Granite River Labs SAS-3 & SAS-4 (12 Gbit/s) Specification Receiver Physical Layer User Guide & Method of Implementation (MOI)

Using

Tektronix BSA/BSX Series BERTScope, DPO/MSO Series High Performance Oscilloscope, DPP125 Model Digital Pre-Emphasis Processor and CR125 Model Clock Recovery Unit, and Artek CLE1000-A2 Variable ISI Generator

with

GRL-SAS3-RX & GRL-SAS4-RX-BSX Calibration and Test Automation Software

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Version	Date	Description of Changes	Author(s)
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1.1	11/2017	Document Revision with Software Updates	Ong Gaik Pheng (GRL) gpong@graniteriverlabs.com
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1 Introduction

The GRL-SAS3-RX and GRL-SAS4-RX-BSX test solutions provide automation control for performing SAS-3 and SAS-4 (12 Gb/s) receiver device calibration and compliance tests to evaluate the SAS physical layer functionality for conformance to the Specifications Standard at 12 Gb/s data rate. The GRL-SAS3-RX and GRL-SAS4-RX-BSX software follow 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 mainly describes how to set up the GRL SAS 12G Rx software to automate both the Tektronix BERTScope and real-time oscilloscope to calibrate the stressed eye opening and test receiver conformance to SAS-3 or SAS-4 (12 Gb/s) specs. The Tektronix BSX BERTScope is used for SAS-4 (12 Gb/s) testing while the Tektronix BSA BERTScope is used for SAS-3 (12 Gb/s), along with the Tektronix DPO/MSO high performance series oscilloscope, DPP125 model digital pre-emphasis processor and CR125 model clock recovery unit. The Artek CLE1000-A2 ISI generator is used as the variable ISI source to enable calibration to be performed with minimum reconfiguration of the setup, which allows measurements to be more fully automated.

The GRL SAS 12G Rx software automates link training and BER validation for Rx DUT compliance testing. The software also provides an optional margin test feature for stressing the receiver to failure at user-defined jitter frequency steps.

GRL-SAS3-RX & GRL-SAS4-RX-BSX can be further customized by the user or GRL Engineering using GRL's full KayaQ™ automation framework license. Contact GRL at support@graniteriverlabs.com or through your Tektronix Account Manager for further details.

Note: The manual methodology (MOI) for calibrating and testing the SAS 12G receiver is provided in Appendix of this document.

2 Reference Documents

[1] SAS-3 Working Draft Standard, Section 5 (sas3r06b 22)
[2] SAS-3 Receiver device compliance proposal (12-244r6)

3 Resource Requirements

3.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS – INSTRUMENTS

Instrument	Qty.	Description	Key Specification Requirement
BERTScope (with Digital Pre-emphasis Processor and Clock Recovery Unit)	1	Tektronix BERTScope BSX/BSA Generator set (for 12 Gb/s): • BSX125/CR125A (SAS-4) (minimum), or • BSA125/DPP125/CR125 (SAS-3) (minimum)	• Option STR for stress generation • Proper test patterns[a] • Digital Pre-emphasis Processor (DPP) provides external clock doubler function to operate at 12G
Real-time Oscilloscope	1	Tektronix DPO/MSO70000DX or 70000SX Series Oscilloscope with DPOJET (Jitter and Eye Analysis) software	• ≥ 16 GHz bandwidth with Windows 7+ OS (for 12 Gb/s) • Option 5XL or higher memory depth • DPOJET setup files[b] • DPOJET SAS Tx Compliance Test Application[c] • Option SAS3[d]
ISI Generator	1	Artek CLE1000-A2	For variable ISI generation[e]
Computer	1	Laptop or desktop PC	For external automation control

[a] BERTScope SAS 12G patterns are distributed with the GRL-SAS3-RX or GRL-SAS4-RX-BSX software and are installed during installation process.

[b] DPOJET setup files are distributed with the GRL-SAS3-RX or GRL-SAS4-RX-BSX software and are installed during installation process.

[c] DPOJET SAS software is required to run SAS 12G Physical Layer Specification measurements including SAS-3 Eye Opening. Works with Option SAS3 from TekExpress SAS Automated Conformance Test Software. Downloadable from www.tek.com/oscilloscope/dpo71254c-software/dpojet-sas-tx-compliance-test-application-dpo-dsa-mso-70000cddxsx-0.

[d] Option SAS3 is required to provide the necessary test scripts for SAS 12G measurements. Included with TekExpress SAS Automated Conformance Test Software and downloadable from www.tek.com.

[e] Refer to Appendix of this document for the Artek CLE1000-A2 driver installation procedure.

TABLE 2. EQUIPMENT REQUIREMENTS – ACCESSORIES

Accessory	Qty.	Description	Key Specification Requirement
SAS Receptacle Test Adapter	1	TF-SAS-TPA-R[a]	>15dB return loss from 50MHz to 6GHz, and insertion loss that meets the Zero-Length Test Load requirements per the Standard
miniSASHD 12G SAS Receptacle	1	TF-SASHD-TPA-R[a]	>15dB return loss from 50MHz to 6GHz, and insertion loss that meets the Zero-Length Test Load requirements per the Standard
Phase-matched Cable Set	1	PMCABLE1M or equivalent	
DC Blocks	1	Picosecond Pulse Labs 5501A or equivalent	Optional (if required by setup)
Pick-off Tees	2	Picosecond Pulse Lab Model 5370-104-14dB	

[a] *Device configuration-dependent.*

3.2 Software Requirements

TABLE 3. SOFTWARE REQUIREMENTS

Software	Description/Source
GRL-SAS3-RX or GRL-SAS4-RX-BSX[a]	Granite River Labs SAS-3 or SAS-4 (12 Gb/s) Receiver Compliance Calibration & Test Automation Software – www.graniteriverlabs.com – *with Node Locked License to single Oscilloscope/PC OS*
TekExpress SAS	Tektronix SAS Automated Conformance Test Software – www.tek.com **Required to be installed on Tektronix Windows-based instruments/scopes to run measurements for SAS hosts and devices.* **Includes Option SAS3 with SAS3_EYEOPENING test integration used for measuring ISI channel and crosstalk effects and relative vertical eye opening after reference equalization.*
DPOJET SAS	Tektronix DPOJET SAS Tx Compliance Test Application for DPO/DSA/MSO 70000C/D/DX/SX (Windows 7 or 10) Oscilloscopes – www.tek.com/oscilloscope/dpo71254c-software/dpojet-sas-tx-compliance-test-application-dpo-dsa-mso-70000cddxsx-0
VISA (Virtual Instrument Software Architecture) API Software	VISA Software is required to be installed on the host PC running GRL-SAS4-RX-BSX 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)

[a] *GRL-SAS3-RX is used with the Tektronix BSA Model BERTScope while GRL-SAS4-RX-BSX is used with the Tektronix BSX Model BERTScope to perform testing for SAS-3 & SAS-4 at 12 Gb/s.*

3.3 Extended Customization

GRL-SAS3-RX & GRL-SAS4-RX-BSX can be further customized by the user or GRL Engineering using GRL's full KayaQ™ automation framework license. Contact GRL at support@graniteriverlabs.com or through your Tektronix Account Manager for further details.

4 GRL SAS 12G Rx Automation Software Setup

4.1 Setup

This section provides procedures for installing, configuring and verifying the operation of the GRL SAS 12G Rx Automation Test solution. It also helps you familiarize yourself with the basic operation of the application.

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

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

4.1.1 Download GRL SAS 12G Rx Software

Download and install the GRL SAS 12G Rx software on a PC or an oscilloscope (where GRL SAS 12G Rx 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 SAS 12G Rx is to be used (see Section 3.2).
2. Download the **SASRxTestVX.XX.XX.zip** package from the Granite River Labs support site.
3. The ZIP file contains:

   a) **SASRxPatternFilesInstallation00xxxxxxxSetup.exe –** Run this on the BERTScope to install the SAS 12G test pattern setup files. This will place the SAS Configuration and Pattern files on the BERTScope in the *'D:\'* directory hierarchy.

   b) **SASRxTestApplication00xxxxxxxSetup.exe** – Run this on the Controller PC or Scope to install the GRL SAS 12G Rx application. This application will create the *'C:\GRL\Rx Test Solution\Applications\SASRxTest'* directory hierarchy.

   c) **SASRxTestScopeSetupFilesInstallation00xxxxxxxx.exe** – Run this on the Scope to install the DPOJET setup files. This will place the SAS Setup and SAS Filter folders in the *'C:\TekApplications\DPOJET'* directory hierarchy.

4.1.2 Launch and Set Up GRL SAS 12G Rx Software

4.1.2.1 On the BERTScope

1. Select **View** > **System** > **Tools Tab.**
2. Under **Utilities** Column, select the **Remote** button.
3. In Remote Client window, select **TCP/IP**.
4. Change **Terminator** to "**LF**". Select the **Connect** Button.

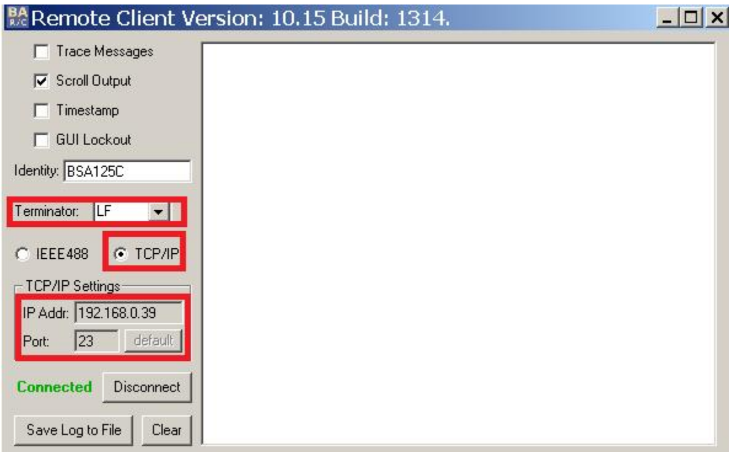


FIGURE 1. REMOTE CLIENT WINDOW

Note: If you see an error pop-up when selecting the Connect button, try a different Port. For example, change Port 23 to 21.

5. Note the IP Address and Port # on Remote Client. They will be needed to connect the BERTScope to the GRL automation software.
6. Minimize, but do not close, the *Remote Client* window.

4.1.2.2 On the PC Used for GRL Framework Installation

1. Navigate to Start Menu > All Programs > GRL > GRL Automated Test Solutions.

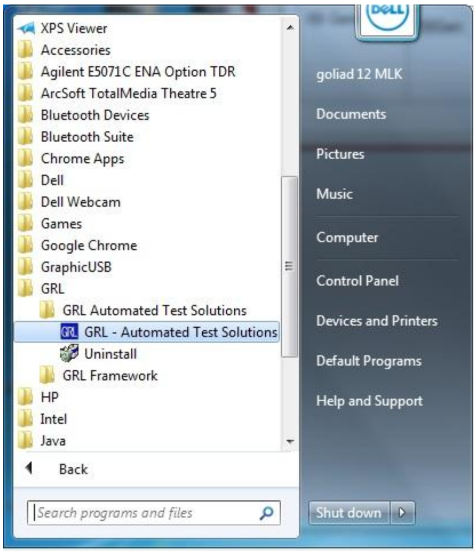


FIGURE 2. GRL AUTOMATED TEST SOLUTIONS IN START MENU

2. Click Application > Rx Test Solution > SAS 12G Rx Test to open the application.

FIGURE 3. RX TEST SOLUTIONS IN GRL AUTOMATED TEST SOLUTIONS WINDOW

3. To enable license, go to License > License Details. The following dialog will pop up.

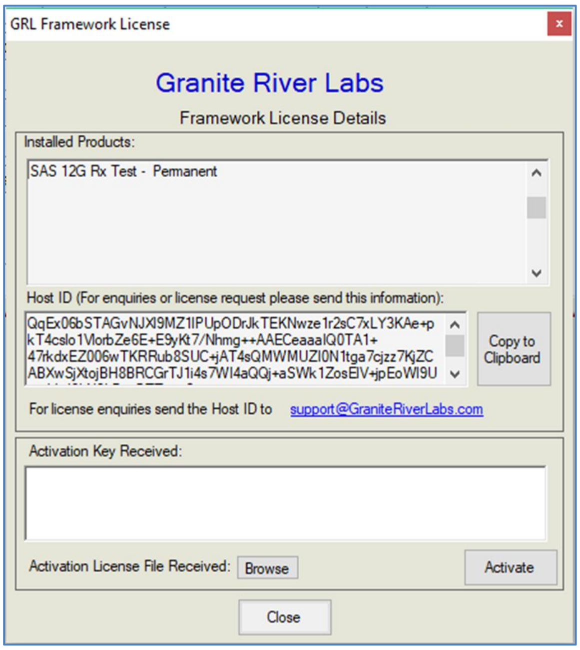


FIGURE 4. LICENSE DETAILS WINDOW

4. Activate License:

   a) If you have an Activation Key, please enter in the box provided and press **Activate**.
   b) If you do not have an Activation Key, press **Close** to use the SW for 10 Days free of charge.

   Note: Once the 10-day trial times out, you will need to request an activation key for future usage on the same computer or oscilloscope. The demo SW 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 a License key by contacting support@graniteriverlabs.com.

5. Click on Equipment Setup icon  on the GRL Framework.
6. Enter the BERTScope IP address and Port number to match what is in the BERTScope *Remote Client* window shown in Section 4.1.2.1.
7. Enter the oscilloscope IP/GPIB Address. If the GRL software is installed on the 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, enter the Scope IP address, for example "TCPIP0::192.168.0.110::inst0::INSTR". Note to ***omit*** the Port number from the address.

   (Note: The Scope IP address can be obtained, if not known, by typing CMD → IPCONFIG on the Scope and observe the IP address listed.)

8. Enter the Controller Serial (COM) address of the Artek CLE1000-A2 ISI Generator connected over USB. (*Note: Refer to Appendix of this document on how to install the CLE1000-A2*).

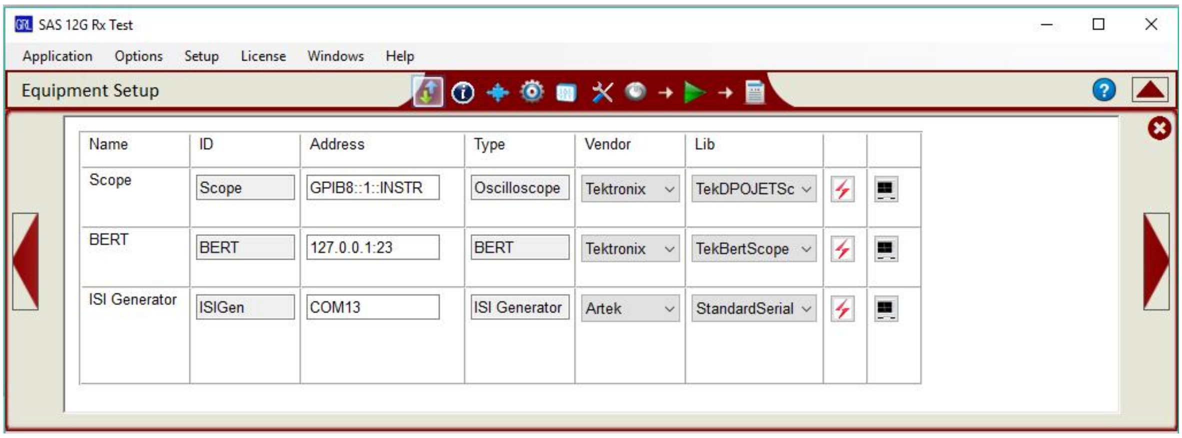


FIGURE 5. EQUIPMENT SETUP WINDOW – VIEW #1

9. Check the connection for each instrument by clicking the "lightning" button. The "lightning" button should turn green if the connection has been verified.

FIGURE 6. EQUIPMENT SETUP WINDOW – VIEW #2

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

4.2 Configuring the Software Before Calibration and Testing

4.2.1 Session Info

The information provided will be included in the report.

The **DUT Info** and **Test Info** are input by the user.

The **Software Info** is automatically populated.

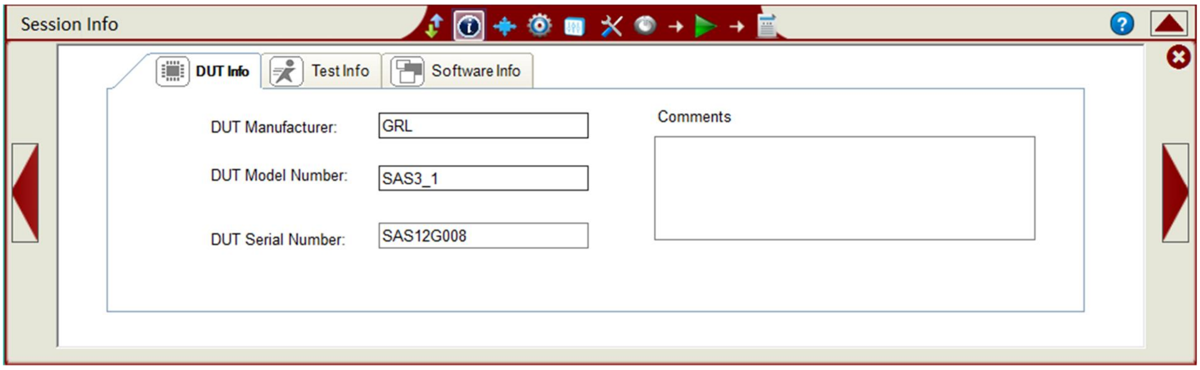


FIGURE 7. SESSION INFO

4.2.2 Conditions for Testing and Calibration

Select  from the menu to access the **Conditions** page to set the conditions for calibration and testing.

When calibrating, the application will calibrate the selected SSC Capabilities and SJ Test Frequencies. The Reference Presets will only be used during testing. The application will perform testing using the selected Reference Presets, SSC Capabilities and SJ Test Frequencies.

Recommended procedure:

- *Step 1*: When calibrating, select all conditions that may be used for future testing, and perform the desired calibration tests.
- *Step 2*: When ready for testing, re-select the desired test conditions. For example, if required to test only one SSC Capability at two frequencies for Reference Preset 1, then select the appropriate conditions for testing.

a) **Preset tab**: Select the desired Reference Presets for testing. For calibration, the application will produce a calibration curve based on a set of predefined Preset values.

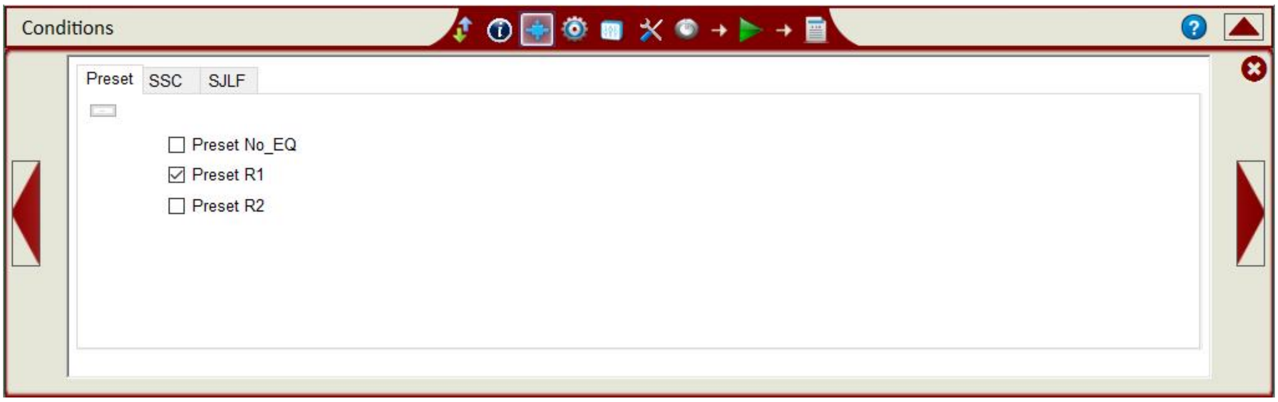


FIGURE 8. SELECT REFERENCE PRESETS

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

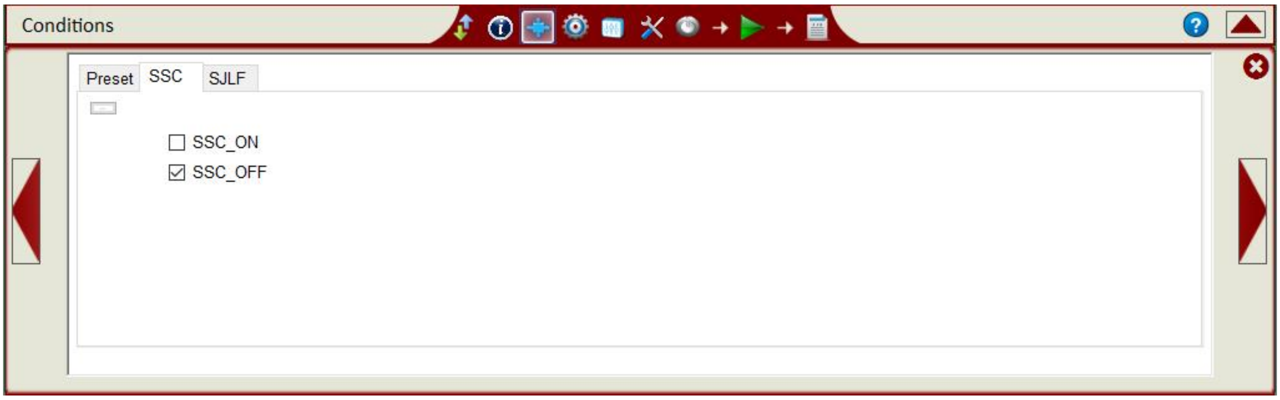


FIGURE 9. SELECT SSC CONDITIONS

c) **SJLF tab**: Select the SJ frequencies for testing or calibration. 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.

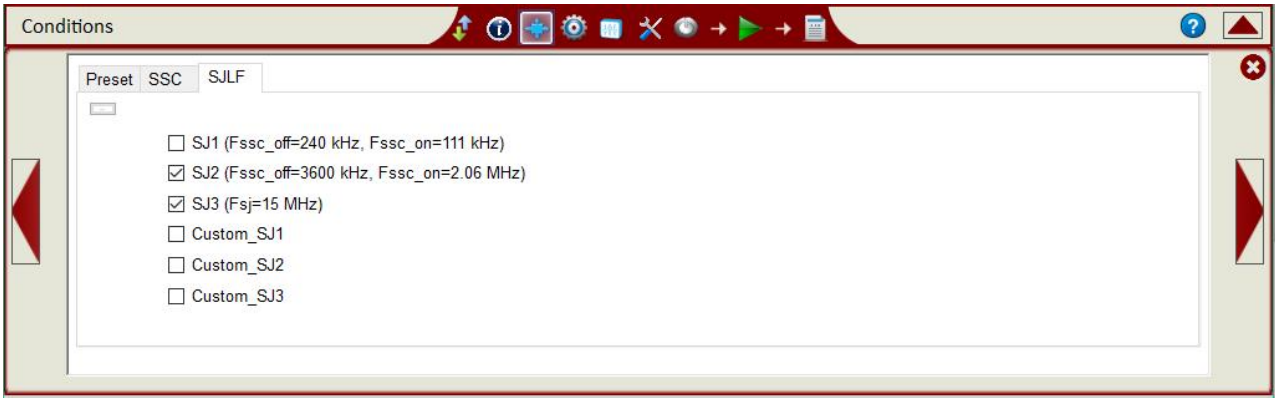


FIGURE 10. SELECT SJ FREQUENCIES

4.2.3 Setup Configuration for Testing

Use the Setup Configuration page to configure the necessary test-related settings prior to running tests.

4.2.3.1 ISI Generator tab

Select the ISI Generator that is being used. Select 'None' if using a fixed ISI Channel. *The ISI Generator will be used for both calibration and testing.*

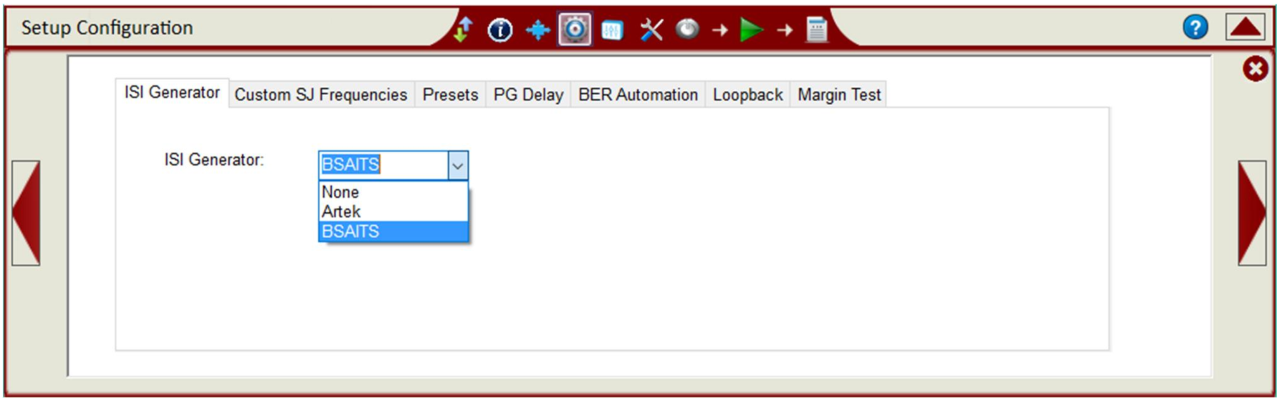


FIGURE 11. SELECT ISI GENERATOR

4.2.3.2 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.*

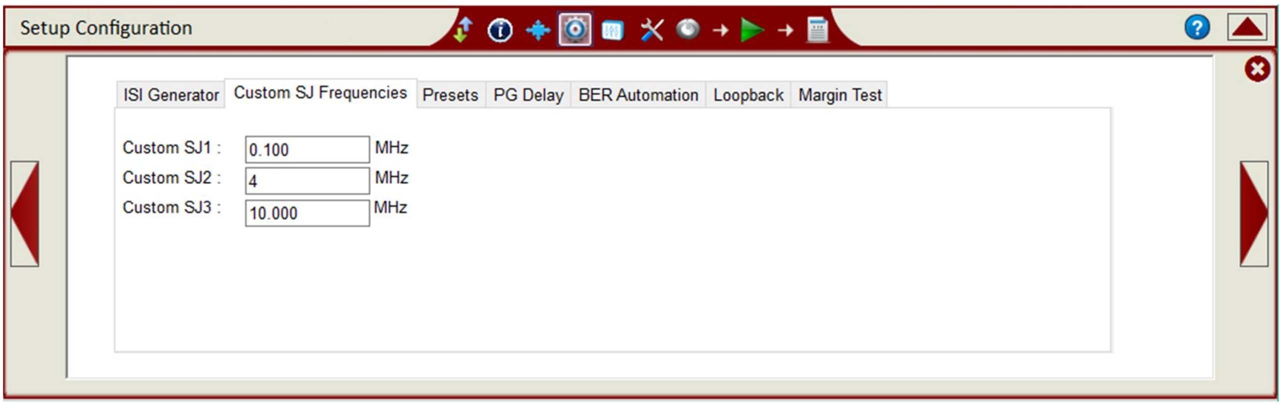


FIGURE 12. CONFIGURE CUSTOM SJ FREQUENCIES

4.2.3.3 Presets tab

Set up the Reference Presets for the selected 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.
- **Optimized Search** mode: This mode ignores any existing user configuration, and requires an additional *Rx Link Optimized Preset Search* test to be performed for the preset values to be determined.

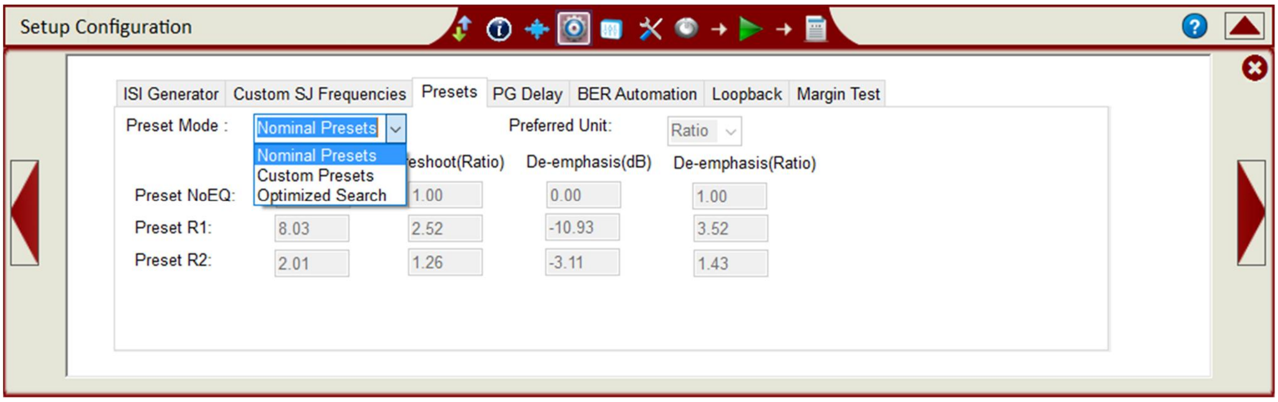


FIGURE 13. CONFIGURE REFERENCE PRESETS

4.2.3.4 PG Delay tab

Select the 'Overwrite PG Delay' option to configure the PG Delay value. If unsure of the value to set, un-select the option and perform the PG Delay calibration. Also select the pattern to use for the PG Delay calibration.

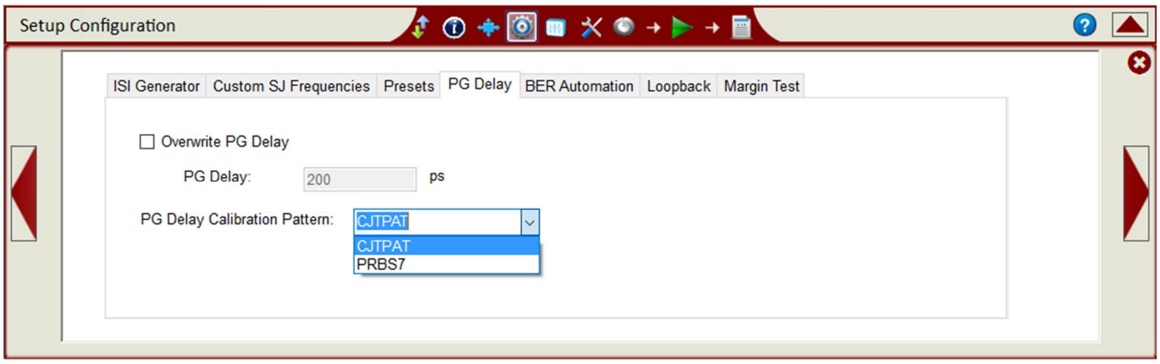


FIGURE 14. CONFIGURE PG DELAY

4.2.3.5 BER Automation tab

Select the method to enable BER Automation.

- **Forced Loopback** method: Select this method if using a proprietary software tool to control the DUT. For this, an appropriate loopback method must be selected under the Loopback tab. The BERTScope will then apply the required stress and run BER tests using its built-in Error Detector. This method requires very little user input.
- **Manual** method: Select this method if the DUT does not support any loopback mode but has a built-in error detector to measure BER. The application will prompt the user to run BER tests manually and report the errors detected which will be saved in the results.
- **Local Script** method: Select this method if using an external *.exe script to force the DUT in the loopback mode and perform BER testing. This requires the user to specify the path for the script file which the application will call when it is ready to test the loopback BER.
- **Remote Script** method: This method is similar to Local Script where it also uses an external *.exe script to control the DUT loopback and BER measurement. Unlike the Local script, this Remote script resides on a remote (separate) PC, and thus requires the user to specify the IP address and port number for the script to be called by the application.

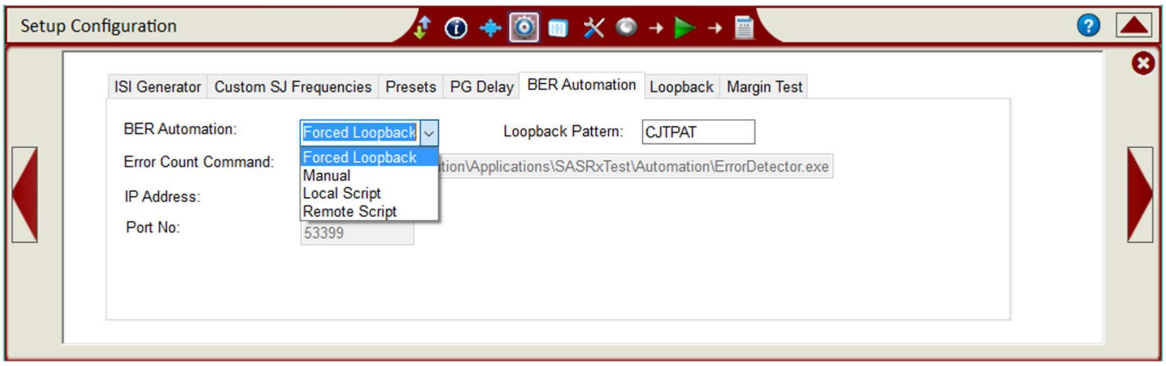


FIGURE 15. CONFIGURE BER AUTOMATION METHOD

4.2.3.6 Loopback tab

Select the method to enable DUT loopback if the Forced Loopback method is selected under the BER Automation tab.

- **None** method: Select this method to place the DUT in the continuous loopback mode. The application will assume that the DUT is in loopback, and will continue to test BER without any prompts.
- **Prompt User** method: Select this method to manually enable DUT loopback at every single time. This is recommended if the loopback method for the DUT is not known or there is a physical method that cannot be automated.
- **Local Script** method: This method is similar to Local Script for the BER Automation, but here the script will be called to force the DUT into loopback instead of testing BER.
- **Remote Script** method: Similar to Local Script, this method will also use an external script to force the DUT into loopback, just that the script is located on a remote terminal.

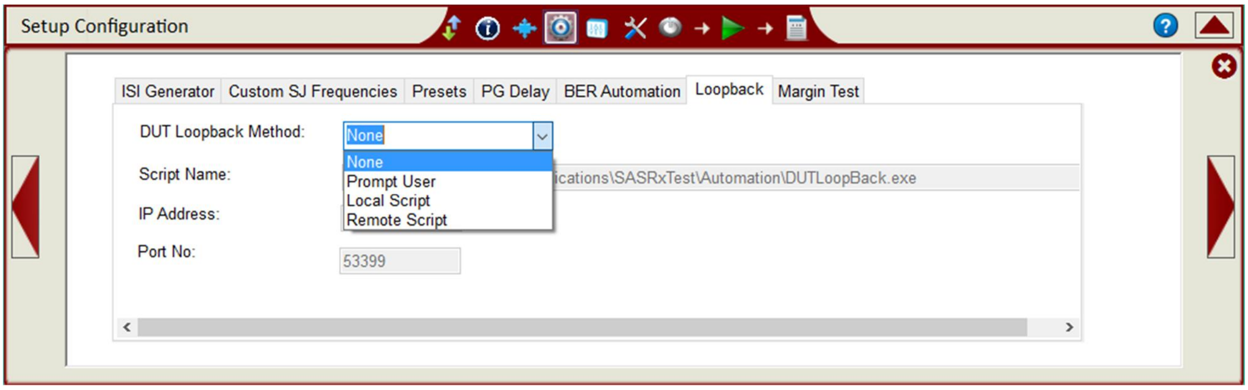


FIGURE 16. CONFIGURE DUT LOOPBACK METHOD

4.2.3.7 Margin Test

Define the target BER and Confidence level to achieve when testing for compliance. If running the optional 'Compliance + Margin' and 'Margin Search' tests, specify the Step Size and Maximum Steps for stepping through margins.

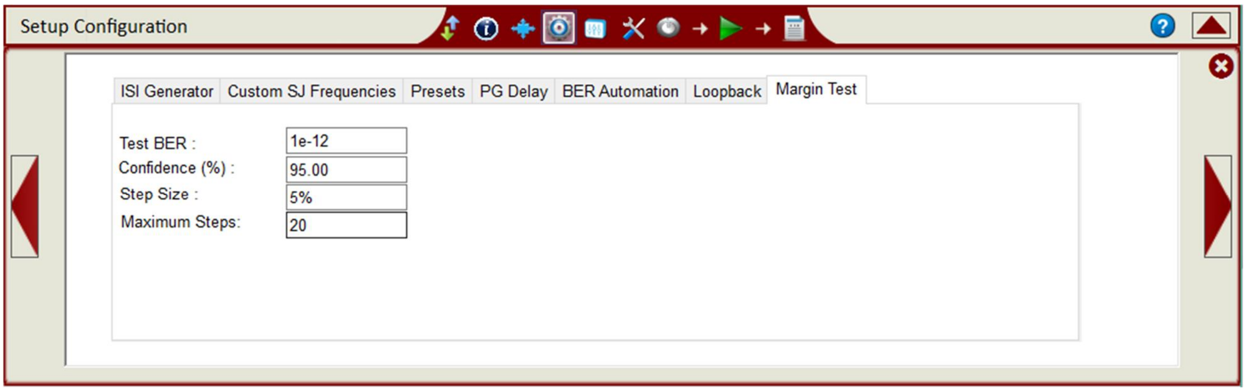
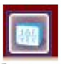


FIGURE 17. CONFIGURE TEST PARAMETERS

4.3 Calibration/Test Selection Page

Select the  button in the main software menu to choose the calibration or tests to be performed on the **Select Tests** page. 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 show an error message.

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. The application supports automated control of the Artek CLE1000-A2 variable ISI generator.

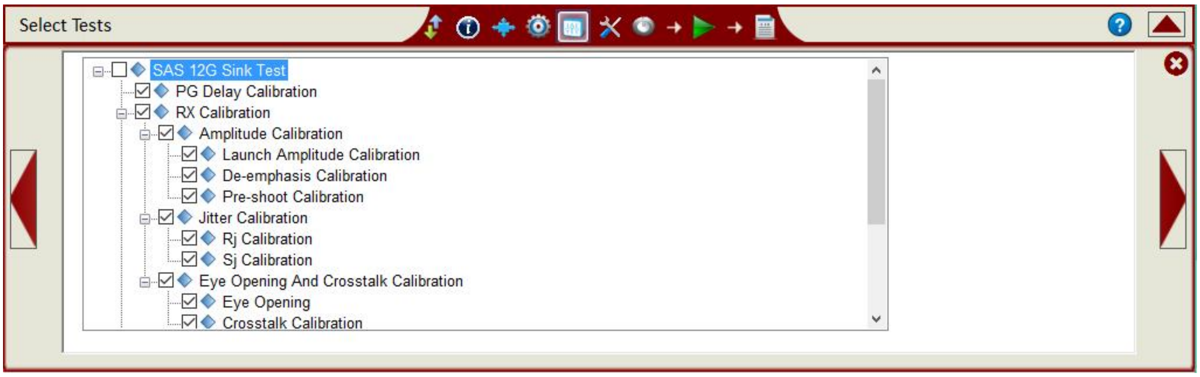


FIGURE 18. CALIBRATION SELECTION

Select the calibration groups to perform calibration for all SAS 12G Rx parameters. Note that while user can select individual calibration parameters, it is possible that a particular calibration may require the previous calibration to be completed before it can proceed. Thus it is advisable to complete all previous calibration before going on to the next calibration.

TABLE 4. CALIBRATION DESCRIPTION

Calibration Name	Description
PG Delay	Calibrate the delay between the Clock and Data outputs of the BERTScope Pattern Generator connected to the inputs of the DPP-C, *every time when changing the cables*. If the PG Delay value is known, this calibration can be skipped, and the value should be entered in the Setup Configuration page as described earlier. *(Note: PG Delay calibration will not be available for selection if using the Tektronix BSX BERTScope, which does not require an external DPP-C.)*
Launch Amplitude	Calibrate the launch amplitudes 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 DPP-C 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.

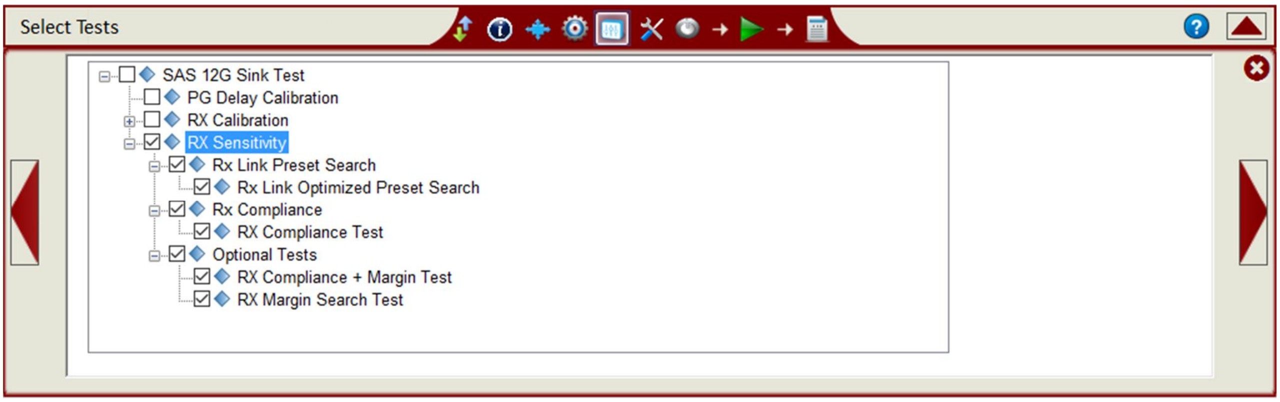


FIGURE 19. TESTS SELECTION

Select the test groups to perform compliance tests for all SAS 12G Rx parameters. Note that user may be prompted for connection changes during testing.

TABLE 5. TEST DESCRIPTION

Test Name	Description
Rx Link Optimized Preset Search	This test permutates through different pre-shoot and de-emphasis settings within specification tolerances to find the optimized preset setting to be used for Rx Compliance and Margin Tests. This test will only be performed if the Preset Mode *(from the Setup Configuration page)* is set to ‘Optimized Search’.
Rx Compliance	This is a compliance test for receiver jitter tolerance which measures jitter response at the calibrated levels mentioned in the specification.
Rx Compliance + Margin	This test is similar to the Rx Compliance test, but measures the jitter tolerance of the DUT at one step above the calibrated levels mentioned in the specification. The step value comes from the step size specified in the Setup Configuration page. The margin is the percentage value of the calibrated value.
Rx Margin Search	This is a jitter search test which measures the maximum SJ value that the DUT can handle at the chosen BER. The step size is the percentage value of the currently applied SJ.

4.4 Calibration/Receiver Test Parameters Configuration Page

Click the Configuration button  in the main software menu to access the Parameters Configuration page. Set any of the available parameters required for SAS 12G Rx calibration and testing as described below.

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

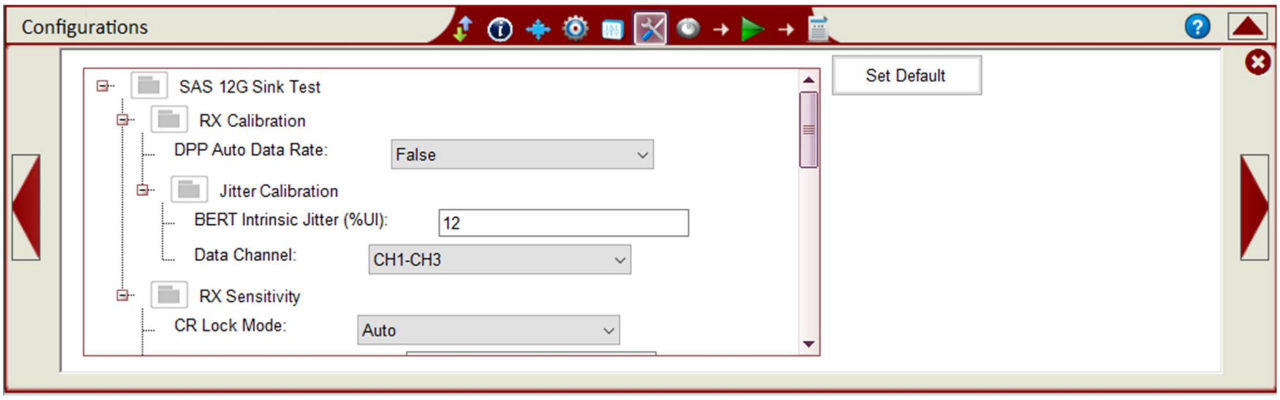


FIGURE 20. PARAMETERS CONFIGURATION PAGE

TABLE 6. CALIBRATION/TEST PARAMETERS DESCRIPTION

Parameter Name	Description
DPP Auto Data Rate	If using the BSA BERTScope, select to enable or disable de-emphasis with data rate automation on the DPP.
BERT Intrinsic Jitter	Set the intrinsic jitter value in %UI to be used for jitter calibration.
Data Channel	Select the channel pair to be connected for data input during calibration.
CR Lock Mode	Select the Auto or Manual lock mode for the clock recovery unit in loopback testing
CR Phase Error Limit	Set the limit for phase error on the clock recovery unit.
Edge Density	Set the edge density value.
Use Clock Recovery Unit	Select to enable or disable clock recovery for loopback mode.
Preset Search Steps	Set the number of steps to find the optimized preset setting to be used for Rx Compliance and Margin Tests. This setting is applicable when the Preset Mode (*from the Setup Configuration page*) is set to 'Optimized Search'.
Preset Search SJ/Frequency	Set the SJ amplitude (%UI) and frequency for the optimized preset search to be used for testing.
Always Default BERT	Select to always enable or disable default configuration on the BERTScope during testing.

Skip Calibrate Detector Delay	Select whether or not to skip the calibration for delay between the clock and data inputs of the error detector during cable change.
Prompt Before CJTPAT Pattern	Select whether or not to receive a software prompt prior to transmitting CJTPAT signaling for BER loopback testing.
Overwrite Detector Delay	Select whether or not to overwrite the delay between the clock and data inputs of the error detector during cable change.
Detector Delay	Set the delay value in ps for the error detector.
SJ Loop Bandwidth	Set the loop bandwidth in Hz for the 3 distinct SJ frequencies to be used in the jitter tolerance configuration.
Symbol Filtering	Select whether or not to enable automatic removal of symbols (symbol filtering) for retimed loopback during BER measurements.

4.5 Calibration Target Configuration Page

If necessary, select from the main menu to change the calibration target value for any of the calibration items. By default, the target values are those defined in the specification. Change the values only when debugging.

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

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

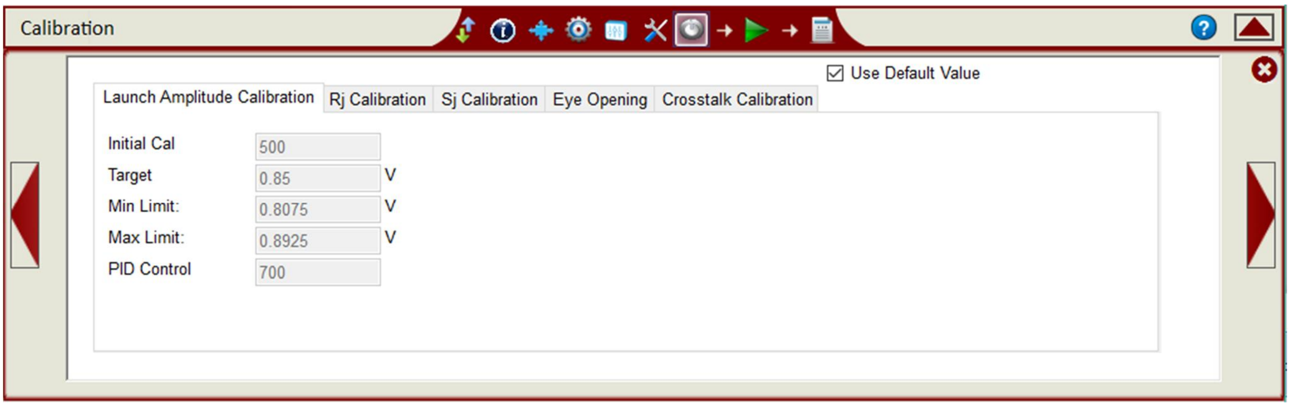


FIGURE 21. CALIBRATION OVERWRITE

4.6 Running the Calibration/Tests

From the pop-up menu, select the Run icon to access the Run Tests page. Select the Run Option before clicking the Run Tests button to start calibration or testing.

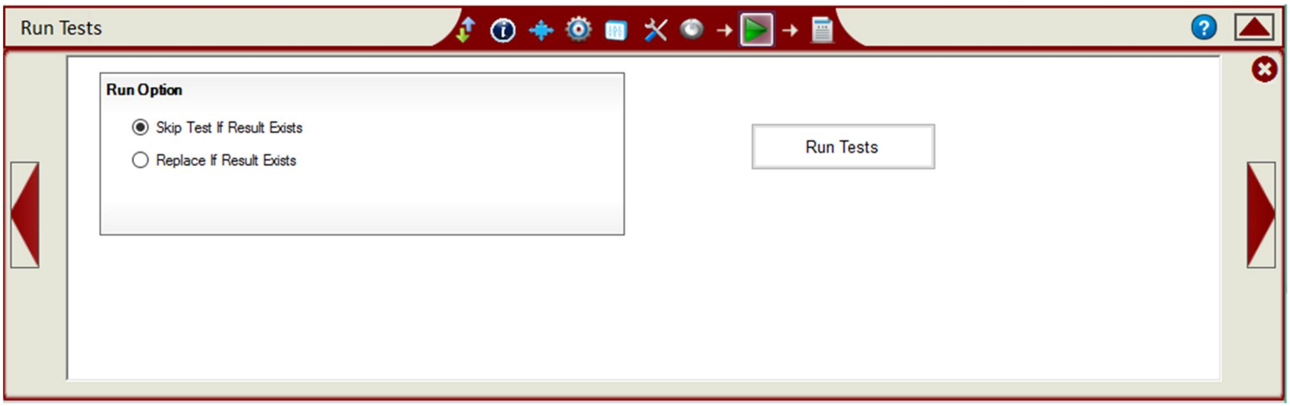


FIGURE 22. RUN TESTS PAGE

TABLE 7. RUN OPTIONS

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

If you need to re-run only certain test on certain conditions, please delete the tests from the Report tab and Run with **Skip Test if Result Exists.** GRL software will keep track of the missing tests in the report and perform those tests only. See figure below.

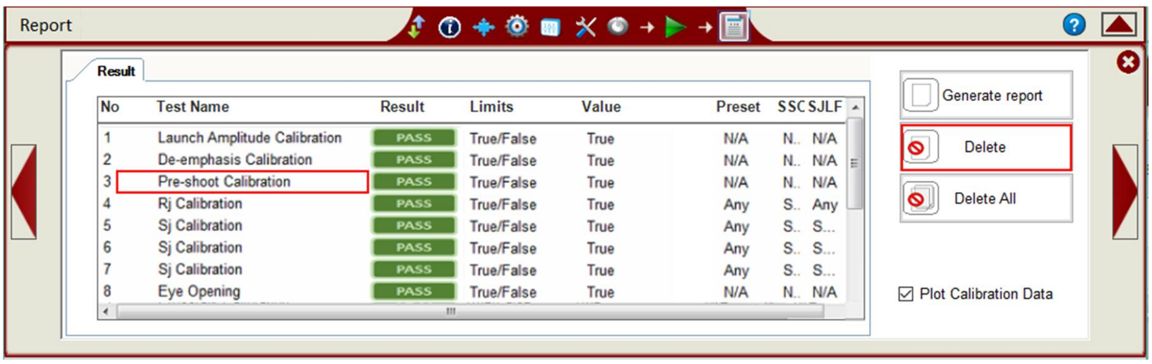


FIGURE 23. DELETE RESULTS

5 Receiver Calibration Setups

The receiver will be calibrated for SAS 12G Signal Amplitude and Jitter as well as Eye Opening and Crosstalk. Calibration will basically be performed at Test Point A and Test Point IR/CR. 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 *SAS3_Eye Opening* software tool (which may be installed on the scope test instrument). This is explained in more details in the manual methodology under Section 9 of this document.

The typical receiver calibration will require the BERTScope and appropriate equipment to provide the necessary jitter, ISI and crosstalk components. A Digital Pre-Emphasis Processor (DPP-C) will be used to perform transmitter equalization (if using the BSA BERTScope), which is required in the link training when calibrating the test pattern. The Artek CLE1000-A2 will be used as the Variable ISI Generator, and the signal will be measured with a real-time Oscilloscope.

Note: The ISI source can be either a Variable ISI Generator or a Fixed Channel. Using a Variable ISI Generator enables calibration to be performed with minimum reconfiguration of the test setup, which allows testing to be more fully automated.

Note: Each time a cable change is required for the BERTScope Pattern Generator outputs, it is advisable to perform PG Delay calibration (if the value is not known), to calibrate the delay between the Clock and Data outputs of the BERTScope Pattern Generator connected to the inputs of the DPP-C.

Note: An external DPP-C is not required if using the Tektronix BSX BERTScope. The BSX BERTScope can be directly connected to the pick-off tees or directional couplers.

5.1 Calibration Connection Setups

5.1.1 Signal Amplitude and Jitter Calibration Setup

The following physical setups can be used to calibrate for signal amplitude and jitter at TP-A.

5.1.1.1 Using Tektronix BSA BERTScope

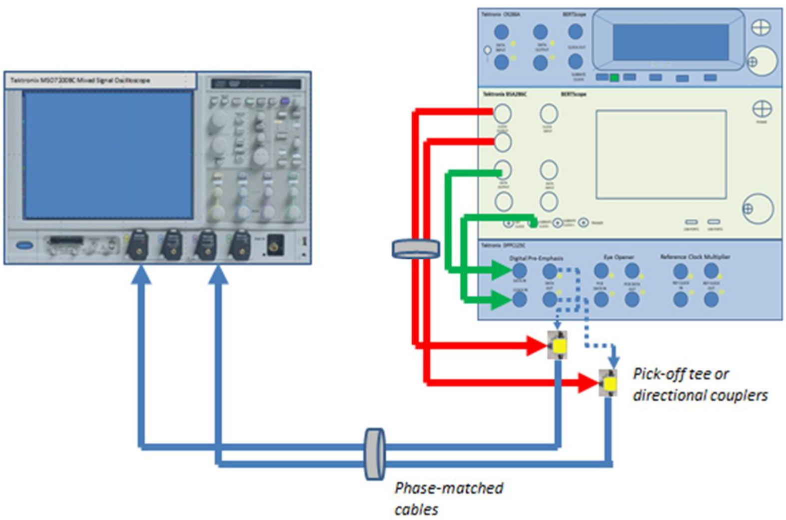


FIGURE 24. SIGNAL AMPLITUDE AND JITTER CALIBRATION SETUP (USING BSA BERTSCOPE)

Connection Steps:

1. Connect DATA OUTPUT(+) of the BERTScope to DATA IN of the DPP-C.
2. Connect Sub-rate Clock Output of the BERTScope to Clock Input of the DPP-C.
3. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports (labeled as 14dB).
4. Connect the pick-off tees inputs to DATA OUT+ and DATA OUT- of the DPP-C respectively.
5. Connect the outputs of pick-off tee 1 and pick-off tee 2 to Channel 1 and Channel 3 of the oscilloscope.

5.1.1.2 Using Tektronix BSX BERTScope

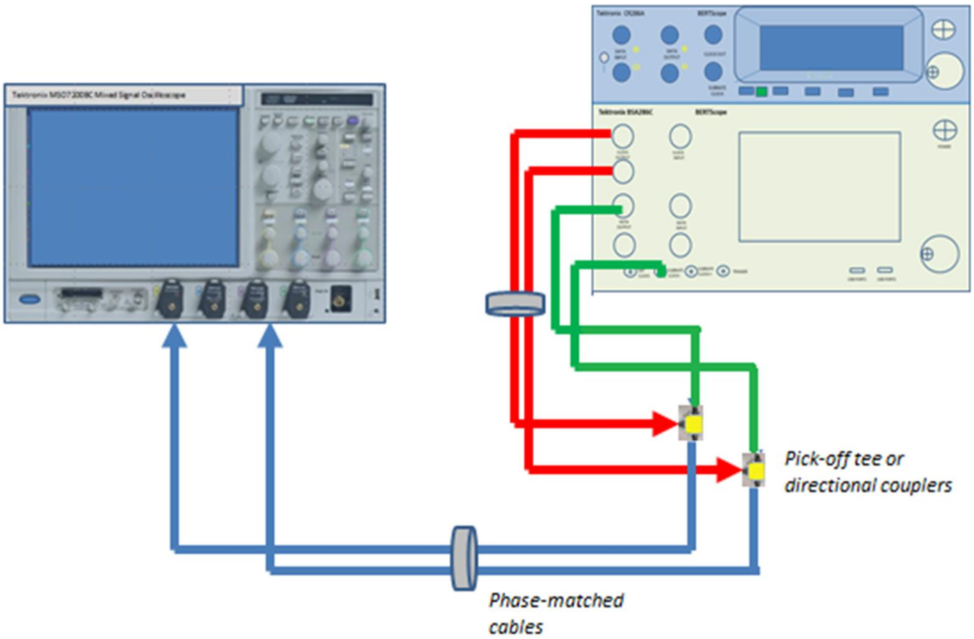


FIGURE 25. SIGNAL AMPLITUDE AND JITTER CALIBRATION SETUP (USING BSX BERTSCOPE)

Connection Steps:

1. Connect DATA OUTPUT(+) of the BERTScope to the input port of pick-off tee 1/pick-off tee 2.
2. Connect Sub-rate Clock Output of the BERTScope to the other input port of pick-off tee 1/pick-off tee 2.
3. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports (labeled as 14dB).
4. Connect the outputs of pick-off tee 1 and pick-off tee 2 to Channel 1 and Channel 3 of the oscilloscope.

5.1.2 Eye Opening and Crosstalk Calibration Setup

The following physical setups can be used to calibrate for eye opening and crosstalk.

5.1.2.1 Using Tektronix BSA BERTScope

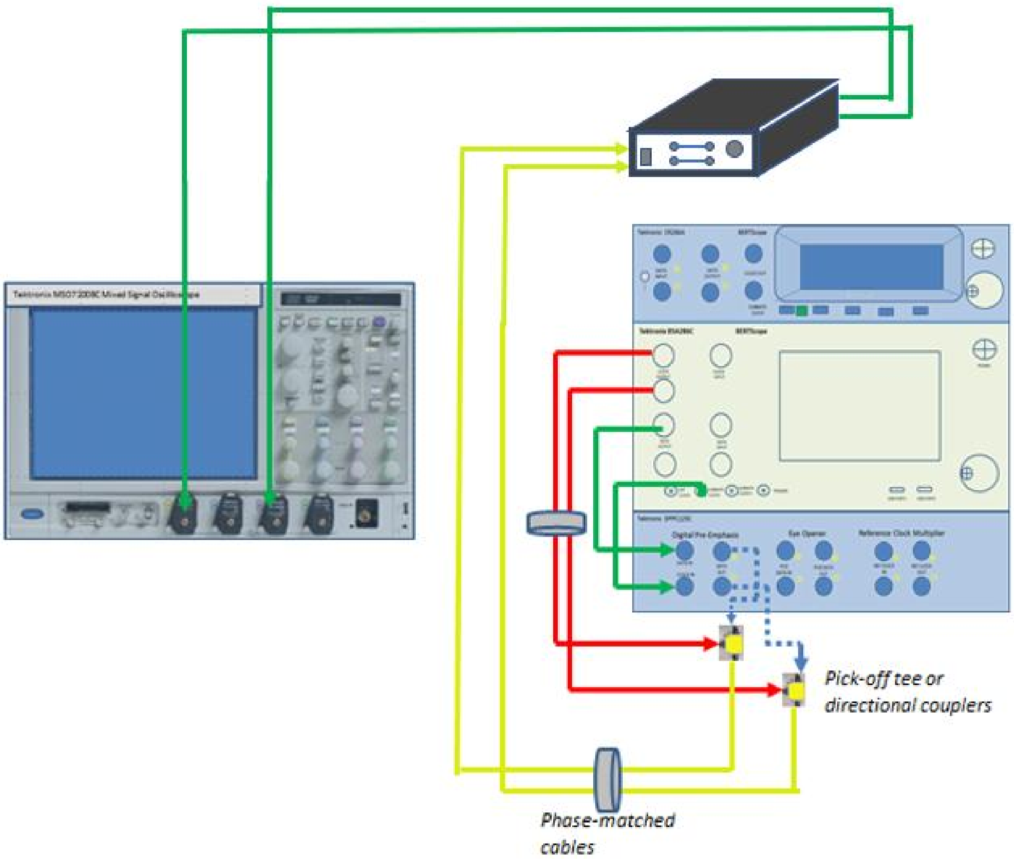


FIGURE 26. EYE OPENING AND CROSSTALK CALIBRATION SETUP (USING BSA BERTSCOPE)

Connection Steps:

1. Connect DATA OUTPUT(+) of the BERTScope to DATA IN of the DPP-C.
2. Connect Sub-rate Clock Output of the BERTScope to Clock Input of the DPP-C.
3. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports (labeled as 14dB).
4. Connect the pick-off tees inputs to DATA OUT+ and DATA OUT- of the DPP-C respectively.
5. Connect the pick-off tees outputs to the inputs of the ISI Generator.
6. Connect the outputs of the ISI Generator to Channels 1 and 3 of the oscilloscope.

5.1.2.2 Using Tektronix BSX BERTScope

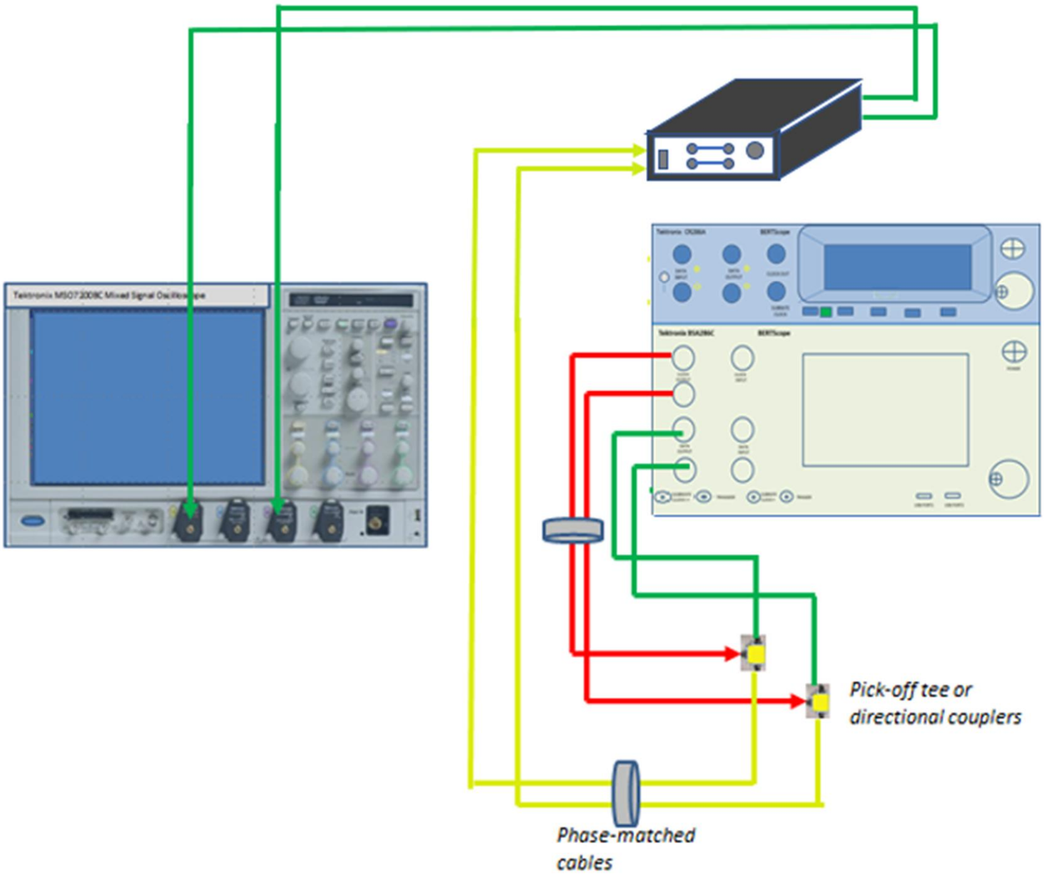


FIGURE 27. EYE OPENING AND CROSSTALK CALIBRATION SETUP (USING BSX BERTSCOPE)

Connection Steps:

1. Connect DATA Outputs of the BERTScope to the pick-off tee 1 and tee 2 input ports.
2. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports (labeled as 14dB).
3. Connect the pick-off tees outputs to the inputs of the ISI Generator.
4. Connect the outputs of the ISI Generator to Channels 1 and 3 of the oscilloscope.

Note: To set up the equipment network connection, connect both the BERTScope and Scope with a LAN cable and then to a Network Switch, on the same network.

6 Receiver Test Setups

After calibration has completed, then testing the Receiver DUT for compliance can be performed.

The typical receiver DUT jitter tolerance test setup will include a clock recovery unit and the BERTScope analyzer/error detector for loopback testing. The DUT shall receive CJTPAT signaling with maximum allowable jitter, noise and signal loss. The loopback pattern will be verified by the BERTScope error detector and shall report a BER of less than 1E-12 with a 95% confidence level for the DUT to be considered as compliant.

Note: An external DPP-C is not required if using the Tektronix BSX BERTScope. The BSX BERTScope can be directly connected to the pick-off tees or directional couplers.

6.1 Test Connection Setups

6.1.1 Jitter Tolerance Compliance Test Setup

The following physical setups can be used to perform the SAS 12G Rx jitter tolerance test.

6.1.1.1 Using Tektronix BSA BERTScope

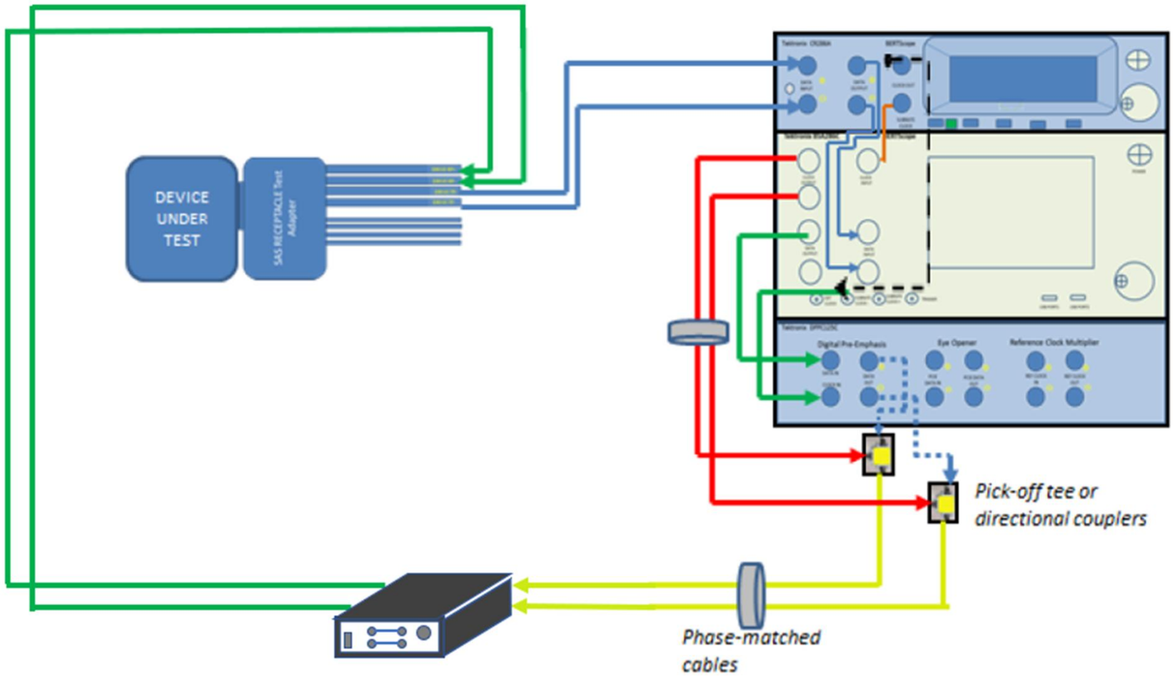


FIGURE 28. COMPLIANCE TEST SETUP FOR RECEIVER DUT JITTER TOLERANCE (USING BSA BERTSCOPE)

Connection Steps:

1. Connect DATA OUTPUT(+) of the BERTScope to DATA IN of the DPP-C.
2. Connect Sub-rate Clock Output of the BERTScope to Clock Input of the DPP-C.
3. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports (labeled as 14dB).
4. Connect the pick-off tees inputs to DATA OUT+ and DATA OUT- of the DPP-C respectively.
5. Connect the pick-off tees outputs to the inputs of the ISI Generator.

6. Connect the outputs of the ISI Generator to Rx+/- of the DUT.
7. Connect Tx+/- of the DUT to Data Input+/- of the clock recovery unit.
8. Connect Data Output+/- of the clock recovery unit to Data Input+/- of the BERTScope Error Detector.
9. Connect the Sub-rate Clock Output of the clock recovery unit to Clock Input of the BERTScope Error Detector.

Note: If using a derived clock, connect the Clock Output of the clock recovery unit to the External Clock Input of the BERTScope.

6.1.1.2 Using Tektronix BSX BERTScope

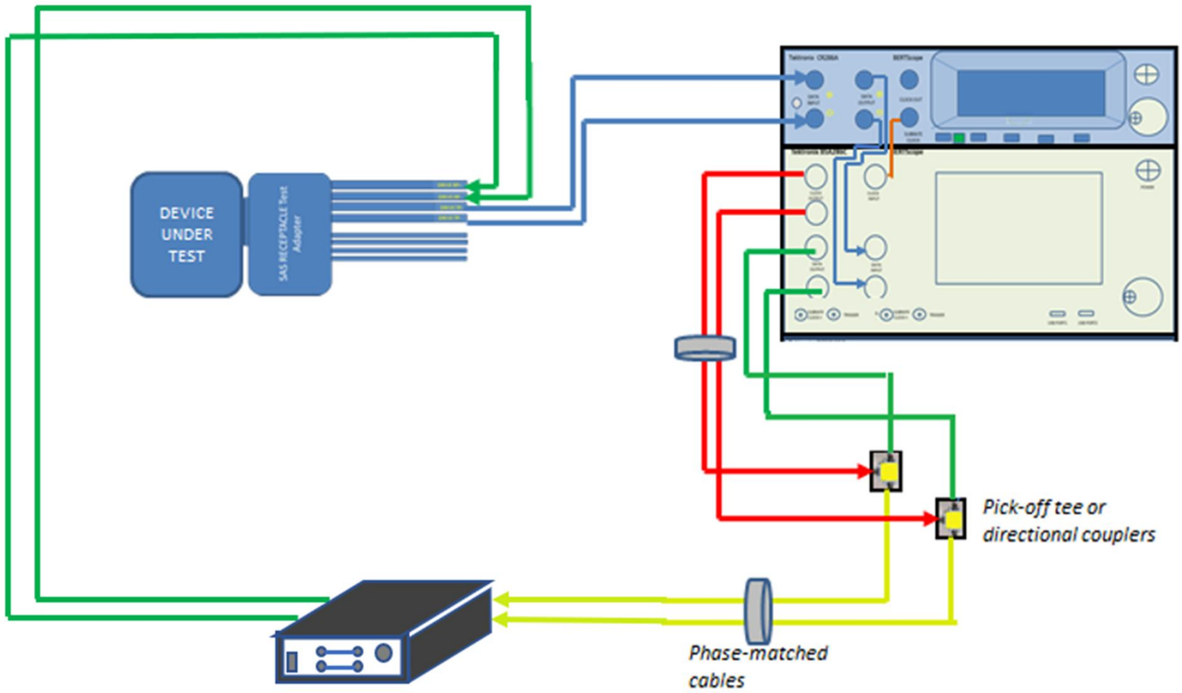


FIGURE 29. COMPLIANCE TEST SETUP FOR RECEIVER DUT JITTER TOLERANCE (USING BSX BERTSCOPE)

Connection Steps:

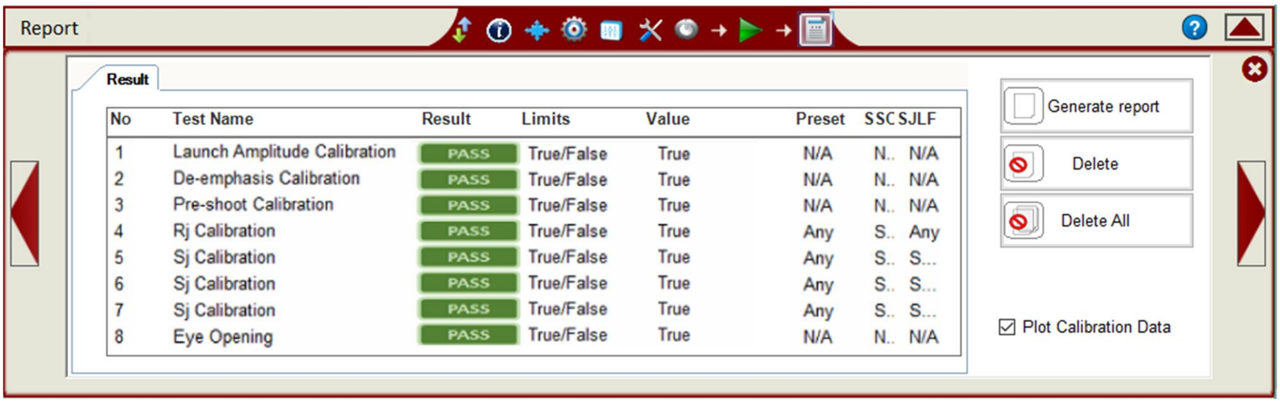
1. Connect DATA Outputs of the BERTScope to the pick-off tee 1 and tee 2 input ports.
2. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports (labeled as 14dB).
3. Connect the pick-off tees outputs to the inputs of the ISI Generator.
4. Connect the outputs of the ISI Generator to RX+/- of the DUT.
5. Connect TX+/- of the DUT to Data Input+/- of the clock recovery unit.
6. Connect Data Output+/- of the clock recovery unit to Data Input+/- of the BERTScope Error Detector.
7. Connect the Sub-rate Clock Output of the clock recovery unit to Clock Input of the BERTScope Error Detector.

7 Test Results and Reports Using GRL SAS 12G Rx Software

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

7.1 Test Report Generation

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

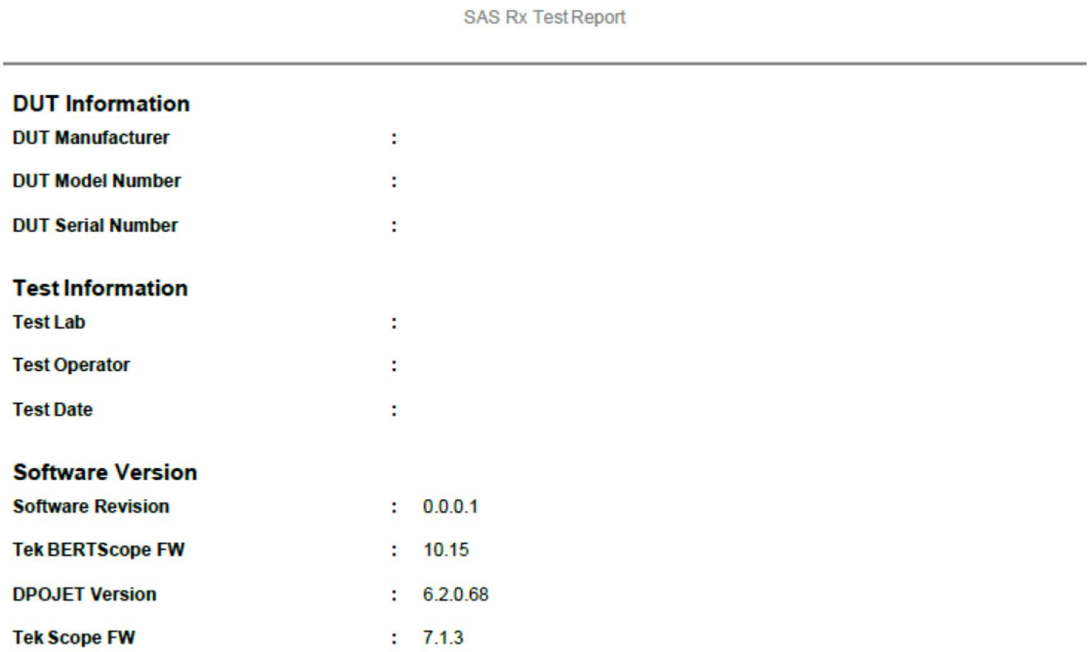


No	Test Name	Result	Limits	Value	Preset	SSC	SJLF
1	Launch Amplitude Calibration	PASS	True/False	True	N/A	N..	N/A
2	De-emphasis Calibration	PASS	True/False	True	N/A	N..	N/A
3	Pre-shoot Calibration	PASS	True/False	True	N/A	N..	N/A
4	Rj Calibration	PASS	True/False	True	Any	S..	Any
5	Sj Calibration	PASS	True/False	True	Any	S..	S...
6	Sj Calibration	PASS	True/False	True	Any	S..	S...
7	Sj Calibration	PASS	True/False	True	Any	S..	S...
8	Eye Opening	PASS	True/False	True	N/A	N..	N/A

FIGURE 30. GENERATE REPORT PAGE

7.1.1 DUT Information

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



SAS Rx Test Report

DUT Information

DUT Manufacturer	:	
DUT Model Number	:	
DUT Serial Number	:	

Test Information

Test Lab	:	
Test Operator	:	
Test Date	:	

Software Version

Software Revision	:	0.0.0.1
Tek BERTScope FW	:	10.15
DPOJET Version	:	6.2.0.68
Tek Scope FW	:	7.1.3

FIGURE 31. DUT INFORMATION

7.1.2 Summary Table

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

No	TestName	Limits	Value	Results	Preset	SSC	SJLF
1	Launch Amplitude Calibration	True/False	True	Pass			
2	De-emphasis Calibration	True/False	True	Pass			
3	Pre-shoot Calibration	True/False	True	Pass			
4	Rj Calibration	True/False	True	Pass	N/A	SSC_ON	N/A
5	Sj Calibration	True/False	True	Pass	N/A	SSC_ON	SJ1
6	Sj Calibration	True/False	True	Pass	N/A	SSC_ON	SJ2
7	Sj Calibration	True/False	True	Pass	N/A	SSC_ON	SJ3
8	Eye Opening	True/False	True	Pass			
9	Crosstalk Calibration	True/False	True	Pass			
10	PG Delay Calibration	True/False	True	Pass			
11	RX Compliance Test	True/False	True	Pass	Preset_R1	SSC_ON	SJ1
12	RX Compliance Test	True/False	False	Fail	Preset_No_EQ	SSC_ON	SJ1
13	RX Compliance Test	True/False	True	Pass	Preset_R2	SSC_ON	SJ1
14	RX Compliance + Margin Test	True/False	True	Pass	Preset_No_EQ	SSC_ON	SJ1
15	RX Margin Search Test	True/False	True	Pass	Preset_No_EQ	SSC_ON	SJ1

FIGURE 32. SUMMARY TABLE

7.1.3 Test Results

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

7.1.3.1 Compliance Test

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

Compliance Test(Preset_No_EQ)

Sj Frequency	SJ1	SJ2	SJ3
SSC_ON	FAIL(203534)	X	X

Compliance Margin Test(Preset_No_EQ)

Sj Frequency	SJ1	SJ2	SJ3
SSC_ON	PASS(0)	X	X

FIGURE 33. COMPLIANCE TEST RESULTS PAGE

7.1.4 Margin Test Plots

This portion is populated from the Margin Search Tests.

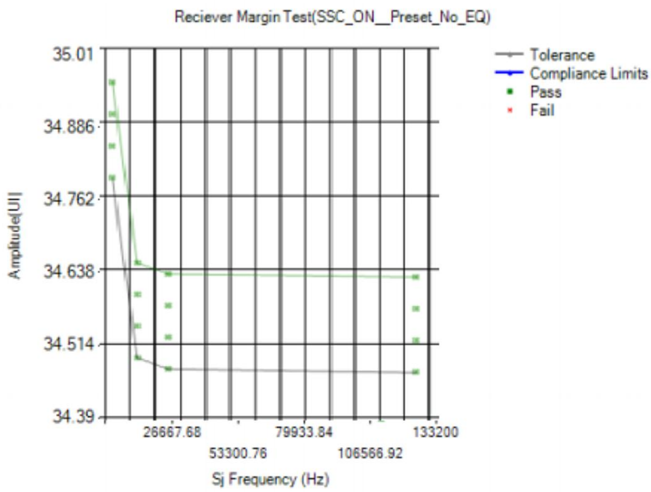


FIGURE 34. MARGIN TEST RESULTS PAGE

7.2 Deleting Test Reports

Click the **Delete** button to delete individual test results or **Delete All** to delete the entire test report.

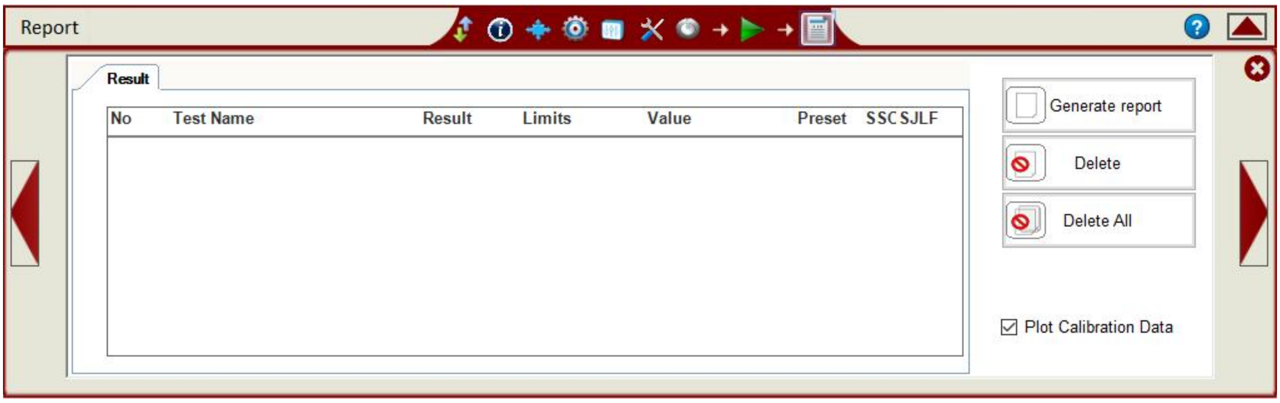


FIGURE 35. TEST REPORT DELETED

8 Saving and Loading Test Sessions

The usage model for the GRL SAS 12G Rx automation software is that Calibration and Test Results are created and maintained as a 'Live Session' in the software. This allows you to Quit the software and return later to continue where you left off.

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

To Save a session, with all of the parameter information, test results, and any waveforms, select **Options** on the menu bar and select **Save Session**.

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

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

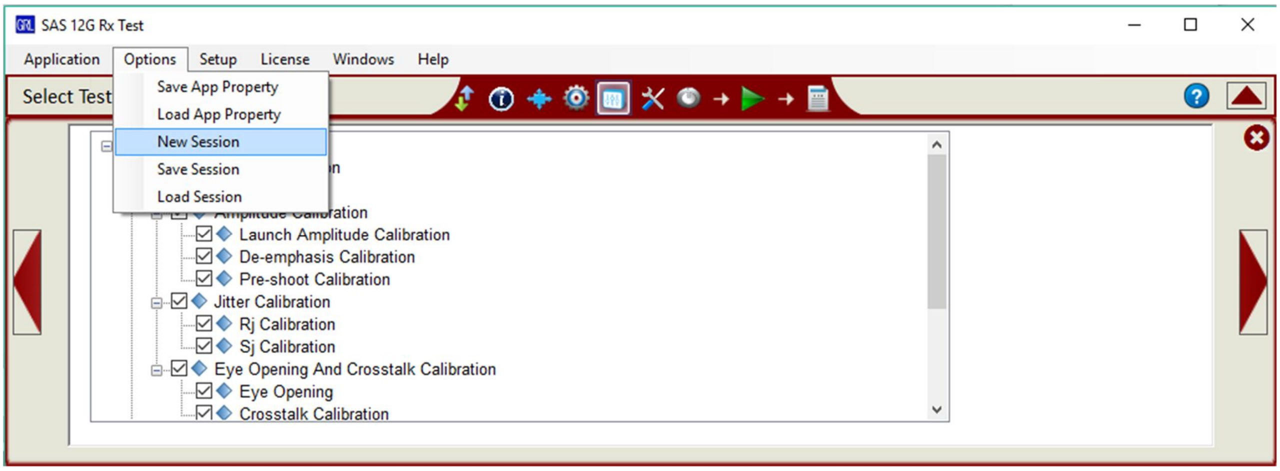


FIGURE 36. SAVING AND LOADING CALIBRATION AND TEST SESSIONS

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.

9 Manual Standard Calibration and Test Procedure

This section provides the manual SAS 12G Receiver Calibration and Test Procedure (using the Tektronix BSA BERTScope) in the following sections, as per the SAS-3 Draft Standard.

9.1 Typical SAS 12G Receiver Calibration/Test Setup

Note: See Appendix of this MOI for additional information (i.e., test patterns, DPP clock timing adjustment) useful for performing the tests in this test suite.

This MOI describes the receiver jitter tolerance test which is performed using a signal that contains the maximum allowable jitter, noise and signal loss.

A typical receiver test setup will include the BERTScope and appropriate equipment to provide the necessary test patterns with jitter, ISI and crosstalk. The setup will also use a Digital Pre-Emphasis Processor to add the required transmitter equalization, as requested during the link training stage while calibrating the test pattern. A real-time Oscilloscope is required for signal calibration while a BERTScope analyzer/error detector will be used for error checking via a clock recovery unit.

The test 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 receiver should be able to tolerate stress impairments which have been partially compensated or corrected through a Tx/Rx link training sequence.

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

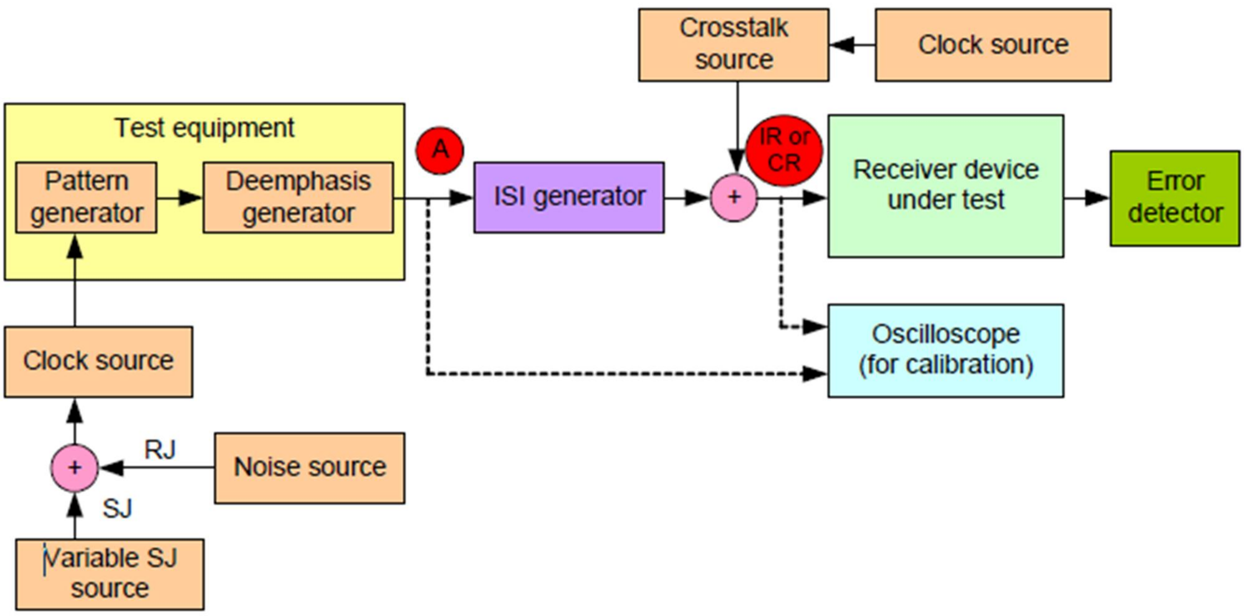


FIGURE 37. TYPICAL STRESSED RX JITTER TOLERANCE TEST/CALIBRATION SETUP BLOCK DIAGRAM

9.1.1 Test Points

Below shows a series of SAS compliance test points as defined by the 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 38. SPECIFIED SAS COMPLIANCE POINTS

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

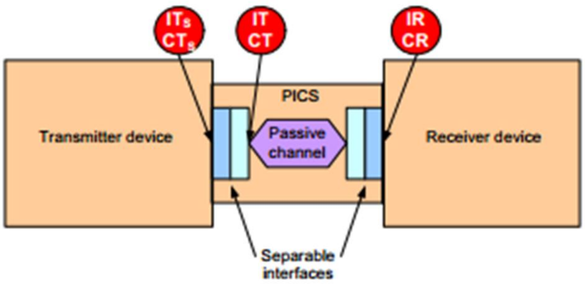


FIGURE 39. 12GBPS TXRX CONNECTION AND COMPLIANCE POINTS

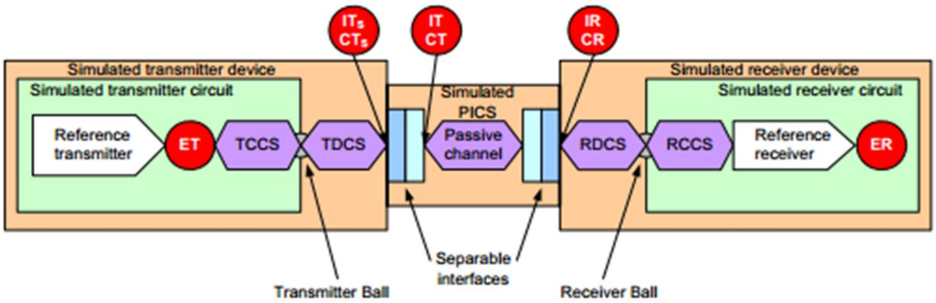


FIGURE 40. SIMULATED 12GBPS TXRX CONNECTION AND COMPLIANCE POINTS

9.2 Recommended SAS 12G Rx Calibration Methodology

a) Calibrate AC/DC Amplitude

Calibrate pre-shoot, de-emphasis and amplitude using a pattern that contains both high-frequency and low-frequency components. This ensures proper equalization of initial high-frequency and low-frequency amplitudes for accurate calibrations.

b) 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)

c) 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

d) Calibrate 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.

e) Calibrate SJ

Calibrate SJ (3 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.

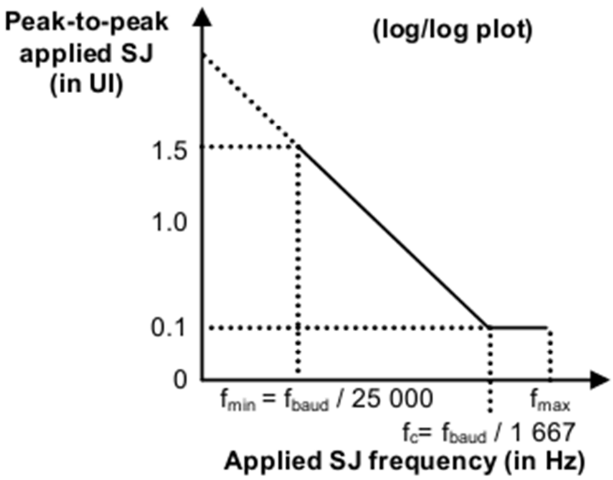


Figure 148 — Applied SJ for trained 1.5 Gbps, 3 Gbps, 6 Gbps, and 12 Gbps without SSC support

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:

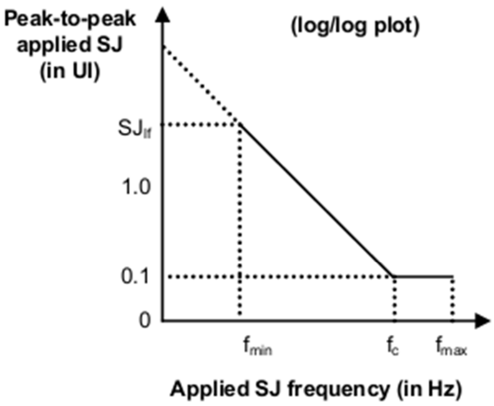


Figure 149 — Applied SJ for trained 1.5 Gbps, 3 Gbps, 6 Gbps and 12 Gbps with SSC support

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 case with SSC support does not imply that SSC should be enabled on the BERTScope to generate stressed eye diagram. 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.

f) 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

g) Calibrate Crosstalk

Calibrate the total peak-to-peak, differential crosstalk noise using the 1010 pattern at 12Gbps with SSC enabled (generated by the BERTScope) 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

9.3 SAS 12G Rx Calibration Setup and Procedure

Calibration for SAS 12G 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, however, is an electrical test point calculated by the *SAS3_Eye Opening* software tool (which may be installed on the scope test instrument).

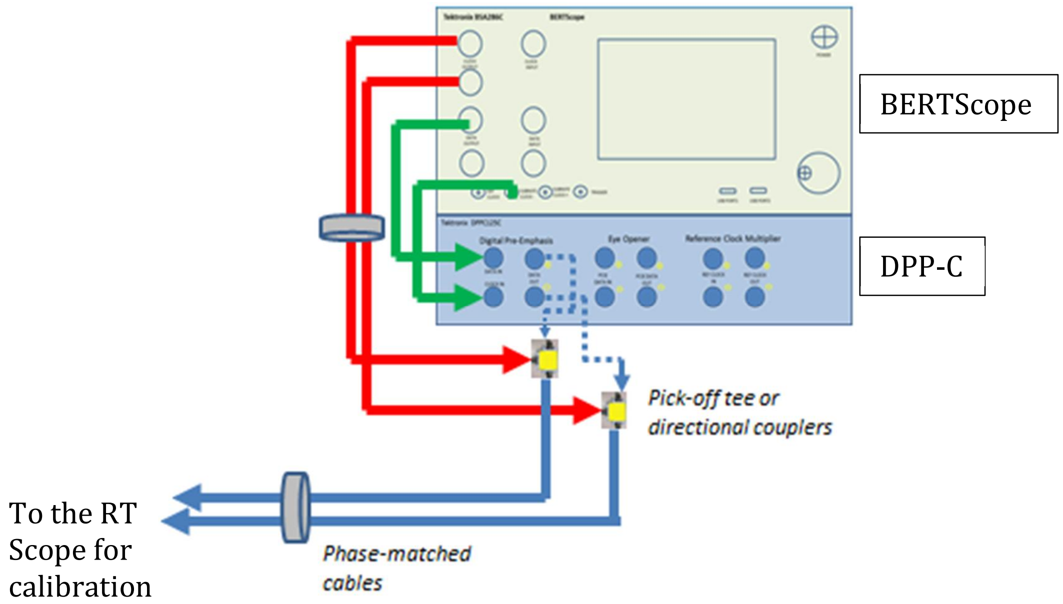
Refer to Figure 37 to view the block diagram for the typical calibration setup.

9.3.1 Physical Setup

9.3.1.1 Connect BERTScope to DPP-C

(Note: An external DPP-C is not required if using the Tektronix BSX BERTScope. The BSX BERTScope can be directly connected to the pick-off tees or directional couplers.)

1. Connect DATA OUTPUT(+) of the BERTScope to DATA IN of the DPP-C.
2. Connect Sub-rate Clock Output of the BERTScope to Clock Input of the DPP-C.
3. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports.
4. Connect the pick-off tees inputs to DATA OUT+ and DATA OUT- of the DPP-C respectively.



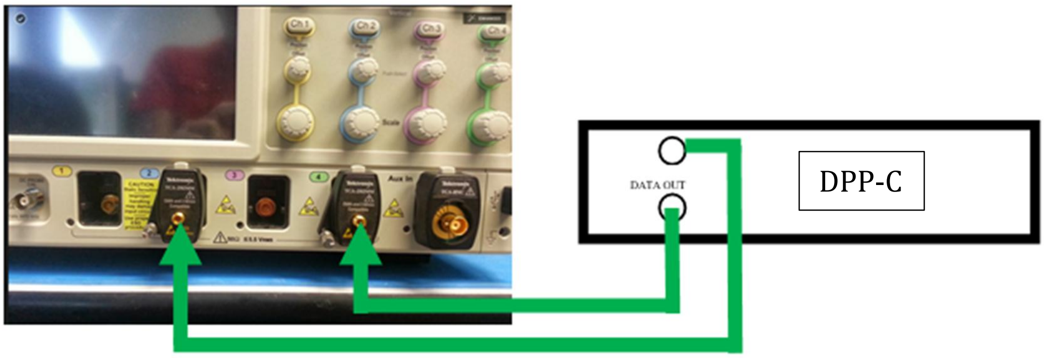
Additional Notes:

- *This setup uses 8-inch cables to connect the BERTScope to the DPP-C. Other cables of equal lengths can also be used to connect the DPP-C to the BERTScope.*
- *It is recommended to use pick-off tees with low-loss thru channel to maximize the dynamic range of the BERTScope data outputs. Optionally, directional couplers can also be used in a similar manner.*
- *SMA(M)-SMA(M) adapters can be used to directly connect pick-off tees to the DPP-C.*

9.3.1.2 Connect DPP-C to RT Scope

1. Connect DATA OUT+ of the DPP-C via the pick-off tee to Channel 2 on the RT Scope.
2. Connect DATA OUT- of the DPP-C via the pick-off tee to Channel 4 on the RT Scope.

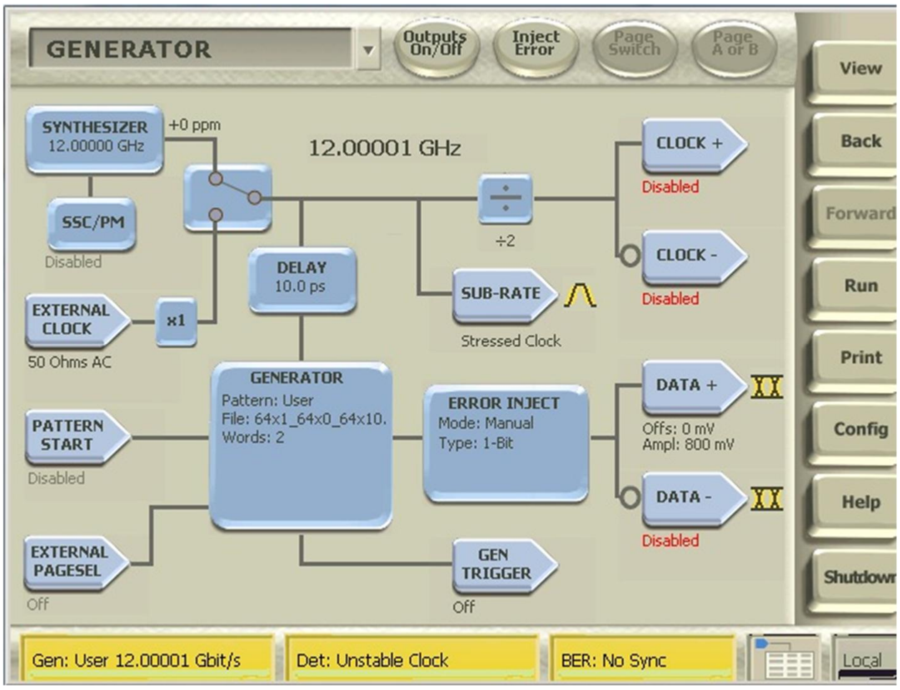
Note: Alternatively, scope Channels 1 and 3 can also be used.



Note: To generate 25GHz bandwidth, use either Channel 1 and Channel 3 or Channel 2 and Channel 4.

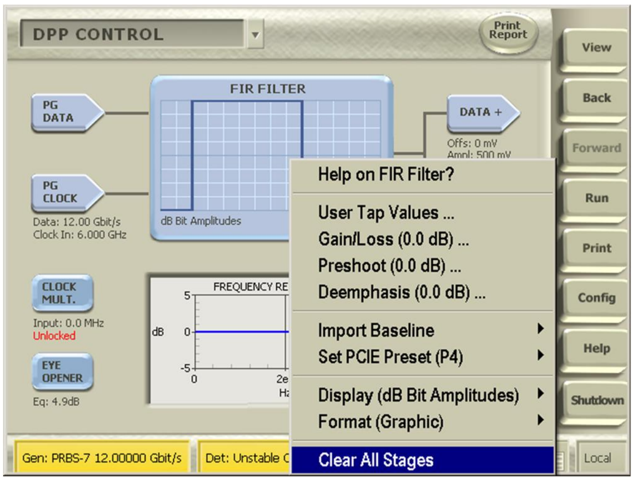
9.3.1.3 Configure BERTScope

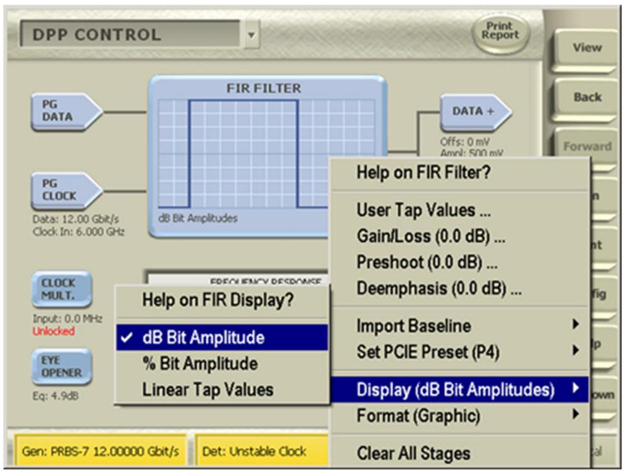
1. Set DATA Rate to 12Gbps.
2. Set Pattern to 64X1_64x0_64x10.ram pattern.
3. Set Amplitude to 800mV on DATA +.
4. Set Sub-rate Clock to 'Stressed Clock'.
5. Set and remain Clock outputs as "Disabled" until Crosstalk calibration.

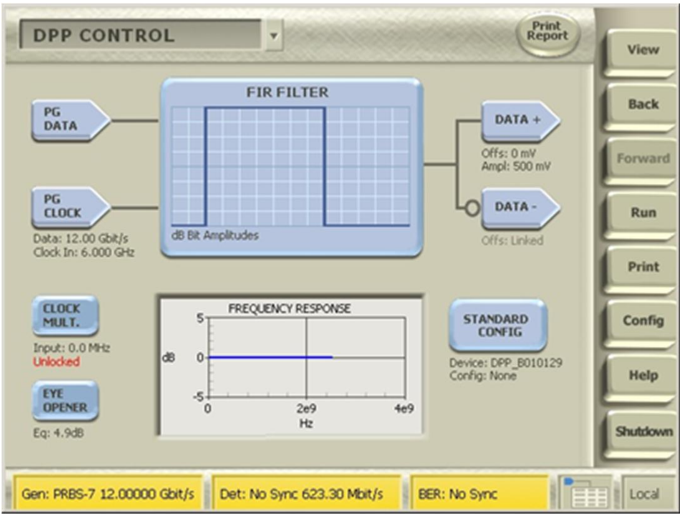


9.3.1.4 Configure DPP-C

1. Select 'Clear All Stages' for the DPP-C to ensure no Pre-shoot or De-emphasis is selected.
2. Set the FIR Filter display to 'dB Bit Amplitude'.
3. Set the amplitude to 1000mVpp (500mV for each data leg).



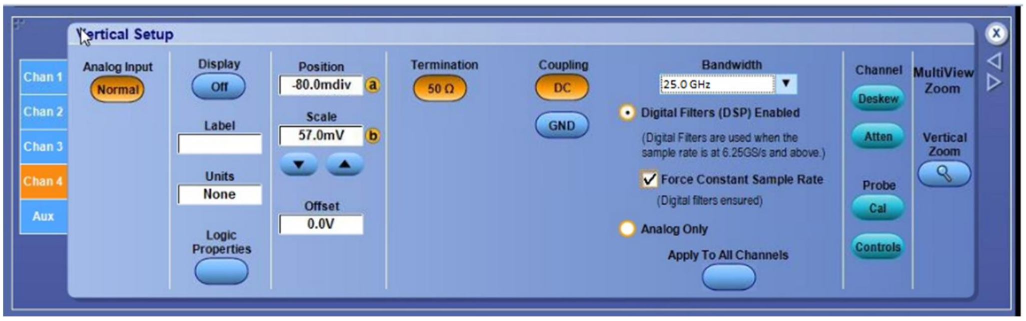




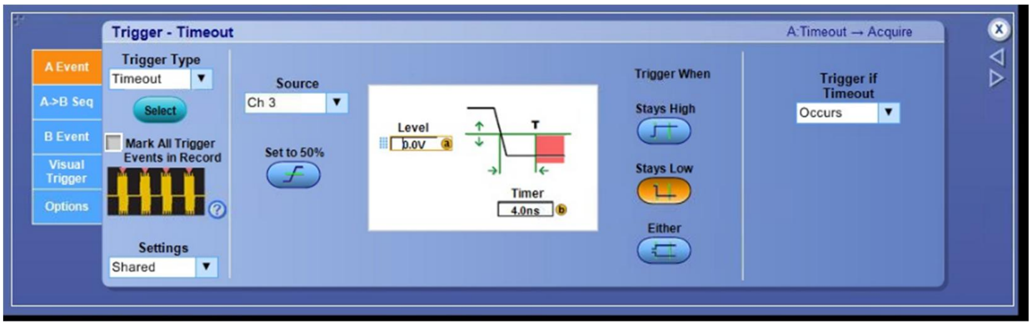
9.3.2 Scope Setup

9.3.2.1 Configure RT Scope for Amplitude Calibrations

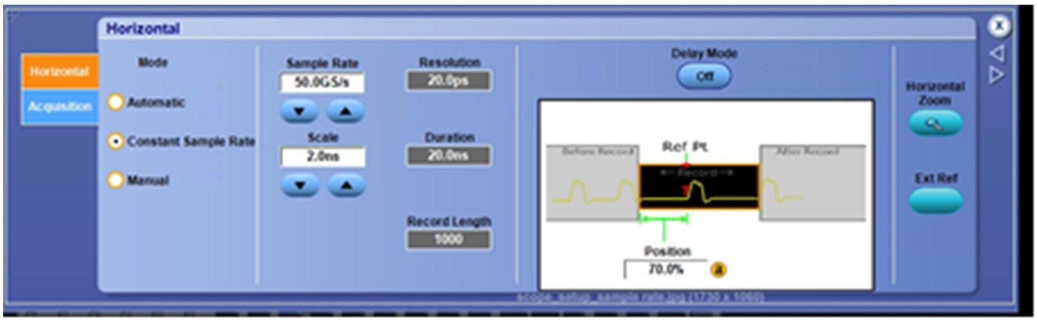
1. Set the Bandwidth to 25GHz or higher.



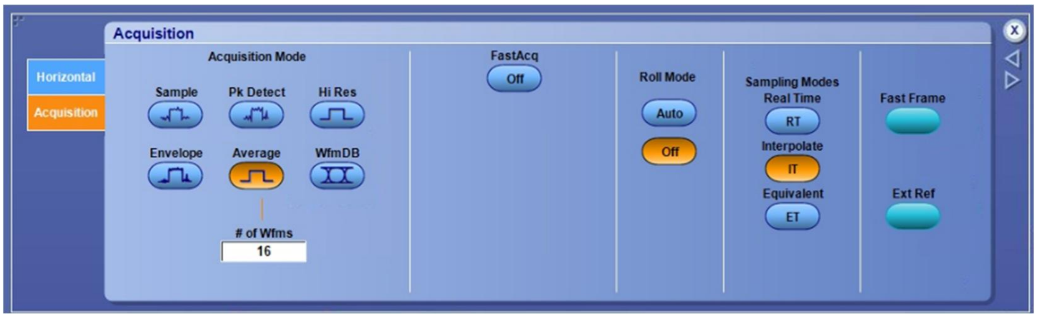
2. Set the Trigger Type to 'Timeout' on Channel 3 or Channel 4:
    - Level: 0mV
    - Timer: 4ns



3. Set the Sample Rate:
    - SR: 50GS/s
    - Scale: 2ns



4. Set the Averaging to 16 WFM.



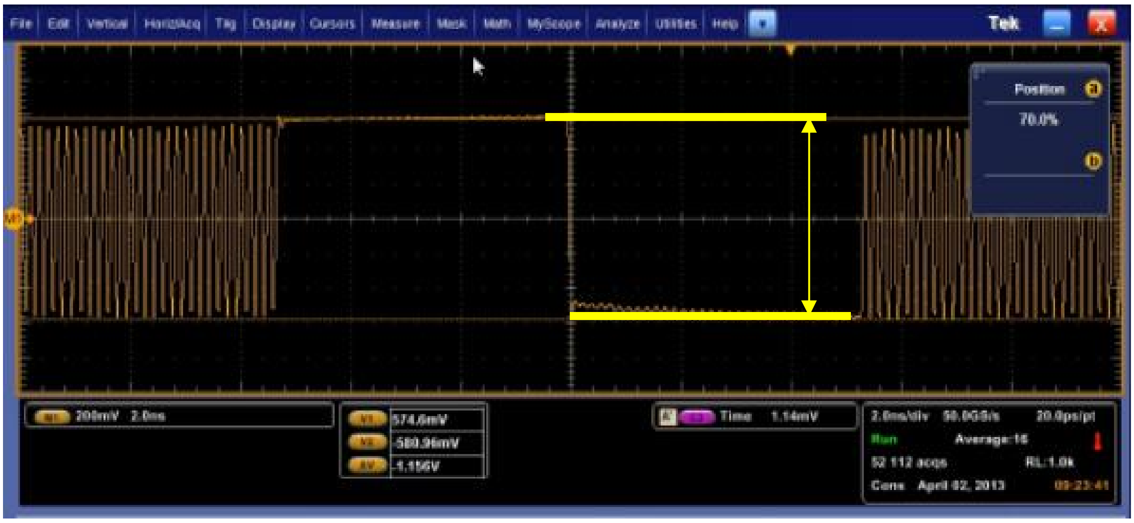
9.3.3 Calibration Steps

9.3.3.1 Step 1: Calibrate AC/DC Amplitude

This step verifies that the amplitudes for high and low frequency components of the launch signal are equalized, with *a HighFrequency/LowFrequency ratio of greater than 0.95*. This is performed using an appropriate pattern having both low and high frequency components, and adjusting the de-emphasis, if required to obtain the target equalized amplitude ratio.

For this example, a 64 1's_64 0's_64 10's pattern with High Frequency (1010) and Low-Frequency (1111 or 0000) components will be used.

1. Measure the mean DC peak-to-peak amplitude using cursors as 1.154V.



2. Measure the mean AC peak-to-peak amplitude using cursors as 1.134V.

3. Calculate the ratio of HighFrequency/LowFrequency = 1.134V/1.154V = 0.982.

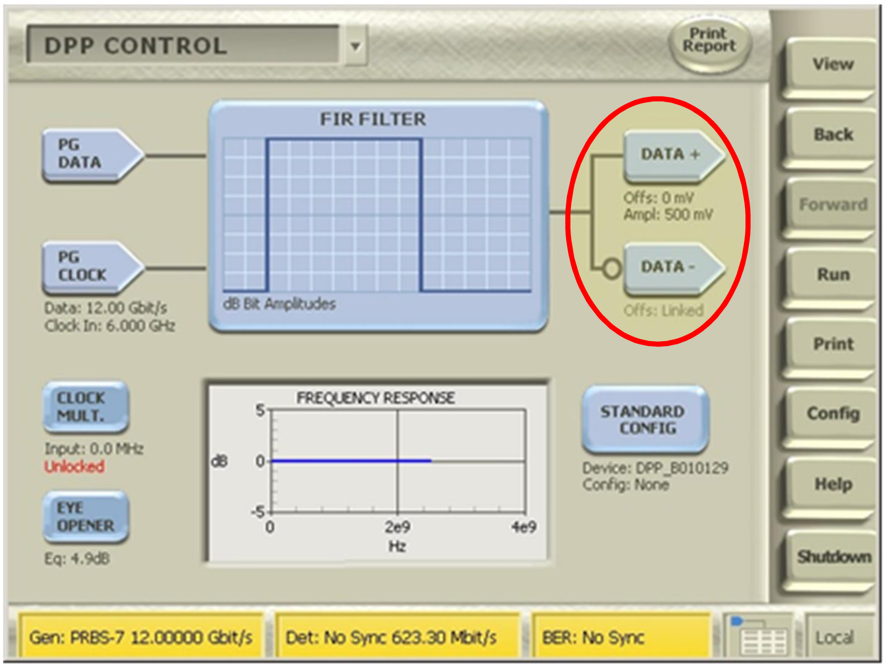
Note: If required, adjust de-emphasis on the DPP-C to equalize the frequency components to achieve the recommended ratio of greater than 0.95.

9.3.3.2 Step 2: 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 DPP-C 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 DPP-C amplitude to achieve the target 850mVpp.



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

9.3.3.3 Step 3: Calibrate and Save Reference Presets

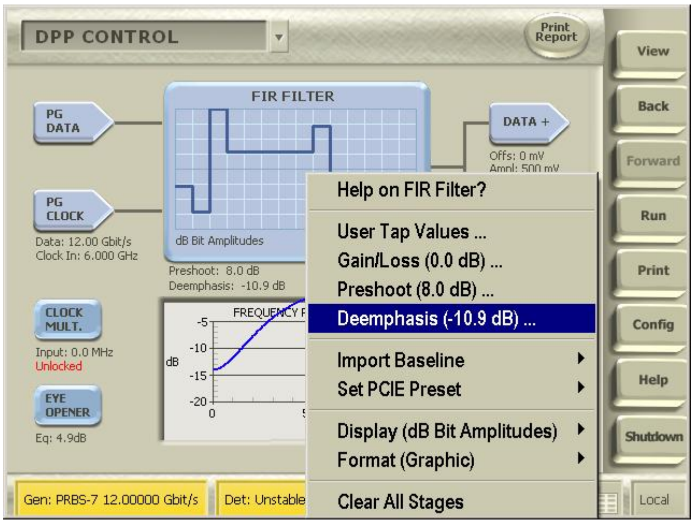
This step verifies that the nominal settings for a reference preset (which uses de-emphasis and pre-shoot) meet the target values, and then saves the settings. A total of 3 reference presets, with nominal de-emphasis and pre-shoot settings for each preset, will be used in testing.

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

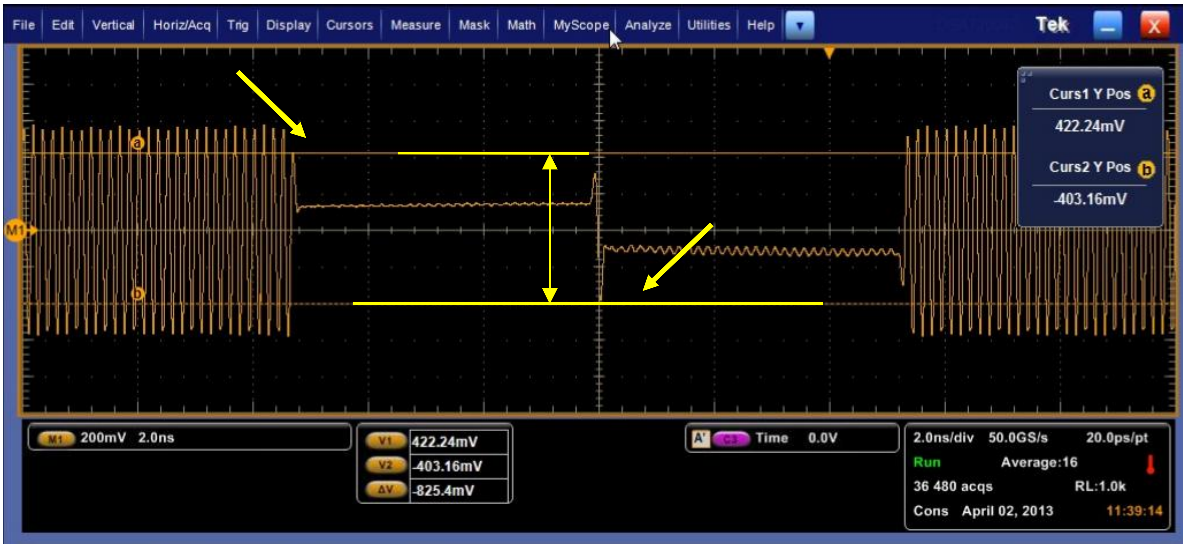
- Target De-emphasis: -10.9dB +/- 2dB
- Target Pre-shoot: 8dB +/- 2dB

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

1. Set De-emphasis and Pre-shoot on the DPP-C to the above target values.

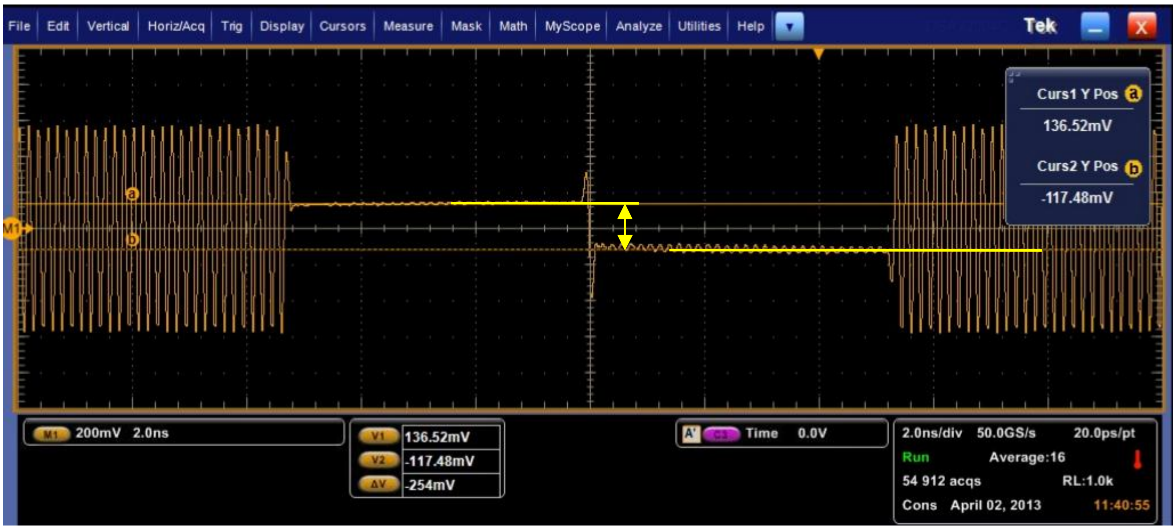


2. Measure the actual de-emphasis and pre-shoot on the scope. Using cursors, measure the peak-to-peak transition amplitude.



The measured transition amplitude in this example is 825mVpp.

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

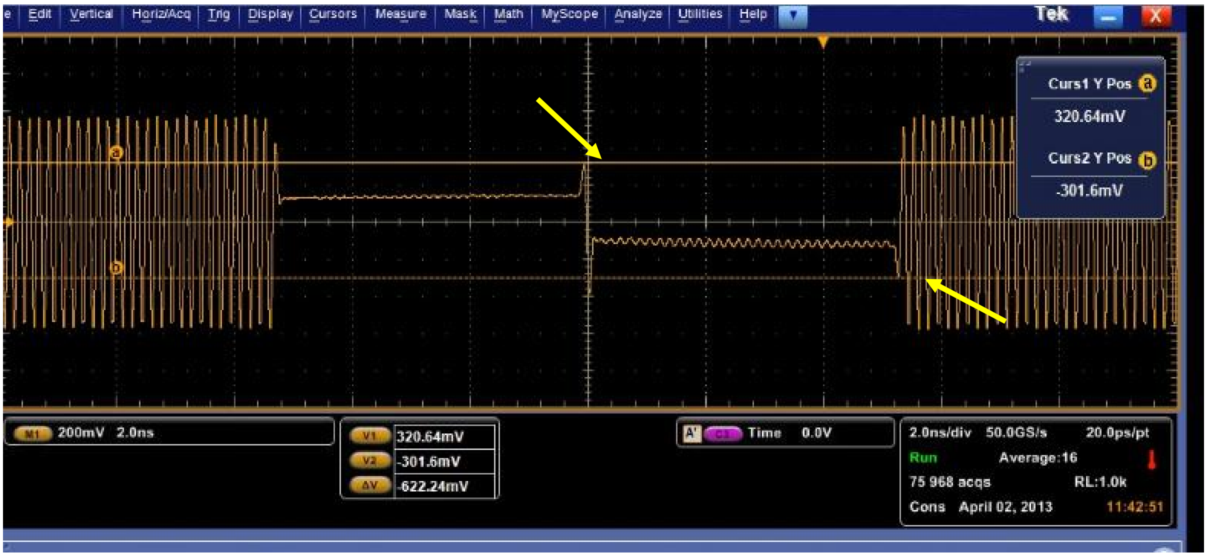


The measured non-transition amplitude in this example is 254mV.

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:

   Pre-shoot = 20log[Pre-shoot/Non-transition]

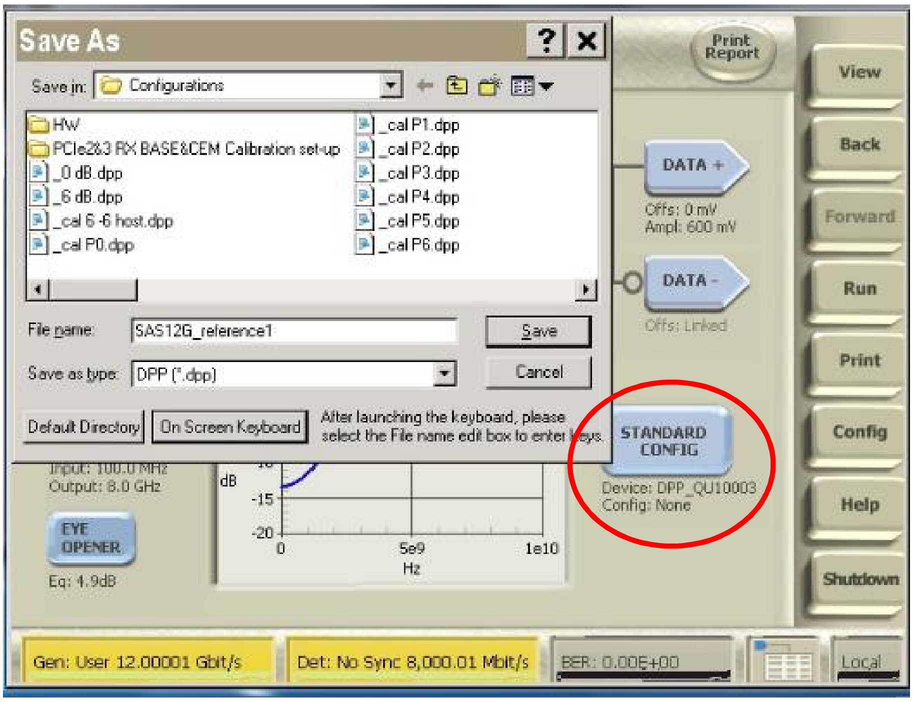
   = 20log[622mV/254mV]

   = 20log[2.44]

   = 7.8dB *(which conforms to the target of 8dB +/- 2dB)*

Note: To obtain more precise measurements, adjust the pre-shoot/de-emphasis accordingly on the DPP-C.

7. Now save the Reference Preset 1 settings by clicking on the **Standard Config** button on the DPP-C and select **Save As**: 'SAS12_reference1'. The settings will be saved with the correct Launch Amplitude.



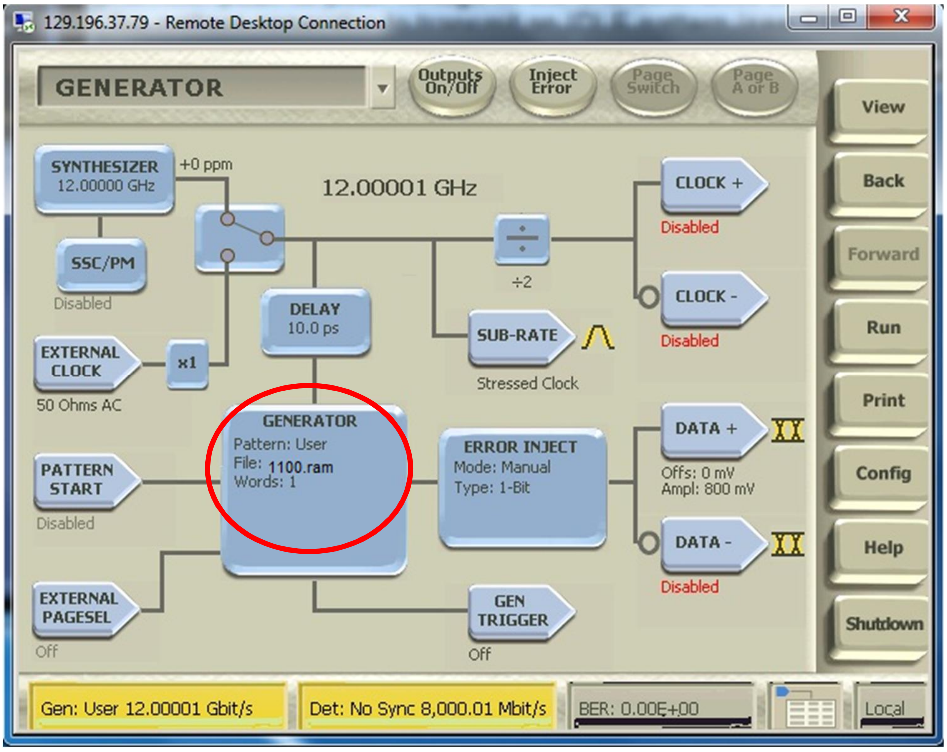
8. Repeat the above calibration and saving procedure for Reference Presets 2 and 3.

9.3.3.4 Step 4: Calibrate RJ

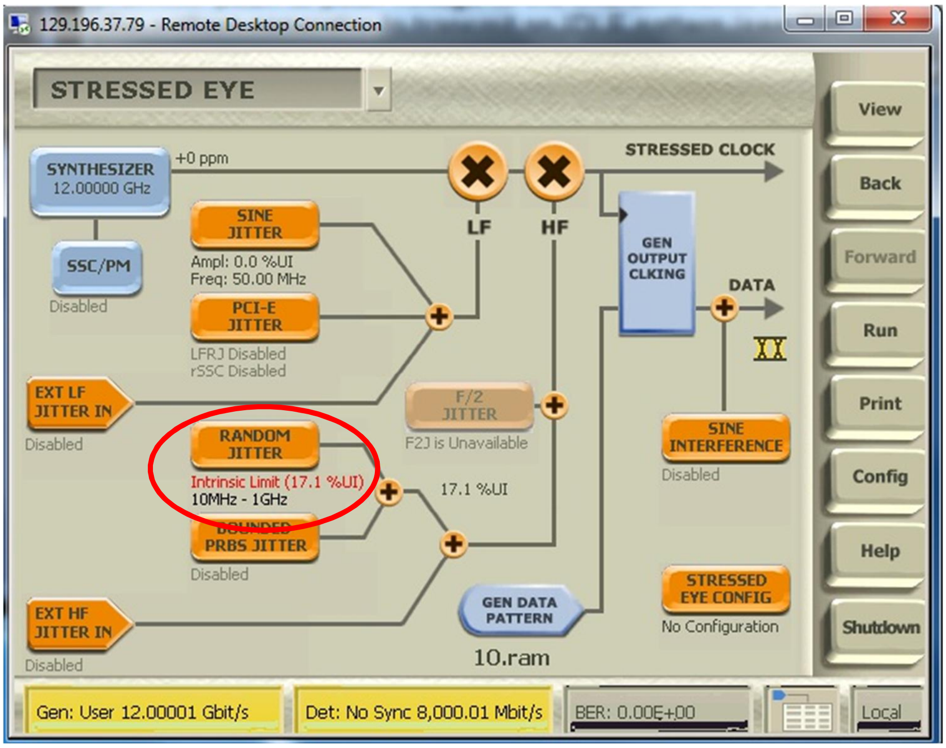
This step verifies that the measured Random Jitter meets the target value of 16.5%UI.

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 1100.ram.

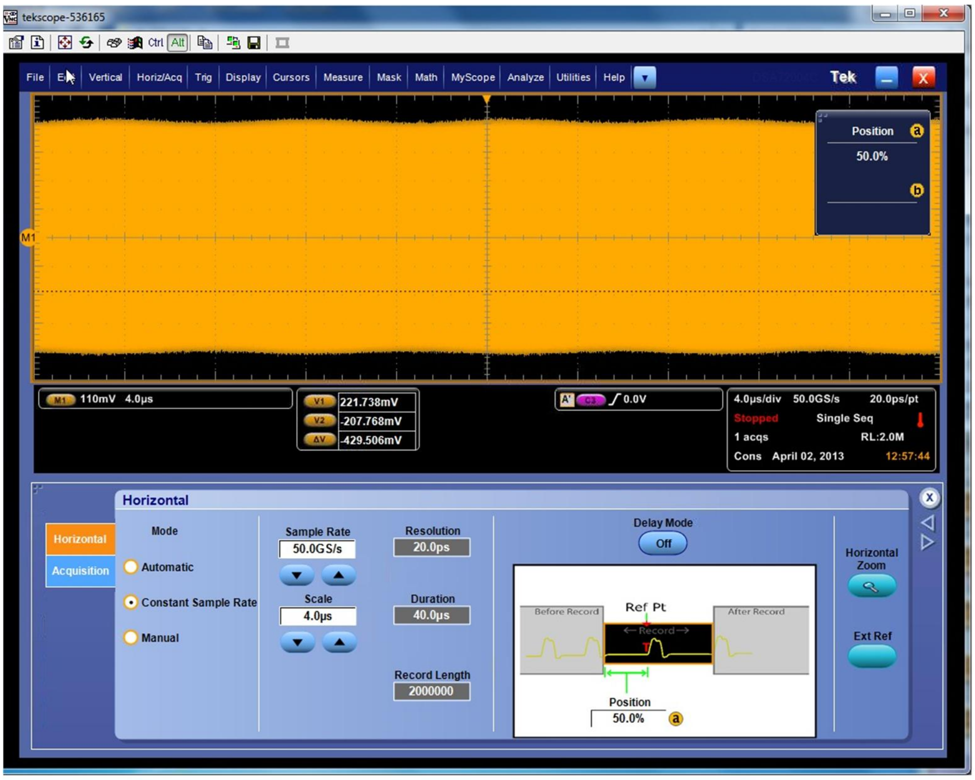


2. Set Random Jitter to 'Intrinsic Limit'. Also enable the Sine Jitter modulator and set the amplitude to 0%UI. The intrinsic jitter generated by the SJ modulator will then be captured in the intrinsic RJ value.



3. On the RT scope, set the Acquisition Mode to 'Sample'.

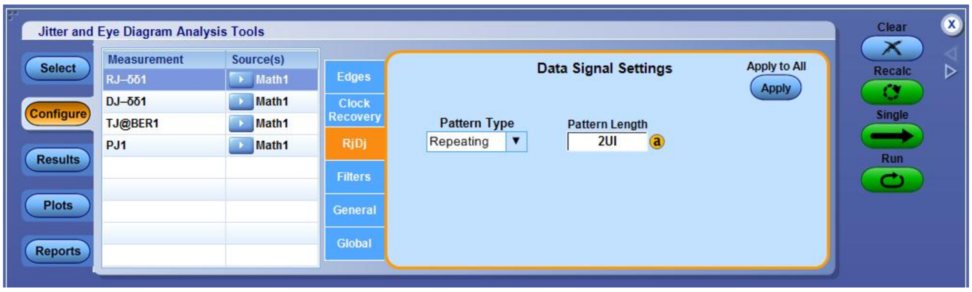
4. Set the Sample Rate to '50GS/s' and the Scale to '4µs/div'.



5. Set the Trigger Type to ‘Edge’.

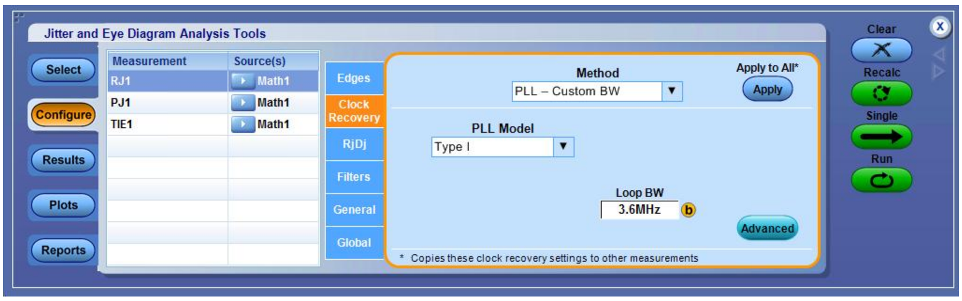
6. In the DPOJET, configure the RJ measurement with the following parameters:

a) RjDj section: Set the Pattern Type for the clock signal as ‘Repeating’, with Pattern Length of ‘2UI’ (i.e., 1100b).

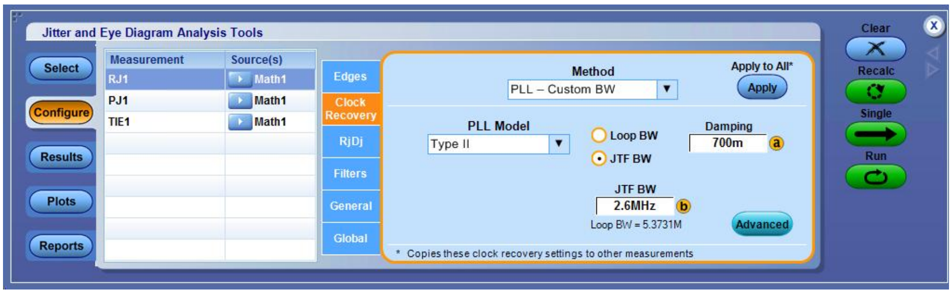


b) Clock Recovery section: Set the PLL Model to ‘Type I’ (*if the DUT does not support SSC*) and ‘Type II’ (*if the DUT supports SSC*).

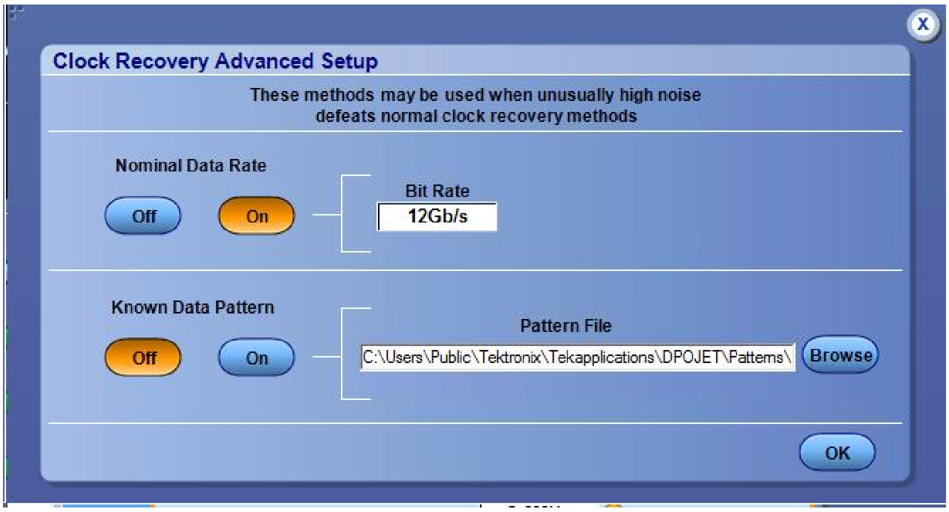
- For non-SSC (Type I): Set the Loop BW to ‘3.6MHz’.



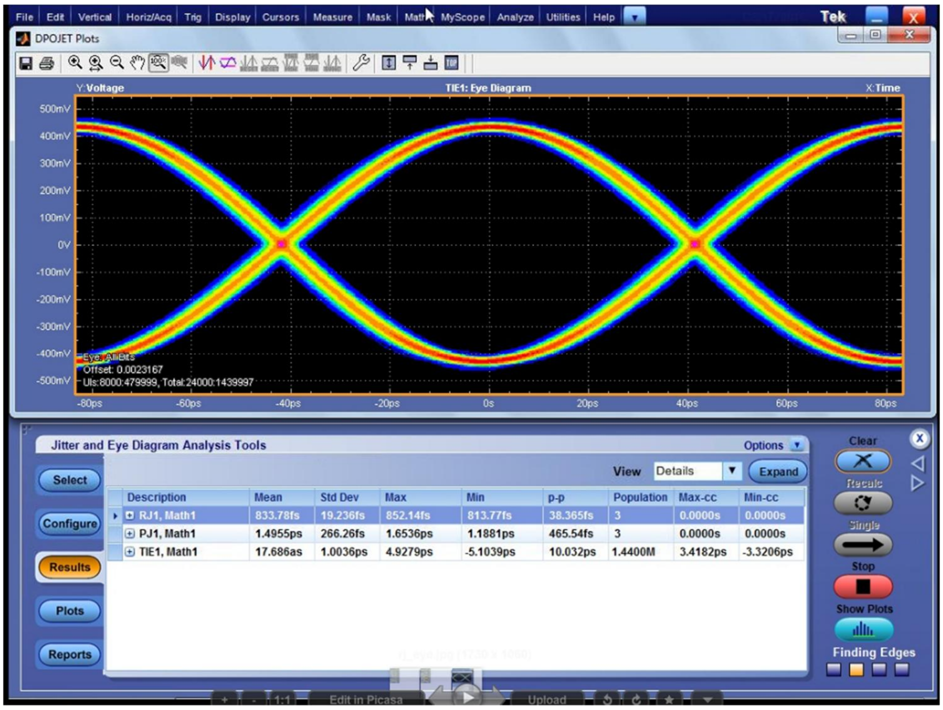
- For SSC (Type II): Set the JTF BW to '2.6MHz' and Damping to '700m'.



c) Clock Recovery Advanced Setup section: Set the Nominal Data Rate to '12Gb/s'.



7. Measure RJ1 with Math1 (CH3-CH4) on the DPOJET.



The measured RJ1 value in this example is 0.933ps RMS.

8. Convert RJ1 to RJ peak-to-peak as follows:

   0.933ps RMS * 14.2 = 13.24ps

9. Then convert to %UI (where 1UI = 83ps) to meet the target of 16.5%UI, as follows:

   (13.24ps/83ps) * 100% = 16%UI

Note: For more precise RJ measurement, adjust RJ accordingly.

9.3.3.5 Step 5: 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.

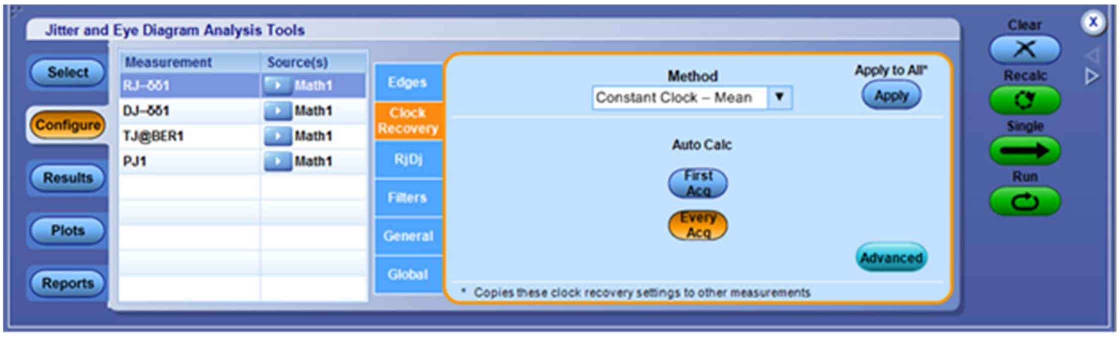
For **SSC support**, SJ will need to be calibrated to the following target values:

- SJ at 111kHz: 34UI
- SJ at 2.06MHz: 0.10UI (or 10%UI)
- SJ at 15MHz: 0.10UI (or 10%UI)

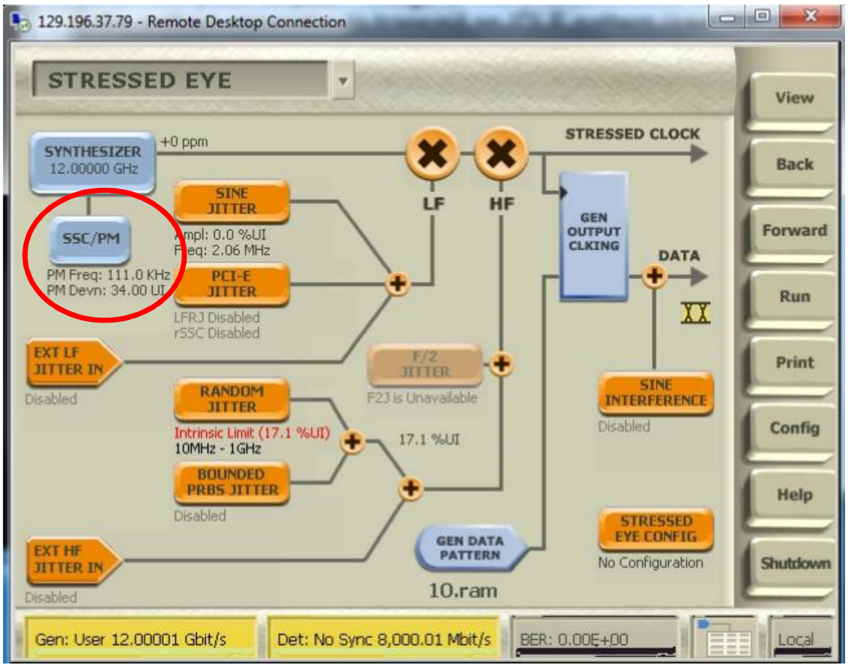
Note: Additional Jitter Tolerance points can be added if desired.

i) Calibrate SJ at 111kHz

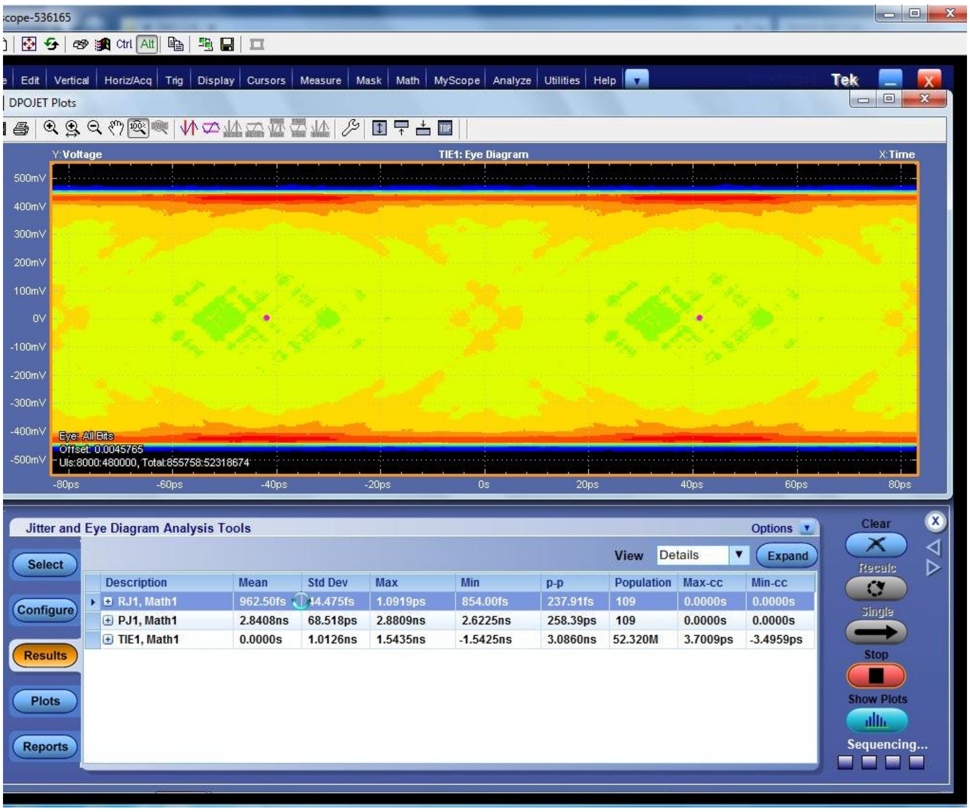
1. In the Clock Recovery section, set the Method to 'Constant Clock – Mean'. This is to prevent filtering of the low frequency jitter modulation for verification.



2. On the BERTScope, turn on the Phase Modulator, and set the PM Frequency to 111KHz and PM Deviation to 34UI.



3. Measure PJ1 on the DPOJET.



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

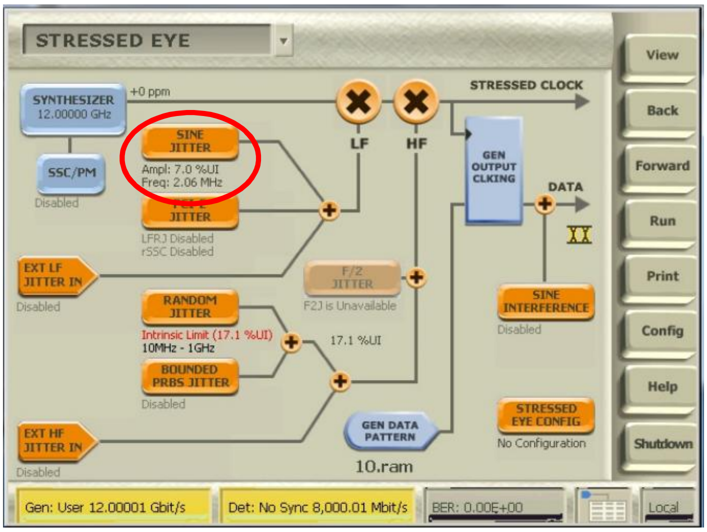
4. Convert the value to UI (where 1UI = 83ps) to meet the target of 34UI, as follows:

   2.84ns/83ps = 34UI

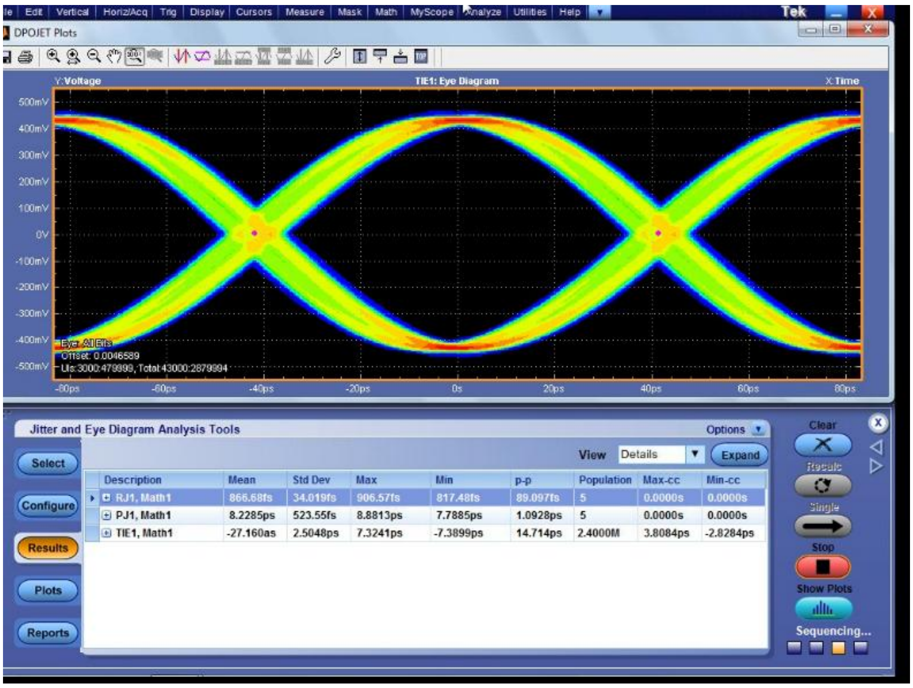
5. Record the SJ value on the BERTScope needed to generate the required SJ at 111kHz, which is to be used for the Jitter Tolerance configuration later.

ii) Calibrate SJ at 2.06MHz

1. Set the Sine Jitter to an initial 7%UI.



2. Measure SJ on the DPOJET.



In the above example, PJ1 is measured at 8.22ps.

3. Convert the value to UI (where 1UI = 83ps) to meet the target of 0.10UI, as follows:

   8.22ps/83ps = 0.099 ~ 0.10UI (or 10%UI)

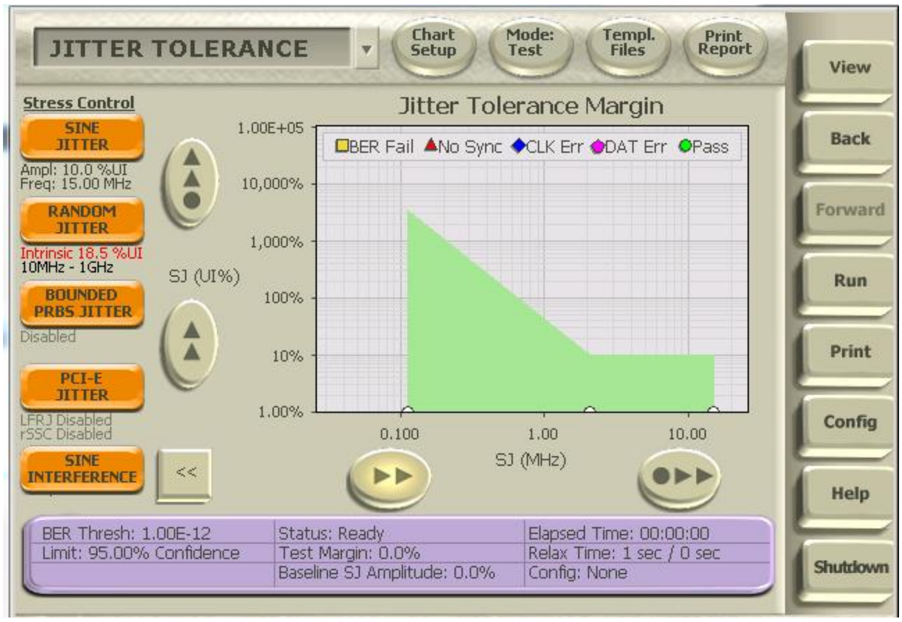
4. Record the SJ value on the BERTScope needed to generate 10% SJ at reference point, which is to be used for the Jitter Tolerance configuration later.

Note: For SJ at 15MHz with 0.10UI (or 10%UI) target, follow the same calibration procedure as above.

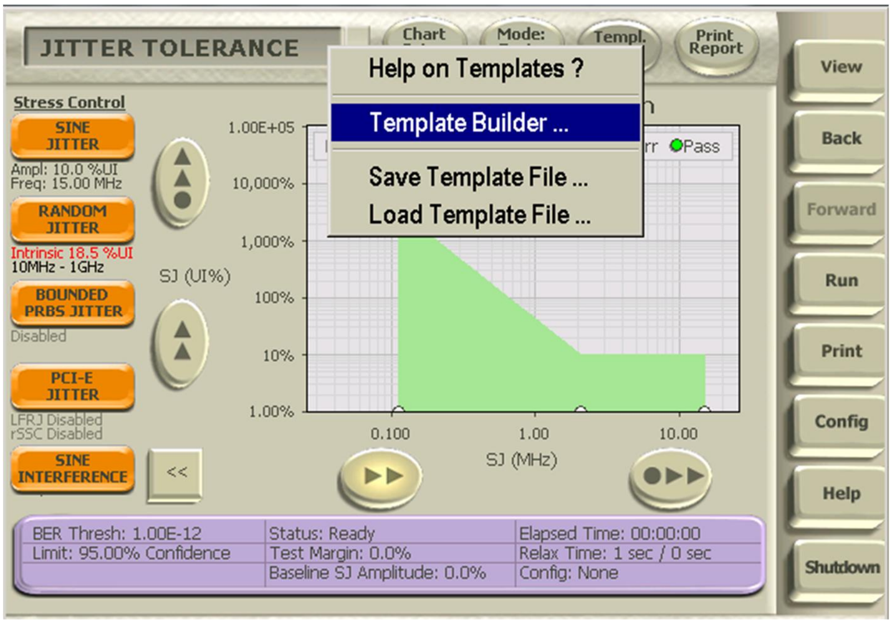
9.3.3.6 Step 5a: Configure Jitter Tolerance Template

This step creates a Jitter Tolerance template to store the 3 calibrated SJ frequencies (for SSC support, as described above) to be used later.

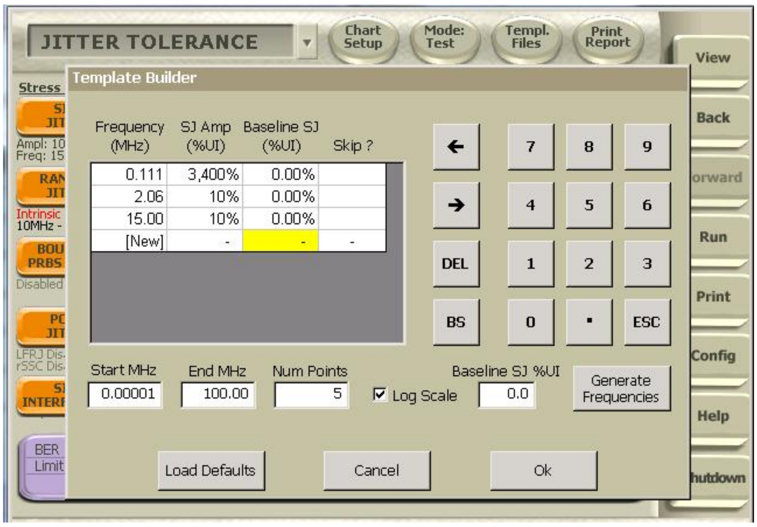
1. On the BERTScope, select VIEW -> JITTER TOLERANCE.



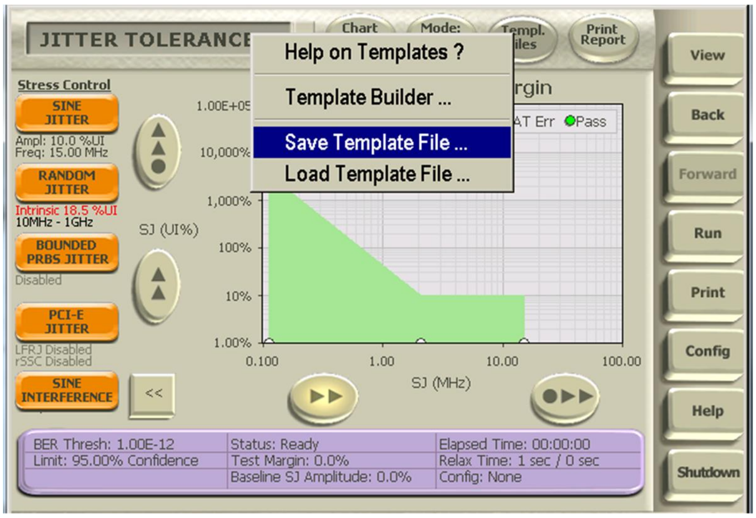
2. Click on the **Templ. Files** button above the screen, and select 'Template Builder'.

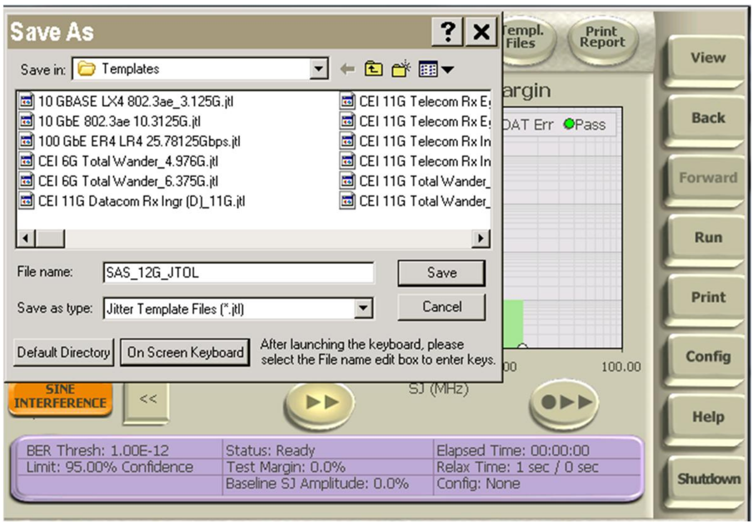


3. Key in the calibrated values for SJ as previously measured.



4. Save the template file as 'SAS_12G_JTOL' or any desired name.



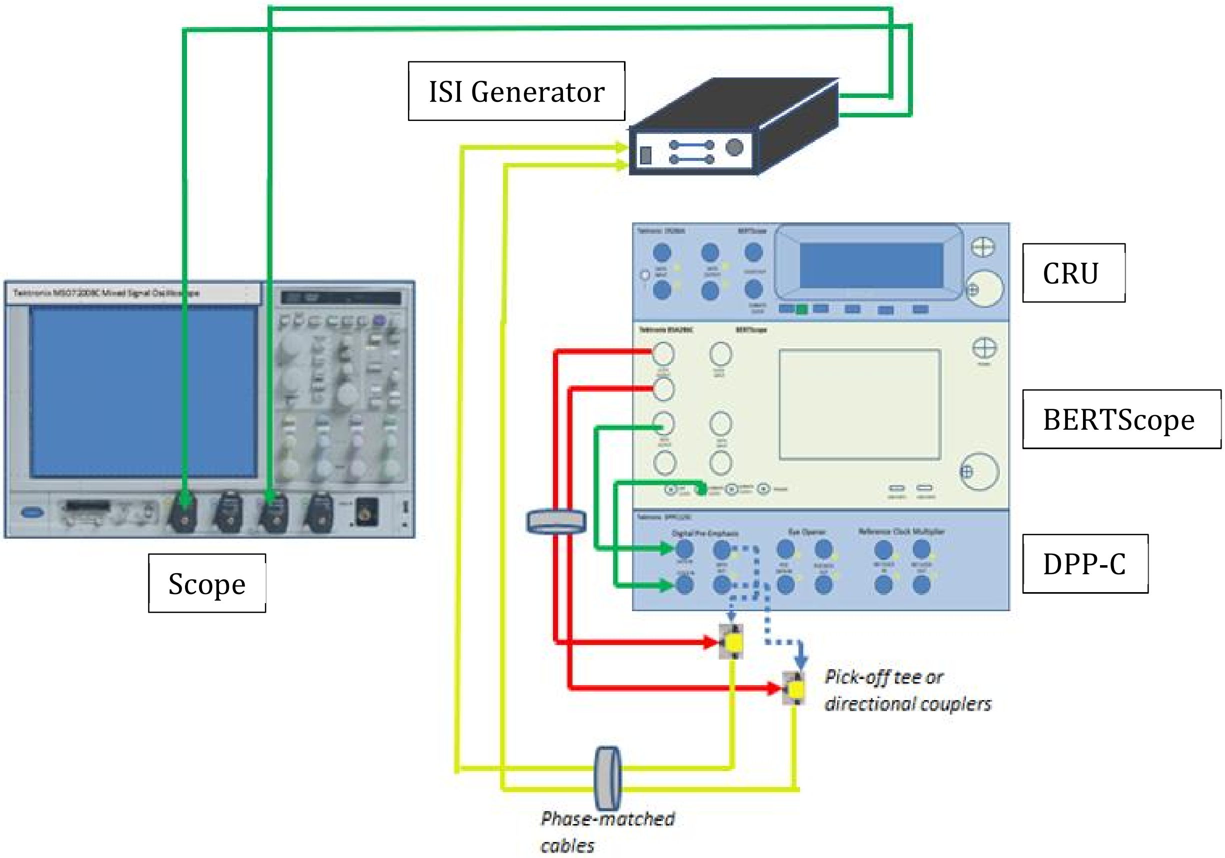


9.3.3.7 Step 6: Calibrate Eye Opening

This step verifies that the SAS-3 Eye Opening is within the target range of 65 to 80%. 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 DPP-C via the pick-off tees to the inputs of the ISI Generator.

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



2. Connect the outputs of the ISI Generator to Channel 2 and Channel 4 of the Scope.

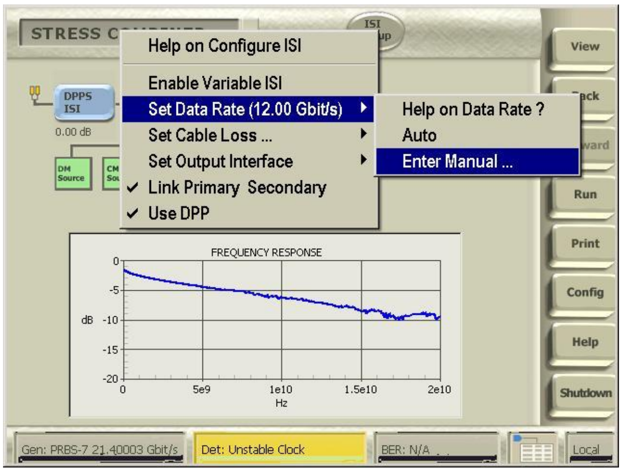
3. Set stresses to 0%UI and disable de-emphasis and pre-shoot (Reference_3) on the BERTScope, DPP-C and ISI Generator.

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

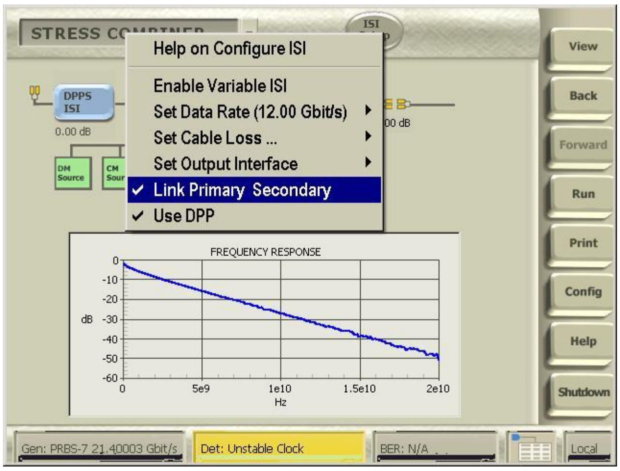
   - No pre-shoot
   - No de-emphasis
   - RJ set to 0%UI
   - SJ set to 0%UI
   - SSC set to 0%UI (or remain SSC as disabled if not enabled)

4. On the BERTScope Pattern Generator, set the Pattern to PRBS31. *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. Configure the ISI Generator as follows:

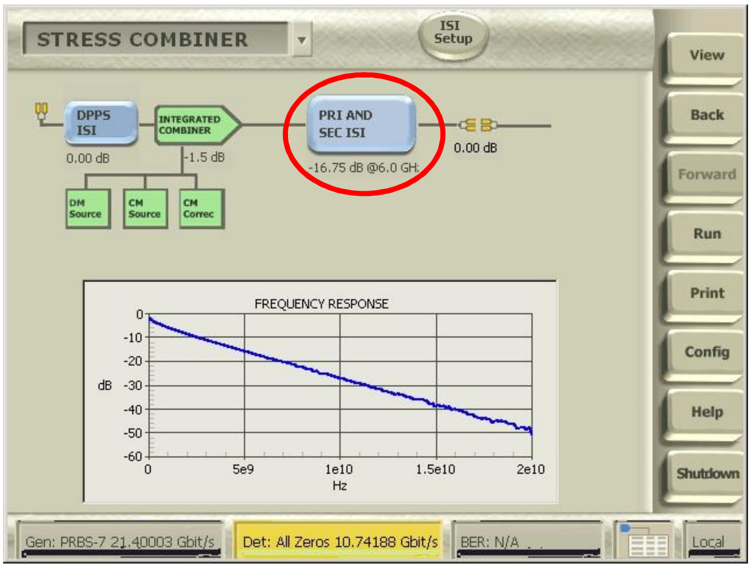
   a) Set the Data Rate:



   b) Link the Primary and Secondary ISI channels to enable finer resolution in insertion-loss step sizes.



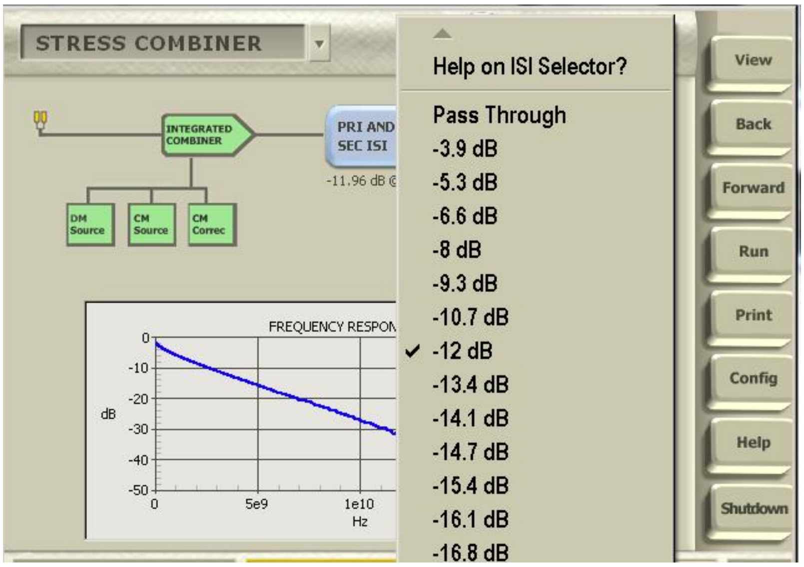
c) '@6GHz' should be displayed for the linked channels.



d) Select an initial insertion loss of -12dB. Adjust until the appropriate insertion loss is obtained to approximate the correct Eye Opening as required by the specification.

In this example, the insertion loss has been determined to be approximately -16.5dB loss at 6GHz.

Note: If using the BERTScope ISI Board, the 40inch trace has been determined to approach the required insertion loss.



6. On the DPOJET, measure the Eye Opening using the SAS3_EYE OPENING measurement.

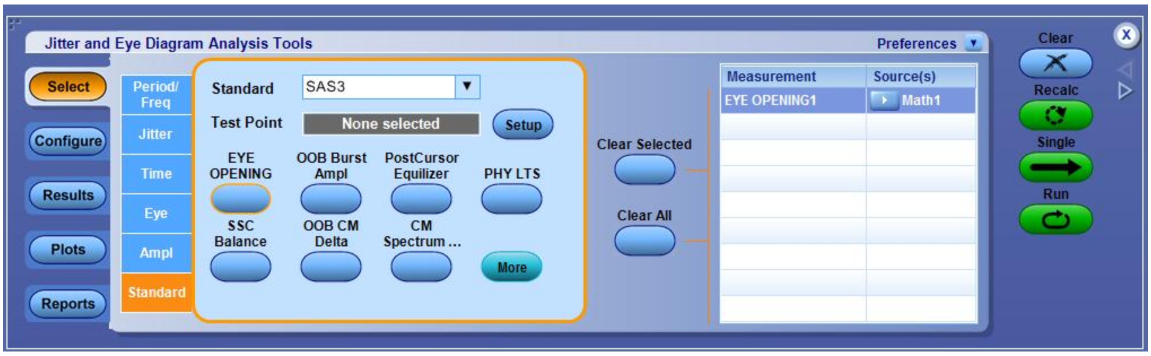
   By default, the SAS3_EYE OPENING measurement on the RT Scope runs in 'Tx' mode. This means it is expecting a signal that represents the 'clean' transmitter output which it will then apply a virtual 6m cable channel model and then perform the reference receiver function.

When in 'Rx' mode, the software assumes the signal has been captured at the far end of a channel and will only apply the reference equalizer and not the virtual 6m cable.

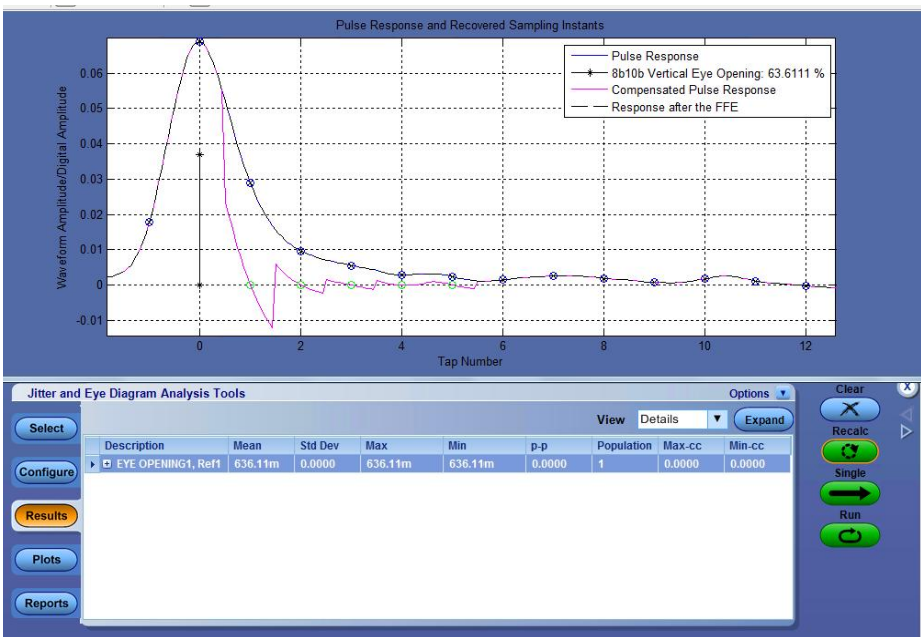
To run in desired 'Rx' mode, create a .txt file called '*SAS3_EO_RX.txt*' at C:\Users\Public\Tektronix\. This will be a blank file. The SAS3 software will simply check for the existence of this file to determine in which mode to operate. In this mode, Rx mode will be activated.

Note: The SAS3_EO_RX.txt file should be removed once calibration is complete to allow Tx mode of operation.

7. On the DPOJET, remove all other measurements before selecting the SAS3_EYE OPENING measurement.



8. Measure the Eye Opening.



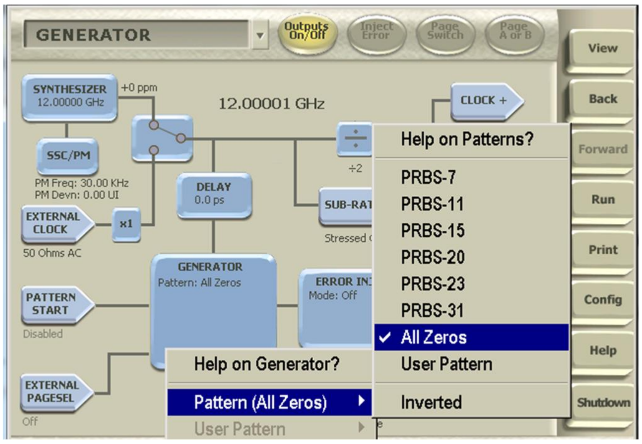
In the above example, the Eye Opening is measured as 63.6% (*which is still not within the target range of 65 to 80%*). Adjust the ISI Generator accordingly until the expected measurement is obtained.

9.3.3.8 Step 7: Calibrate Crosstalk

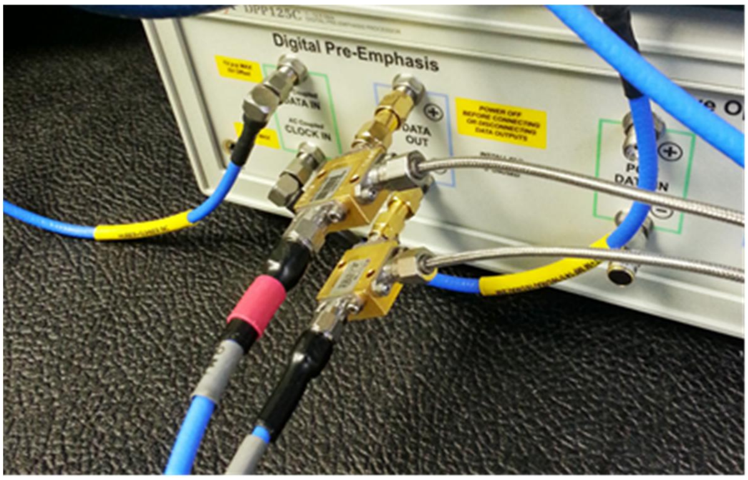
This step verifies that the crosstalk amplitude is within the target maximum 15 to 20mVpp. Similar to the Eye Opening calibration, the ISI Generator will also be applied. For this case, the BERTScope Clock Output will be used to generate the crosstalk, and can be adjusted to achieve the expected crosstalk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

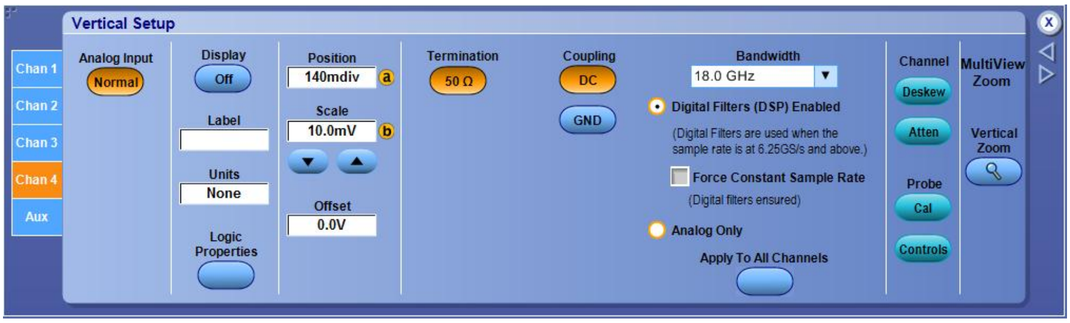
1. On the BERTScope, transmit the 'All Zeroes' Pattern to ensure no signal is being transmitted during crosstalk calibration.



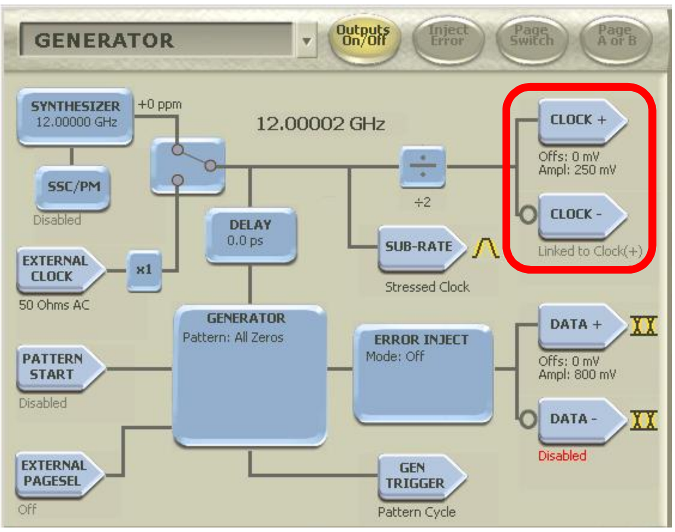
2. On the same page, enable and verify that the BERTScope Clock Output is set to divide-by-2. (*Note: While this is automatically performed at 12Gbps, verification is recommended.*) The 6GHz Clock supplies a 1010 pattern at 12Gbps.
3. Check that the BERTScope Clock Output are connected to the pick-off tees inputs at the output of the DPP-C, respectively.



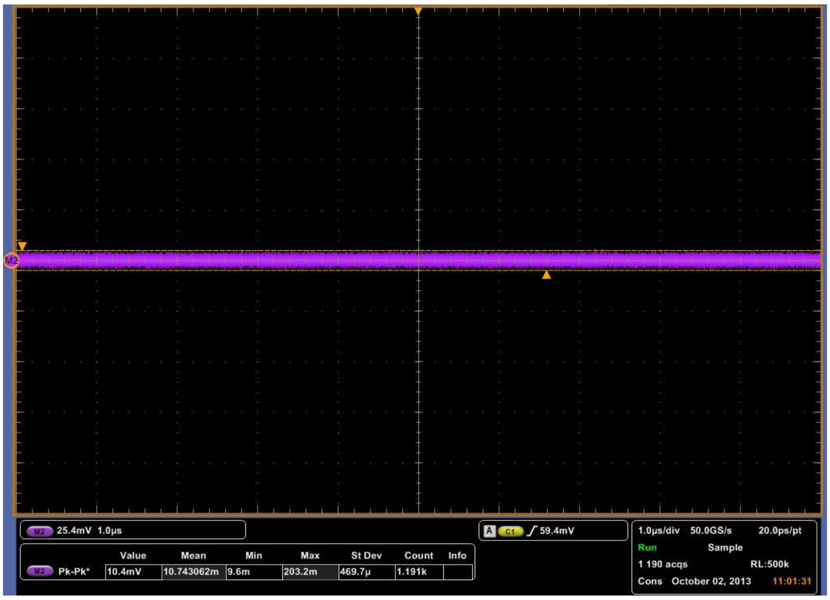
4. On the RT scope, set Channel 2 and Channel 4 to the minimum scale of 10mV.



5. On the BERTScope, set the Clock +/- amplitudes to 250mV.



6. Set the scope to measure the maximum Vpp on Channel 3 – Channel 4 over 5 seconds. The typical initial amplitude is as shown below.



7. Adjust the Clock Amplitude until the amplitude measured is between the maximum 15 to 20mVpp as targeted.

9.4 SAS 12G Rx Compliance Test Setup and Procedure

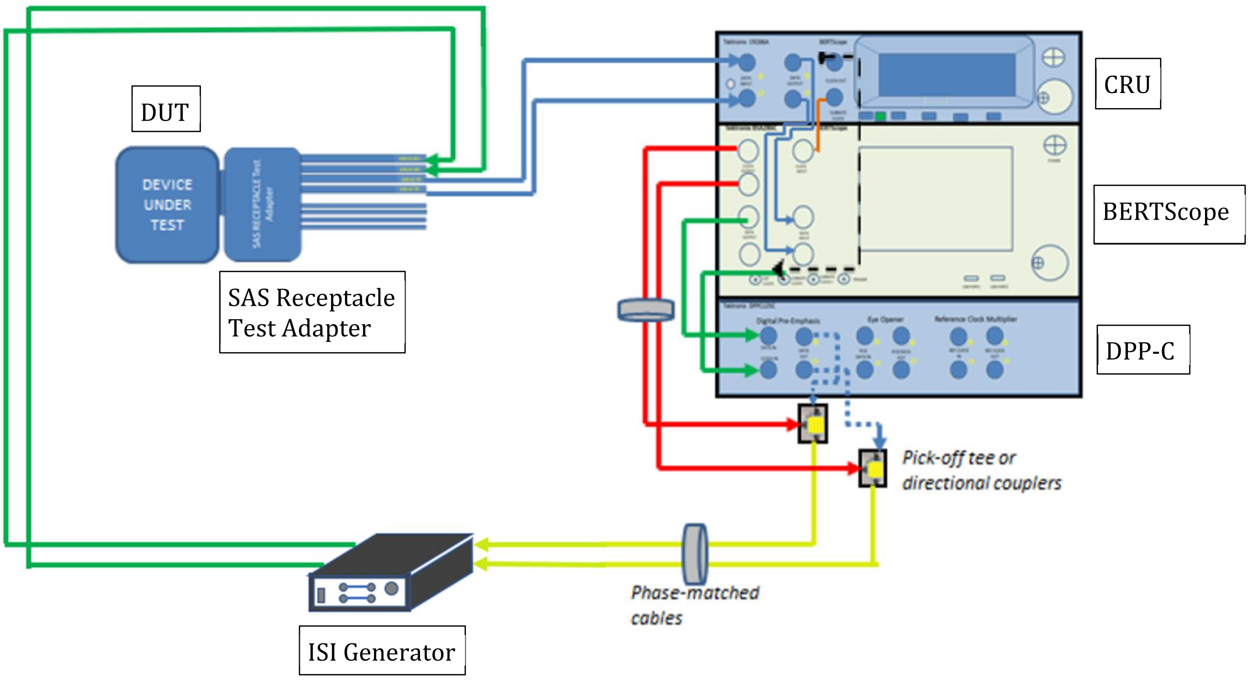
Compliance testing for receiver DUT jitter tolerance will use a clock recovery unit and the BERTScope analyzer/error detector in the loopback mode. The BERTScope will typically transmit CJTPAT signaling (which includes ISI effects, jitter and crosstalk) to the receiver DUT. During loopback, the clock recovery unit will extract clock data from the DUT's transmitted signal, and send the data to the BERTScope 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 37 to view the block diagram for the typical test setup.

9.4.1 Physical Setup

(Note: An external DPP-C is not required if using the Tektronix BSX BERTScope. The BSX BERTScope can be directly connected to the pick-off tees or directional couplers.)

1. Connect DATA OUTPUT(+) of the BERTScope to DATA IN of the DPP-C.
2. Connect Sub-rate Clock Output of the BERTScope to Clock Input of the DPP-C.
3. Connect Clock Outputs of the BERTScope to the pick-off tees tapped input ports.
4. Connect the pick-off tees inputs to DATA OUT+ and DATA OUT- of the DPP-C respectively.
5. Connect the pick-off tees outputs to the inputs of the ISI Generator.
6. Connect the outputs of the ISI Generator to the Rx+/- ports of the DUT via the SAS Receptacle Test Adapter.
7. Connect the Tx+/- ports of the DUT to Data Input+/- of the Clock Recovery unit (CRU).
8. Connect Data Output+/- of the CRU to Data Input+/- of the BERTScope Error Detector.
9. Connect the Sub-rate Clock Output of the CRU to Clock Input of the Error Detector.



9.4.2 Configure BERTScope Jitter Tolerance

Set the following number of received bits per respective maximum number of errors allowable for the BERTScope jitter tolerance. The specified number of bits will be transmitted to the DUT and the number of observable errors will be recorded. This is done to ensure a confidence level of 95% for the target BER of less than 1E-12.

Number of Errors	Number of Bits
0	3×10^{12}
1	4.74×10^{12}
2	6.3×10^{12}
3	7.75×10^{12}
4	9.15×10^{12}
5	1.05×10^{13}

9.4.3 Set Up CRU with/without SSC Support

Follow the same procedure from calibration to configure the CRU for SSC support (if supported by the DUT).

9.4.4 Set Up BERTScope Error Detector for Symbol Filtering

Perform Tx/Rx training on the signal with ISI and crosstalk sources enabled.

a) The BERTScope pattern generator will transmit the following Train_Tx-SNW pattern (Reference_SPL-2).

Table 73 — Transmitter training pattern

Transmitter training pattern	Description
Train_Tx pattern	Sequence of: 1) pattern marker (see 5.10.4.2.3.4.3); 2) TTIU (see 5.10.4.2.3.5); and 3) 58 data dwords set to 00000000h that are transmitted scrambled and 8b10b encoded.

The scrambler is the same as that defined for the link layer (see 6.6) and shall be initialized at the end of RCDT. The scrambler shall not be reinitialized for the remainder of the Train_Tx-SNW.

b) The receiver DUT will complete link training for the Train_Tx-SNW.
c) The BERTScope pattern generator will transmit the following Train_Rx-SNW pattern (Reference_SPL-2).

The Train_Rx-SNW contains receiver training patterns formed by TRAIN and TRAIN_DONE (see 6.2) as defined in table 74.

Table 74 — Receiver training patterns

Receiver training pattern	Description
TRAIN pattern	Sequence of: 1) TRAIN primitive sequence; and 2) 58 data dwords set to 00000000h that are transmitted scrambled and 8b10b encoded.
TRAIN_DONE pattern	Sequence of: 1) TRAIN_DONE primitive sequence; and 2) 58 data dwords set to 00000000h that are transmitted scrambled and 8b10b encoded.

The scrambler is the same as that defined for the link layer (see 6.6). If there is no Train_Tx-SNW, then the scrambler shall be initialized at the end of RCDT. If there is a Train_Tx-SNW, then the scrambler shall be initialized at the end of Train_Tx-SNW. The scrambler shall not be reinitialized for the remainder of the Train_Rx-SNW.

d) The receiver DUT will complete link training for the Train_Rx-SNW.

The formal back channel communication mechanism described in parts a) through d) above requires either access to state control registers that provide link training feedback or separately a protocol aware toolset (e.g., analyzer).

9.4.5 Test Receiver Jitter Tolerance BER

Transmit CJTPAT signaling to the DUT and verify BER on the BERTScope 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 be considered as compliant.

10 Appendix A: Connecting Tektronix Oscilloscope to PC

The following procedure explains how to connect the Tektronix DPOJET Series oscilloscope 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.

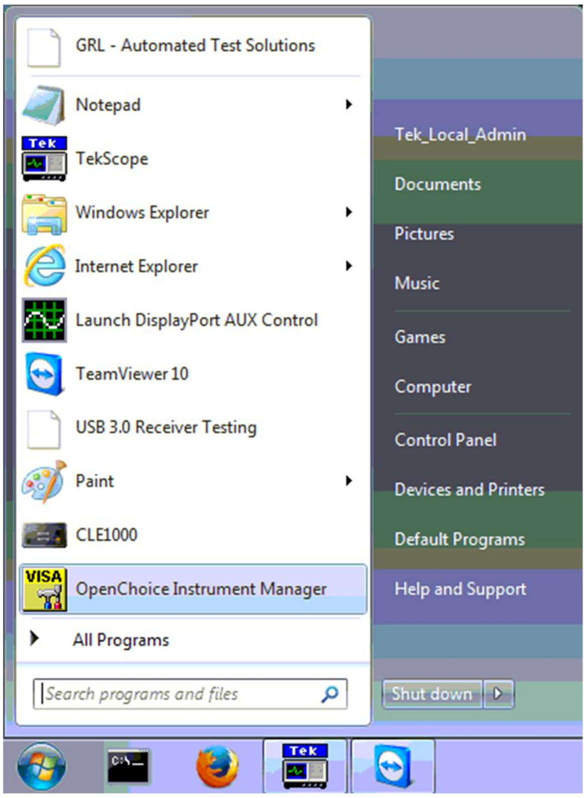


FIGURE 41. OPENCHOICE INSTRUMENT MANAGER IN START MENU

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.

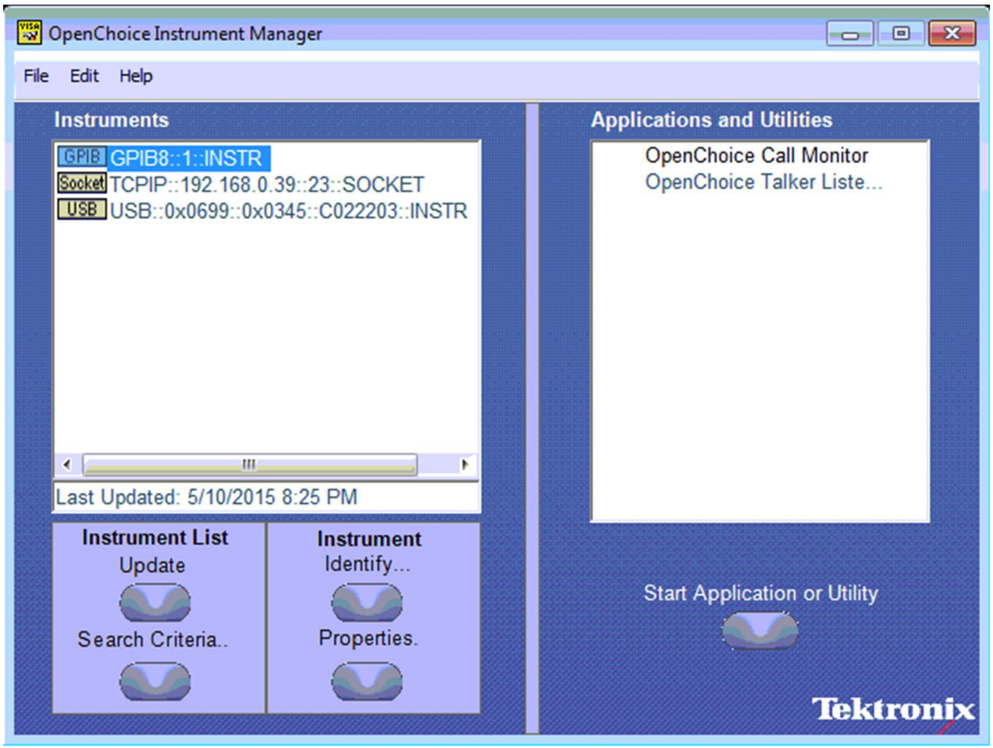


FIGURE 42. OPENCHOICE INSTRUMENT MANAGER MENU

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 SAS 12G Rx Test Application, type in the Scope address into the 'Address' field. If the GRL SAS 12G 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.

11 Appendix B: ARTEK CLE1000-A2 Installation

11.1 ISI Generator Driver Installation

If using the Artek CLE1000-A2 for Variable ISI Calibration, 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-A2 to the PC being used as the controller using a USB 2.0 cable.
2. Turn on the front panel power switch on the CLE1000-A2.
3. Right-click on **My Computer > Manage > Device Manager**. If no software for the CLE1000-A2 has been installed, you will see a 'bang' in the Device Manager.

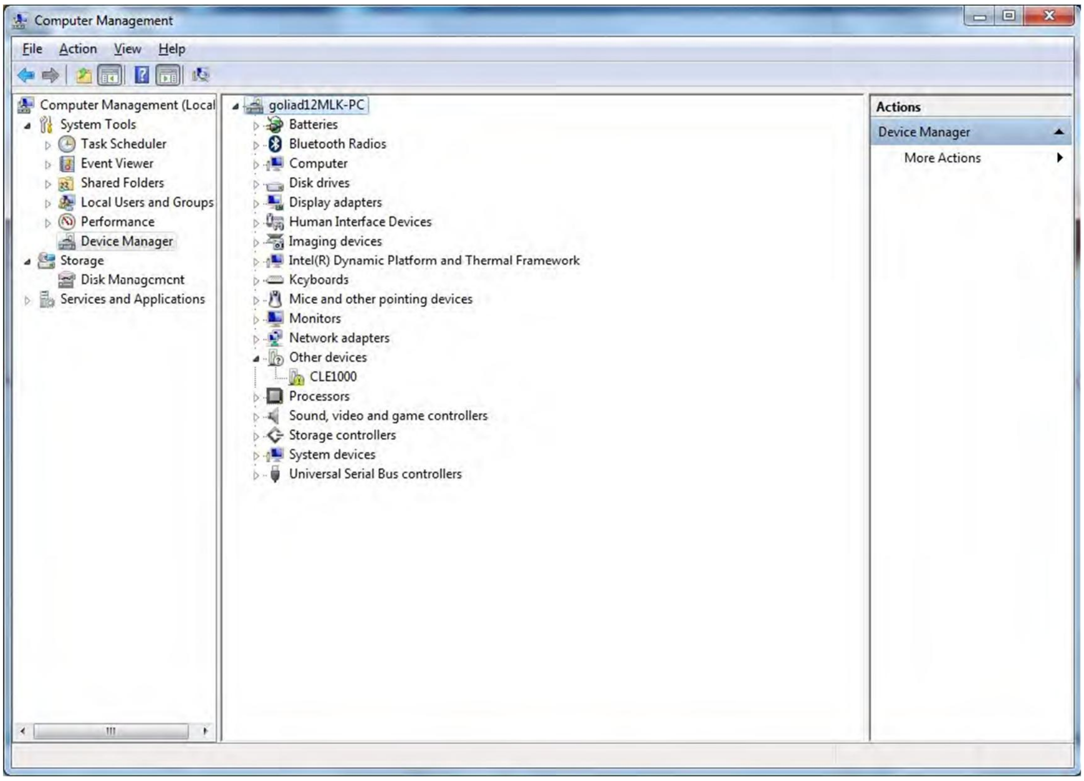


FIGURE 43. DEVICE MANAGER WINDOW

4. To install the CLE1000-A2 driver, go to http://www.aceunitech.com/support.html and download the Control Software package for the CLE1000-A2.
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.

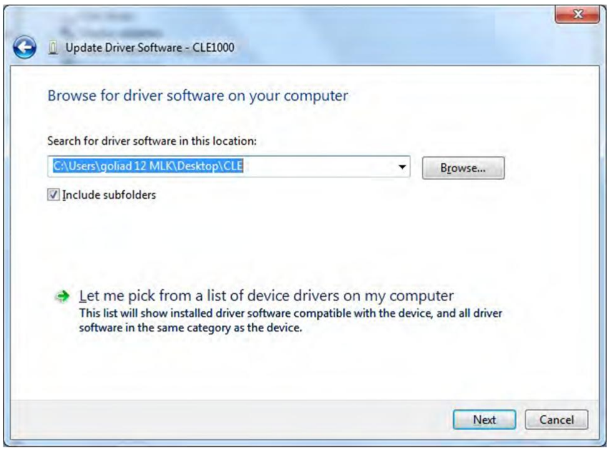


FIGURE 44. UPDATE DRIVER WINDOW

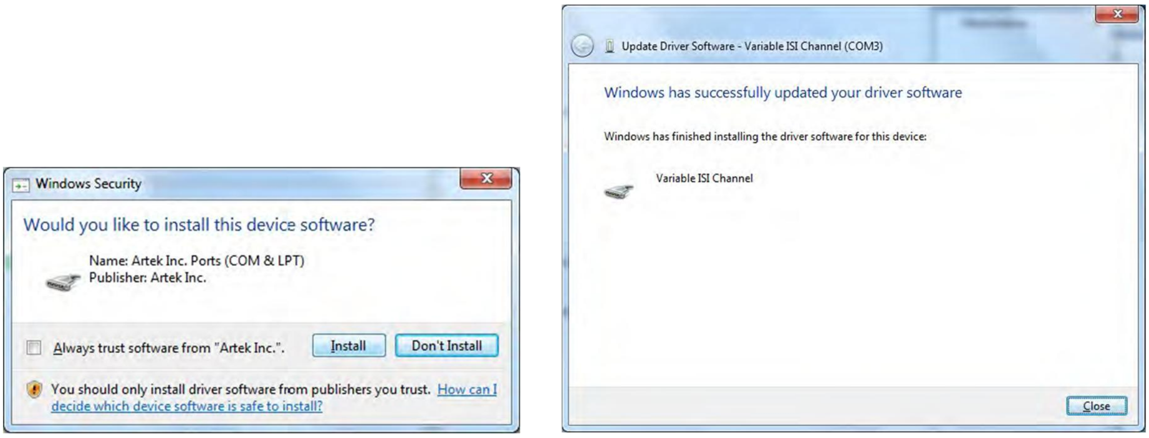


FIGURE 45. WINDOWS SECURITY WINDOW AND CONFIRMATION WINDOW

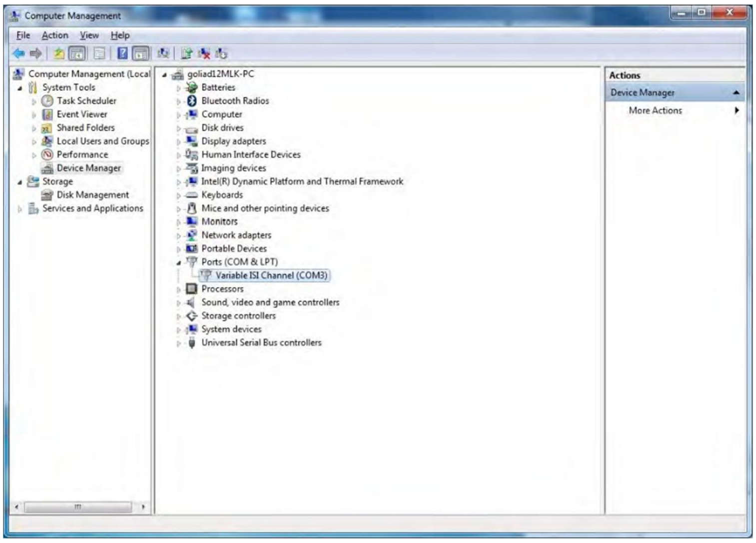


FIGURE 46. DEVICE MANAGER WINDOW AFTER INSTALLATION

The CLE1000-A2 is now ready to be used remotely with the GRL automation software.

11.2 CLE1000-A2 User Interface (UI) Installation

It may also be useful to install the CLE1000-A2 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.

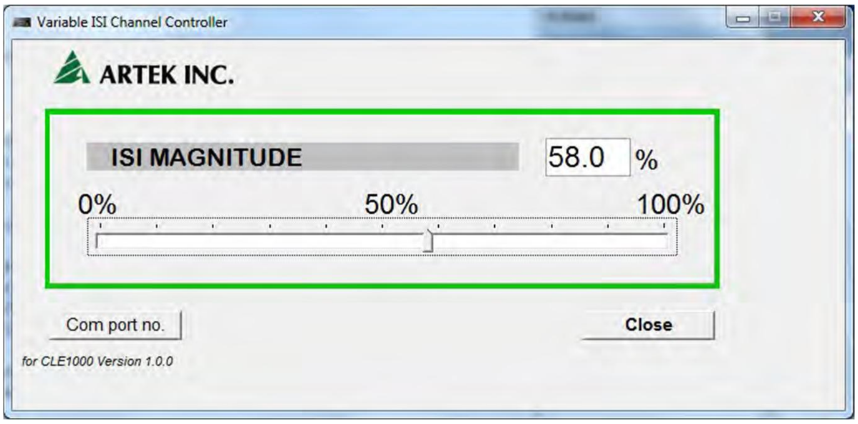


FIGURE 47. CLE1000-A2 UI

12 Appendix C: 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.

13 Appendix D: DPP-C to Data Skew Configuration

To correctly compensate for the delay in the Data Out vs. the Sub-rate Clock output from the BSA BERTScope, the cable interconnecting the Sub-rate Out to the DPP-C should be approximately 1.6 meters (60 inches) longer than the cable connecting the BERTScope Data Out to the DPP-C Data In. With the additional cable length providing the rough delay match, use the calibration method shown in Figure 50 to fine tune the delay match to ensure optimum DPP timing.

13.1 Connection and Configuration

13.1.1 Step 1. Connect the DPP-C to the BERTScope Analyzer

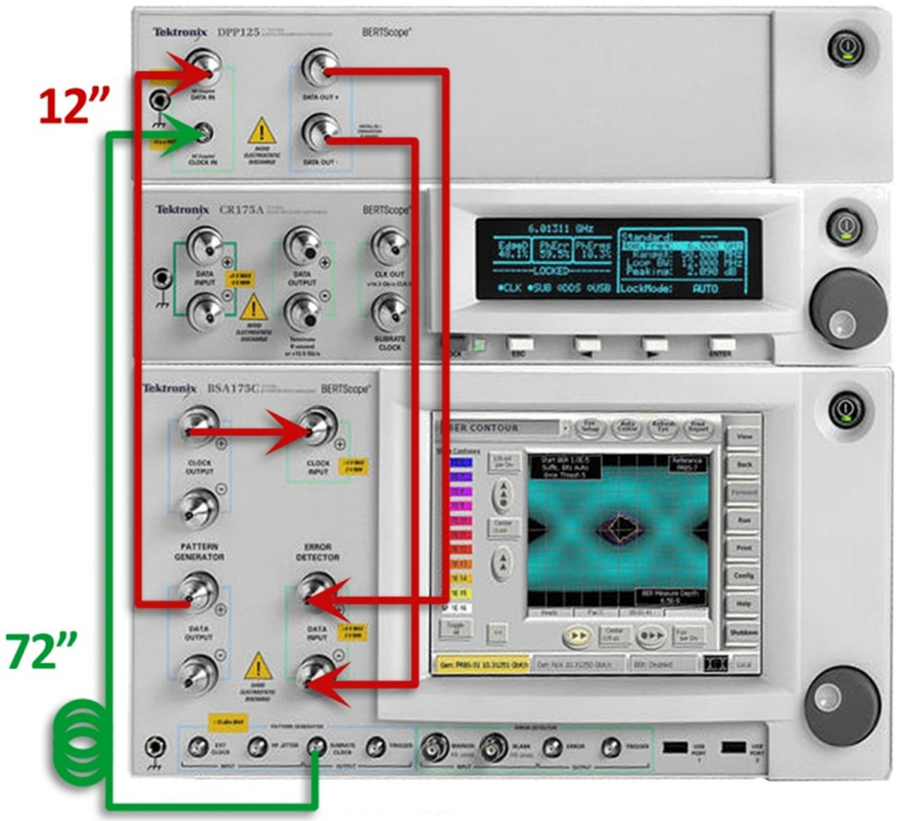


FIGURE 48. CONNECTIONS FOR DPP TIMING CALIBRATION

1. Using a cable of ~ 0.3 meters (12 inches), connect the Data Output+ of the BERTScope Generator to the Data Input of the DPP-C.
2. Using a cable of ~ 1.8 meters (72 inches) longer than the data cable, connect the Sub-rate Clock Out of the BERTScope Generator to the Clock In of the DPP-C.
3. Loop back the DPP-C Outputs to the Analyzer Error Detector Inputs. *This cable length is not critical.*
4. Turn on SJ. *(Go to View -> Stressed Eye -> Sine Jitter -> Enable)*
5. Set the SJ amplitude to 30%UI.
6. Set the SJ frequency to 50MHz.
7. Turn on RJ. *(Go to View -> Stressed Eye -> Random Jitter -> Enable)*

8. Set the RJ amplitude to zero. "Intrinsic Limit" will be indicated.

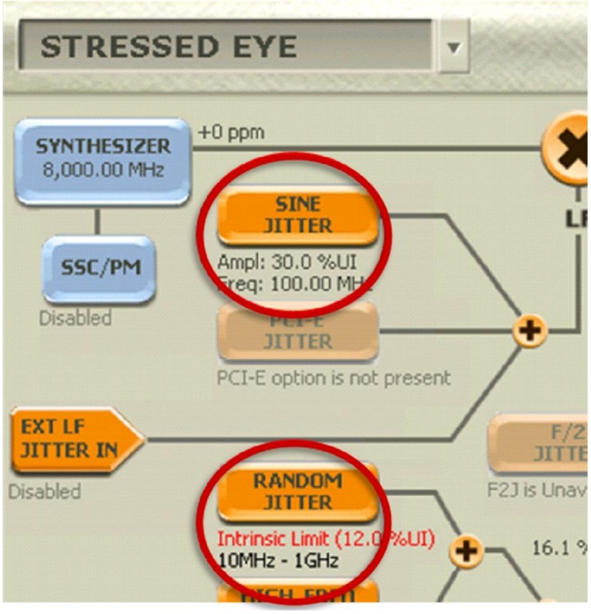


FIGURE 49. STRESS LEVEL CONFIGURATION

13.1.2 Step 2. Calibrate to Remove the Clock to Data Delay

1. Set the Generator Delay to 125 ps. *(Go to View -> Generator -> Delay)*

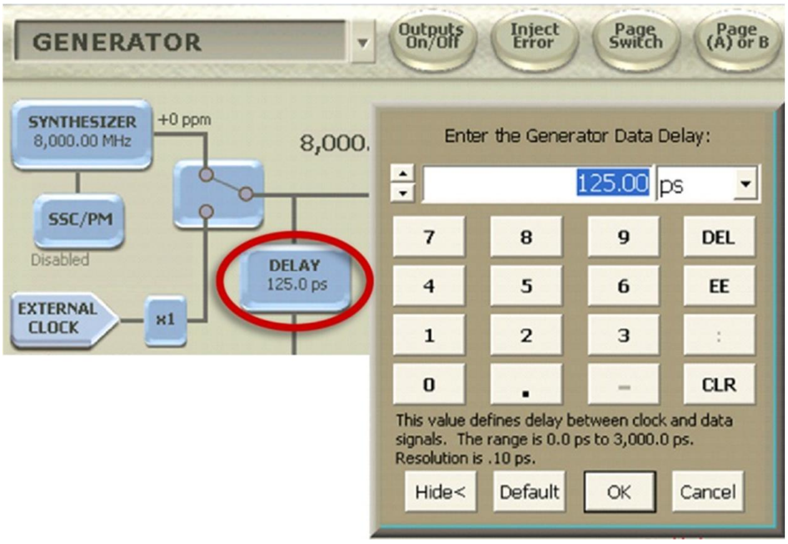


FIGURE 50. GENERATOR DELAY SETTING

2. On the BERTScope Detector view, check for error free operation (click 'Run' to start error counting). If not operating error free, advance the Generator delay to 183ps. Verify that the Detector is operating error free at this point. Record the Generator Delay.
3. Once error free operation is obtained, locate the boundary between error free and errored operation by decreasing the Generator Delay and using a binary search method as shown in Figure 51. Record the Generator Delay.

4. Return the Generator Delay to the error free point located in Step 2.
5. Locate the boundary between error free and errored operation by increasing the Generator Delay and using a binary search as shown in the figure below. Record the Generator Delay.
6. Set the Generator Delay to the average of the Delay values found in Steps 3 and 5. Record this Generator Delay value for later use in creating a Calibration Configuration file.

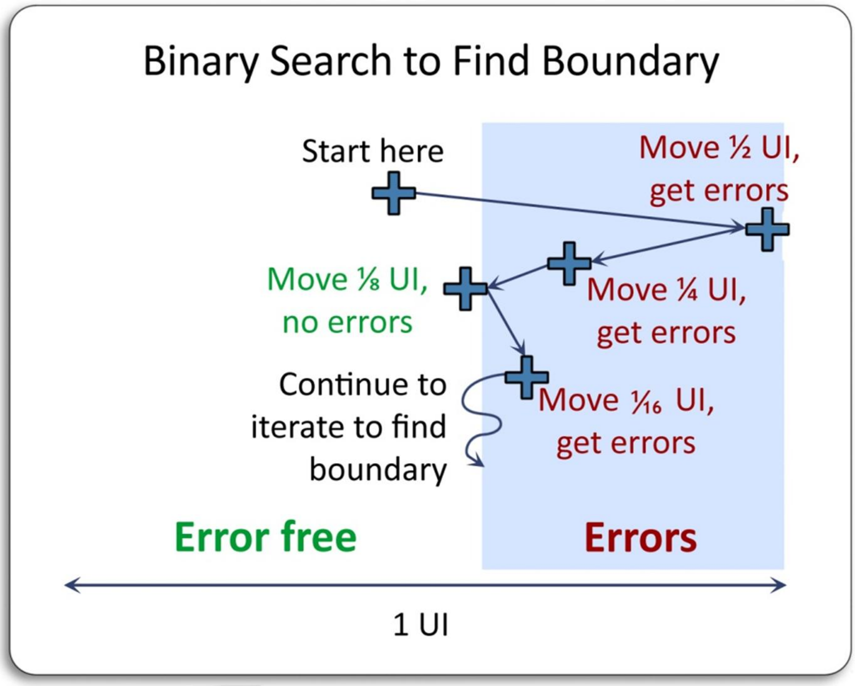


FIGURE 51. LOCATE OPTIMUM DELAY

13.1.3 Step 3. Record Generator Delay Value

After completing the Clock to Data skew calibration, record the BERTScope's Generator Delay setting for use in the Calibrated BERTScope Configuration file.

END_OF_DOCUMENT