Granite River Labs

Serial Attached SCSI (SAS-3) 12 Gbit/s Specification Receiver Physical Layer User Guide & Method of Implementation (MOI)

Using

Anritsu High Performance BERT and Real-Time Oscilloscope with GRL-SAS3-RXA Calibration and Test Automation Software

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Revision Record

Revision	Date	Description of Changes	Author(s)
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1 Introduction

The GRL-SAS3-RXA test solution provides automation control for performing SAS-3 based 12 Gbit/s signalling calibration and compliance tests to evaluate the SAS-3 physical layer functionality for receiver (Rx) device electrical conformance to the Specifications Standard at 12 Gb/s data rate. The GRL-SAS3-RXA software follows the industry standard methodology using MJSQ test methods for 12 Gb/s. When combined with a satisfactory level of interoperability testing, these tests provide a reasonable level of confidence that the device-under-test (DUT) will function properly in many SAS 12G environments.

This User Guide & MOI provides information on using the GRL-SAS3-RXA automation software to set up, calibrate and test a 12 Gbit/s based DUT for receiver jitter tolerance compliance. The GRL software is run from the computer or oscilloscope to automate both the Anritsu BERT and real-time oscilloscope to calibrate the stressed signal and test receiver conformance to SAS-3 (12 Gb/s) specs. The BERT and appropriate equipment are used to generate the necessary test patterns with jitter and ISI components. The real-time oscilloscope is required for signal calibration while the BERT analyzer/error detector is used for error checking via loopback mode. To enable loopback mode for Bit Error Ratio (BER) compliance testing, the DUT will go into a forced loopback state, where the loopback test pattern of the DUT will be measured and should achieve a specified BER with a 95% confidence level.

The GRL-SAS3-RXA software performs test automation to the T10/BSR Specification using high performance real-time oscilloscopes and the Anritsu BERT, along with a compliant ISI generator as main test equipment.

Note: For manual test methodology, refer to Appendix of this documentation or approved vendor-specific MOI's as technical reference.

2 Reference Documents

SAS-3 Standard (sas3r06, T10/BSR INCITS 519 Revision 6)

3 Resource Requirements

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

3.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – INSTRUMENTS

System	Qty.	Description/Key Specification Requirement
GRL-SAS3-RXA	1	Granite River Labs SAS-3 (12 Gb/s) Receiver Compliance Calibration & Test Automation Software – www.graniteriverlabs.com *– with Node Locked License to single Oscilloscope/PC OS*
High Performance Real-Time Oscilloscope[a]	1	≥ 25 GHz bandwidth with Windows 7+ OS (for 12 Gb/s)[b]
Anritsu MP1900A BERT[c]	1	MP1900A Signal Quality Analyzer, with following modules: • MU181000A/B 12.5 GHz Synthesizer • MU181500B Jitter Modulation Source • MU195020A 21G/32G bit/s SI Pulse Pattern Generator • MU195040A 21G/32G bit/s SI Error Detector • MU195050A Noise Generator
ISI Source Generator	1	Compliant ISI channel source for variable or fixed ISI output (Anritsu J1758A ISI Board recommended if using internal variable ISI function of MP1900A BERT)
VISA (Virtual Instrument Software Architecture) API Software	1	VISA Software is required to be installed on the host PC running GRL-SAS3-RXA software. GRL's software framework has been tested to work with all three versions of VISA available on the Market: 1. NI-VISA: http://www.ni.com/download/ni-visa-17.0/6646/en/ 2. Keysight IO Libraries: www.keysight.com *(Search on IO Libraries)* 3. Tektronix TekVISA: www.tek.com *(Downloads > Software > TekVisa)*
Octave 4.0.0	1	Octave Tool is required to run the Eye Opening MATLAB script. Octave 4.0.0 must be used and can be downloaded from: https://mirror.us-midwest-1.nexcess.net/gnu/octave/windows/octave-4.0.0_0-installer.exe
Computer	1	Laptop or desktop PC running Windows 7+ OS for automation control

[a] Oscilloscope with scope software requirements as specified in vendor specific MOI's. For example, when using the Keysight Scope, scope software such as Keysight InfiniiSim / EZ-JIT / Serial Data Analysis / Serial Data Equalization that are required for testing and signal processing must be pre-installed on the Scope. Similarly, the Tektronix Scope shall be used with DPOJET (Jitter and Eye Analysis Tools) software for making measurements.

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

[c] *BERT SAS-3 patterns are distributed with GRL-SAS3-RXA software and are installed during installation process.*

TABLE 2. EQUIPMENT REQUIREMENTS – ACCESSORIES

Accessory	Qty.	Description	Key Specification Requirement
SAS Receptacle Test Adapter	1	*– DUT connector type dependent*	>15dB return loss from 50MHz to 6GHz, and insertion loss that meets the Zero-Length Test Load requirements of the SAS-3 Draft Standard
Connection Cables		*– DUT connector type and test configuration dependent*	
DC Block	2 pairs	Anritsu K261 Precision DC Block	*Optional (if required in setup only)* 10kHz to 40GHz bandwidth

4 GRL-SAS3-RXA Automation Software Setup

This section provides the procedures to start up and pre-configure the GRL-SAS3-RXA automation software before running tests. It also helps users familiarize themselves with the basic operation of the software.

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

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

4.1 Download GRL-SAS3-RXA Software

Download and install the GRL-SAS3-RXA software on a PC or an oscilloscope (where GRL-SAS3-RXA is referred to as 'Controller PC' or 'Scope' respectively in this User Guide & MOI):

1. Install VISA (Virtual Instrument Software Architecture) on to the PC/Scope where GRL-SAS3-RXA is to be used (see Section 3.1).
2. Download the software ZIP file package from the Granite River Labs support site.
3. The ZIP file contains:
   - **SAS_AN_RxPatternFilesInstallation0000000xxSetup.exe –** Run this on the Anritsu MP1900A BERT Signal Quality Analyzer to install the SAS-3 test pattern setup files.
   - **SAS_AN_RxTestApplication0000000xxSetup.exe –** Run this on the Controller PC or Scope to install the GRL-SAS3-RXA application.
   - **SAS_AN_RxTestScopeSetupFilesInstallation0000000xxSetup.exe –** Run this on the Scope to install the scope setup files.

4.2 Launch and Set Up GRL-SAS3-RXA Software

1. Once the GRL-SAS3-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 software framework.

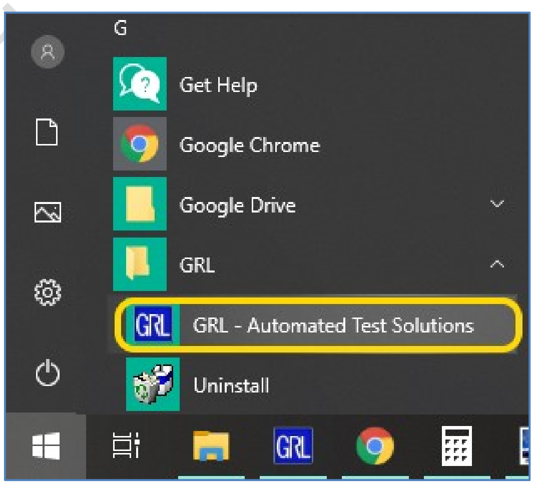


FIGURE 1. SELECT AND LAUNCH GRL FRAMEWORK

2. From the **Application → Rx Test Solution** drop-down menu, select **Anritsu SAS 12G Rx Test** to start the SAS-3 Rx Test Application. If the selection is grayed out, it means that your license has expired.

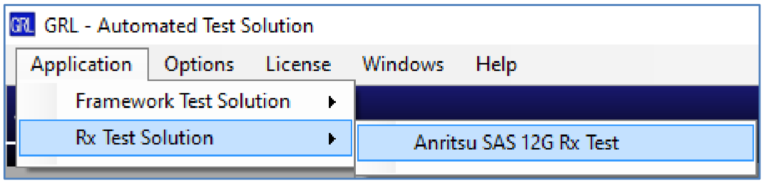


FIGURE 2. START SAS-3 RX TEST APPLICATION

3. To enable license, go to License→License Details.

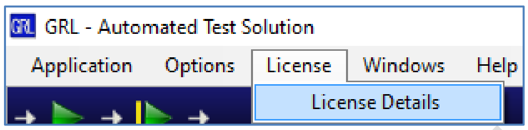


FIGURE 3. SEE LICENSE DETAILS

a) Check the license status for the installed application.

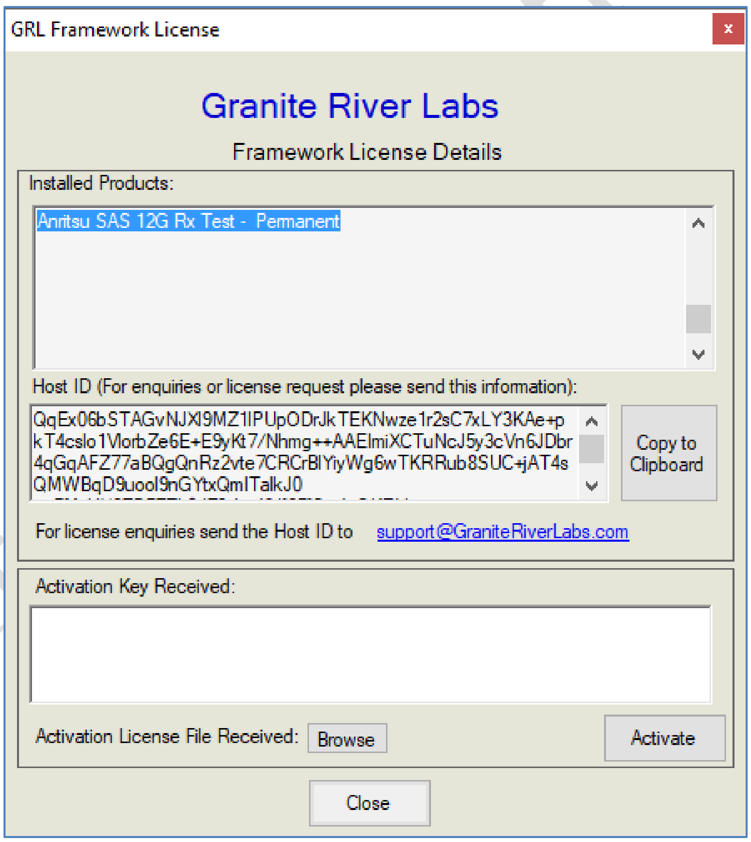


FIGURE 4. CHECK LICENSE FOR INSTALLED APPLICATIONS

b) Activate a License:

- If you have an Activation Key, enter it in the field provided and select "Activate".
- If you do not have an Activation Key, select "Close" to use a demo version of the software over a free 10-day trial period.

Note: *Once the 10-day trial period ends, you will need to request an Activation Key to continue using the software on the same computer or oscilloscope. The demo software is also limited in its capability, in that it will only calibrate the maximum frequency for each data rate. Thus, the demo version cannot be used to fully calibrate and test a device. For Demo and Beta Customer License Keys, please request an Activation Key by contacting support@graniteriverlabs.com.*

4. Select the Equipment Setup icon on the Anritsu SAS-3 Rx Test application menu.
5. Connect the Anritsu MP1900A BERT via LAN to the GRL automation control enabled Scope or PC.
6. If using an external ISI source (e.g., Artek CLE Series), connect the ISI source via USB to the GRL automation control enabled Scope or PC. *(Note: The USB driver software for the Artek ISI Generator must be installed on the Scope or PC. The driver is available from the ISI Generator manufacturer. Refer to Appendix of this MOI & User Guide for driver installation information.)*
7. On the Scope or controller PC, obtain the network addresses for all the connected instruments from the device settings. Note these addresses as they will be used to connect the instruments to the GRL automation software.
8. On the Equipment Setup page of the GRL Anritsu SAS-3 Rx Test application, type in the address of each connected instrument into the 'Address' field. *(Note: If the GRL software is installed on the* ***Tektronix Scope****, ensure the Scope is connected via GPIB and type in the GPIB network address, for example "GPIB8::1::INSTR".)* If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example "TCPIP0::192.168.0.110::inst0::INSTR". Note to ***omit*** the Port number from the address.
9. Select the "lightning" button ( ) for each connected instrument.

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

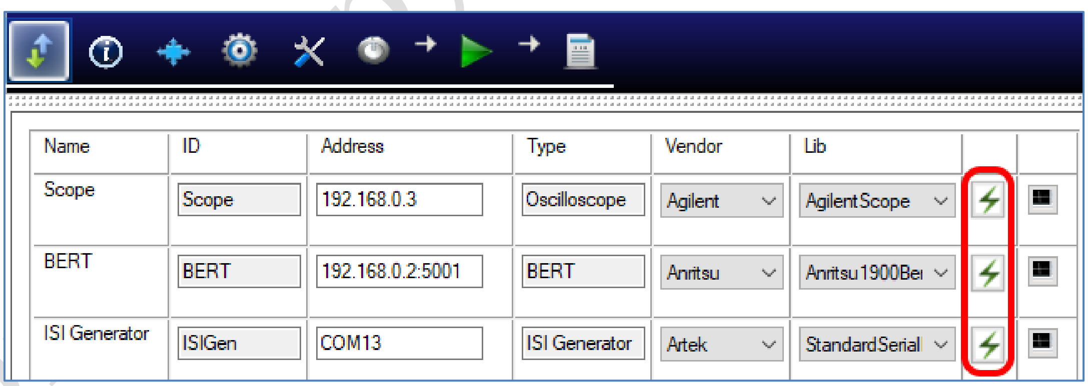


FIGURE 5. CONNECT INSTRUMENTS WITH GRL SOFTWARE

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

4.3 Pre-Configure GRL-SAS3-RXA 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.

4.3.1 Enter Test Session Information

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

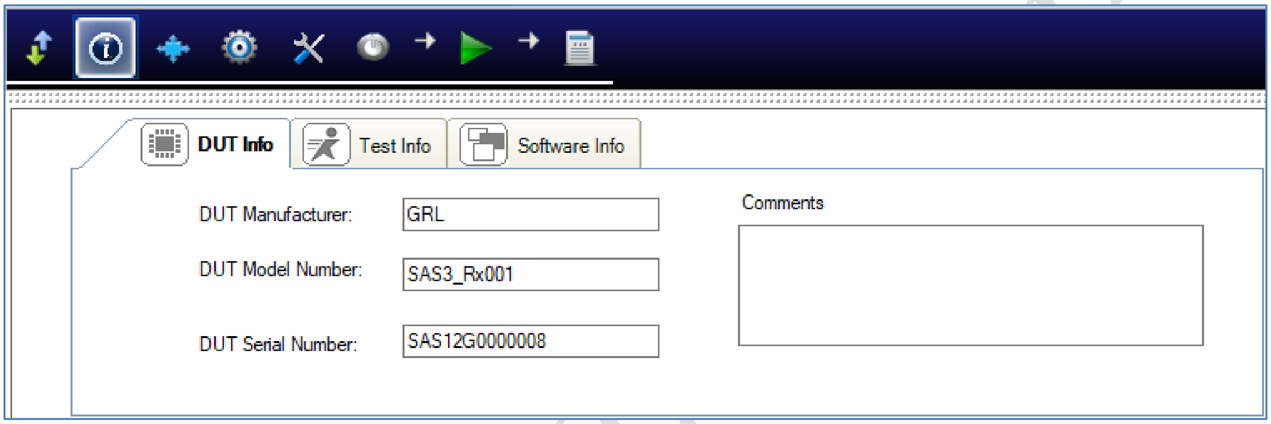


FIGURE 6. SESSION INFO PAGE

4.3.2 Set Measurement Conditions

Select from the menu to access the **Conditions** page to set the conditions for calibration and compliance testing. The GRL software will perform calibration and testing using the selected Spread Spectrum Clock (SSC) Capabilities and SJ Test Frequencies.

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 only one SSC Capability at two frequencies, then select the appropriate conditions for testing.

a) **SSC tab**: Select to enable or disable SSC Capability as supported by the DUT for calibration or testing.

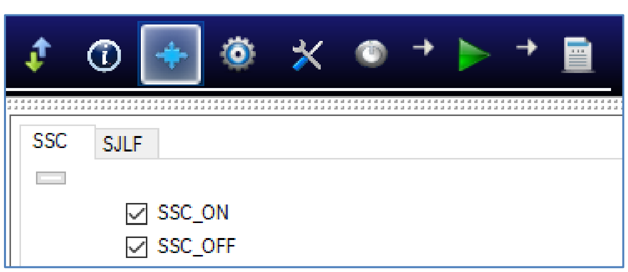


FIGURE 7. SELECT SSC CONDITIONS

b) **SJLF tab**: Select the SJ frequencies as required for calibration or testing. Select the Custom_SJ frequencies to use additional SJ frequencies not defined by the Specification. These frequency values can be entered in the Setup Configuration page under the *Custom SJ Frequencies* tab.

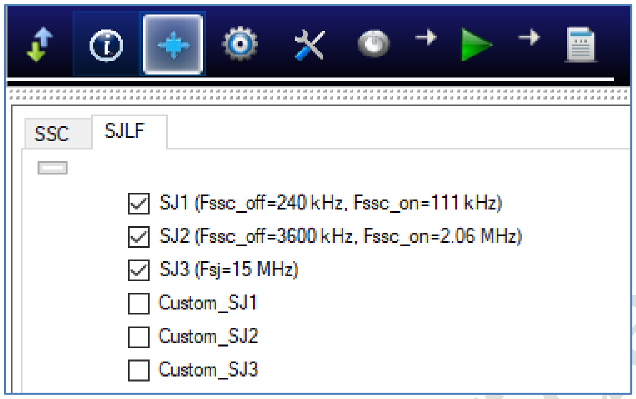


FIGURE 8. SELECT SJ FREQUENCIES

5 Calibrating Using GRL-SAS3-RXA Software

The GRL-SAS3-RXA test solution supports automated Rx calibration for SAS 12G Signal Amplitude and Jitter as well as Eye Opening and Crosstalk. To perform calibration, the GRL software is run from the oscilloscope or an external controller PC to enable automation control for each step of calibration.

Calibration will basically be performed at Test Point A and Test Point IR/CR that generally apply for all SAS data rates. Test Point A (TP-A) is a physical test point for calibration while Test Point IR/CR is an electrical test point calculated by the Scope test instrument for SAS-3 Eye Opening compliance. See Appendix of this User Guide & MOI for more details.

The Anritsu BERT and appropriate equipment are used in the setup to provide the necessary test patterns with jitter, ISI and crosstalk components during calibration. A real-time high-performance Oscilloscope is required for signal calibration while a compliant ISI source is used to generate insertion loss.

Note: A Variable ISI Generator is recommended to be used as the ISI source in the calibration/test setup. Variable ISI enables calibration/testing to be performed with minimum reconfiguration of the setup, which allows measurements to be more fully automated.

The GRL-SAS3-RXA software provides a series of calibration that can be performed in the sequence as described in Appendix of this User Guide & MOI for the SAS-3 receiver. Also refer to Appendix for more details on SAS-3 calibration requirements.

When calibration is completed, the GRL software will generate a test report detailing all results obtained from the calibration.

5.1 Set Up SAS-3 Rx Calibration with Automation

After the software has been pre-configured from Section 4.3, continue with the calibration setup. The following procedures show how to set up the physical connections to perform automated Rx calibration for stressed signals.

5.1.1 Connect Equipment for Signal Amplitude and Jitter Calibration

The following connection diagram shows the recommended equipment setup to calibrate for signal amplitude and jitter at TP-A.

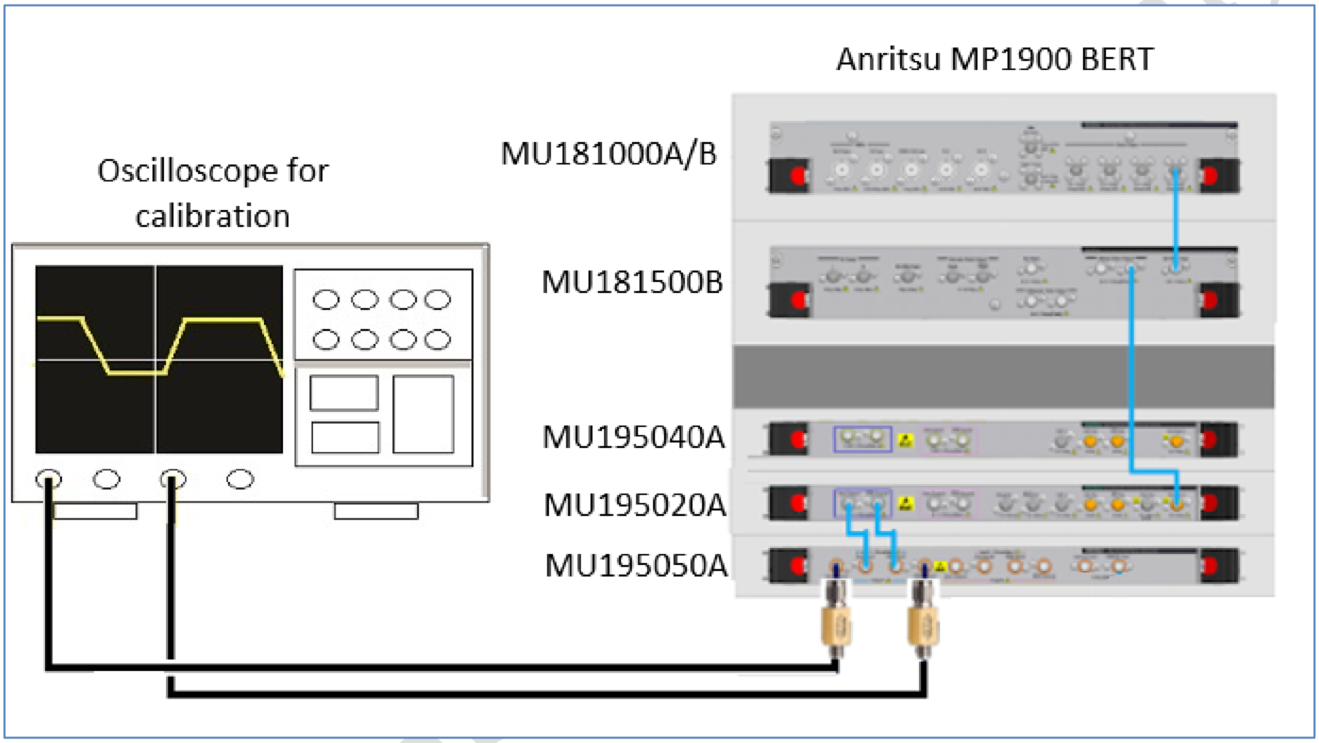


FIGURE 9. SIGNAL AMPLITUDE AND JITTER CALIBRATION SETUP

Connection Steps:

1. Connect the MU181000A/B clock output to the MU181500B Ext clock input.
2. Connect the MU181500B jittered clock output to the MU195020A Ext clock input.
3. Connect the MU195020A data outputs to the MU195050A data inputs.
4. Connect the MU195050A data outputs through DC blocks to the oscilloscope channels.

5.1.2 Connect Equipment for Eye Opening and Crosstalk Calibration

The following connection diagram shows the recommended equipment setup to calibrate for eye opening and crosstalk from TP-A to Test Point IR/CR.

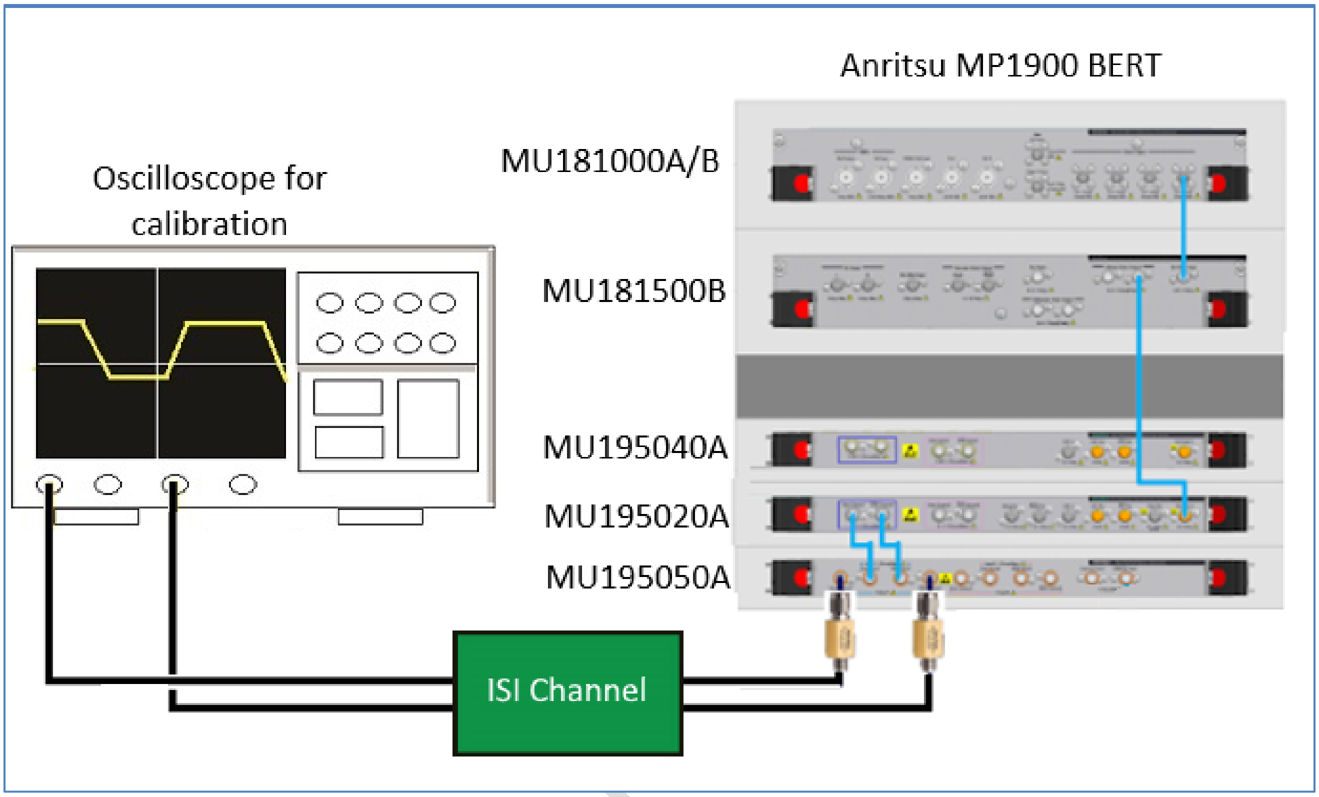


FIGURE 10. EYE OPENING AND CROSSTALK CALIBRATION SETUP

Connection Steps:

1. Using back the same BERT connections from the TP-A calibration, disconnect the MU195050A data outputs from the oscilloscope channels.
2. Connect the MU195050A data outputs to a compliant ISI source.
3. Connect the ISI source to the oscilloscope channels.

6 Compliance Testing Using GRL-SAS3-RXA Software

The GRL-SAS3-RXA software supports automated Rx compliance testing with forced loopback mode for the receiver DUT.

Receiver compliance testing is performed for DUT jitter tolerance that requires using the BERT analyzer/error detector via loopback mode for error checking. The DUT shall receive CJTPAT signaling with maximum allowable jitter, noise and signal loss. The loopback pattern will be verified by the BERT error detector and shall report a Bit Error Ratio (BER) of less than 1E-12 with a 95% confidence level for the DUT to be considered as compliant.

When testing is completed, the GRL software will generate a test report detailing all results obtained from the test runs.

6.1 Set Up SAS-3 Rx DUT Test with Automation

The following procedures show how to set up the physical connections to perform automated Rx stressed input compliance testing for the DUT.

6.1.1 Connect Equipment for Jitter Tolerance Compliance Test

The connection diagram below shows the recommended equipment setup to test the DUT for SAS-3 Rx jitter tolerance.

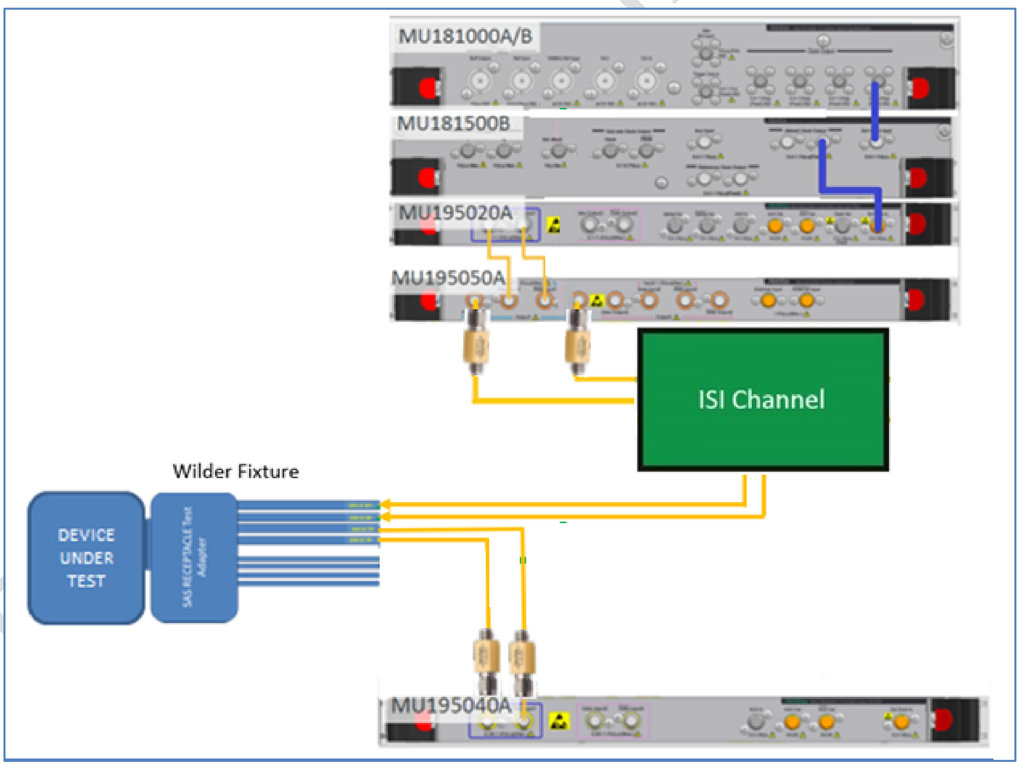


FIGURE 11. COMPLIANCE TEST SETUP FOR RECEIVER DUT JITTER TOLERANCE

Connection Steps:

1. Using back the same BERT connections from calibration, remove the Scope channel connections from the Variable ISI generator.

2. Connect the outputs of the Variable ISI generator to the Rx lanes of the DUT through the SAS receptacle test adapter (the Wilder fixture is used here).
3. Connect the DUT Tx lanes to the MU195040A data inputs through DC blocks for loopback error detection.

7 Configuring and Selecting Calibration and Compliance Tests Using GRL-SAS3-RXA Software

7.1 Set Up Calibration/Compliance Test Requirements

After setting up the physical equipment, select from the GRL Anritsu SAS-3 Rx Test Application menu to access the Setup Configuration page. Use this page to configure the necessary measurement-related settings prior to running calibration and tests.

7.1.1 ISI Generator Tab

Select the type of supported ISI generators to be used:

- "MP1900 ISI": This is provided as an Option. The Anritsu BERT can be used in the setup for ISI automation if an external ISI channel is not available.
- "None": This is the recommended method which is used to provide the required physical channel Insertion Loss for calibration and testing.
- "Artek": This is provided as an Option. A compliant Artek CLE Model Series ISI channel can be used in the setup for ISI automation. *(Also see Appendix for more information on installing the Artek CLE Series.)*

The ISI source will be used for both calibration and compliance testing.

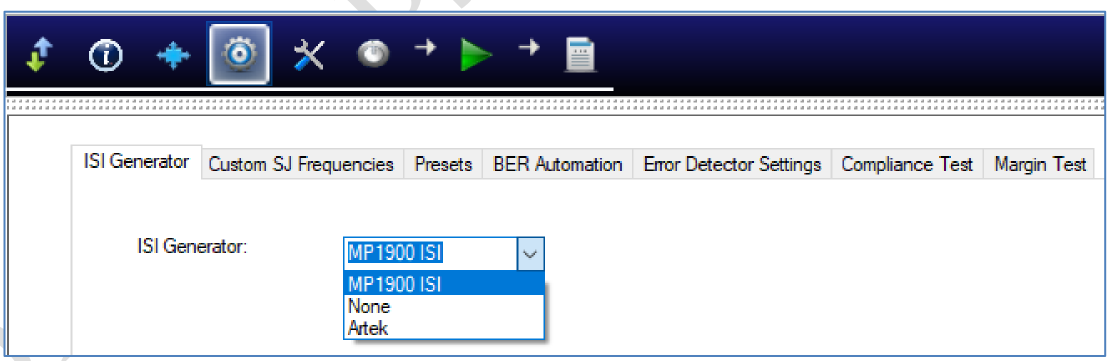


FIGURE 12. SELECT ISI SOURCE

7.1.2 Custom SJ Frequencies Tab

Enter the value for any Custom_SJ frequency selected from the Conditions page. *This configuration will be used for SJ calibration and for testing.*

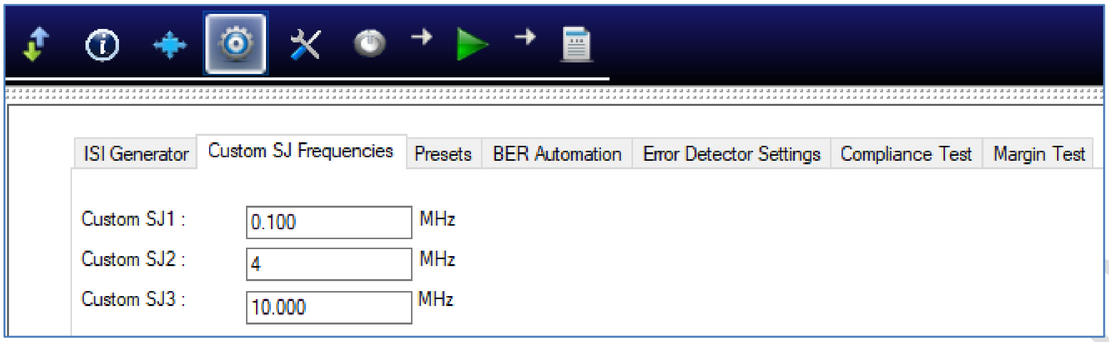


FIGURE 13. CONFIGURE CUSTOM SJ FREQUENCIES

7.1.3 Presets Tab

Set up Reference Presets for the selected Preset Mode.

- **Nominal Presets** mode: The settings in this mode are defined by the Specification, which disables any user configuration and displays the specified nominal values.
- **Custom Presets** mode: This mode allows user configuration for the presets.

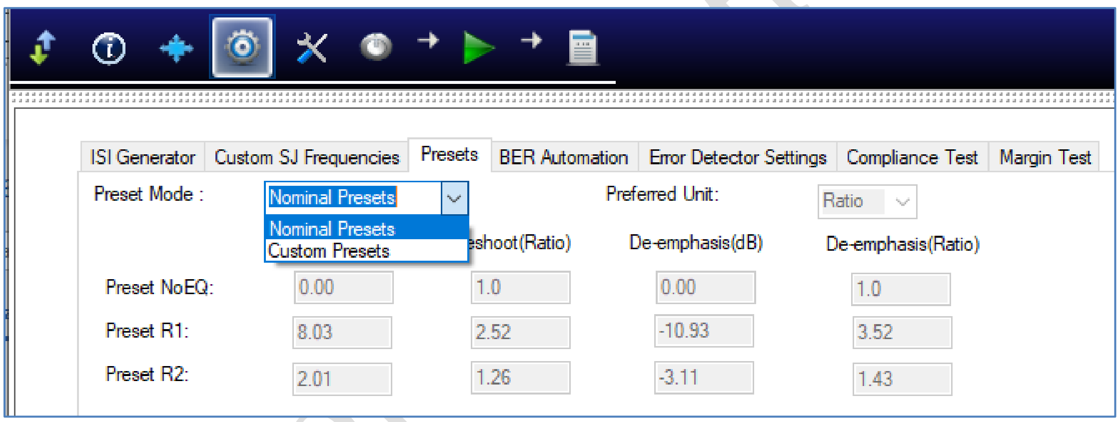


FIGURE 14. CONFIGURE REFERENCE PRESETS

7.1.4 BER Automation Tab

Select the test method to run the BER Rx automation tests for the DUT.

- **Forced Loopback** mode: This mode allows running BER Rx automation tests using software loopback method (if the DUT can be configured to loopback mode).
- **Manual** mode: This mode allows running BER Rx automation tests manually.

If "Forced Loopback" has been selected as the test method, then specify the test pattern type to be used for loopback in the **Loopback Pattern** field.

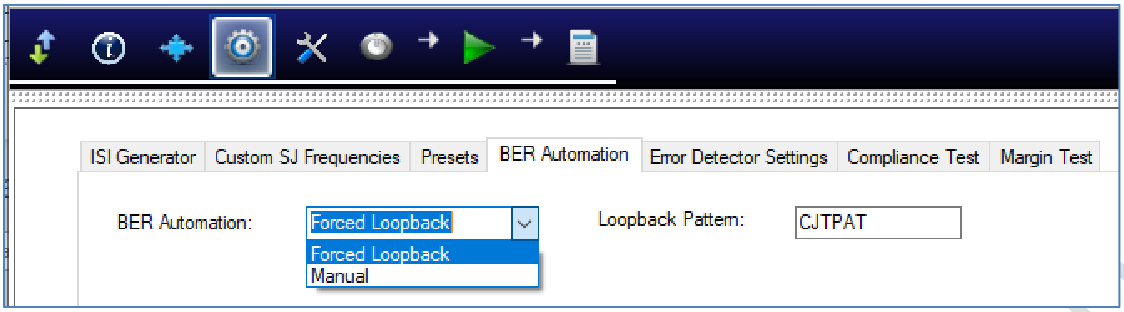


FIGURE 15. CONFIGURE BER AUTOMATION TEST

7.1.5 Error Detector Settings Tab

Select to enable (**ON**) or disable (**OFF**) the CTLE method to be used for error detection. If CTLE is enabled, select the appropriate gain setting index (**dB**) to be applied.

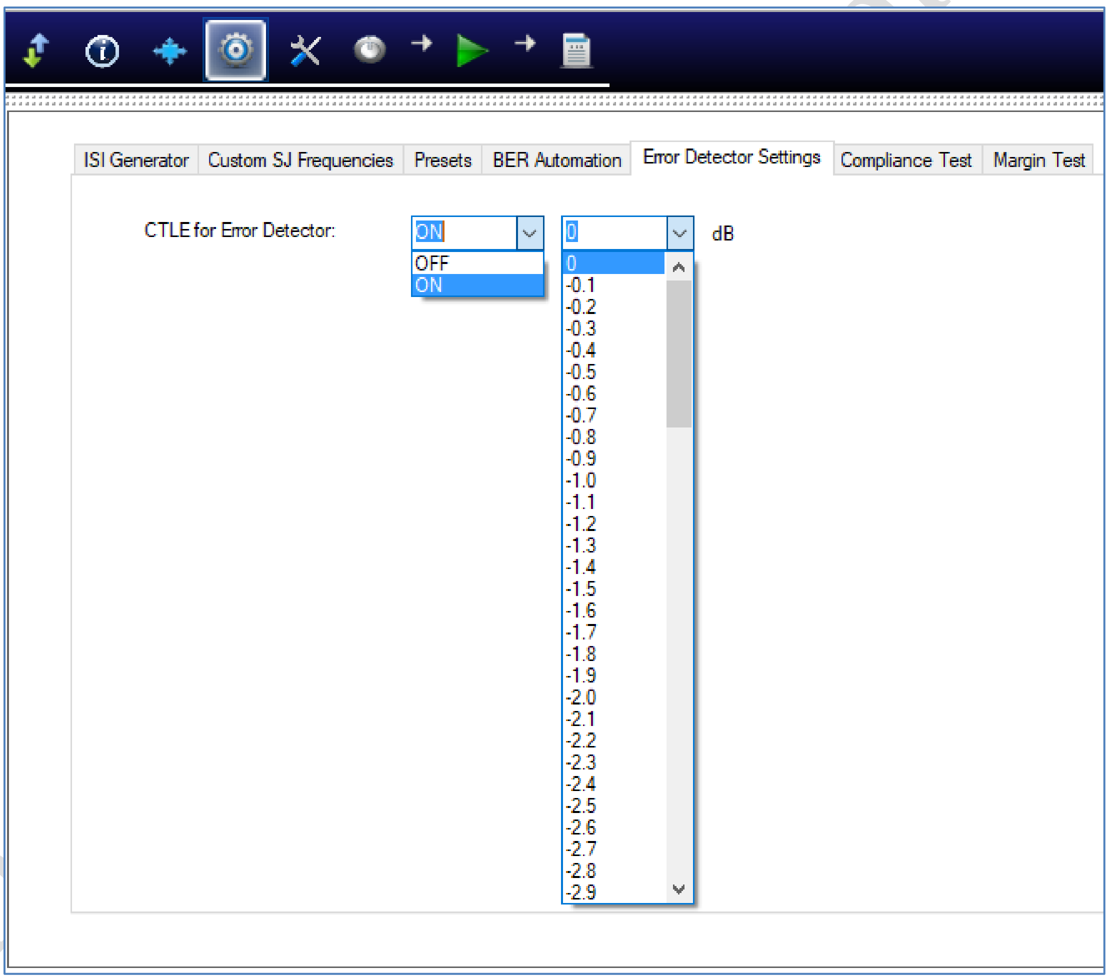


FIGURE 16. CONFIGURE ERROR DETECTOR CTLE

7.1.6 Compliance Test Tab

Specify the duration for the BER test run in the **Compliance Test Time** field and the maximum error limits in the **Maximum Error Count** field to be tested for compliance.

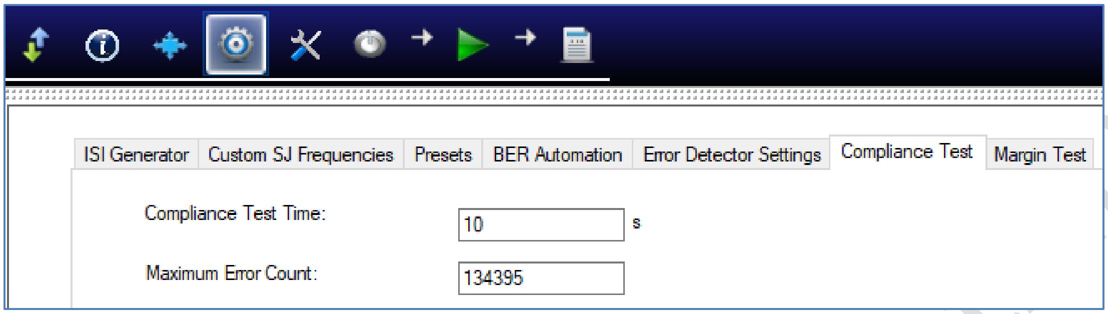


FIGURE 17. CONFIGURE BER COMPLIANCE

7.1.7 Margin Test Tab

Specify the test duration in the **Margin Test Time** field, maximum error limits in the **Maximum Error Count** field, **Step Size** and **Maximum Steps** to be applied during marginal testing.

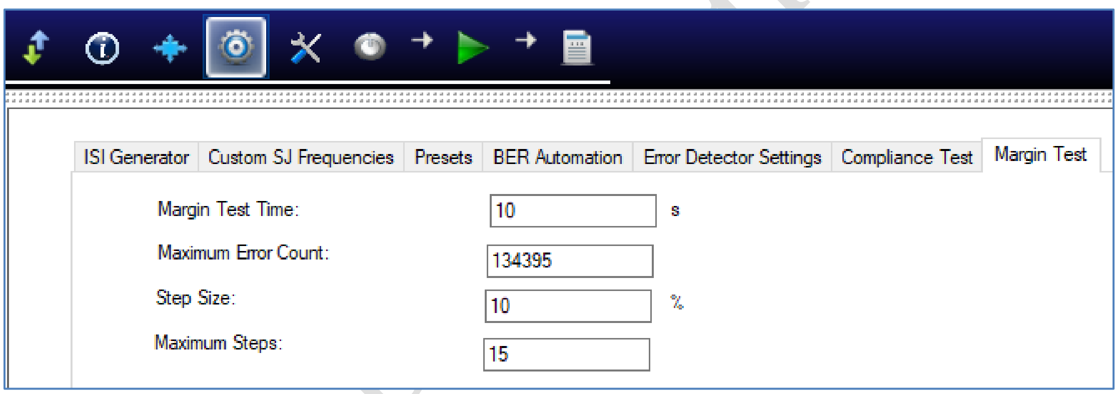


FIGURE 18. CONFIGURE MARGIN TEST PARAMETERS

7.2 Select Calibration and Compliance Tests

After setting up calibration/compliance test requirements, go to the test selection page which allows all available Rx calibration and DUT compliance tests to be selected. Select the check boxes of the respective calibration and tests to be performed.

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.

Note: For calibration/testing, it is recommended to use a variable ISI channel as it allows the channel to be more easily adjusted to meet the required specification.

7.2.1 Select Calibration

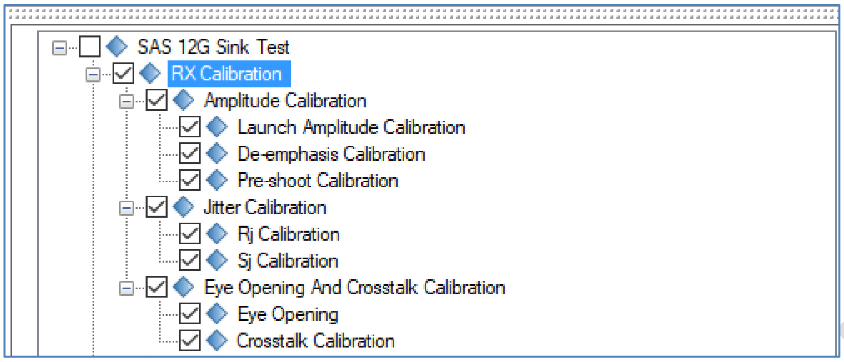


FIGURE 19. RX CALIBRATION SELECTION

TABLE 3. CALIBRATION DESCRIPTION

Calibration	Description
Launch Amplitude	Calibrate the launch amplitude using the 64ones_64zeros pattern. This pattern includes high-frequency components (1010) and low-frequency components (11111 or 000) to determine if the initial signal generated by the BERT has equalized amplitudes for both high-frequency and low-frequency components.
De-emphasis	Calibrate de-emphasis using the 64ones_64zeros_64ones_zeros pattern to ensure the value is accurately measured.
Pre-shoot	Calibrate pre-shoot using the same pattern as de-emphasis calibration.
RJ/SJ	Calibrate RJ or SJ using the 1100 clock pattern.
Eye Opening	Calibrate eye opening using any frequency-rich pattern. For this calibration, the PRBS15 pattern will be used.
Crosstalk	Calibrate crosstalk using an All Zeros pattern that measures only the crosstalk being injected.

7.2.1 Select DUT Compliance Tests

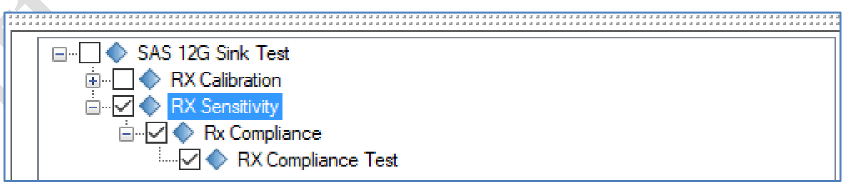


FIGURE 20. RX COMPLIANCE TEST SELECTION

TABLE 4. TEST DESCRIPTION

Test	Description
Rx Compliance	This is a compliance test for receiver jitter tolerance which measures jitter response at the calibrated levels mentioned in the Specification.

7.2.2 Select Margin Search Tests

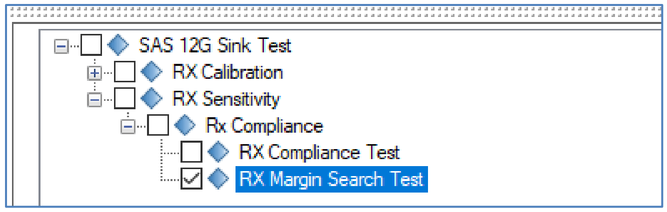


FIGURE 21. RX MARGIN SEARCH TEST SELECTION

TABLE 5. TEST DESCRIPTION

Test	Description
Rx Margin Search	This is an optional test for conducting a margin search for jitter tolerance.

7.3 Calibration/Compliance Test Parameters Configuration Page

Select  from the menu to access the Configurations page.

Set any of the available parameters required for measurement as described below. To return all parameters to their default values, select the 'Set Default' button.

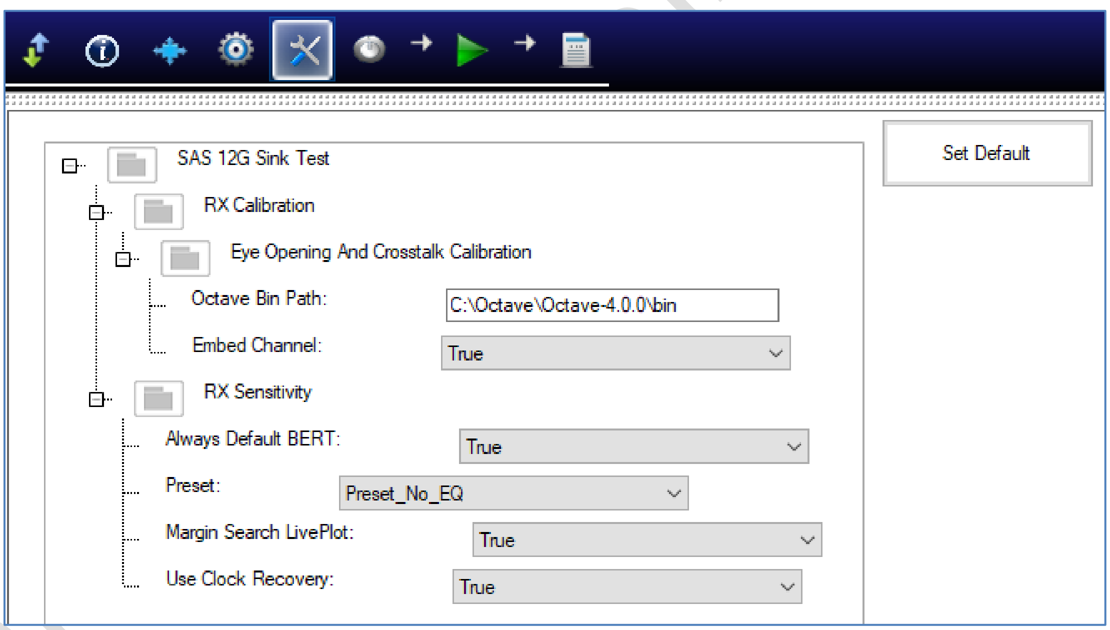


FIGURE 22. CALIBRATION/COMPLIANCE TEST PARAMETERS CONFIGURATION

TABLE 6. CALIBRATION/COMPLIANCE TEST PARAMETERS DESCRIPTION

Parameter	Description
Octave Bin Path	Specify the bin directory where the Octave scripts are located which will be executed when calibrating for eye opening and crosstalk.

Embed Channel	Select 'True' to enable channel embedding at the corresponding test compliance point.
Always Default BERT	Select 'True' to always enable or 'False' to always disable default configuration on the BERT during testing.
Preset	Select the Reference Preset to be used for testing if "Custom Presets" has been selected as the Preset Mode in the Setup Configuration page (refer Section 7.1).
Margin Search Live Plot	Select 'True' to enable a graphical margin plot that updates as the margin test is performed to indicate progress of the test results. To disable select 'False'.
Use Clock Recovery	If "Forced Loopback" has been selected from the BER Automation tab in the Setup Configuration page (refer Section 7.1), then select 'True' to enable the Clock Recovery method. To disable select 'False'.

7.4 Configure Calibration Target Values

For debugging purposes ONLY, the default calibration target values can be changed for any of the calibration. 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.

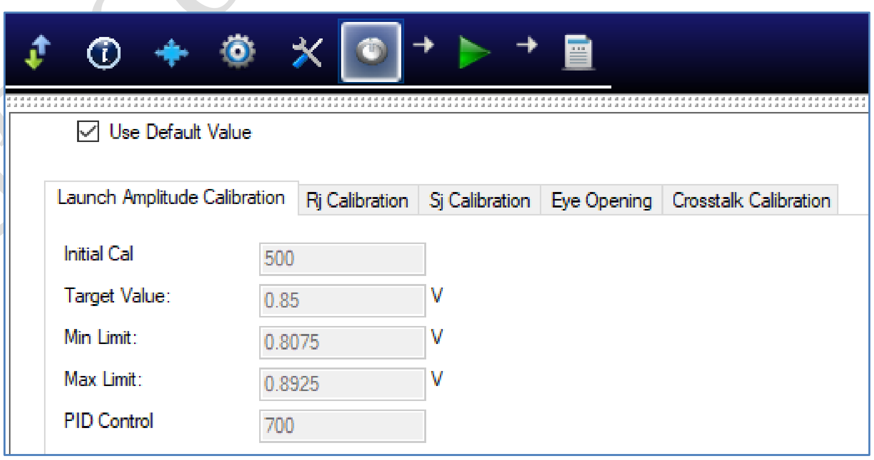
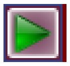


FIGURE 23. CALIBRATION TARGET OVERWRITE

8 Running Automation Calibration and Tests Using GRL-SAS3-RXA Software

Once calibration and tests 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 software automatically runs the selected calibration and tests when initiated.

Before running the tests, select the option to:

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

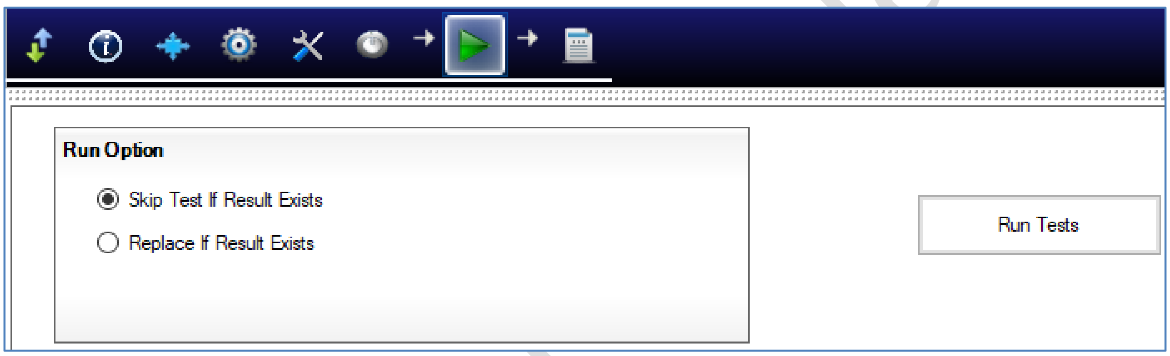


FIGURE 24. RUN TESTS PAGE

Select the **Run Tests** button to automatically start running the selected calibration and tests. At the start of a specific calibration/test, the corresponding connection diagram will initially appear to allow the user to verify with the recommended physical setup before continuing with the next step. Figure 25 below shows an example of a connection diagram pop-up window.

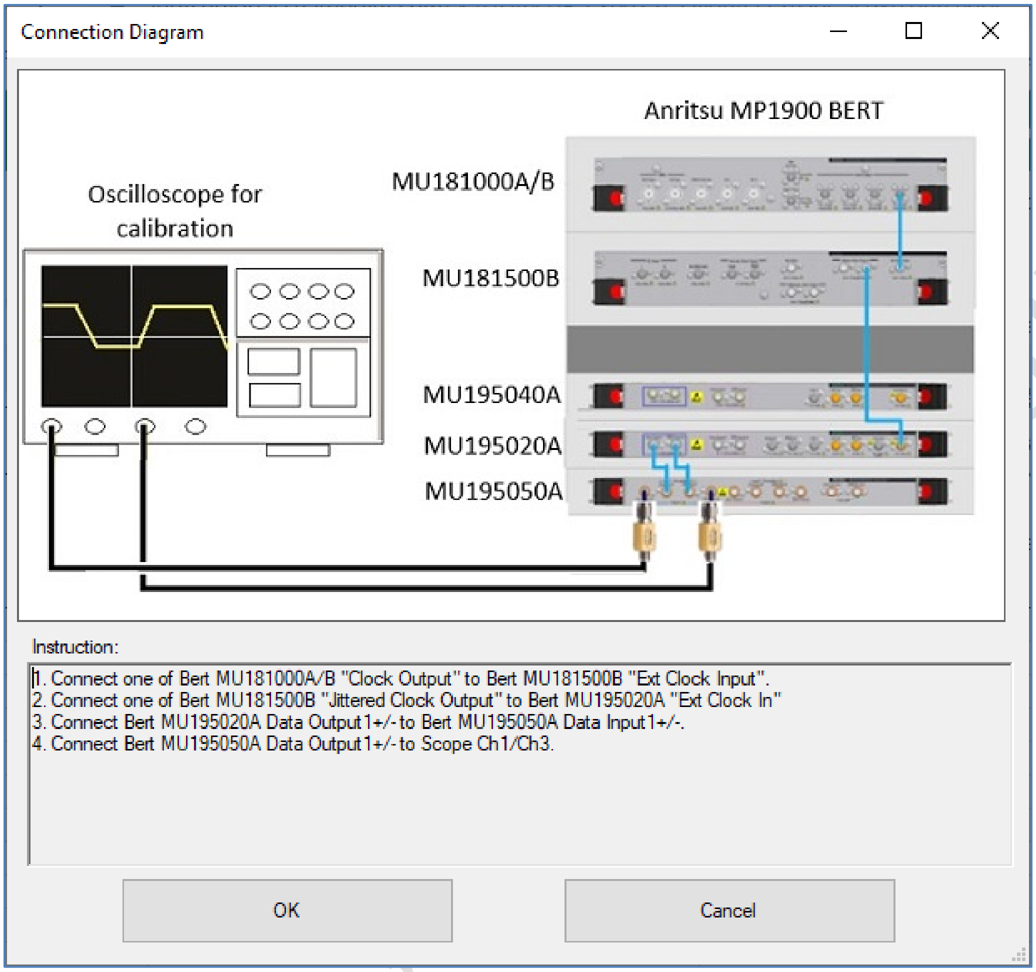


FIGURE 25. CONNECTION DIAGRAM POP-UP WINDOW EXAMPLE

9 Interpreting GRL-SAS3-RXA Test Report

When all calibration and test runs have completed from the previous section, the GRL-SAS3-RXA software will automatically display the results on the **Report** page.

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.

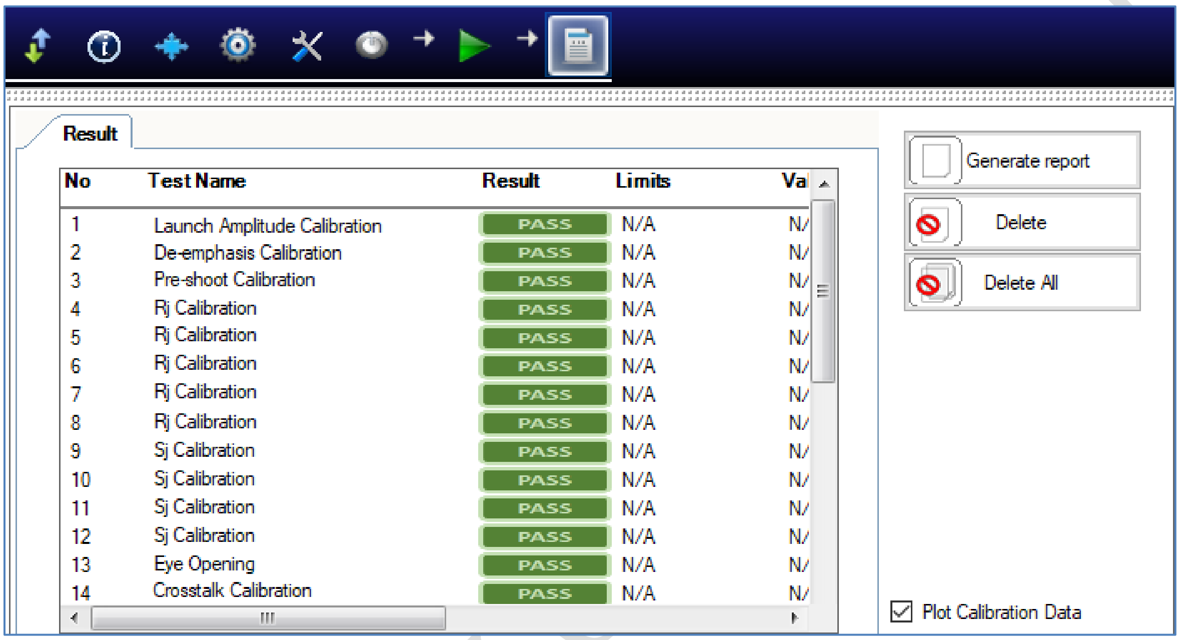


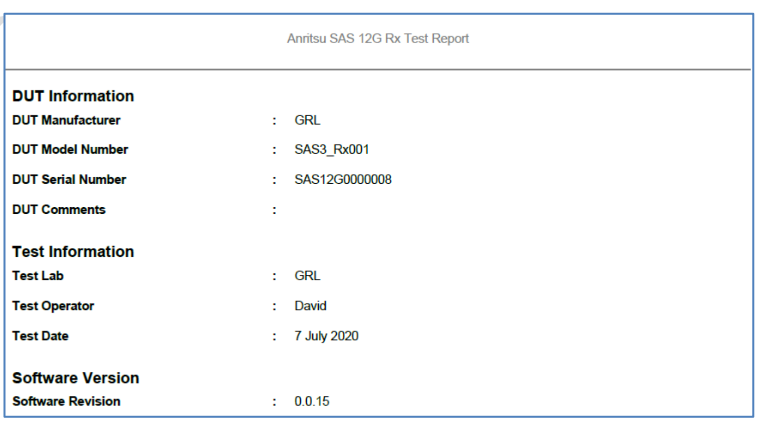
FIGURE 26. TEST REPORT PAGE

9.1 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.

9.1.1 Test Session Information

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



Anritsu SAS 12G Rx Test Report

DUT Information

DUT Manufacturer	:	GRL
DUT Model Number	:	SAS3_Rx001
DUT Serial Number	:	SAS12G0000008
DUT Comments	:	

Test Information

Test Lab	:	GRL
Test Operator	:	David
Test Date	:	7 July 2020

Software Version

Software Revision	:	0.0.15

FIGURE 27. TEST SESSION INFORMATION EXAMPLE

9.1.2 Test Summary Table

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

No	TestName	Limits	Value	Results	SSC	SJLF
1	Launch Amplitude Calibration	N/A	N/A	Pass		
2	De-emphasis Calibration	N/A	N/A	Pass		
3	Pre-shoot Calibration	N/A	N/A	Pass		
4	Rj Calibration	N/A	N/A	Pass	SSC_ON	N/A
5	Rj Calibration	N/A	N/A	Pass	SSC_OFF	N/A
6	Sj Calibration	N/A	N/A	Pass	SSC_ON	SJ1
7	Sj Calibration	N/A	N/A	Pass	SSC_ON	SJ2
8	Sj Calibration	N/A	N/A	Pass	SSC_ON	SJ3
9	Sj Calibration	N/A	N/A	Pass	SSC_OFF	SJ1
10	Sj Calibration	N/A	N/A	Pass	SSC_OFF	SJ2
11	Sj Calibration	N/A	N/A	Pass	SSC_OFF	SJ3
12	Sj Calibration	N/A	N/A	Pass	SSC_ON	Custom_SJ1
13	Sj Calibration	N/A	N/A	Pass	SSC_ON	Custom_SJ2
14	Sj Calibration	N/A	N/A	Pass	SSC_ON	Custom_SJ3
15	Sj Calibration	N/A	N/A	Pass	SSC_OFF	Custom_SJ1
16	Sj Calibration	N/A	N/A	Pass	SSC_OFF	Custom_SJ2
17	Sj Calibration	N/A	N/A	Pass	SSC_OFF	Custom_SJ3
18	Eye Opening	N/A	N/A	Pass		
19	Crosstalk Calibration	N/A	N/A	Pass		
20	RX Compliance Test	N/A	N/A	Pass	SSC_ON	SJ1
21	RX Compliance Test	N/A	N/A	Pass	SSC_ON	SJ2
22	RX Compliance Test	N/A	N/A	Pass	SSC_ON	SJ3
23	RX Compliance Test	N/A	N/A	Pass	SSC_ON	Custom_SJ1
24	RX Compliance Test	N/A	N/A	Pass	SSC_ON	Custom_SJ2
25	RX Compliance Test	N/A	N/A	Pass	SSC_ON	Custom_SJ3
26	RX Compliance Test	N/A	N/A	Pass	SSC_OFF	SJ1
27	RX Compliance Test	N/A	N/A	Pass	SSC_OFF	SJ2
28	RX Compliance Test	N/A	N/A	Pass	SSC_OFF	SJ3
29	RX Compliance Test	N/A	N/A	Pass	SSC_OFF	Custom_SJ1
30	RX Compliance Test	N/A	N/A	Pass	SSC_OFF	Custom_SJ2
31	RX Compliance Test	N/A	N/A	Pass	SSC_OFF	Custom_SJ3
32	RX Margin Search Test	N/A	N/A	Pass	SSC_ON	Custom_SJ3
33	RX Margin Search Test	N/A	N/A	Pass	SSC_OFF	SJ1

Compliance Test

Sj Frequency	SJ1	SJ2	SJ3	Custom_SJ1	Custom_SJ2	Custom_SJ3
SSC_ON	PASS(0)	PASS(0)	PASS(0)	PASS(0)	PASS(0)	PASS(0)
SSC_OFF	PASS(0)	PASS(0)	PASS(0)	PASS(0)	PASS(0)	PASS(0)

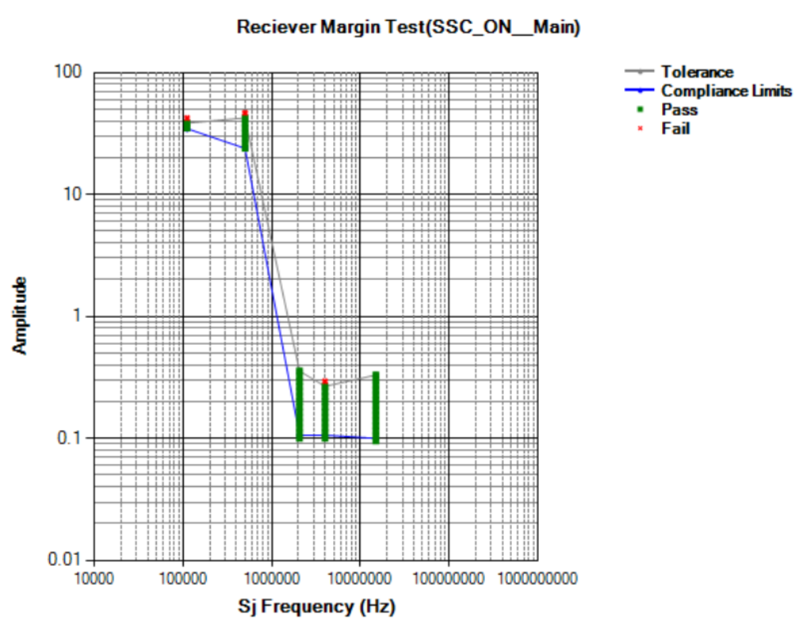
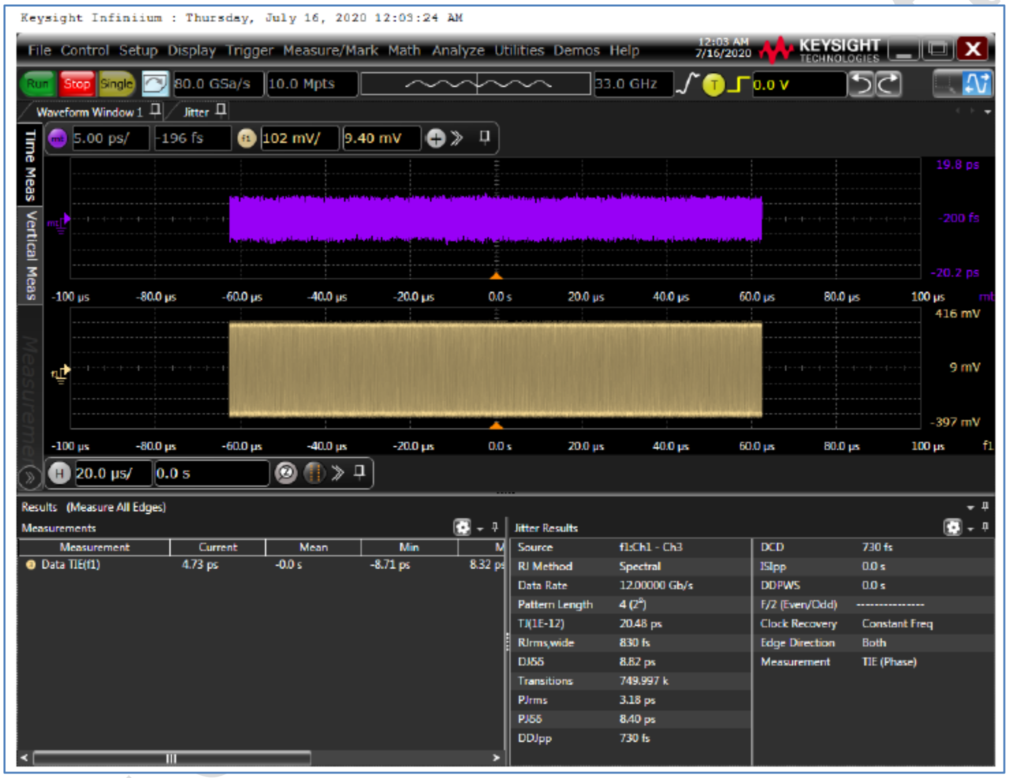


FIGURE 28. TEST SUMMARY TABLE EXAMPLE

9.1.3 Test Results

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

10. Sj Calibration [SSC_OFF,SJ2]		
Pass/Fail Stats	:	Pass
Sj Frequency	:	3.6000 MHz
Cal Parameter	:	Sj _SSC_OFF__SJ2
Settings	:	107.0000 mUI
Measured Value	:	100.8000 mUI
Test completed time	:	16 July 2020 0:03:34 AM



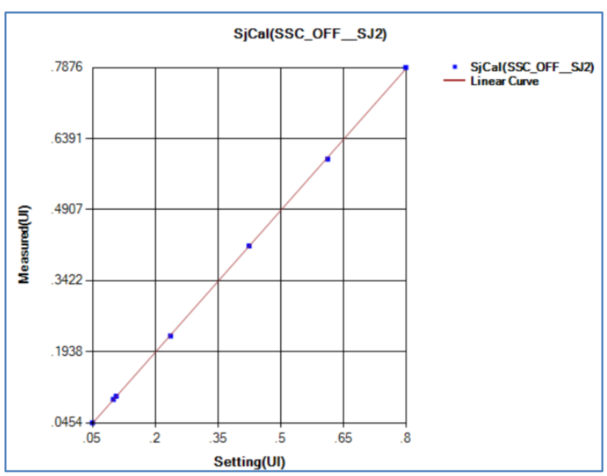


FIGURE 29. TEST RESULTS EXAMPLE

9.2 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.

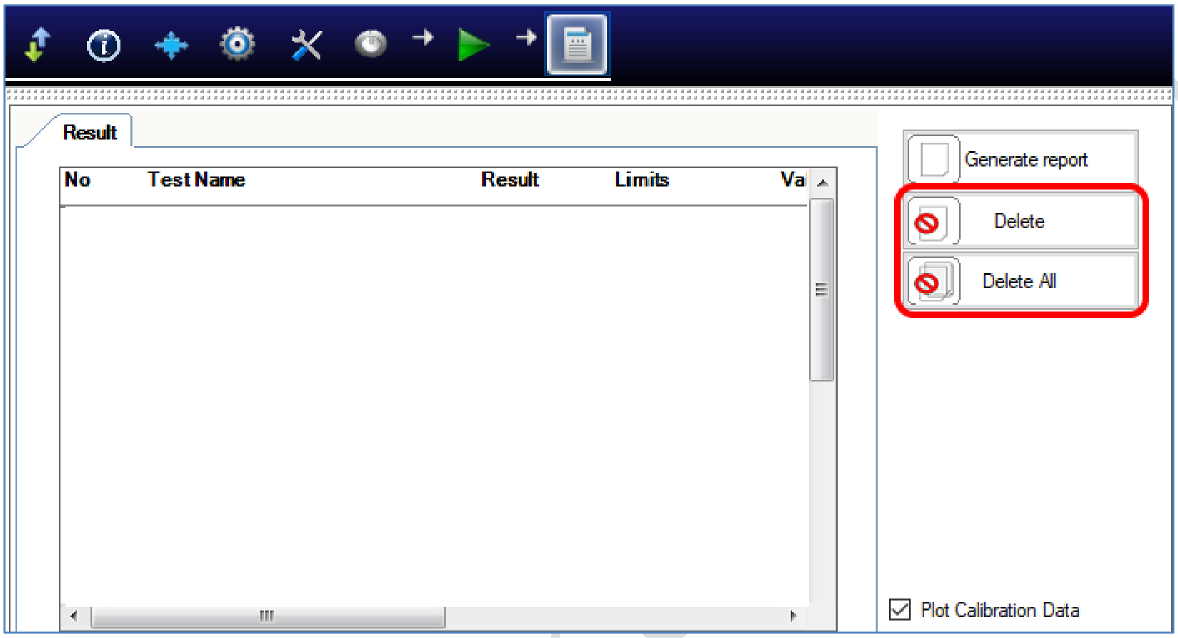


FIGURE 30. TEST REPORT DELETED

10 Saving and Loading Test Sessions

The GRL-SAS3-RXA software enables calibration and test results to be created and maintained as a 'Live Session' in the application. This allows you to quit the application and return later to continue where you left off.

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

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

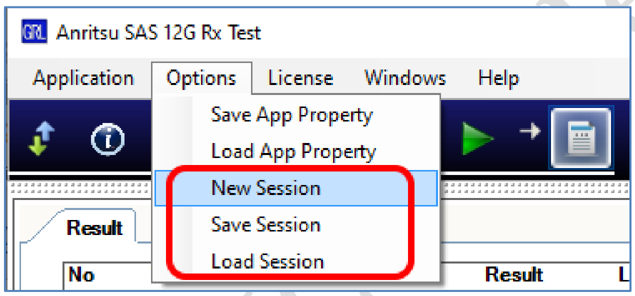


FIGURE 31. SAVING AND LOADING CALIBRATION AND TEST SESSIONS

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

11 Appendix A: Method of Implementation (MOI) for Manual SAS-3 Receiver Measurements

This section provides the manual SAS-3 12G Rx calibration and compliance test methodology based on the SAS-3 Draft Standard. *Note the Keysight Scope will be used in the following MOI.*

11.1 SAS-3 Receiver Calibration/Test Setup Overview

This MOI describes how to measure presets, stresses, SJ, eye opening and crosstalk and test the SAS-3 Rx device for receiver compliance using a signal that contains the maximum allowable jitter, noise and signal loss.

The BERT and appropriate equipment are used in the setup to provide the necessary test patterns with jitter, ISI and crosstalk. A real-time Oscilloscope is required for signal calibration (in this case the Keysight Scope will be used) while a compliant variable ISI source is used to generate insertion loss. The analyzer/error detector on the BERT will be used for error checking via loopback mode.

The calibration will be run using the required components of mainly SSC control, minimum transmitter voltage amplitude, asynchronous crosstalk, CJTPAT test pattern and jitter (which includes random and deterministic jitter of various types including a sinusoidal periodic jitter component that is swept across specific frequency intervals). The Rx DUT should be able to tolerate stress impairments when entering loopback state to determine BER compliance.

For BER compliance testing, the BERT will transmit CJTPAT signaling to the Rx DUT and verify that the loopback pattern reports a BER that is less than 1E-12 with a 95% confidence level.

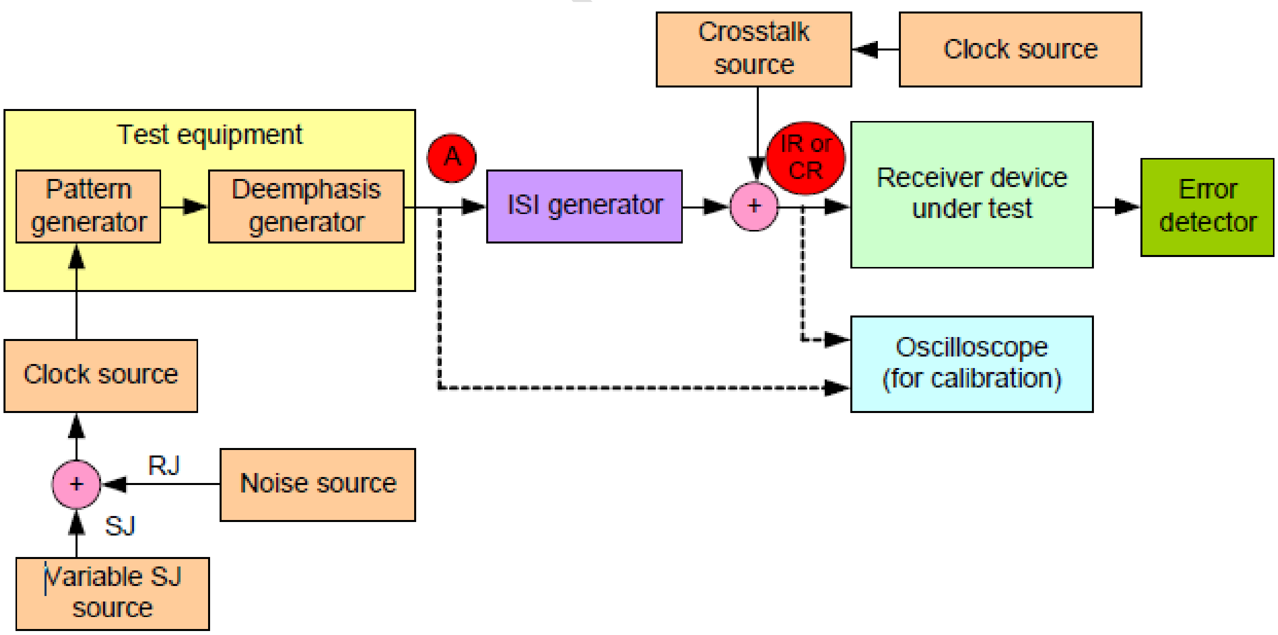


FIGURE 32. STRESSED RX JITTER TOLERANCE TEST/CALIBRATION SETUP BLOCK DIAGRAM (FROM SAS-3 DRAFT STANDARD)

11.1.1 Test Points

Below shows a series of SAS compliance test points as defined by the SAS-3 Draft Standard.

Table 4 — Compliance points

Compliance point	Type	Description
1.5 Gbit/s, 3 Gbit/s, 6 Gbit/s, and 12 Gbit/s compliance points		
IT	intra-enclosure (i.e., internal)	The signal from a transmitter device , as measured at probe points in a test load attached with an internal connector.
IT_S	intra-enclosure (i.e., internal)	The location of a transmitter device where S-parameters are measured and where the TxRx connection begins for 1.5 Gbit/s, 3 Gbit/s, and 6 Gbit/s. This location is at the transmitter device side of the internal connector with a test load or a TxRx connection attached with an internal connector.
IR	intra-enclosure (i.e., internal)	The signal going to a receiver device , as measured at probe points in a test load attached with an internal connector.
CT	inter-enclosure (i.e., cabinet)	The signal from a transmitter device, as measured at probe points in a test load attached with an external connector.
CT_S	inter-enclosure (i.e., cabinet)	The location of a transmitter device where S-parameters are measured and where the TxRx connection begins for 1.5 Gbit/s, 3 Gbit/s, and 6 Gbit/s. This location is at the transmitter device side of the external connector with a test load or a TxRx connection attached with an external connector.
CR	inter-enclosure (i.e., cabinet)	The signal going to a receiver device, as measured at probe points in a test load attached with an external connector.
12 Gbit/s only compliance points		
ET	transmitter circuit	The output signal from a transmitter circuit measured with the test load, TDCS, and TCCS de-embedded.
ER	receiver post equalization	A point defined at the output of the reference receiver device

FIGURE 33. SAS COMPLIANCE TEST POINT SPECIFICATIONS (FROM SAS-3 DRAFT STANDARD)

The following diagrams show a clearer view of the compliance points.

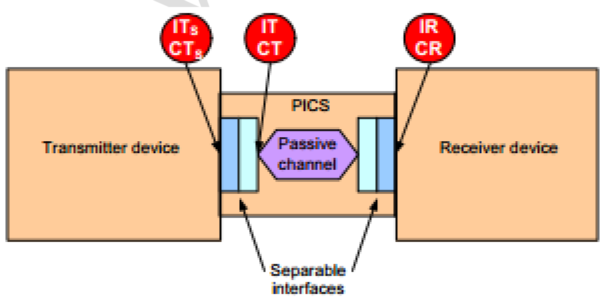


FIGURE 34. 12GBPS TXRX CONNECTION AND COMPLIANCE POINTS

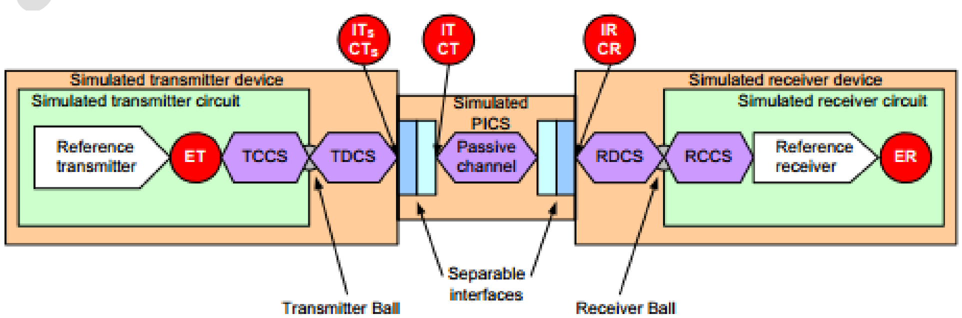


FIGURE 35. SIMULATED 12GBPS TXRX CONNECTION AND COMPLIANCE POINTS

11.2 Recommended SAS-3 Rx Calibration Flow

Note: The following specification diagram/tables have been extracted from the SAS-3 Draft Standard as reference.

a) Launch Amplitude

Launch amplitude calibrated for the target minimum peak-to-peak amplitude of 850mVpp, as specified below.

Table 64 — ISI generator characteristics for trained 12 Gbit/s at ET and ER

Characteristic	Units	Minimum	Maximum	Compliance point
Peak to peak voltage [a] [b]	mV(P-P)	850	1 000	ET (see 5.3.3)

b) Calibrate Reference Presets

Calibrate nominal preshoot/de-emphasis settings for three reference presets (reference_1, reference_2 and no_equalization), as specified below.

Table 46 — Transmitter circuit coefficient presets at ET

Coefficient setting [a]	V_{HL} (mV) [b]		R_{pre} (V/V) [b]			R_{post} (V/V) [b]		
	Min.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.
normal [c]	-	-	-	-	-	-	-	-
reference_1 [d] [e]	850	1 200	2.10	2.52	2.97	2.94	3.52	4.16
reference_2 [e] [f]	850	1 200	1.05	1.26	1.49	1.19	1.43	1.68
no_equalization [e] [g]	850	1 200	0.84	1.00	1.19	0.84	1.00	1.19

c) Calibrate Random Jitter (RJ)

Calibrate the maximum RJ value using a clock pattern (1100) with appropriate PLL applied, as specified below.

Table 64 — RJ charateristics for trained 12 Gbps stressed receiver device tolerance test

Characteristic	Units	Minimum	Nominal	Maximum
Tx RJ [a] [b] [c]	UI	0.135 [d]	0.150 [e]	0.165 [f]

[a] For characteristics with minimum and maximum values, the test setup shall be configured to be within the range specified by the minimum and maximum values. The range shall not be used to define corner test conditions required for compliance.
[b] Measured at ER, IR, or CR in figure 146. The RJ measurement shall be performed with a repeating 0011b or 1100b pattern (e.g., D24.3) with SSC disabled. RJ is 14 times the RJ 1 sigma value, based on a BER of 10^{-12}.
[c] Measured after application of the JTF (see 5.9.3.2).
[d] 0.135 UI is 11.25 ps at 12 Gbps.
[e] 0.150 UI is 12.5 ps at 12 Gbps.
[f] 0.165 UI is 13.75 ps at 12 Gbps.

d) Calibrate Applied Sinusoidal Jitter (SJ)

Calibrate SJ (over three frequencies) for jitter tolerance using the 1100 pattern. The calibration will be performed for DUTs with SSC support or/and without SSC support, as defined below.

For the case without SSC support:

5.9.5.7.6.9 Applied SJ

Figure 148 defines the applied SJ for trained receiver devices that do not support SSC.

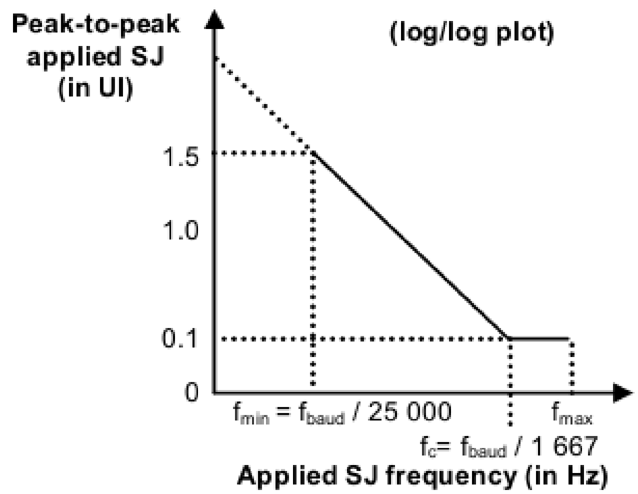


Figure 148 — Applied SJ for trained 1.5 Gbps, 3 Gbps, 6 Gbps, and 12 Gbps without SSC support

Table 65 defines f_{min}, f_c, and f_{max} for figure 148. f_{baud} is defined in table 32 (see 5.9.1).

Table 65 — f_{min}, f_c, and f_{max} for trained 1.5 Gbps, 3 Gbps, 6 Gbps, and 12 Gbps without SSC support

Physical link rate	f_{min}	f_c	f_{max}
1.5 Gbps	60 kHz	900 kHz	5 MHz
3 Gbps	120 kHz	1 800 kHz	7.5 MHz
6 Gbps	240 kHz	3 600 kHz	15 MHz
12 Gbps	240 kHz	3 600 kHz	15 MHz

For the case with SSC support:

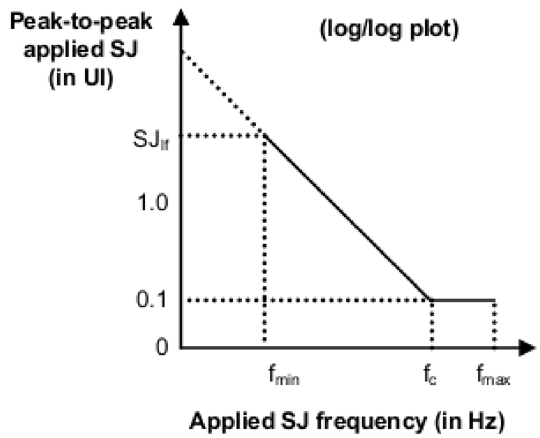


Figure 149 — Applied SJ for trained 1.5 Gbps, 3 Gbps, 6 Gbps and 12 Gbps with SSC support

Table 66 defines f_{min}, f_c, f_{max}, and SJ_{lf} for figure 149.

Table 66 — f_{min}, f_c, f_{max}, and SJ_{lf} for trained 1.5 Gbps, 3 Gbps, 6 Gbps, and 12 Gbps with SSC support

Physical link rate	f_{min}	f_c	f_{max}	SJ_{lf}
1.5 Gbps	97 kHz	1.03 MHz	5 MHz	11.3 UI
3 Gbps	97 kHz	1.46 MHz	7.5 MHz	22.6 UI
6 Gbps	97 kHz	2.06 MHz	15 MHz	45.3 UI
12 Gbps	111 kHz	2.06 MHz	15 MHz	34.6 UI

Note: The "with SSC support" jitter tolerance above increases the low-frequency SJ to 34.6UI. This low SJ frequency would allow for testing of DUT CR rejection at near SSC frequencies.

e) Calibrate Eye Opening or ISI Generation Using SAS3 Eye Opening tool

Measure the SAS3 Eye Opening (*which is the ratio of Vertical Eye Opening to Reference Pulse Response Amplitude*) to the target ratio of between 65 to 80%. Also calibrate the reference pulse response cursor peak-to-peak value to the target values as indicated below.

Table 64 — ISI generator characteristics for trained 12 Gbit/s at ET and ER

Characteristic	Units	Minimum	Maximum	Compliance point
Peak to peak voltage [a] [b]	mV(P-P)	850	1 000	ET (see 5.3.3)
Coefficient 1 (i.e., C1) [c] [d] [e]	V/V	-0.15	0	ET
Coefficient 3(i.e., C3) [c] [d] [f]	V/V	-0.3	0	ET
VMA [g] [h]	mV(P-P)	80		ET
Reference pulse response cursor peak to peak amplitude [i] [j]	mV(P-P)	125	145	ER (see 5.3.3)
Vertical eye opening to reference pulse response cursor ratio [j] [k] [l]	%	65	80	ER
DFE coefficient magnitude to reference pulse response cursor ratio [m]	%	5	50	ER

f) Calibrate Crosstalk

Calibrate the total peak-to-peak, differential crosstalk noise using the 1010 pattern at 12Gbps with SSC enabled (generated by the BERT) and using a cumulative probability of 1E-6 (mVpp). Calibration will be based on the following specifications from Table D.2 of SAS3 Specification.

End-to-end simulation type [a]	S-parameter files [b] [c]	Measurement point	Description of S-parameter files	Crosstalk amplitude at a cumulative probability of 10^{-6} (mV_{p-p}) [d] [e]	
				Min	Max
Stressed receiver device (see figure D.4)	LongPassiveD2H_CR_RR.s4p	IR or CR	RDCS + D2H RCCS	15	20

11.3 SAS-3 Rx Calibration Setup and Procedure

Calibration for SAS-3 will be performed at two test points: Point A and Point IR/CR. Test Point A (TP-A) is a physical test point for calibration. Test Point IR/CR is an electrical test point calculated by the Scope test instrument for SAS-3 (12 Gbit/s) compliance.

Refer to Figure 32 to view the block diagram for the general calibration setup.

11.3.1 Physical Setups

11.3.1.1 Connect Equipment at Test Point A (TP-A)

The connection diagram below shows the recommended equipment setup to calibrate for signal amplitude and jitter at TP-A.

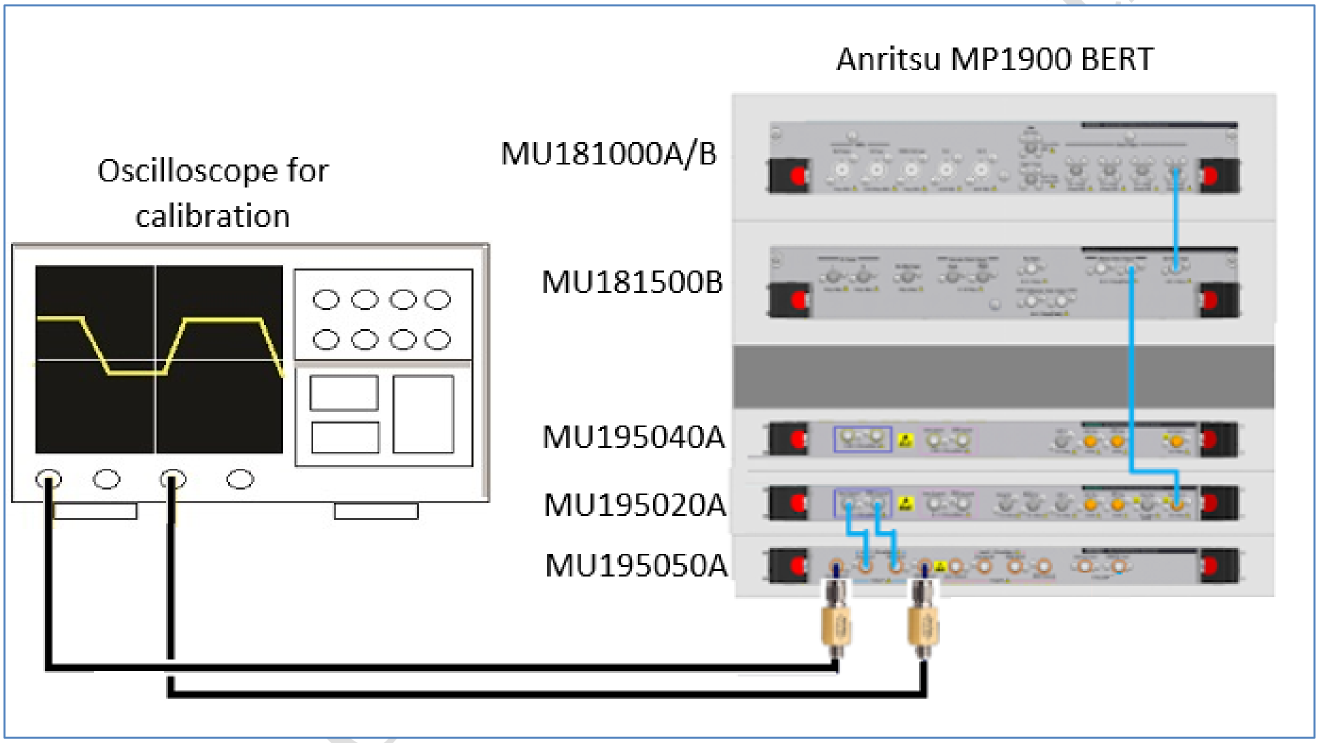


FIGURE 36. CALIBRATION CONNECTION SETUP AT TEST POINT A

Connection Steps:

1. Connect the MU181000A/B clock output to the MU181500B Ext clock input.
2. Connect the MU181500B jittered clock output to the MU195020A Ext clock input.
3. Connect the MU195020A data outputs to the MU195050A data inputs.
4. Connect the MU195050A data outputs through DC blocks to Channels 1 and 3 on the oscilloscope.

11.3.1.2 Connect Equipment at Test Point A-IR/CR

The connection diagram below shows the recommended equipment setup to calibrate for eye opening and crosstalk from TP-A to Test Point IR/CR.

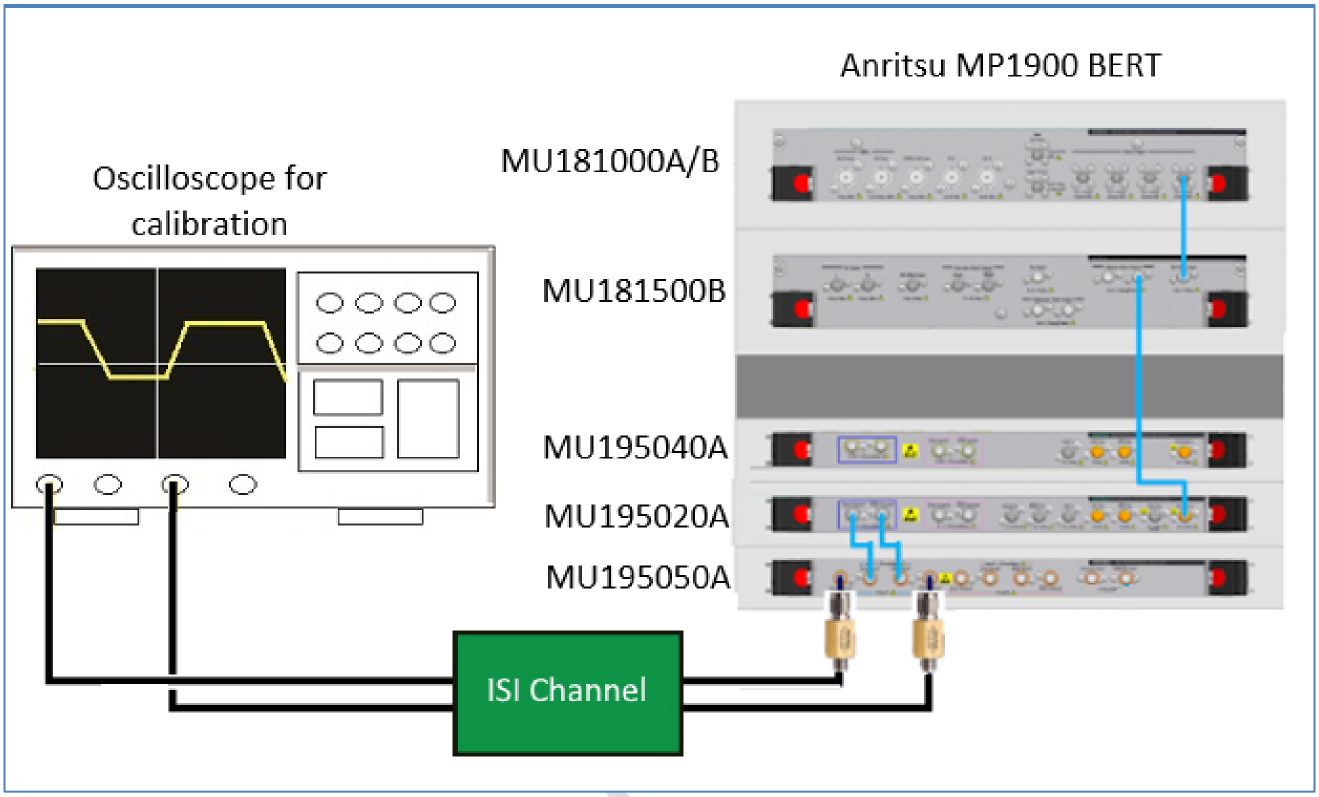


FIGURE 37. CALIBRATION CONNECTION SETUP AT TEST POINT A-IR/CR

Connection Steps:

1. Using back the same BERT connections from the TP-A calibration, disconnect the MU195050A data outputs from the oscilloscope channels.
2. Connect the MU195050A data outputs to a compliant ISI source.
3. Connect the ISI source to Channels 1 and 3 on the oscilloscope.

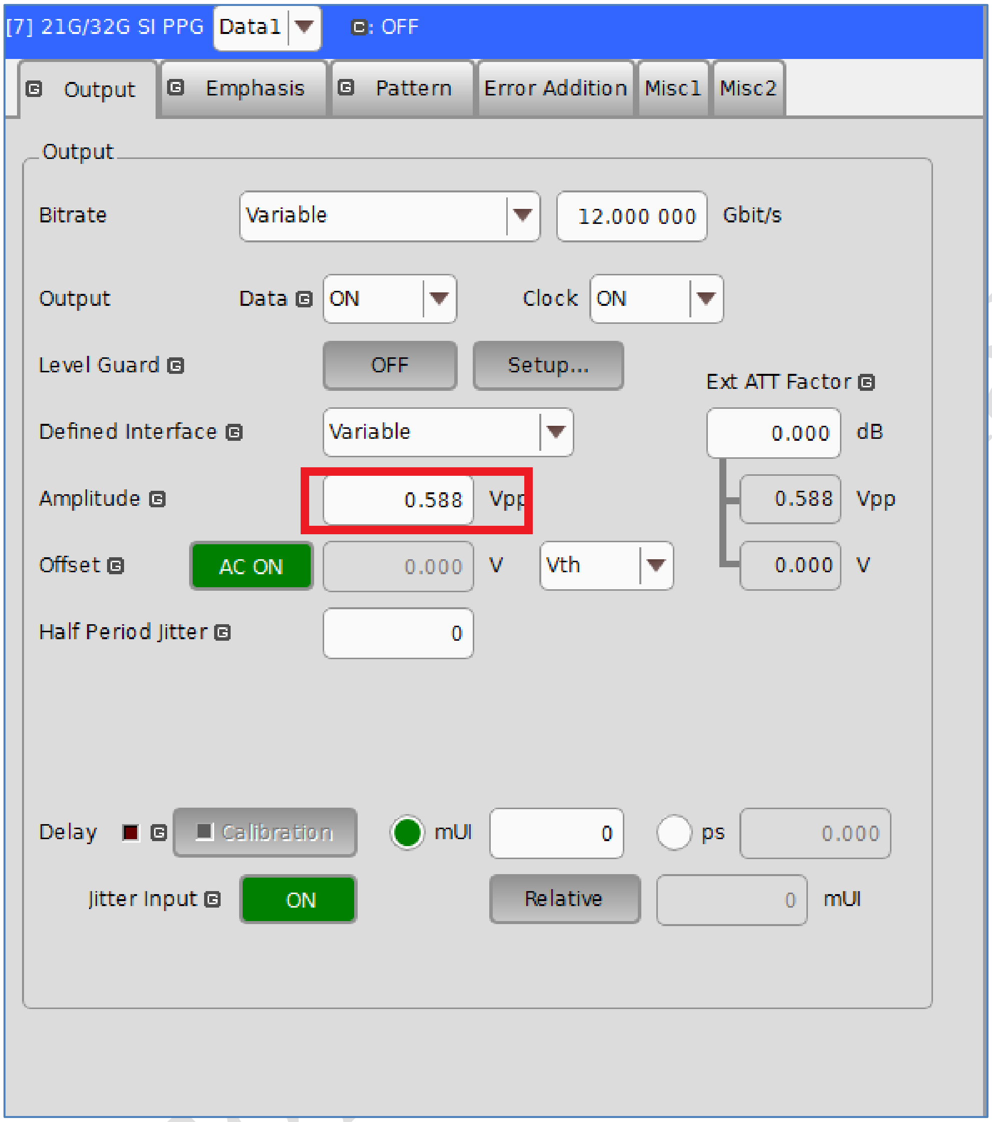
11.3.2 Calibration Steps

11.3.2.1 Step 1: Calibrate Peak-to-Peak Launch Amplitude

This step verifies that the peak-to-peak Launch Amplitude meets the target of 850mVpp or above. If required, the PPG DATA Outputs can be adjusted to reach the target value.

For this example, a 64X1_64x0_64x10.ram pattern will be used.

1. Measure the peak-to-peak Launch Amplitude using cursors, while adjusting the PPG Data Output amplitude to achieve the target 850mVpp.



The amplitude measured in this example is 859mVpp, which meets the target.

11.3.2.2 Step 2: Calibrate and Save Reference Presets

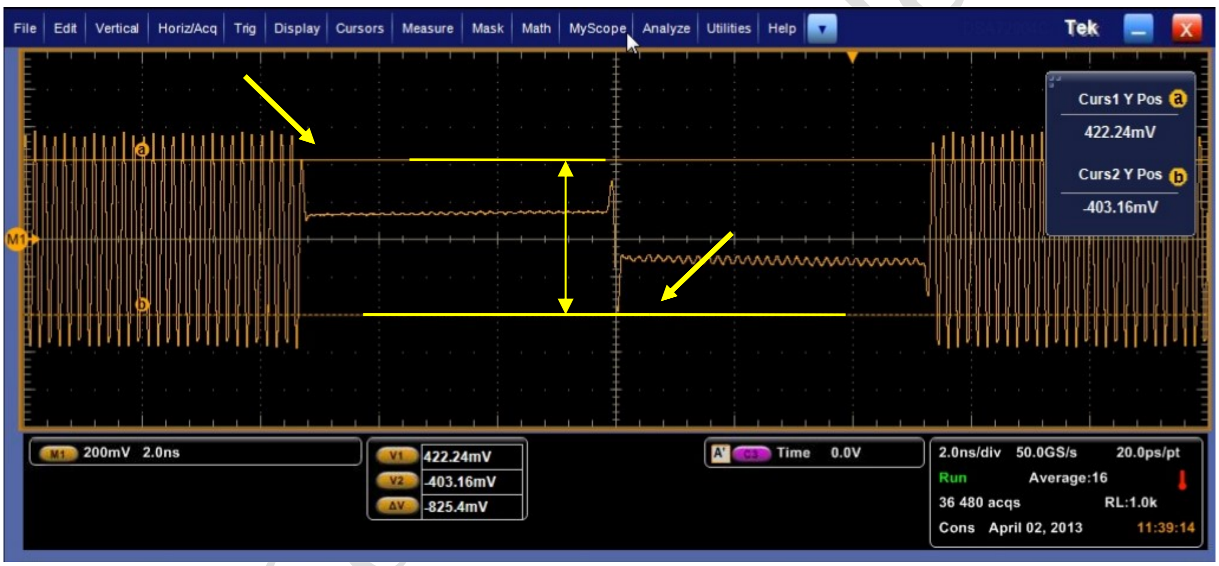
This step verifies that the nominal settings for a reference preset (which uses de-emphasis and pre-shoot) meet the target values, and then saves the settings. A total of 3 reference presets, with nominal de-emphasis and pre-shoot settings for each preset, will be used in testing.

For this example, Reference Preset 1 will be calibrated using the 64X1_64x0_64x10.ram pattern to the following target values:

- Target De-emphasis: -10.9dB +/- 2dB
- Target Pre-shoot: 8dB +/- 2dB

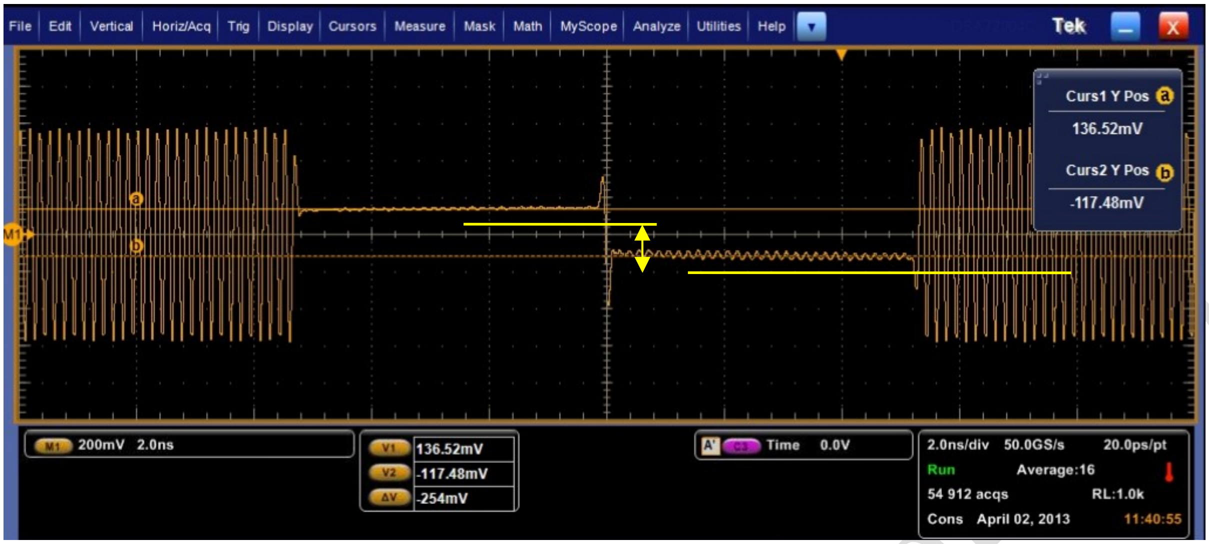
The calibrated nominal settings will then be saved for future use.

1. Set De-emphasis and Pre-shoot on the BERT to the above target values.
2. Measure the actual de-emphasis and pre-shoot on the scope. Using cursors, measure the peak-to-peak transition amplitude.



The measured transition amplitude in this example is 825mVpp.

3. Using cursors, measure the peak-to-peak non-transition amplitude.



The measured non-transition amplitude in this example is 254mV.

4. Calculate De-emphasis as follows:

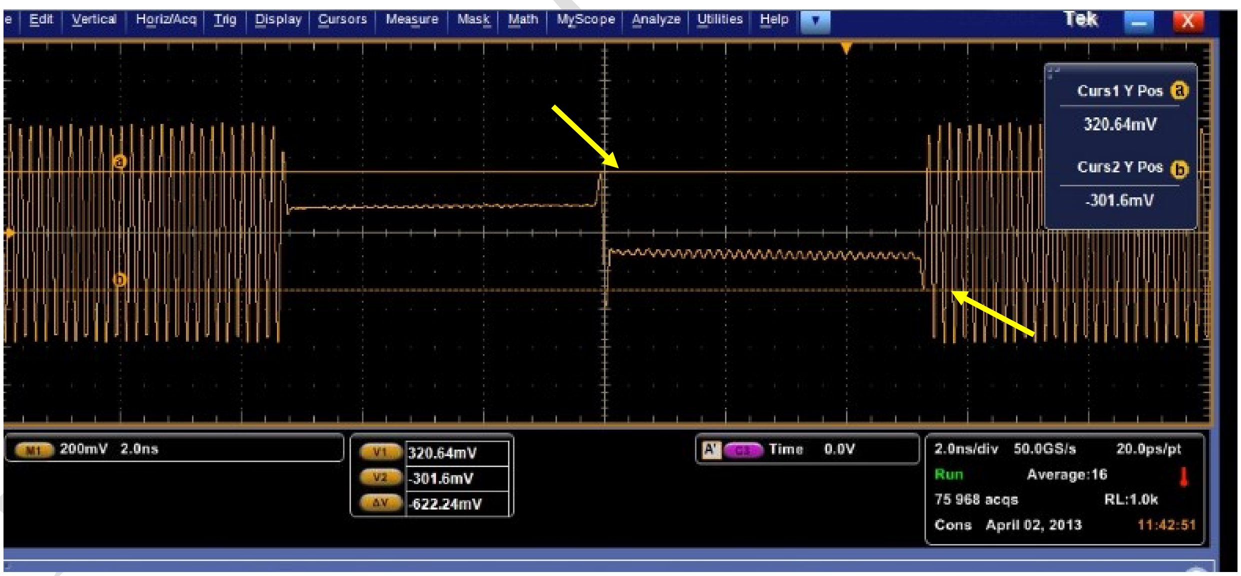
De-emphasis = 20log[Non-transition/Transition]

= 20log[254mV/824mV]

= 20log[0.31]

=-10.2dB *(which conforms to the target of -10.9dB +/- 2dB)*

5. Now, measure the pre-shoot amplitude using cursors.



The measured pre-shoot amplitude in this example is 622mV.

6. Calculate pre-shoot as follows:

$$\text{Pre-shoot} = 20\log[\text{Pre-shoot}/\text{Non-transition}]$$
$$= 20\log[622mV/254mV]$$
$$= 20\log[2.44]$$
$$= 7.8dB$$ *(which conforms to the target of 8dB +/- 2dB)*

7. Save the Reference Preset 1 settings to a file, for example 'SAS-12G_reference1' on the BERT.
8. Repeat the above calibration and saving procedure for Reference Presets 2 and 3.

11.3.2.3 Step 3: Calibrate RJ

This step verifies that the measured Random Jitter meets the target value of 0.165UI.

For this example, the Clock Pattern (1100) will be used, and the PLL will be enabled on the RT scope.

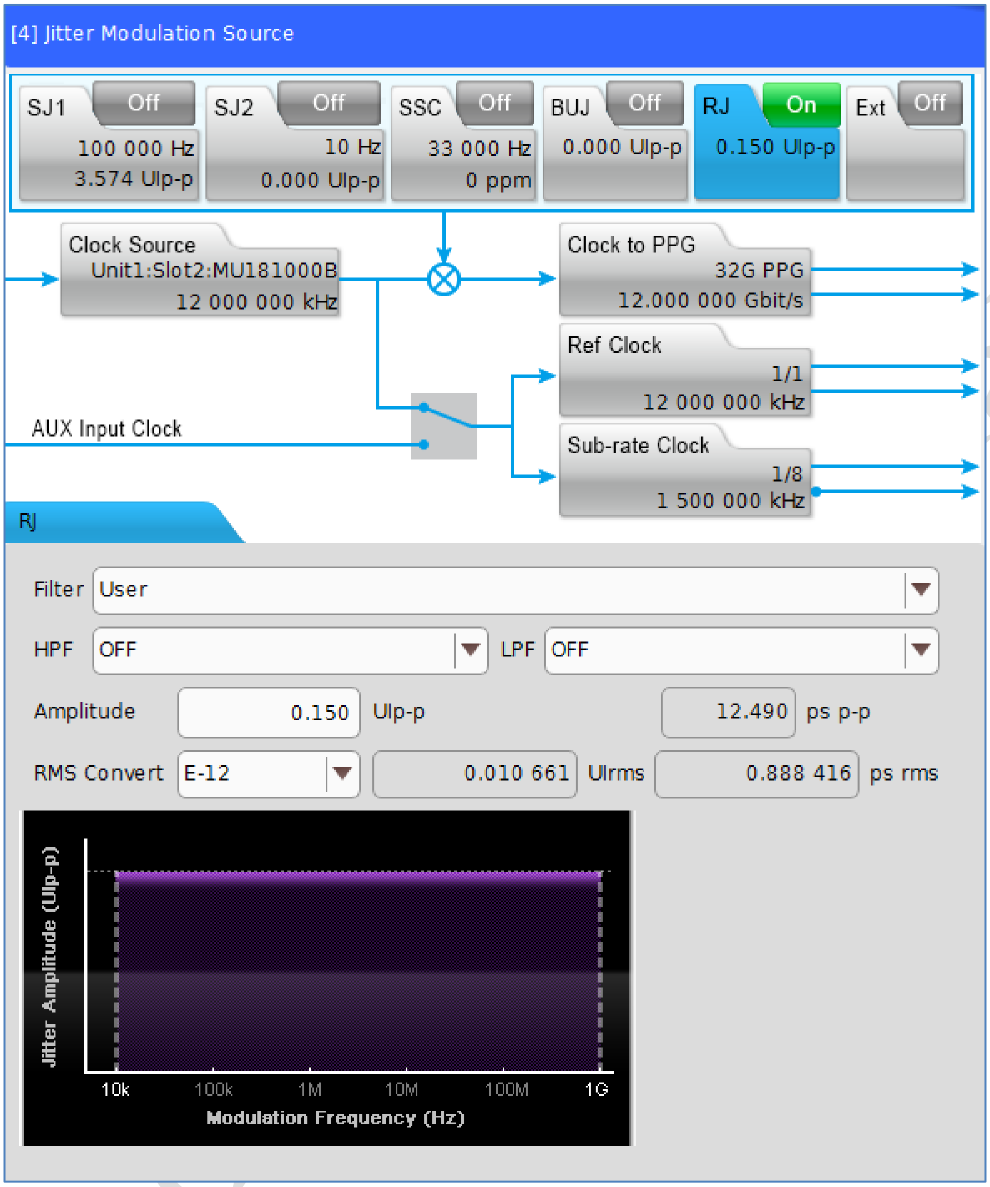
1. Set the Generator Pattern to the 1100 pattern.

   a) **If the DUT does not support SSC**, follow these steps:

2. Set the BERT amplitude to the calibrated voltage from the Launch Amplitude calibration step (refer Section 11.3.2.1). Set Random Jitter (RJ) to 0.15UIp-p.
3. Using the Keysight EZJIT Plus/Tektronix DPOJET or equivalent function on the Scope, configure the PLL Model as follows:
   - Type I/First Order, JTF Loop Bandwidth = 3.6MHz
4. Measure RJ (rms) on the Scope, while adjusting the BERT amplitude to achieve the specified target RJ of 0.15 UI peak-to-peak.
5. Perform additional measurements to plot the "RJ Setting vs Measured RJ" linear curve.

   b) **If the DUT supports SSC**, follow these steps:

1. Set the BERT amplitude to the calibrated voltage from the Launch Amplitude calibration step (refer Section 11.3.2.1). Set Random Jitter (RJ) to 0.15UIp-p.
2. Enable the Keysight EZJIT Plus Jitter Analysis function on the Scope and configure the PLL Model as follows:
   - Type II, Second Order, JTF Loop Bandwidth = 2.6MHz, Damping Factor = 0.86
3. Measure RJ (rms) on the Scope, while adjusting the BERT amplitude to achieve the specified target RJ of 0.15 UI peak-to-peak.
4. Perform additional measurements to plot the "RJ Setting vs Measured RJ" linear curve.



11.3.2.4 Step 4: Calibrate SJ

This step verifies the Jitter Tolerance at 3 distinct SJ frequencies, as defined by the SAS specification.

Magnitude and SJ will vary depending on testing with or without SSC support.

For **SSC support**, SJ will need to be calibrated to the following target values:

- SJ at 111kHz: 34UI
- SJ at 2.06MHz: 0.10UI
- SJ at 15MHz: 0.10UI

For **Non-SSC support**, SJ will need to be calibrated to the following target values:

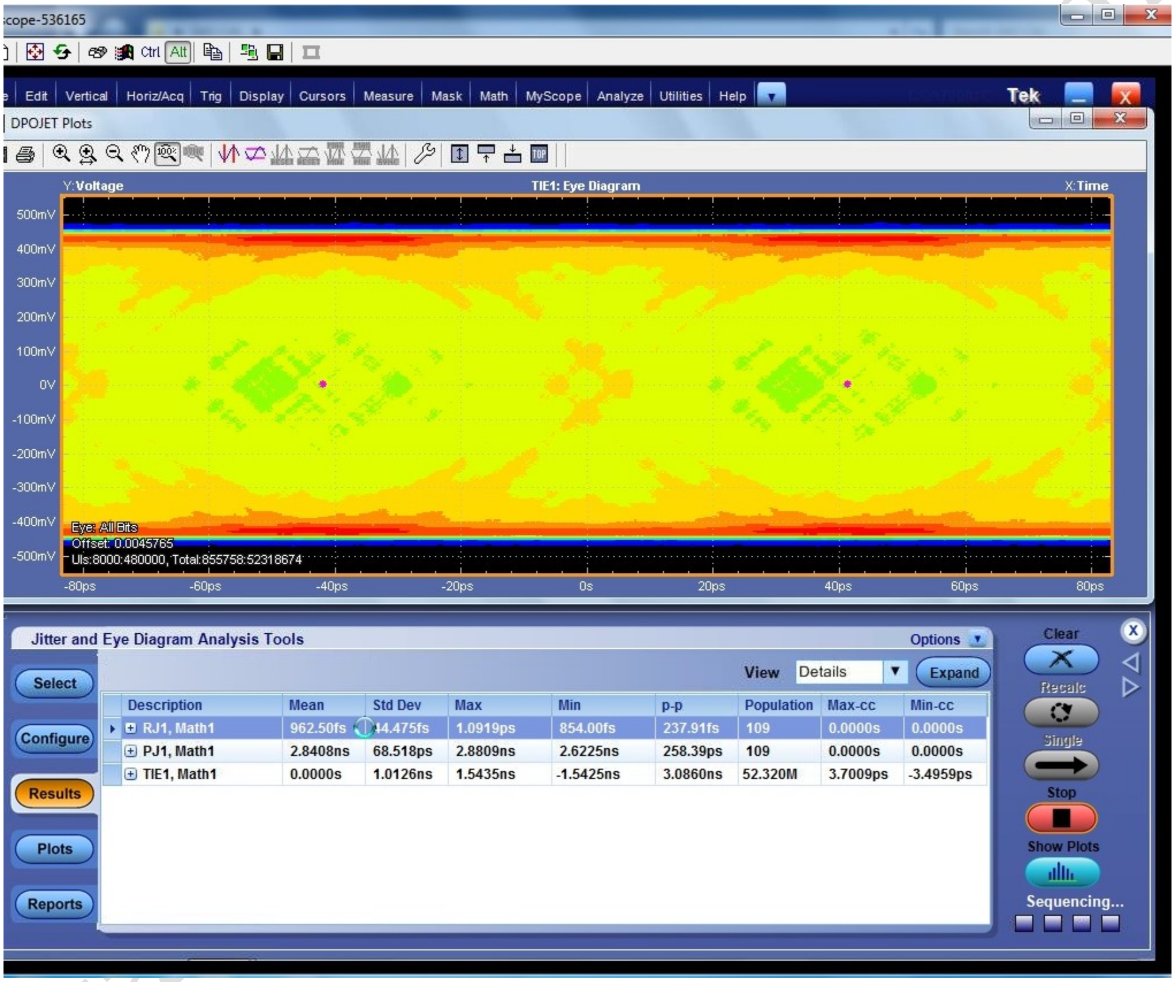
- SJ at 240kHz: 1.5UI

- SJ at 3.6MHz: 0.10UI
- SJ at 15MHz: 0.10UI

Note: Additional Jitter Tolerance points can be added if desired.

i) Calibrate SJ

1. On the Scope, set the Clock Recovery Method to 'Constant Clock'. This is to prevent filtering of the low frequency jitter modulation for verification.
2. On the BERT, set the SJ Frequency to 111KHz and SJ Amplitude to 34UI.



In the above example, PJ1 is measured at 2.84ns.

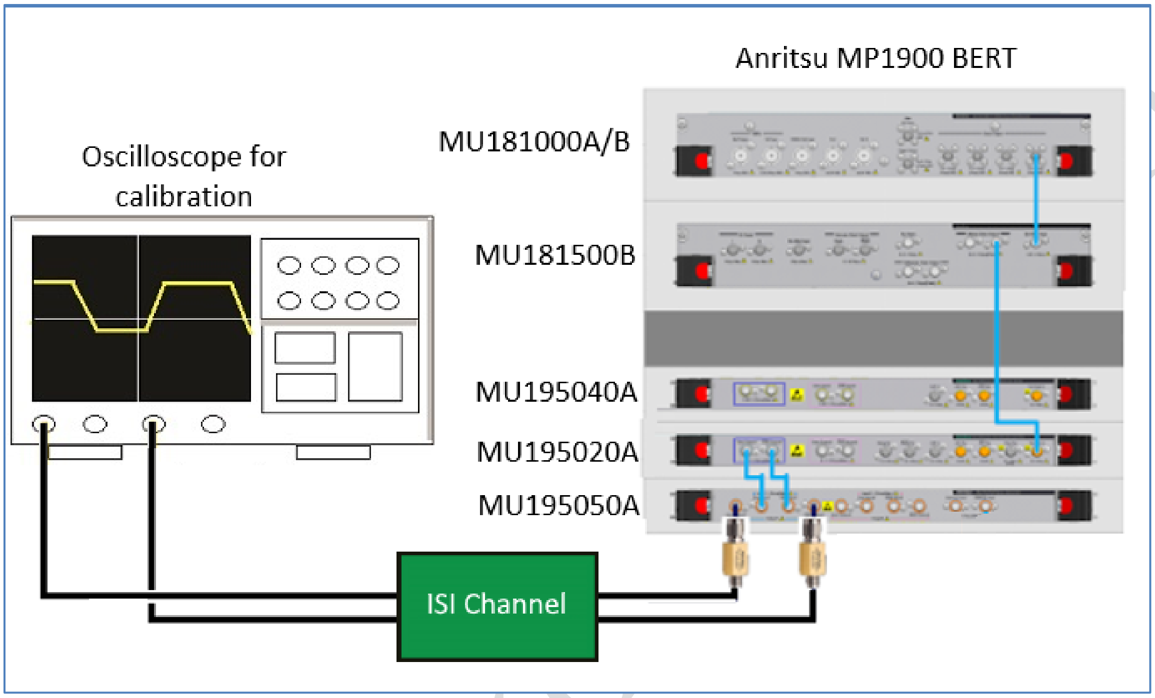
3. Convert the value to UI (where 1UI = 83ps) to meet the target of 34UI, as follows:

   2.84ns/83ps = 34UI

4. Record the SJ value on the BERT needed to generate the required SJ at 111kHz, which is to be used for the Jitter Tolerance configuration later.
5. Repeat steps 1 to 4 for all SSC and Non-SSC SJ cases.

11.3.2.5 Step 5: Calibrate Eye Opening

This step verifies that the SAS-3 Eye Opening is within the target range of 63 to 73%. An ISI Generator will be implemented and can be adjusted to achieve the expected Eye Opening value. For this example, the Artek CLE1000-A2 will be used as the Variable ISI Generator.



1. Connect the outputs of the BERT to the inputs of the ISI Generator.

Note: Alternatively, the ISI Board can also be used as the ISI Generator (fixed channel).

2. Connect the outputs of the ISI Generator to Channel 1 and Channel 3 of the Scope.
3. Set stresses to 0%UI and disable de-emphasis and pre-shoot (Reference_3) on the BERT and ISI Generator.

   The SAS-3 Specification requires the following conditions to be set when calibrating the ISI Generator:

   - No pre-shoot
   - No de-emphasis
   - RJ set to 0%UI
   - SJ set to 0%UI
4. On the BERT PPG, set the Pattern to PRBS15. *Note: The SAS3_Eye Opening script will work with any frequency-rich pattern (e.g., PRBS patterns), thus 8b/10b encoding is not required.*
5. Using the Eye Opening script, measure the Eye Opening.
6. Adjust the ISI Generator accordingly until the target measurement is obtained (within the range of 63 to 73%).

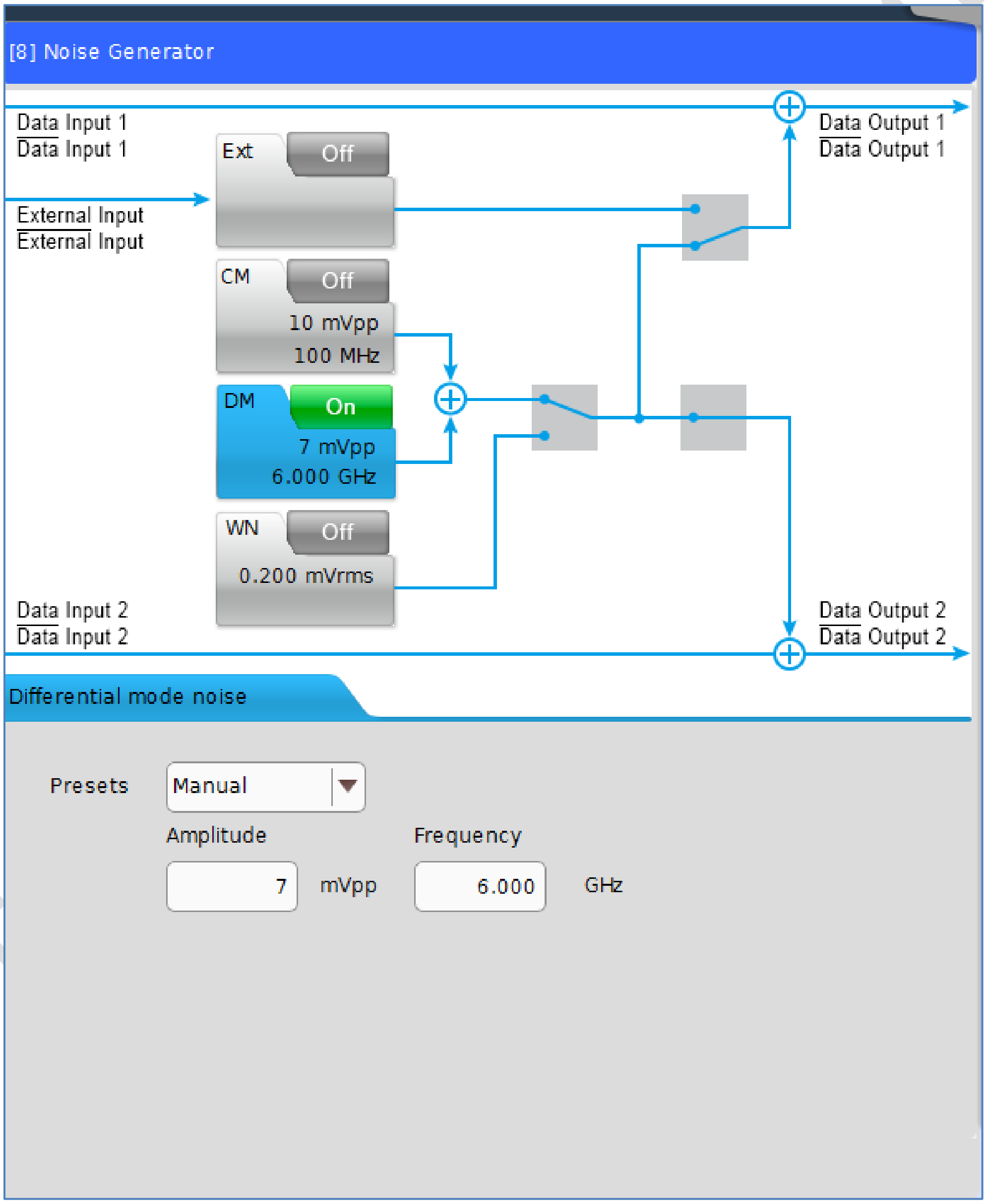
   **Note: Methodology for the Eye Opening measurement is outside the scope of this MOI.*

11.3.2.6 Step 6: Calibrate Crosstalk

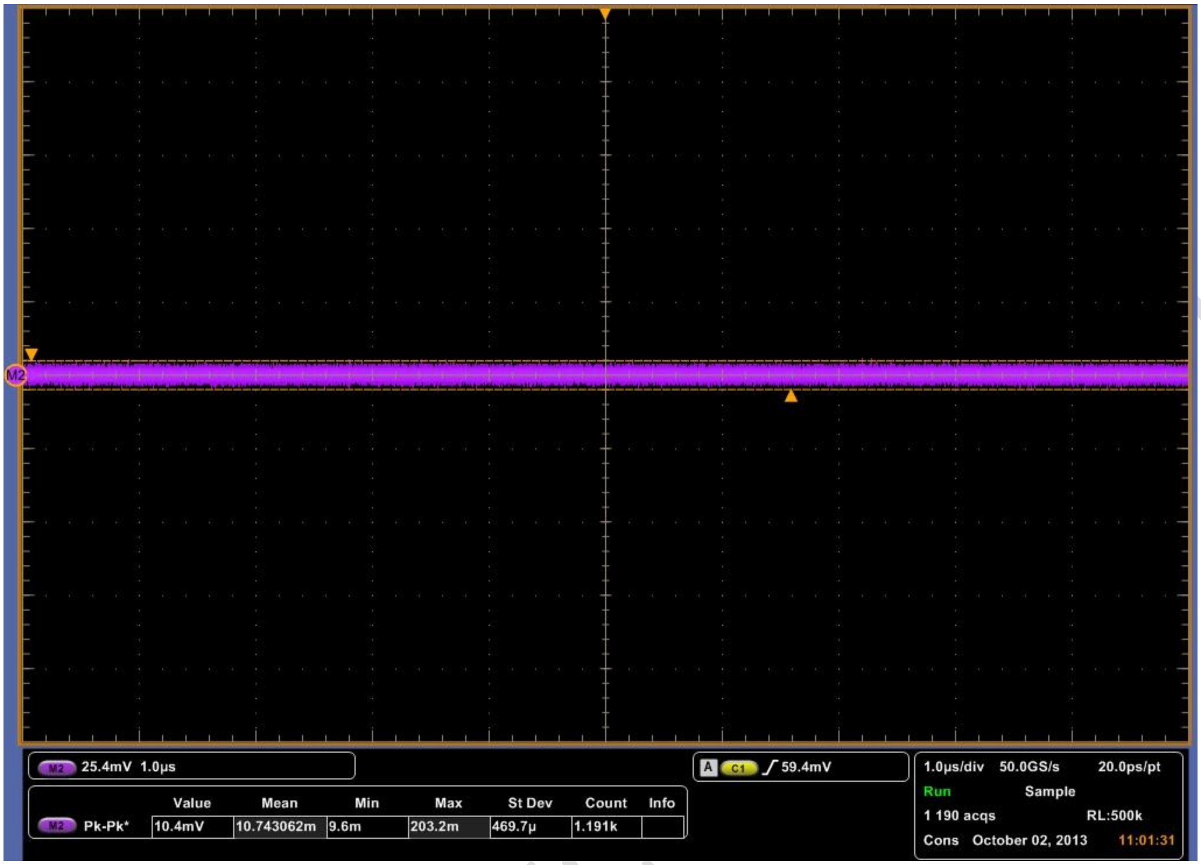
This step verifies that the crosstalk amplitude is within the target maximum 15 to 20mVpp. Similar to the Eye Opening calibration, the ISI Generator will also be applied. For this case, the BERT DM Output will be used to generate the crosstalk, and can be adjusted to achieve the expected crosstalk value.

SAS-3r05G, Table D.5 specifies that S-parameter files and crosstalk amplitude per usage models (part 1 of 2) crosstalk amplitude should be between 15 to 20mV pk-pk. *Note: The crosstalk required is Far End Crosstalk (FEX) and should include ISI effects (the loss profile as previously calibrated for ISI generator) as well as being applied in differential mode.*

1. On the BERT, set the DM Frequency to 6GHz and Output to 7mVpp.



2. Set the scope to measure the maximum Vpp. The typical initial amplitude is as shown below.



3. Adjust the DM Output Amplitude until the amplitude measured is between the maximum 15 to 20mVpp as targeted.

11.4 SAS-3 Rx Compliance Test Setup and Procedure

Compliance testing for jitter tolerance of the receiver DUT will use the BERT analyzer/error detector in loopback mode. The BERT will typically transmit CJTPAT signaling (which includes ISI effects, jitter and crosstalk) to the Rx DUT. During loopback, the DUT will transmit the test signal to the BERT error detector for error checking. The DUT will pass compliance if the target BER of less than 1E-12 with a 95% confidence level is met.

Refer to Figure 32 to view the block diagram for the general test setup.

11.4.1 Physical Setup

The connection diagram below shows the recommended equipment setup to test the DUT for SAS-3 Rx jitter tolerance.

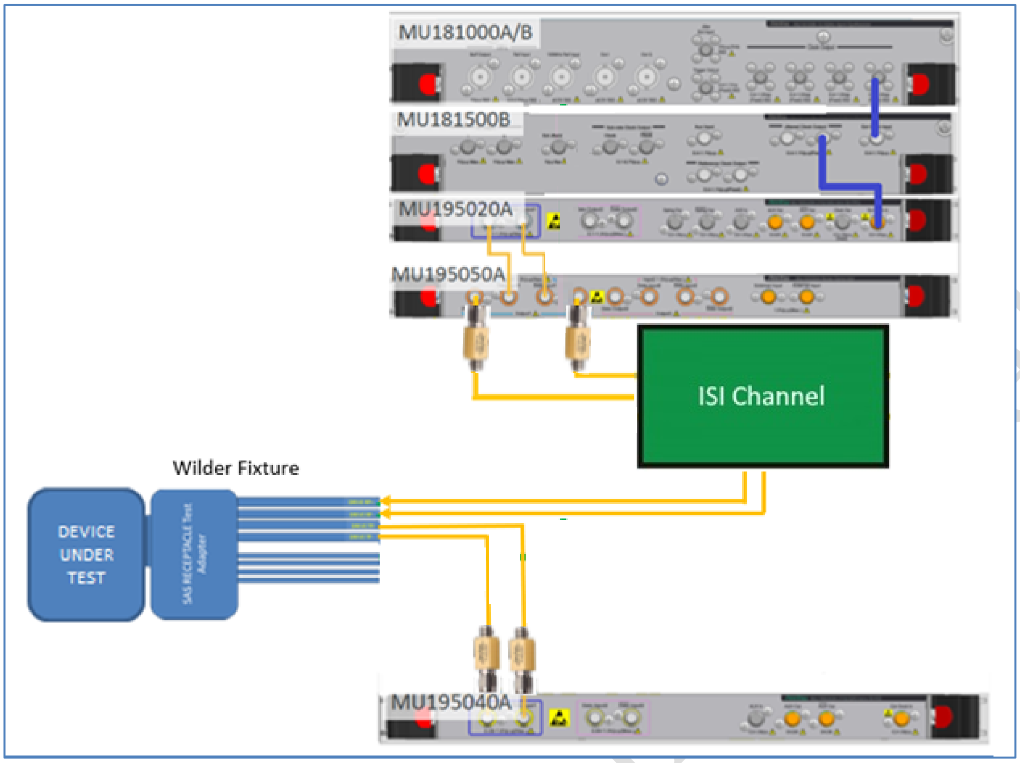


FIGURE 38. COMPLIANCE TEST SETUP FOR RECEIVER DUT JITTER TOLERANCE

Connection Steps:

1. Using back the same BERT connections from calibration, remove the Scope channel connections from the Variable ISI generator.
2. Connect the outputs of the Variable ISI generator to the Rx lanes of the DUT through the SAS receptacle test adapter (the Wilder fixture is used here).
3. Connect the DUT Tx lanes to the MU195040A data inputs through DC blocks for loopback error detection.

11.4.2 Test for Rx Jitter Tolerance BER Compliance

Transmit CJTPAT signaling to the Rx DUT and verify BER on the BERT error detector over the loopback mode. Based on the maximum errors detected for the given number of bits received, verify that the DUT reports a BER of less than 1E-12 with a 95% confidence level, in order to pass compliance.

12 Appendix B: Connecting Keysight Oscilloscope to PC

Refer to the following procedure on how to connect the Keysight oscilloscope 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.

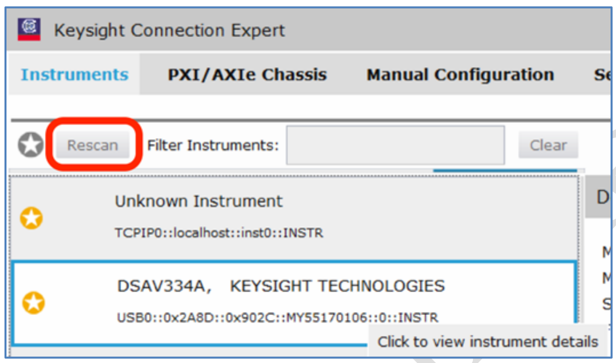


FIGURE 39. KEYSIGHT CONNECTION EXPERT

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

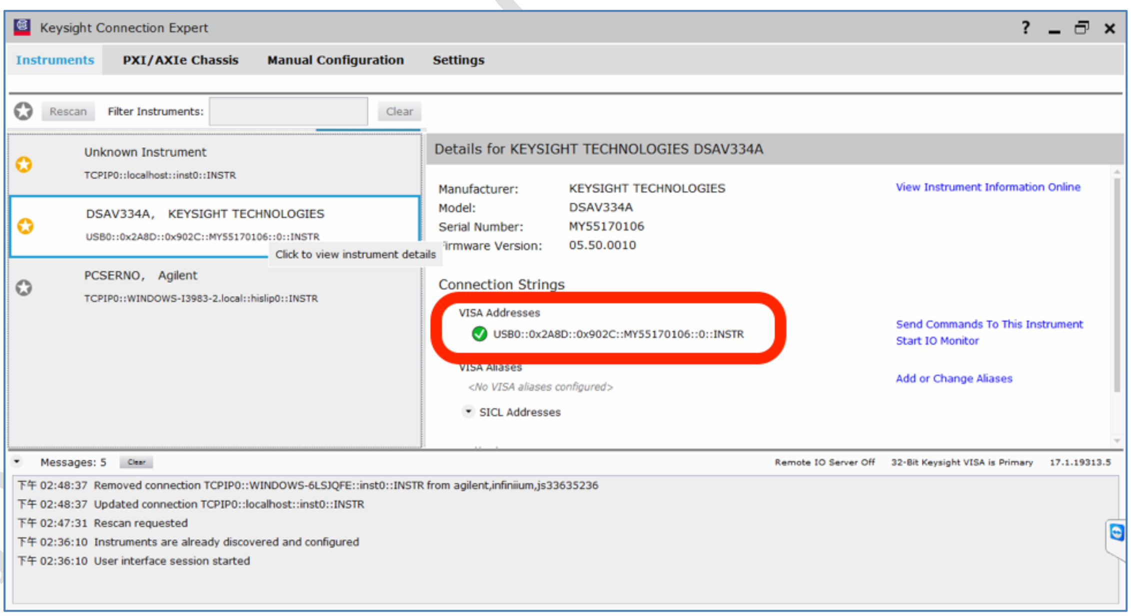


FIGURE 40. OSCILLOSCOPE'S VISA ADDRESS

6. When connecting the Keysight Scope to the PC through GPIB/USB, type in the VISA address into the 'Address' field on the Equipment Setup page of the GRL Anritsu SAS-3 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.

13 Appendix C: Connecting Tektronix Oscilloscope to PC

If using a Tektronix DPOJET Series oscilloscope, refer to the following procedure on how to connect the Scope to be used with a PC. The Tektronix Scope can be connected to the PC through GPIB, USB, or LAN.

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

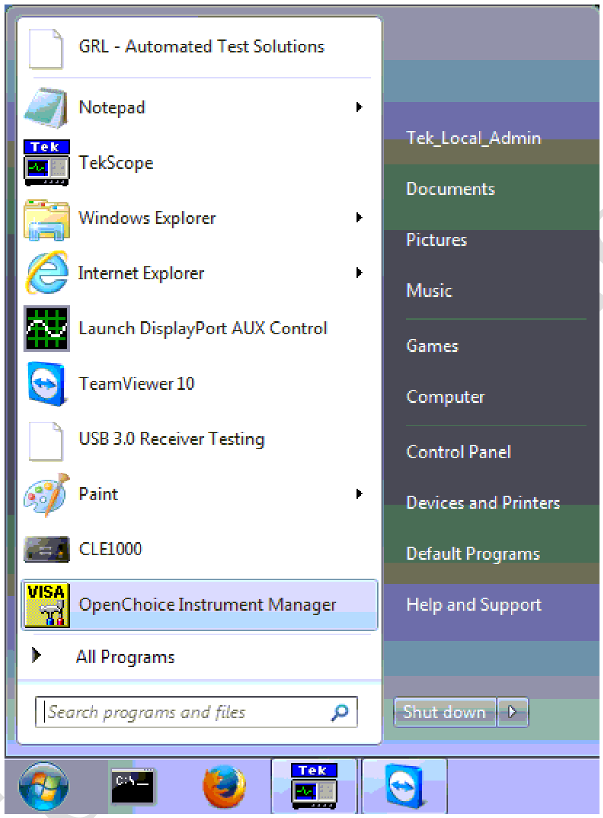


FIGURE 41. OPENCHOICE INSTRUMENT MANAGER IN START MENU

3. The left "Instruments" panel on the OpenChoice Instrument Manager will display all connected instruments. The functional buttons below the "Instruments" panel – "Instrument List Update", "Search Criteria", "Instrument Identify" and "Properties" can be used to detect the Scope in case it does not initially appear under "Instruments".
   a) "Instrument List Update": Select to refresh the instrument list and locate new instruments connected to the PC.
   b) "Search Criteria": Select to configure the instrument search function.
   c) "Instrument Identify": Select to use a supported programming language to send a query to identify the selected instrument.
   d) "Properties": Select to display and view the selected instrument properties.

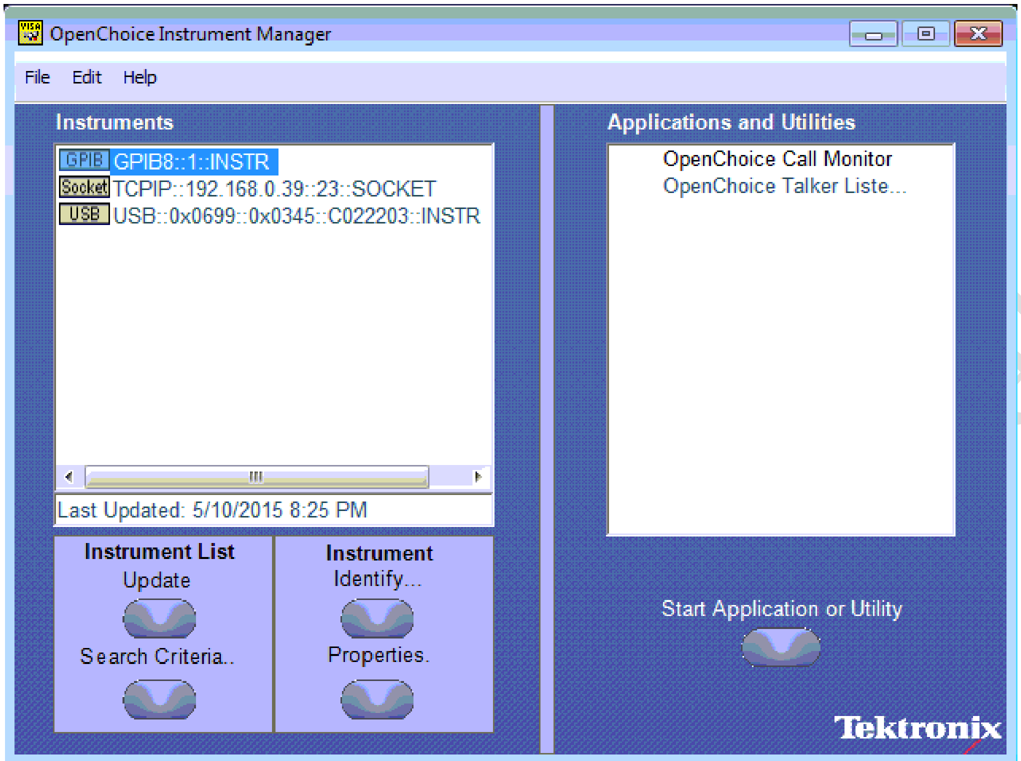


FIGURE 42. OPENCHOICE INSTRUMENT MANAGER MENU

4. If connecting the Tektronix Scope to the PC via USB, select the "Search Criteria" function to ensure that USB connection is enabled, and then select the "Instrument List Update" function. When the Scope appears on the "Instruments" panel, select it and then go to the "Instrument Identify" function. This will display the model and serial number of the Scope once detected. Select the "Properties" function to view the Scope address.
5. If connecting the Tektronix Scope to the PC via LAN, the Scope IP address must be pre-determined beforehand. Then select the "Search Criteria" function to ensure that LAN connection is enabled and type in the Scope IP address. When the Scope shows up in the list, select it followed by "Search". The Scope should then appear on the "Instruments" panel. Select it and access the "Instrument Identify" function to view the Scope model and serial number as well as the "Properties" function to view the Scope address.
6. On the Equipment Setup page of the GRL PCIe CEM 4.0 Rx Test Application, type in the Scope address into the 'Address' field. If the GRL PCIe CEM 4.0 Rx Test Application is installed on the Tektronix Scope, ensure the Scope is connected via GPIB and type in the GPIB network address, for example "GPIB8::1::INSTR". If the GRL software is installed on the PC to control the Scope, type in the Scope IP address, for example "TCPIP0::192.168.0.110::inst0::INSTR". Note to ***omit*** the Port number from the address.

14 Appendix D: Artek CLE1000 Series Installation

14.1 ISI Generator Driver Installation

If using a Artek CLE1000 Series model for variable ISI generation, follow these steps to install the ISI generator driver before selecting it as an ISI channel in the GRL automation software.

1. Connect the CLE1000 to the computer being used as the controller using a USB 2.0 cable.
2. Turn on the front panel power switch on the CLE1000.
3. Right-click on **My Computer > Manage > Device Manager**. If no software for the CLE1000 has been installed, you will see a 'bang' in the Device Manager window.

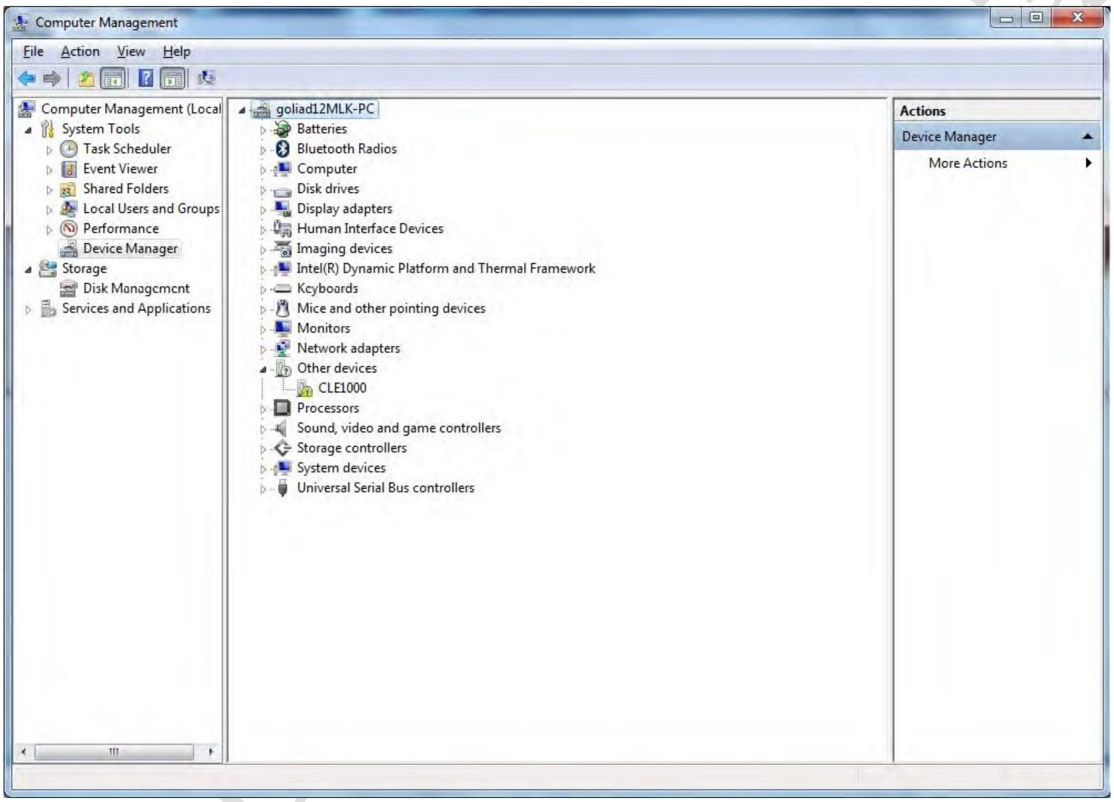


FIGURE 43. DEVICE MANAGER WINDOW

4. To install the CLE1000 driver, go to http://www.aceunitech.com/support.html and download the Control Software package for the CLE1000.
5. Unzip the CLE1000 Software folder and install the driver as follows:
   a) In Device Manager, right-click on **CLE1000** > **Update Driver**.
   b) Select **Browse My Computer for Driver** from Windows dialog (see Figure 44).
   c) Browse to the root directory of the unzipped CLE1000 Software folder.
   d) Click **Next** and then click **Install** to complete installation for the driver software (see Figure 45).
6. Once installation has completed, the Device Manager window should look like the example in Figure 46.

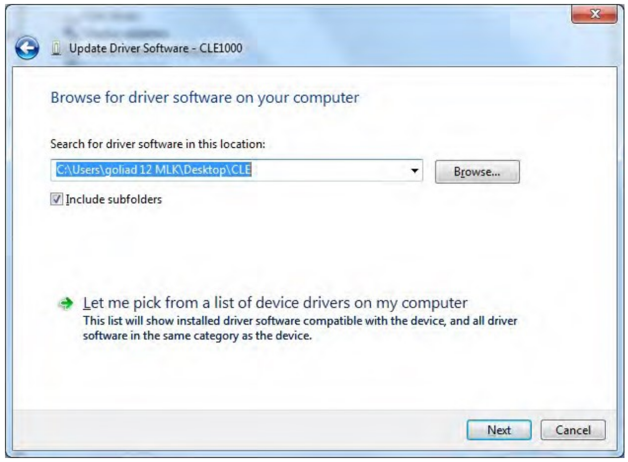


FIGURE 44. UPDATE DRIVER WINDOW

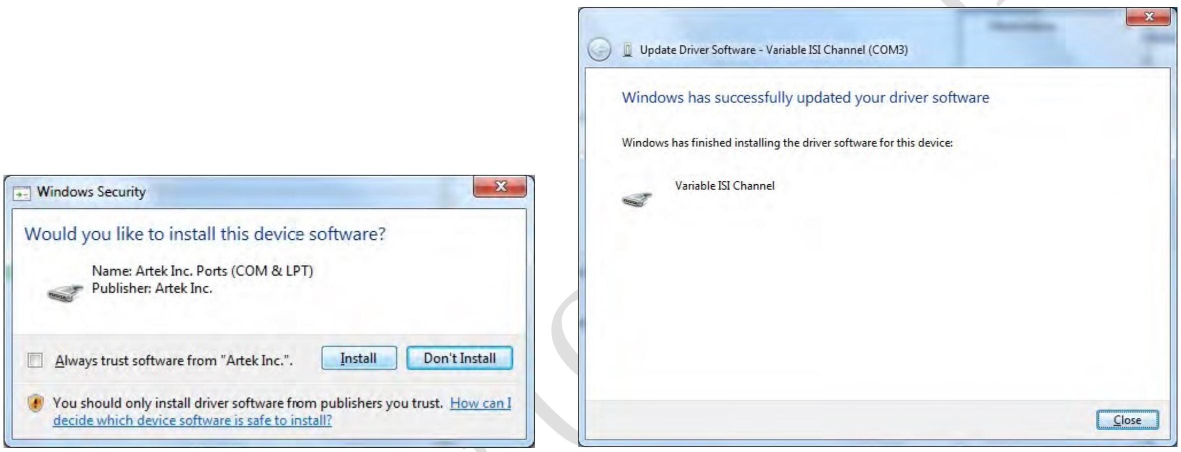


FIGURE 45. WINDOWS SECURITY WINDOW AND CONFIRMATION WINDOW

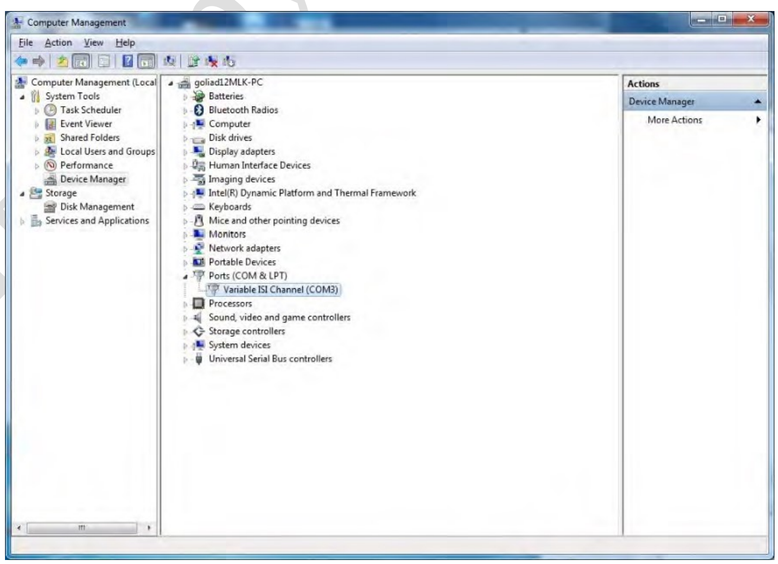


FIGURE 46. DEVICE MANAGER WINDOW AFTER INSTALLATION

The CLE1000 is now ready to be used remotely with the GRL automation software.

14.2 CLE1000 User Interface (UI) Installation

It may also be useful to install the CLE1000 UI, so that the ISI channel can also be controlled manually from the computer. To install the UI, follow these steps:

1. In the CLE1000 Software folder, select and install the Setup.exe file. Upon successful installation, the following UI window will appear.
2. Close this window if manual control is not required.

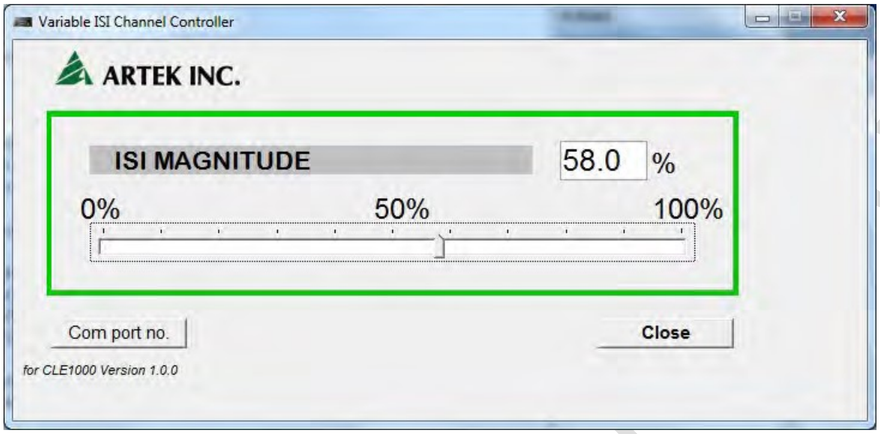


FIGURE 47. CLE1000 UI

15 Appendix E: SPL-3 Test Pattern Requirements

Table 228 — TWO_DWORDS phy test pattern examples

PHY TEST PATTERN DWORDS CONTROL field	PHY TEST PATTERN DWORDS field	Description
00h	4A4A4A4A 4A4A4A4Ah	D10.2 characters (see table 49 in 5.3.6). This pattern contains 01b repeating and has the highest possible frequency. This pattern may be used for measuring intra-pair skew, rise time, fall time, and RJ (see SAS-3).
00h	B5B5B5B5 B5B5B5B5h	D21.5 characters (see table 49 in 5.3.6). This pattern contains 10b repeating and has the highest possible frequency. This pattern may be used for measuring intra-pair skew, rise time, fall time, and RJ (see SAS-3).
00h	78787878 78787878h	D24.3 characters (see table 49 in 5.3.6). This pattern contains 0011b or 1100b repeating (depending on starting disparity) and has half the highest possible frequency. This pattern may be used for calibrating the JTF, calibrating the reference transmitter test load, and measuring transmitter device S-parameters (see SAS-3).
00h	D926D926 D926D926h	Pairs of D25.6 and D6.1 characters (see table 49 in 5.3.6). This pattern contains 1001b repeating and has half the highest possible frequency.
00h	7E7E7E7E 7E7E7E7Eh	D30.3 characters (see table 49 in 5.3.6). This pattern contains four bits of one polarity, three bits of the other polarity, and three bits of the first polarity (e.g., 1111000111b), followed by the inverse (e.g., 0000111000b). This pattern may be used for measuring transmitter equalization and SSC-induced jitter (see SAS-3).
88h	BC4A4A7B BC4A4A7Bh	ALIGN (0) primitives (see table 98 in 6.2.3). This pattern appears during OOB bursts (SAS-3), the SATA speed negotiation sequence (see 5.10.2.2), and the SAS speed negotiation sequence (see 5.10.4.2).
88h	BC070707 BC070707h	ALIGN (1) primitives (see table 98 in 6.2.3). This pattern appears during the SAS speed negotiation sequences (see 5.10.4.2).
80h	BC4A4A7B 4A787E7Eh	Pairs of an ALIGN (0) (see table 98 in 6.2.3) and a dword containing D10.2, D24.3, D30.3, and D30.3 characters (see table 49 in 5.3.6).

A.2 Compliant jitter tolerance pattern (CJTPAT)

The compliant jitter tolerance pattern (CJTPAT) is the JTPAT for RD+ and RD- (see table A.1) included as the payload in an SSP DATA frame or an SMP frame. The CJTPAT is:

1) SOF;
2) six data dwords containing either:
   A) an SSP DATA frame header; or
   B) an SMP frame header followed by 23 vendor specific bytes;
3) 112 data dwords containing JTPAT for RD+ and RD-;
4) one data dword containing a CRC value; and
5) EOF.

Deletable primitives may be included in the transmission of the CJTPAT, but the number of deletable primitives transmitted should be as small as possible so that the percentage of the transfer that is the JTPAT is as high as possible.

END_OF_DOCUMENT