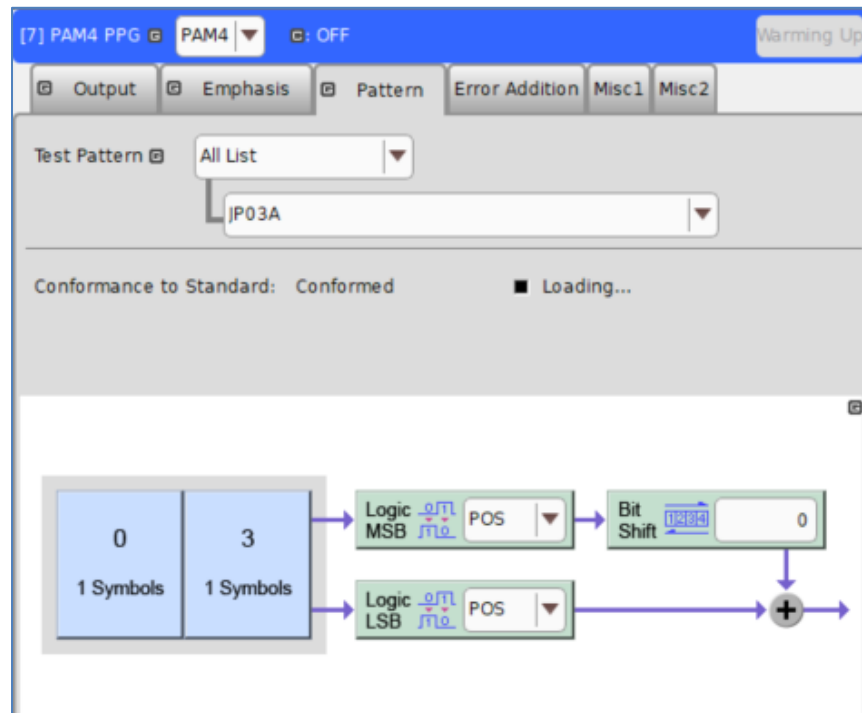


FIGURE 80. MU196020A (VICTIM) PATTERN SETTINGS

7. On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output the signal.



FIGURE 81. MP1900A BERT OUTPUT ON

8. Launch the N1091CKCA IEEE802.3Tx Test Application on the N1000A sampling oscilloscope and measure the jitter amplitude.
9. Adjust the SJ1 setting of the MU181500B jitter modulation source and calibrate the Amplitude setting at each jitter frequency according to the test criteria for the Jitter Tolerance test, as specified in Table 5 below.

TABLE 5. JITTER AMPLITUDE TEST CRITERIA FOR JITTER TOLERANCE TEST (REFERENCED FROM IEEE802.3CK STANDARD TABLE 162-17)

	Case A	Case B	Case C	Case D	Case E	Case F
Jitter Frequency [MHz]	0.04	0.4	1.333	4	12	40
Jitter Amplitude (pk-pk) [UI]	5	0.5	0.15	0.05	0.05	0.05

Use the following jitter values for MU181500B Jitter Modulation Source calibration:

TABLE 6. JITTER AMPLITUDE FOR MU181500B CALIBRATION

	Case A	Case B	Case C	Case D	Case E	Case F
Jitter Frequency [Hz]	40,000	400,000	1,333,000	4,000,000	12,000,000	40,000,000
Jitter Amplitude (pk-pk) [UI]	-	0.248	0.072	0.024	0.024	0.024
	-	0.5	0.148	0.05	0.048	0.048
	-	1	0.3	0.1	0.1	0.1

Turn **On** SJ1 of the MU181500B jitter modulation source and set the jitter frequency and amplitude values from Table 6 above. Measure the jitter peak-to-peak values using the N1000A sampling scope.

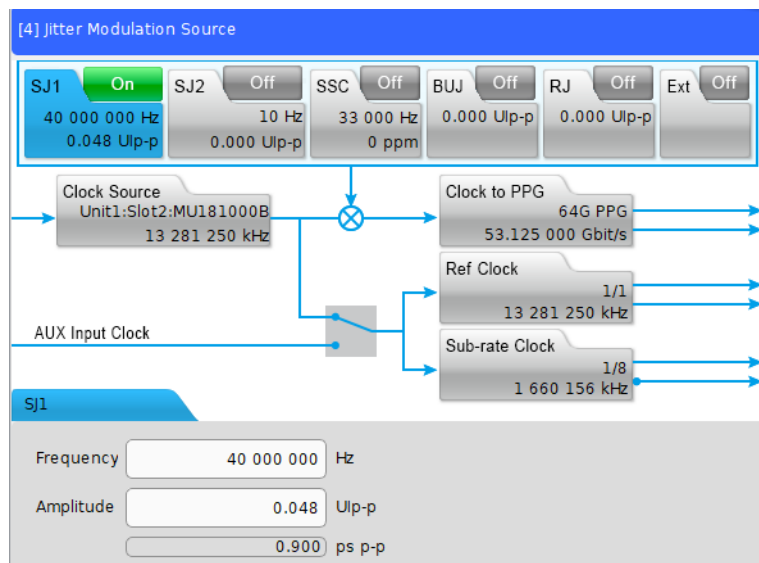


FIGURE 82. MU181500B SJ1 SETTINGS

- Check that the MU181500B jitter amplitude from the measurement correlate to the values in Table 5 for each jitter frequency.

9.4 Perform Rx Jitter Tolerance Calibration (for KR Interface)

9.4.1 Verify the jitter amplitude of the MU196020A PAM4 PPG (Slot 1) used as the Victim signal

Note: The Noise signal from the Interference Tolerance calibration will not be used in the following jitter tolerance calibration.

1. Set up the connections for the Anritsu MP1900A BERT modules and jitter amplitude calibration setup as shown in Figure 12 and Figure 18 respectively.
2. Turn on the MP1900A BERT and the N1000A sampling oscilloscope and warm up for approximately 30 minutes. Initialize the settings on both the BERT and scope. It is also a prerequisite to perform calibration on the input port of the N1060A module prior to calibration/testing.
3. Set the reference clock for the MU196020A PAM4 PPG (Slot 1) as follows:
 - a) On the MU1815000B Settings screen as shown below, select the **Clock Source** setting as **MU181000B**.

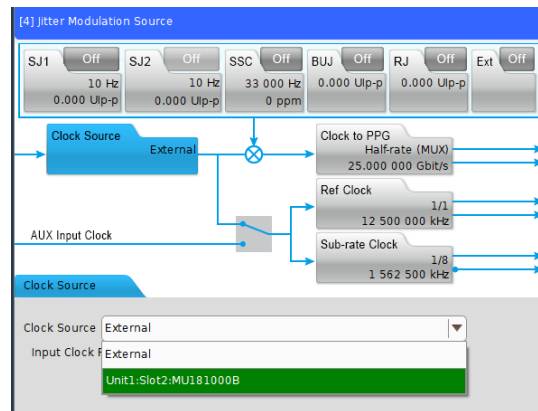


FIGURE 83. MU181500B CLOCK SOURCE SETTING

- b) On the MU196020A Misc2 Settings screen as shown below, select the **Clock Source** setting as **MU181500B**.

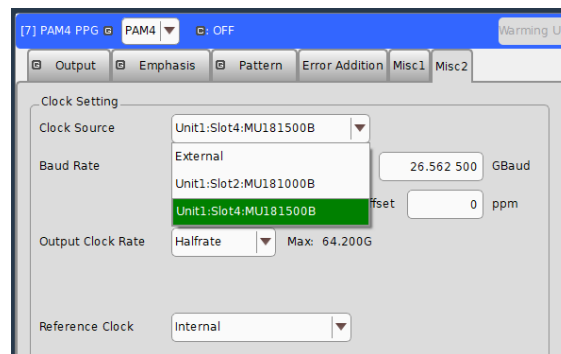


FIGURE 84. MU196020A MISC2 CLOCK SOURCE SETTING

4. On the MU196020A Output setting screen, set the following:
 - Baud Rate: **53.125 Gbaud**
 - Total Amplitude: **0.4 Vpp**

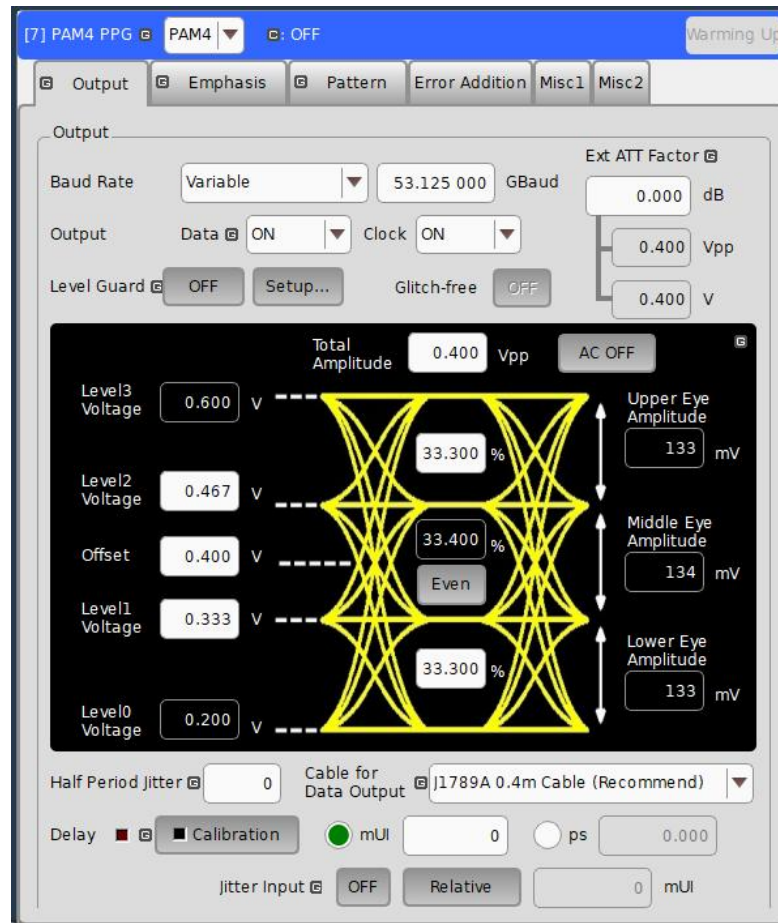


FIGURE 85. MU196020A (VICTIM) OUTPUT SETTINGS

5. On the MU196020A Emphasis setting screen, turn **Off** the **Manual Setting**.

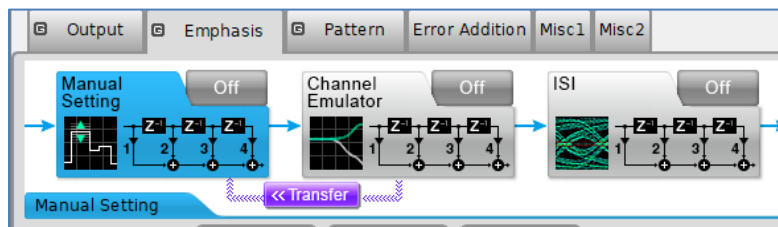


FIGURE 86. MU196020A (VICTIM) EMPHASIS SETTINGS

6. On the MU196020A Pattern setting screen, select the **Test Pattern** as **JP03A**.

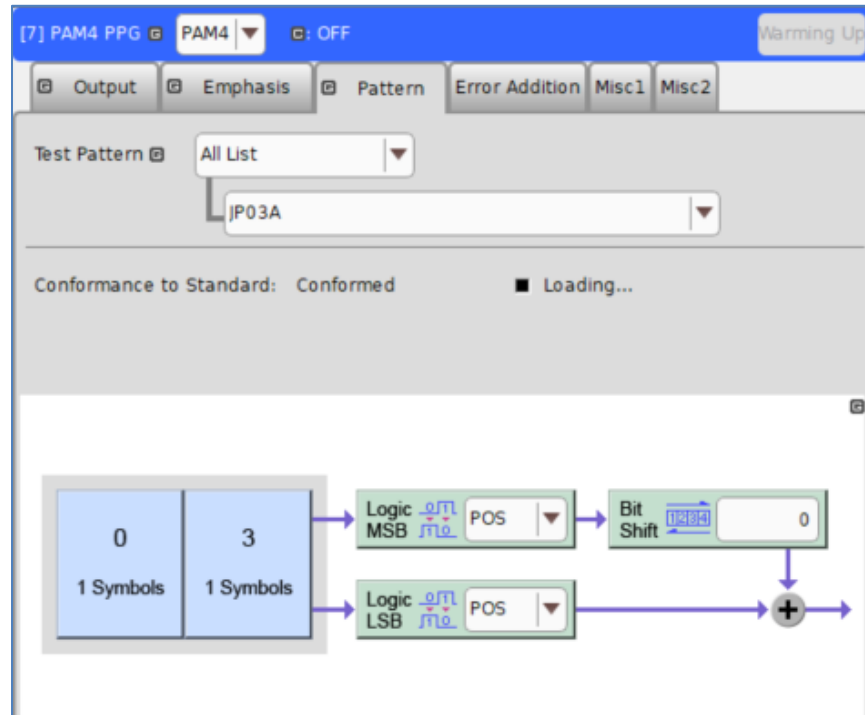


FIGURE 87. MU196020A (VICTIM) PATTERN SETTINGS

7. On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output the signal.



FIGURE 88. MP1900A BERT OUTPUT ON

8. Launch the N1091CKCA IEEE802.3Tx Test Application on the N1000A sampling oscilloscope and measure the jitter amplitude.
9. Adjust the SJ1 setting of the MU181500B jitter modulation source and calibrate the Amplitude setting at each jitter frequency according to the test criteria for the Jitter Tolerance test, as specified in Table 7 below.

TABLE 7. JITTER AMPLITUDE TEST CRITERIA FOR JITTER TOLERANCE TEST (REFERENCED FROM IEEE802.3CK STANDARD TABLE 162-17)

	Case A	Case B	Case C	Case D	Case E	Case F
Jitter Frequency [MHz]	0.04	0.4	1.333	4	12	40
Jitter Amplitude (pk-pk) [UI]	5	0.5	0.15	0.05	0.05	0.05

Use the following jitter values for MU181500B Jitter Modulation Source calibration:

TABLE 8. JITTER AMPLITUDE FOR MU181500B CALIBRATION

	Case A	Case B	Case C	Case D	Case E	Case F
Jitter Frequency [Hz]	40,000	400,000	1,333,000	4,000,000	12,000,000	40,000,000
Jitter Amplitude (pk-pk) [UI]	-	0.248	0.072	0.024	0.024	0.024
	-	0.5	0.148	0.05	0.048	0.048
	-	1	0.3	0.1	0.1	0.1

Turn **On** SJ1 of the MU181500B jitter modulation source and set the jitter frequency and amplitude values from Table 6 above. Measure the jitter peak-to-peak values using the N1000A sampling scope.

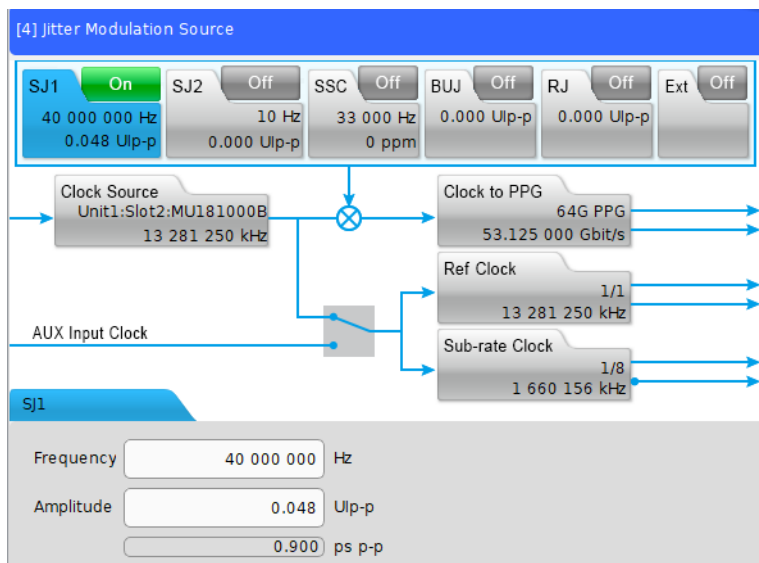


FIGURE 89. MU181500B SJ1 SETTINGS

- Check that the MU181500B jitter amplitude from the measurement correlate to the values in Table 7 for each jitter frequency.

9.5 Perform DUT Rx Interference Tolerance Test for Test 1 & Test 2 Cases (for CR Interface)

9.5.1 Configure MU196020A PAM4 PPG Victim signal, FEXT signal & noise signal settings and the value calculated by the COM tool

- Set up the connections for the Anritsu MP1900A BERT modules, Test 1 case setup and Test 2 case setup as shown in Figure 12, Figure 29 and Figure 30 respectively.
- Set the following settings for the MU196020A PAM4 PPG (**Slot 1, Victim**):
 - On the **Emphasis** setting screen, apply the following configuration:
 - Turn **On** “Manual Setting”.
 - Select the “Standard/Preset” (Emphasis type) as **Coefficient**.
 - For the “Coefficient” settings, set the “C-2”, “C-1”, “C0” and “C1” values according to the COM calculation results for the “**TXLE_taps**” [C-3 C-2 C-1 C0 C1] information. Figure 90 below shows an example of the coefficient settings for TXLE_taps [0 0.04 -0.22 0.74 0].

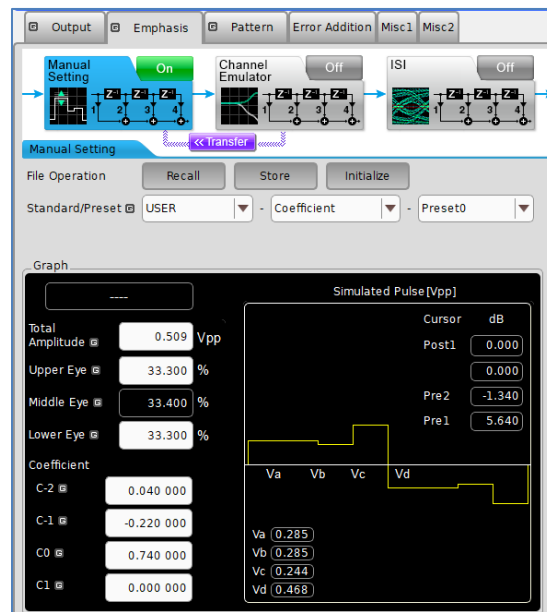


FIGURE 90. MU196020A (SLOT 1, VICTIM) EMPHASIS SETTINGS

- On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

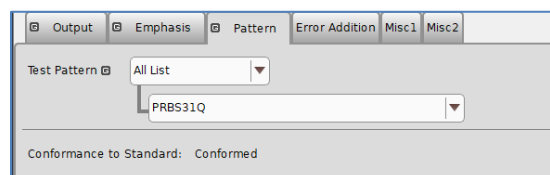


FIGURE 91. MU196020A (SLOT 1, VICTIM) PATTERN SETTING

- Set the following settings for the MU196020A PAM4 PPG (**Slot 2, FEXT**):
 - On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

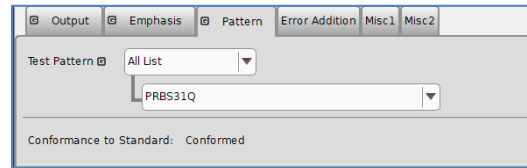


FIGURE 92. MU196020A (Slot 2, FEXT) PATTERN SETTING

4. Set the following settings for the MU196020A PAM4 PPG (**Slot 3, Noise**):
 - a) Set the Total Amplitude to the value calculated by the COM tool based on the results of the Noise signal Total Amplitude setting vs. output amplitude in Section 9.1.4. Refer to Section 9.1.5, “Calculate the noise amplitude to be added using the COM tool”.

9.5.2 Determine the Emphasis setting of the MU196020A (Slot 1) and the Equalizer setting of the DUT Rx

1. On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output all signals of the MU196020A PAM4 PPG.



FIGURE 93. MP1900A BERT OUTPUT ON

2. Referring to Figure 94 below, allow the Rx equalizer value to automatically optimize or set sweep to determine the minimum BER result. Set the Tx (NEXT crosstalk) of the DUT to the **PRBS31Q** pattern, **Preset 0**, and Output **On**.

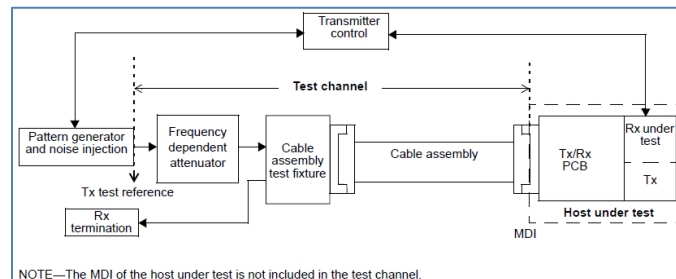


FIGURE 94. INTERFERENCE TOLERANCE TEST SETUP SCHEMATIC (REFERENCED FROM IEEE802.3CK STANDARD, FIGURE 110-3A)

3. Adjust the Emphasis Coefficient C-2 setting of the MU196020A (Slot 1) and perform optimization for the Rx equalizer as in Step 2 above. From there, determine the minimum BER value.
 - The C-2 setting should be adjusted from -0.04 to +0.04 with step 0.005 based on the value set in Step 2 a) from Section 9.5.1 above. Determine the C-2 setpoint at which the BER is minimized. *[Note: The BER measurement time is 200 ms.]*
4. Determine the optimal BER value for the range of Coefficient Min and Max settings in Table 9 below, and for the value set in Step 2 a) from Section 9.5.1 above.

TABLE 9. COEFFICIENT AND EMPHASIS ADJUSTMENT SETTINGS

Coefficient	Min Setting	Max Setting	Emphasis Adjustment			
			-	Initial Setting	+	Step
C-2	0	0.1	-0.04	Values calculated using the COM tool	+0.04	0.005
C-1	-0.3	0	-0.08		+0.08	0.01
C0	0.5	1	-0.2		+0.2	0.05
C1	-0.1	0	-0.05		+0.05	0.05

- Similarly, adjust the C-1, C0 and C1 settings accordingly to determine the C-1, C0 and C1 settings with the lowest BER respectively.

9.5.3 Measure BER and FEC error ratio to target specification

- After adjusting the MU196020A Emphasis and Rx equalization to obtain the minimum BER settings, proceed to measure the BER and FEC error ratio (using a FEC error counter).
- Make sure the BER meets the target of less than 2.4×10^{-4} and the FEC error ratio of less than 10^{-3} . *[Note: The measurement time is $> 5.6 \mu s$ at TP0 target BER E-5, or $\geq 56 \mu s$ when observing up to 10 times the margin performance of the above.]*

9.6 Perform DUT Rx Interference Tolerance Test for Test 1 & Test 2 Cases (for KR Interface)

9.6.1 Configure MU196020A PAM4 PPG Victim signal, FEXT signal & noise signal settings and the value calculated by the COM tool

- Set up the connections for the Anritsu MP1900A BERT modules, Test 1 case setup and Test 2 case setup as shown in Figure 12, Figure 31 and Figure 32 respectively.
- Set the following settings for the MU196020A PAM4 PPG (**Slot 1, Victim**):
 - On the **Emphasis** setting screen, apply the following configuration:
 - Turn **On** “Manual Setting”.
 - Select the “Standard/Preset” (Emphasis type) as **Coefficient**.
 - For the “Coefficient” settings, set the “C-2”, “C-1”, “C0” and “C1” values according to the COM calculation results for the “**TXLE_taps**” [C-3 C-2 C-1 C0 C1] information. Figure 95 below shows an example of the coefficient settings for TXLE_taps [0 0.04 -0.22 0.74 0].

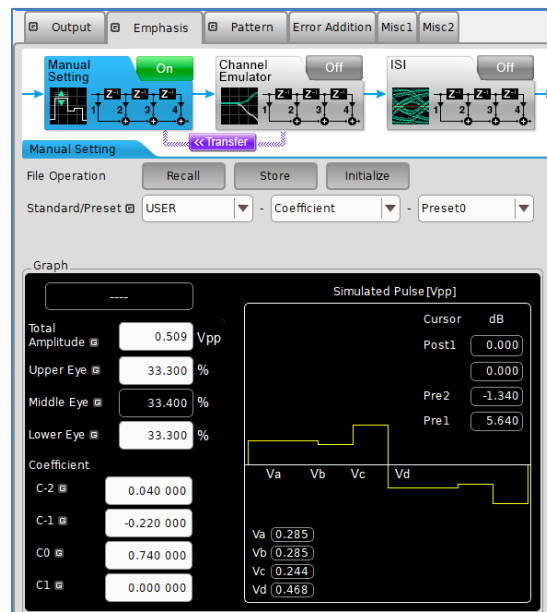


FIGURE 95. MU196020A (SLOT 1, VICTIM) EMPHASIS SETTINGS

- On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

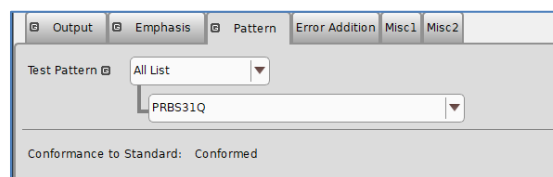


FIGURE 96. MU196020A (SLOT 1, VICTIM) PATTERN SETTING

- Set the following settings for the MU196020A PAM4 PPG (**Slot 2, FEXT**):
 - On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

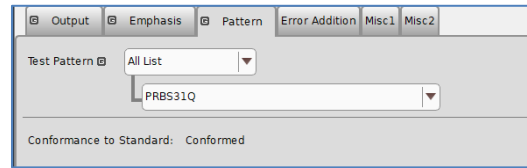


FIGURE 97. MU196020A (Slot 2, FEXT) PATTERN SETTING

4. Set the following settings for the MU196020A PAM4 PPG (**Slot 3, Noise**):
 - a) Set the Total Amplitude to the value calculated by the COM tool based on the results of the Noise signal Total Amplitude setting vs. output amplitude in Section 9.1.4. Refer to Section 9.1.5, “Calculate the noise amplitude to be added using the COM tool”.

9.6.2 Determine the Emphasis setting of the MU196020A (Slot 1) and the Equalizer setting of the DUT Rx

1. On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output all signals of the MU196020A PAM4 PPG.



FIGURE 98. MP1900A BERT OUTPUT ON

2. Referring to Figure 99 below, allow the Rx equalizer value to automatically optimize or set sweep to determine the minimum BER result. Set the Tx (NEXT crosstalk) of the DUT to the **PRBS31Q** pattern, **Preset 0**, and Output **On**.

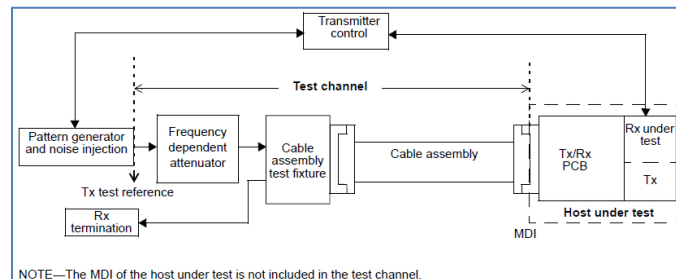


FIGURE 99. INTERFERENCE TOLERANCE TEST SETUP SCHEMATIC (REFERENCED FROM IEEE802.3CK STANDARD, FIGURE 110-3A)

3. Adjust the Emphasis Coefficient C-2 setting of the MU196020A (Slot 1) and perform optimization for the Rx equalizer as in Step 2 above. From there, determine the minimum BER value.
 - The C-2 setting should be adjusted from -0.04 to +0.04 with step 0.005 based on the value set in Step 2 a) from Section 9.6.1 above. Determine the C-2 setpoint at which the BER is minimized. *[Note: The BER measurement time is 200 ms.]*
4. Determine the optimal BER value for the range of Coefficient Min and Max settings in Table 10 below, and for the value set in Step 2 a) from Section 9.6.1 above.

TABLE 10. COEFFICIENT AND EMPHASIS ADJUSTMENT SETTINGS

Coefficient	Min Setting	Max Setting	Emphasis Adjustment			
			-	Initial Setting	+	Step
C-2	0	0.1	-0.04	Values calculated using the COM tool	+0.04	0.005
C-1	-0.3	0	-0.08		+0.08	0.01
C0	0.5	1	-0.2		+0.2	0.05
C1	-0.1	0	-0.05		+0.05	0.05

- Similarly, adjust the C-1, C0 and C1 settings accordingly to determine the C-1, C0 and C1 settings with the lowest BER respectively.

9.6.3 Measure BER and FEC error ratio to target specification

- After adjusting the MU196020A Emphasis and Rx equalization to obtain the minimum BER settings, proceed to measure the BER and FEC error ratio (using a FEC error counter).
- Make sure the BER meets the target of less than 2.4×10^{-4} and the FEC error ratio of less than 10^{-3} . *[Note: The measurement time is $> 5.6 \mu\text{s}$ at TP0 target BER E-5, or $\geq 56 \mu\text{s}$ when observing up to 10 times the margin performance of the above.]*

9.7 Perform DUT Rx Jitter Tolerance Test for Test 2 Case (for CR Interface)

Note: The jitter tolerance test is performed for the Test 2 case only.

9.7.1 Configure MU196020A PAM4 PPG Victim signal and FEXT signal settings and the value calculated by the COM tool

1. Set up the connections for the Anritsu MP1900A BERT modules and the Test 2 case setup as shown in Figure 12 and Figure 33 respectively.
2. Set the following settings for the MU196020A PAM4 PPG (**Slot 1, Victim**):

Note: If the DUT Rx interference tolerance test has already been performed (as described in Section 9.5), the Emphasis settings used in that test should be applied in the following configuration.

a) On the **Emphasis** setting screen, apply the following configuration:

- Turn **On** “Manual Setting”.
- Select the “Standard/Preset” (Emphasis type) as **Coefficient**.
- For the “Coefficient” settings, set the “C-2”, “C-1”, “C0” and “C1” values according to the COM calculation results for the “**TXLE_taps**” [C-3 C-2 C-1 C0 C1] information. Figure 100 below shows an example of the coefficient settings for TXLE_taps [0 0.04 -0.22 0.74 0].

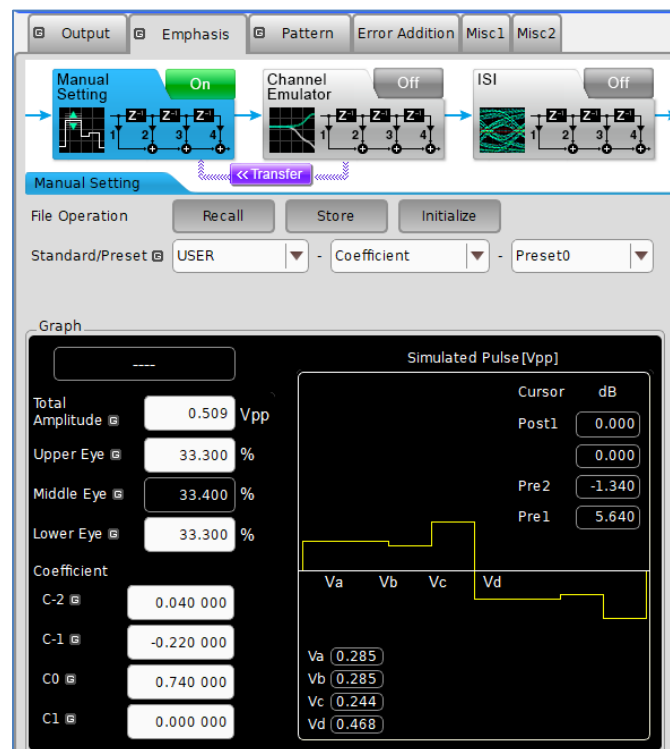


FIGURE 100. MU196020A (SLOT 1, VICTIM) EMPHASIS SETTINGS

b) On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

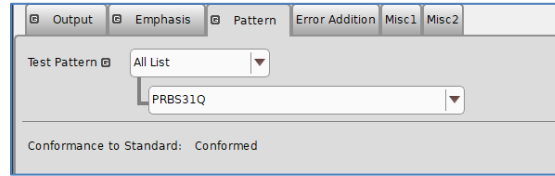


FIGURE 101. MU196020A (SLOT 1, VICTIM) PATTERN SETTING

3. Set the following settings for the MU196020A PAM4 PPG (**Slot 2, FEXT**):
 - a) On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

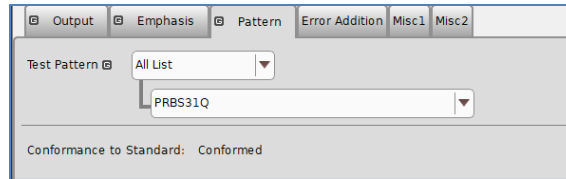


FIGURE 102. MU196020A (SLOT 2, FEXT) PATTERN SETTING

9.7.2 Determine the Emphasis setting of the MU196020A (Slot 1) and the Equalizer setting of the DUT Rx

Note: If the DUT Rx interference tolerance test has already been performed (as described in Section 9.5), the Emphasis settings used in that test should be applied in the following configuration.

1. On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output all signals of the MU196020A PAM4 PPG.



FIGURE 103. MP1900A BERT OUTPUT ON

2. Referring to Figure 104 below, allow the Rx equalizer value to automatically optimize or set sweep to determine the minimum BER result. Set the Tx (NEXT crosstalk) of the DUT to the **PRBS31Q** pattern, **Preset 0**, and Output **On**.

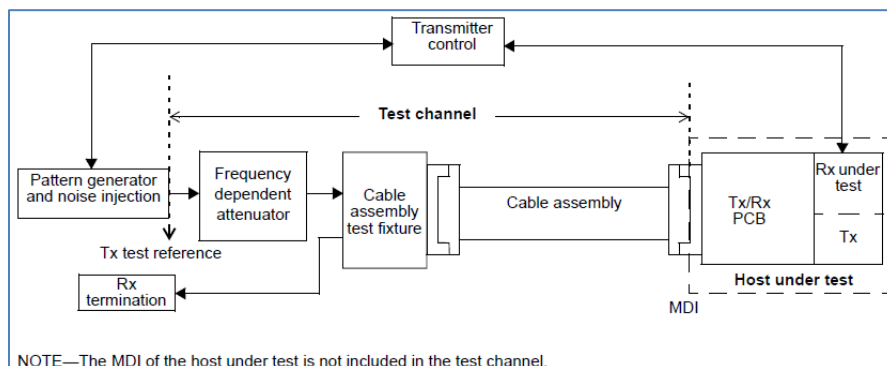


FIGURE 104. INTERFERENCE TOLERANCE TEST SETUP SCHEMATIC (REFERENCED FROM IEEE802.3CK STANDARD, FIGURE 110-3A)

3. Adjust the Emphasis Coefficient C-2 setting of the MU196020A (Slot 1) and perform optimization for the Rx equalizer as in Step 2 above. From there, determine the minimum BER value.

- The C-2 setting should be adjusted from -0.04 to +0.04 with step 0.005 based on the value set in Step 2 a) from Section 9.7.1 above. Determine the C-2 setpoint at which the BER is minimized. *[Note: The BER measurement time is 200 ms.]*
4. Determine the optimal BER value for the range of Coefficient Min and Max settings in Table 11 below, and for the value set in Step 2 a) from Section 9.7.1 above.

TABLE 11. COEFFICIENT AND EMPHASIS ADJUSTMENT SETTINGS

Coefficient	Min Setting	Max Setting	Emphasis Adjustment			
			-	Initial Setting	+	Step
C-2	0	0.1	-0.04	Values calculated using the COM tool	+0.04	0.005
C-1	-0.3	0	-0.08		+0.08	0.01
C0	0.5	1	-0.2		+0.2	0.05
C1	-0.1	0	-0.05		+0.05	0.05

5. Similarly, adjust the C-1, C0 and C1 settings accordingly to determine the C-1, C0 and C1 settings with the lowest BER respectively.

9.7.3 Set the jitter amplitude and measure the BER and FEC error ratio to target specification for each jitter frequency

1. After adjusting the MU196020A Emphasis and Rx equalization to obtain the minimum BER settings, proceed to measure the BER and FEC error ratio (using a FEC error counter) for each jitter frequency as specified in Table 12 below.

TABLE 12. JITTER AMPLITUDE TEST CRITERIA FOR JITTER TOLERANCE TEST (REFERENCED FROM IEEE802.3CK STANDARD TABLE 162-17)

	Case A	Case B	Case C	Case D	Case E	Case F
Jitter Frequency [MHz]	0.04	0.4	1.333	4	12	40
Jitter Amplitude (pk-pk) [UI]	5	0.5	0.15	0.05	0.05	0.05

2. The jitter amplitude setting is set to 0UI, 0.5xA, 0.8xA, 0.9xA, A, 1.1xA and then gradually increased to measure the BER, respectively, when the MU181500B setting A [UI] corresponds to the test reference value.
3. Make sure the BER meets the target of less than 2.4×10^{-4} and the FEC error ratio of less than 10^{-3} . *[Note: The measurement time is $> 5.6 \mu\text{s}$ at TP0 target BER E-5, or $\geq 56 \mu\text{s}$ when observing up to 10 times the margin performance of the above.]*

9.8 Perform DUT Rx Jitter Tolerance Test for Test 2 Case (for KR Interface)

Note: The jitter tolerance test is performed for the Test 2 case only.

9.8.1 Configure MU196020A PAM4 PPG Victim signal and FEXT signal settings and the value calculated by the COM tool

- Set up the connections for the Anritsu MP1900A BERT modules and the Test 2 case setup as shown in Figure 12 and Figure 34 respectively.
- Set the following settings for the MU196020A PAM4 PPG (**Slot 1, Victim**):

Note: If the DUT Rx interference tolerance test has already been performed (as described in Section 9.5), the Emphasis settings used in that test should be applied in the following configuration.

a) On the **Emphasis** setting screen, apply the following configuration:

- Turn **On** “Manual Setting”.
- Select the “Standard/Preset” (Emphasis type) as **Coefficient**.
- For the “Coefficient” settings, set the “C-2”, “C-1”, “C0” and “C1” values according to the COM calculation results for the “**TXLE_taps**” [C-3 C-2 C-1 C0 C1] information. Figure 105 below shows an example of the coefficient settings for TXLE_taps [0 0.04 -0.22 0.74 0].

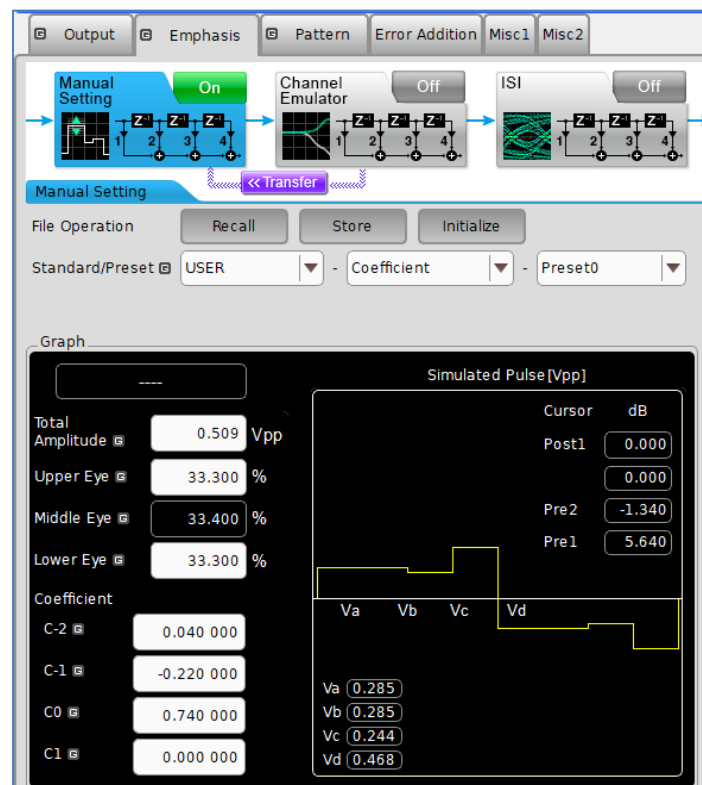


FIGURE 105. MU196020A (SLOT 1, VICTIM) EMPHASIS SETTINGS

b) On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

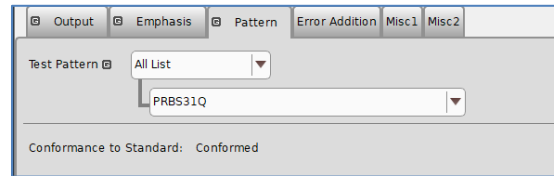


FIGURE 106. MU196020A (SLOT 1, VICTIM) PATTERN SETTING

3. Set the following settings for the MU196020A PAM4 PPG (**Slot 2, FEXT**):
 - a) On the **Pattern** setting screen, select the “Test Pattern” as **PRBS31Q**.

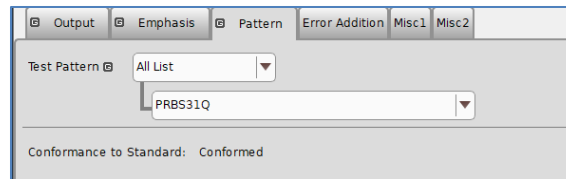


FIGURE 107. MU196020A (SLOT 2, FEXT) PATTERN SETTING

9.8.2 Determine the Emphasis setting of the MU196020A (Slot 1) and the Equalizer setting of the DUT Rx

Note: If the DUT Rx interference tolerance test has already been performed (as described in Section 9.5), the Emphasis settings used in that test should be applied in the following configuration.

1. On the upper left corner of the MP1900A BERT screen, turn **ON** the **Output** button to output all signals of the MU196020A PAM4 PPG.



FIGURE 108. MP1900A BERT OUTPUT ON

2. Referring to Figure 109 below, allow the Rx equalizer value to automatically optimize or set sweep to determine the minimum BER result. Set the Tx (NEXT crosstalk) of the DUT to the **PRBS31Q** pattern, **Preset 0**, and Output **On**.

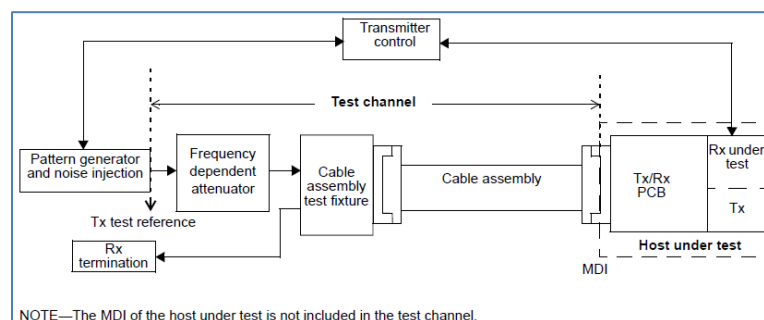


FIGURE 109. INTERFERENCE TOLERANCE TEST SETUP SCHEMATIC (REFERENCED FROM IEEE802.3CK STANDARD, FIGURE 110-3A)

3. Adjust the Emphasis Coefficient C-2 setting of the MU196020A (Slot 1) and perform optimization for the Rx equalizer as in Step 2 above. From there, determine the minimum BER value.

- The C-2 setting should be adjusted from -0.04 to +0.04 with step 0.005 based on the value set in Step 2 a) from Section 9.8.1 above. Determine the C-2 setpoint at which the BER is minimized. *[Note: The BER measurement time is 200 ms.]*
4. Determine the optimal BER value for the range of Coefficient Min and Max settings in Table 13 below, and for the value set in Step 2 a) from Section 9.8.1 above.

TABLE 13. COEFFICIENT AND EMPHASIS ADJUSTMENT SETTINGS

Coefficient	Min Setting	Max Setting	Emphasis Adjustment			
			-	Initial Setting	+	Step
C-2	0	0.1	-0.04	Values calculated using the COM tool	+0.04	0.005
C-1	-0.3	0	-0.08		+0.08	0.01
C0	0.5	1	-0.2		+0.2	0.05
C1	-0.1	0	-0.05		+0.05	0.05

5. Similarly, adjust the C-1, C0 and C1 settings accordingly to determine the C-1, C0 and C1 settings with the lowest BER respectively.

9.8.3 Set the jitter amplitude and measure the BER and FEC error ratio to target specification for each jitter frequency

1. After adjusting the MU196020A Emphasis and Rx equalization to obtain the minimum BER settings, proceed to measure the BER and FEC error ratio (using a FEC error counter) for each jitter frequency as specified in Table 14 below.

TABLE 14. JITTER AMPLITUDE TEST CRITERIA FOR JITTER TOLERANCE TEST (REFERENCED FROM IEEE802.3CK STANDARD TABLE 162-17)

	Case A	Case B	Case C	Case D	Case E	Case F
Jitter Frequency [MHz]	0.04	0.4	1.333	4	12	40
Jitter Amplitude (pk-pk) [UI]	5	0.5	0.15	0.05	0.05	0.05

2. The jitter amplitude setting is set to 0UI, 0.5xA, 0.8xA, 0.9xA, A, 1.1xA and then gradually increased to measure the BER, respectively, when the MU181500B setting A [UI] corresponds to the test reference value.
3. Make sure the BER meets the target of less than 2.4×10^{-4} and the FEC error ratio of less than 10^{-3} . *[Note: The measurement time is $> 5.6 \mu s$ at TP0 target BER E-5, or $\geq 56 \mu s$ when observing up to 10 times the margin performance of the above.]*

10 Appendix B: Using Channel Operating Margin (COM) Tool

The following steps describe how to use the COM tool (version 3.70) on a PC with MATLAB Runtime version 9.0 installed for measurements.

1. Launch the COM tool (version 3.70).
2. Return the key input for the COM parameter EXCEL sheet input request. When the “INPUT CONFIG FILE .xls” screen appears, specify the parameter EXCEL file.
3. In response to “How many FEXT channels are to be entered?”, Return (no FEXT) or enter the number of FEXT lanes and Return.
4. In response to “How many NEXT channels are to be entered?”, Return (no NEXT) or enter the number of NEXT lanes and Return.
5. On the “Input thru channel response .s4p” screen, specify the S-parameter measurement result .s4p file for the thru lane.
6. On the “Input fext channel response .s4p #xx” screen, specify the FEXT S-parameter measurement result .s4p file. Specify files for the number of FEXT lanes entered in advance.
7. On the “Input next channel response .s4p #xx” screen, specify the NEXT S-parameter measurement result .s4p file. Specify files for the number of NEXT lanes entered in advance.
8. The COM calculation will be executed, and the “results\100GEL_(xxx)_(date)” folder will be automatically created under the folder where the COM tool version 3.70 executable file is located, and the “case1 and case2_(xxx)_(date)” folders and results.csv file will be saved in it.

11 Appendix C: Connecting Keysight Oscilloscope to PC

Refer to the following procedure on how to connect the Keysight scope to be used with a PC. The Keysight scope can be connected to the PC through GPIB, USB, or LAN.

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

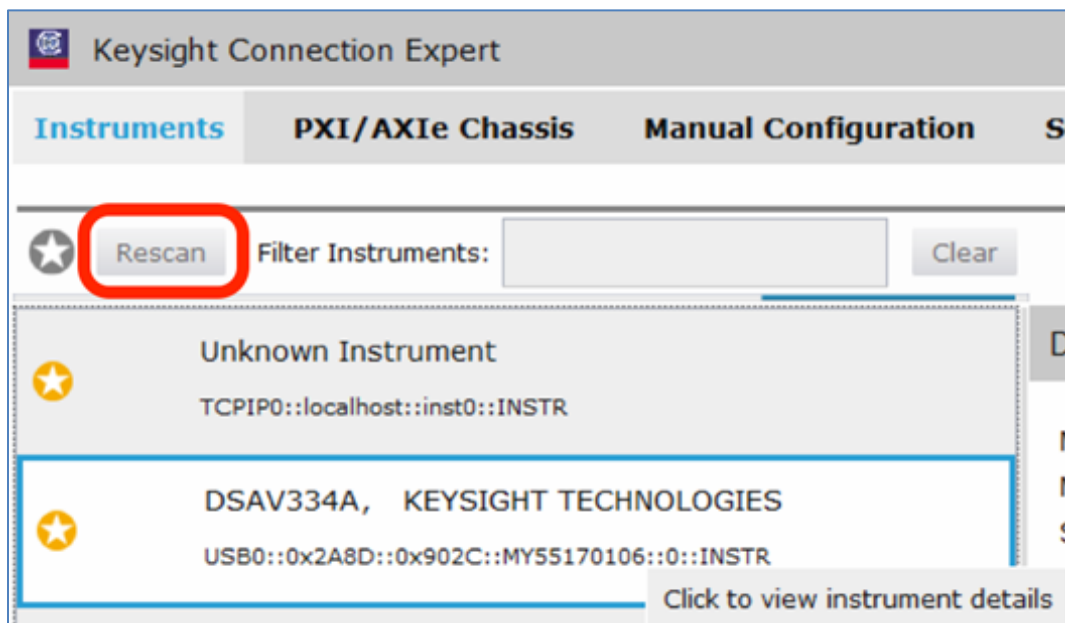


FIGURE 110. KEYSIGHT CONNECTION EXPERT

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

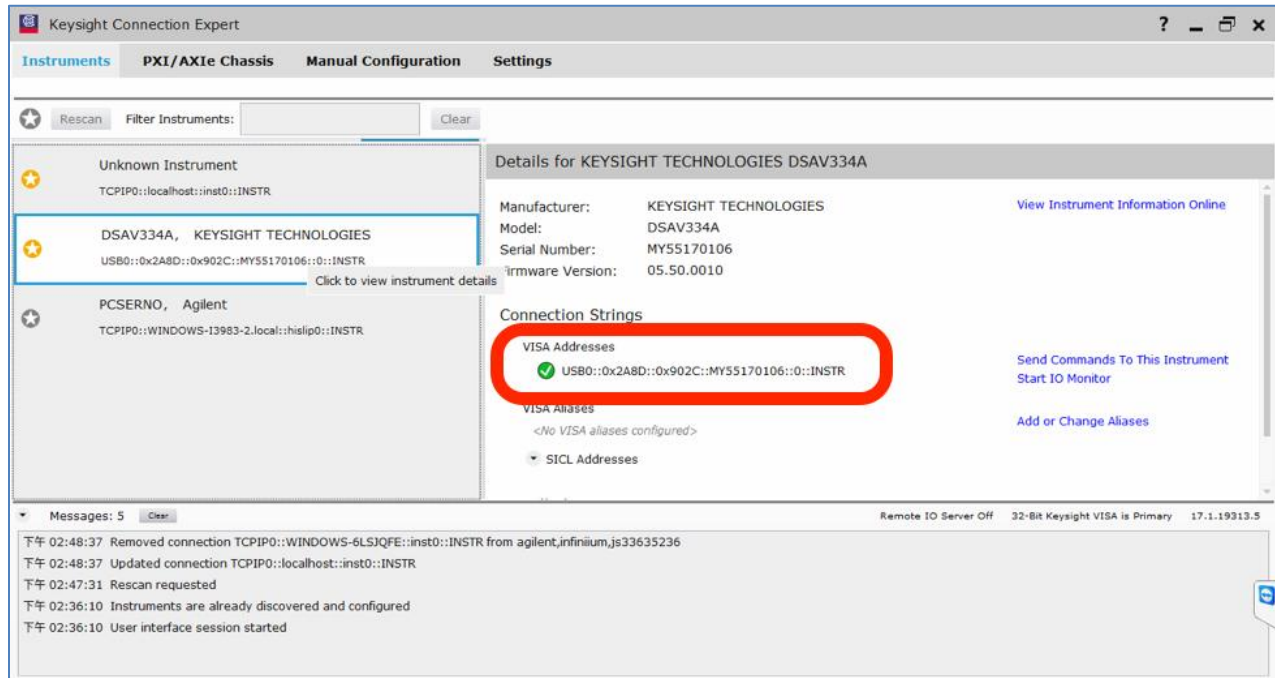


FIGURE 111. OSCILLOSCOPE'S VISA ADDRESS

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 IEEE802.3ck PAM4 CR/KR Rx Test Application. If connected via LAN, type in the Scope IP address, for example "TCPIP0::192.168.0.110::inst0::INSTR". Note to **omit** the Port number from the address.

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

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