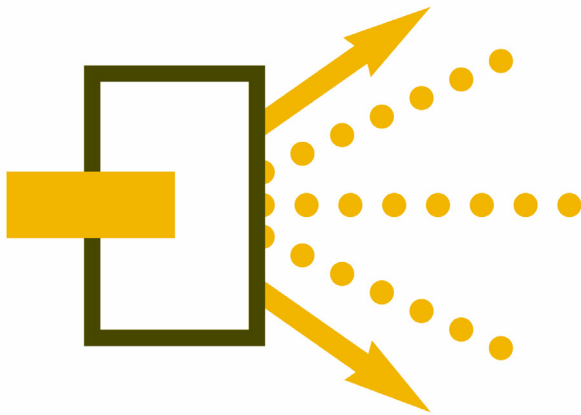


SDA-SAS

Software Option

Rev 1.1



Serial Attached SCSI

Featuring LeCroy's



Based on Clause 5 PHY Layer Tests from UNH-IOL



Operator's Manual

April 2006



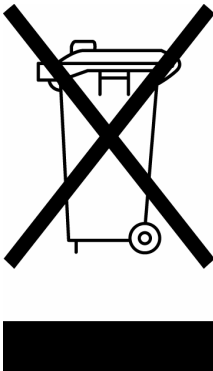
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INTRODUCTION TO SAS	3
Product Definition and Technology	3
SAS Roadmap	3
SAS Specification Basics	4
Transfer Rate	4
SAS Compliance Test Points.....	4
INTRODUCTION TO SDA-SAS.....	5
What is SDA-SAS?	5
Required Equipment	5
What Is X-Replay?	6
SOFTWARE INSTALLATION AND SYSTEM CONFIGURATION.....	7
Option Key Installation	7
CD-ROM Installation	7
X-Replay Configuration	8
Typical Configuration (Recommended)	8
Remote Configuration (GPIB or TCP/IP).....	8
PREPARING TO MAKE SAS MEASUREMENTS.....	11
Channel Deskew (SMA Cables).....	11
X-REPLAY OPERATION.....	13
Use of Configuration Variables in Test Sequences	13
Menu Structure.....	13
File	13
Edit.....	14
Sequence.....	14
Result Log.....	14
Report.....	15
Export to *.XML file – Database Access	15
Options.....	15
Devices	16
View	17
Help.....	17
Running SAS Tests	17
SAS TEST SUITE DESCRIPTION.....	18
Group 1 – OOB tests.....	19
Test 5.1.1: Tx maximum transients.....	19
Test 5.1.2: Rx maximum transients	20
Test 5.1.3: Tx Device OFF Voltage	21
Test 5.1.4: Tx OOB Offset Delta.....	21
Test 5.1.5: Tx OOB Common Mode Delta.....	21
Test 5.1.6: Tx Minimum OOB ALIGN Burst Amplitude.....	22
Test 5.1.7: Tx Maximum Noise during OOB Idle	22
Group 2 – SAS Signaling Tests.....	23
Test 5.2.1: TX Bit Rate	23
Test 5.2.2: TX Jitter	23
Test 5.2.3: TX Output Imbalance.....	24
Test 5.2.4: TX Rise and Fall Times	24
Test 5.2.5: TX Skew	24
Group 3: Impedance/Crosstalk tests.....	25
APPENDIX A - TEST PATTERN GENERATION	26
Test Pattern Generation Using LeCroy SAS <i>Tracer/Trainer</i>	26

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INTRODUCTION TO SAS

Product Definition and Technology

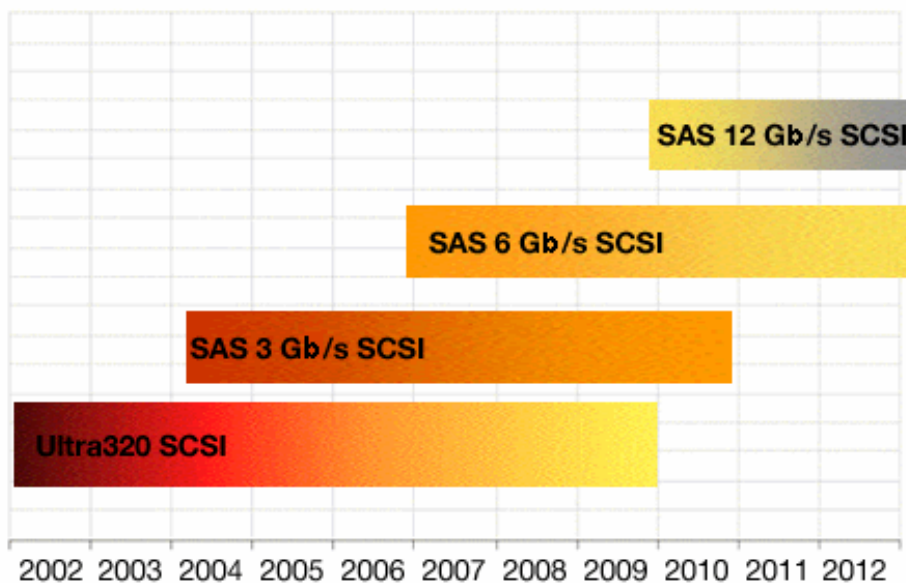
SAS (Serial Attached SCSI) is the logical evolution of SCSI (Small Computers System Interface), including its long-established software advantage and the Serial ATA electrical and physical connection interface. With enterprise storage requirements escalating and becoming more complex, factors such as larger capacity, greater density, security, scalability, and accessibility are more critical than ever. Enterprise data centers must be on line all the time, fulfill requests from numerous users simultaneously, allow for constant growth and expansion, and allow servicing while in operation. Serial Attached SCSI meets all these demands while providing the highest performance.

As the technology evolves, device support will be further enhanced, making it an even more attractive alternative for enterprise users who want a solution far superior and more flexible than any other storage technology. The results of aligning the Serial Attached SCSI and Serial ATA technologies to serve storage users, who need large capacity at a lower cost, will provide even greater choice to the storage industry.

For further information, contact the SCSI Trade Association (STA) at:

http://www.scsita.org/news_events/serial_storage.html

SAS Roadmap



Courtesy SCSITA.org

SAS Specification Basics

Transfer Rate

Table 34 — General electrical characteristics

Characteristic	Units	1,5 Gbps	3,0 Gbps
Physical link rate	MBps	150	300
Bit rate (nominal)	Mbaud	1 500	3 000
Unit interval (UI)(nominal)	ps	666,6	333,3
Differential media impedance (nominal)	ohm	100	
A.C. coupling capacitor, maximum ^a	nF	12	
Maximum noise during OOB idle time ^b	mV(P-P)	120	

^a The coupling capacitor value for A.C. coupled transmit and receive pairs.
^b With a measurement bandwidth of 1,5 times the highest supported baud rate (i.e., 4,5 GHz for 3,0 Gbps), no signal level during the idle time shall exceed the specified maximum differential amplitude.

SAS Compliance Test Points

Table 33 — Compliance points

Compliance point	Type	Description
IT	intra-enclosure (i.e., internal)	The signal from a transmitter device (see 3.1.243), as measured at probe points in a test load attached with an internal connector (e.g., with a SAS plug (see 5.2.3.2.1), SAS internal cable receptacle (see 5.2.3.2.2), SAS internal cable SATA-style signal cable receptacle (see ATA/ATAPI-7 V3), SAS backplane receptacle (see 5.2.3.2.3), SAS internal wide cable receptacle (see 5.2.3.4.2), SAS internal wide plug (see 5.2.3.4.3), SAS internal compact wide cable plug (see 5.2.3.4.5), or SAS internal compact wide receptacle (see 5.2.3.4.6))
IR	intra-enclosure (i.e., internal)	The signal going to a receiver device (see 3.1.150), 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 (e.g., with a SAS external cable plug (see 5.2.3.3.2), a SAS external receptacle (see 5.2.3.3.3), a SAS external compact cable plug (see 5.2.3.3.5), or a SAS external compact receptacle (see 5.2.3.3.6)).
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.

INTRODUCTION TO SDA-SAS

What is SDA-SAS?

The New LeCroy SAS Development Software for the SDA family of serial data analyzers is designed with two major objectives in mind:

First and foremost, SDA-SAS provides the necessary tools to demonstrate SAS device compliance in a systematic, step-by-step fashion, in accordance with specifications defined in Clause 5 of **ISO/IEC 14776-151, Serial Attached SCSI-1.1 (SAS-1.1) Standard T10/1601-D, Revision 10**.

Quick and easy access to all the compliance tests described in the UNH-IOL Serial Attached SCSI (SAS) Consortium Version 2.0 Technical Document, dated January 16, 2005 and implemented in the X-Replay Automated test Environment, which enables in-process measurement and reporting of SAS critical parameters.

The standard features of the SDA also provide a broad tool set for advanced debugging of the PHY layer interfaces, including jitter, eye pattern, and bit error rate.

SAS Development Software (SDA-SAS) is available as an option to the SDA family of Serial Data Analyzers by installing X-Stream DSO firmware version 4.7 or later. SDA-SAS should be used in conjunction with the minimum necessary instrument bandwidth:

- For SAS running at 1.5 Gb/s: SDA 6000A / SDA 6020
- For SAS running at 3.0 and 6.0 Gb/s: an SDA 11000 or higher BW is necessary.

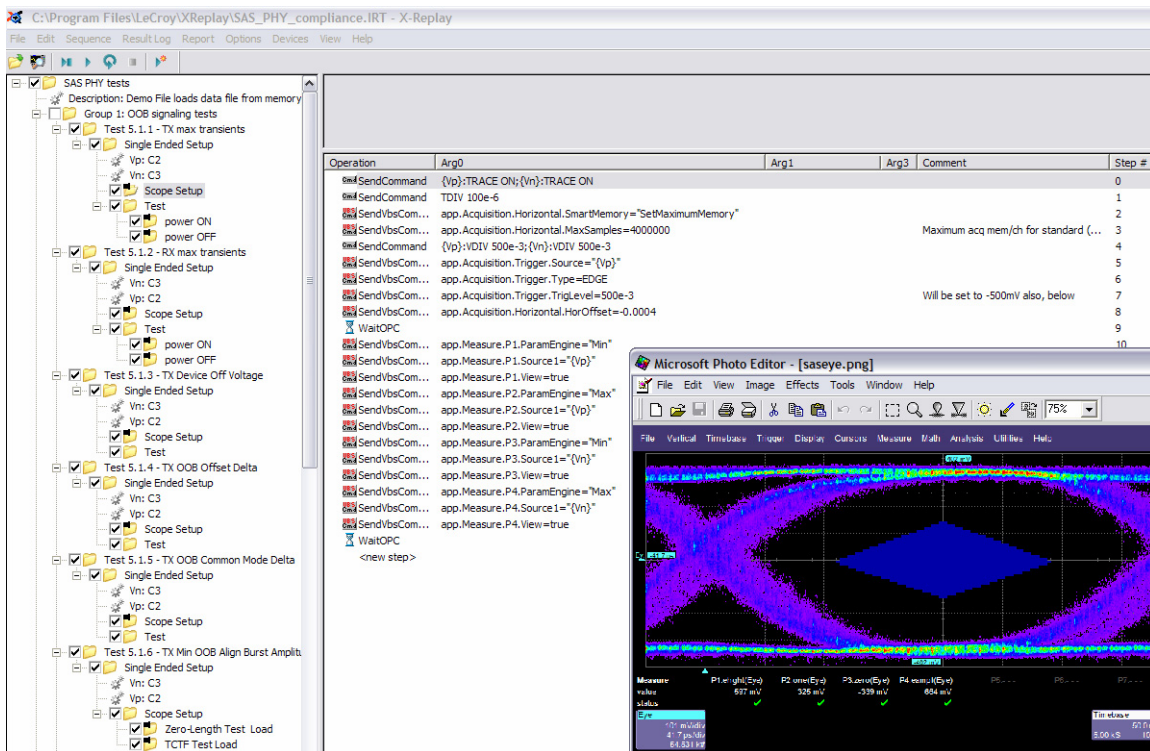
Required Equipment

- SDA 6000A, 6020 or SDA 11000 equipped with ASDA-J Advanced Serial Data Analysis software option and SAS option key
- SAS Compliance & Development software option (LeCroy SDA-SAS)
- SAS Zero Length test fixture (Drive or Backplane Style) with SMA connectors
- Transmitter Compliance Transfer Function (TCTF) or Low Loss TCTF fixture with SMA connectors
- 2 differential probes (D600-type for SDA 6000A or SDA 6020, D11000PS-type for SDA 11000)
- 1 SMA 'T' connector
- 1 BNC-to-SMA adapter
- High-quality SMA Cables
- A Host computer, though not required, is highly recommended to execute X-Replay, the Compliance & Development Software Engine.
- Option DMD-1 (Dual Monitor Display), though not required, is highly recommended for execution of X-Replay in a second screen.

What Is X-Replay?

The new SDA-SAS Software application incorporates X-Replay, a unique application framework. X-Replay is a MS Windows-based application that contains all the commands and instructions necessary to configure, acquire, display, and report measurement results. For instance, the X-Replay environment enables you to:

- Create or change test criteria in order to make context-sensitive parametric measurements.
- Export all test results as XML, for import into a database program such as Microsoft Access for further manipulation.
- Generate reports from within X-Replay, showing the latest test results. Reports are html, meant to be viewed with Microsoft Internet Explorer, or pdf formatted for Adobe Acrobat users.



The SAS Compliance software resides in X-Stream DSO software in the scope, and it is activated through the use of an alphanumeric code matched to the scope's serial number. This code is unique to each scope serial number, and it is activated when ordering SDA-SAS software.

While the software key enables the scope to perform the measurements, X-Replay contains the SAS script, the test results database and the report generation engine. For ultimate flexibility, X-Replay can be executed from a host computer at a remote location, provided that there is a Windows-compatible network connection. By default X-Replay comes already installed on the scope.

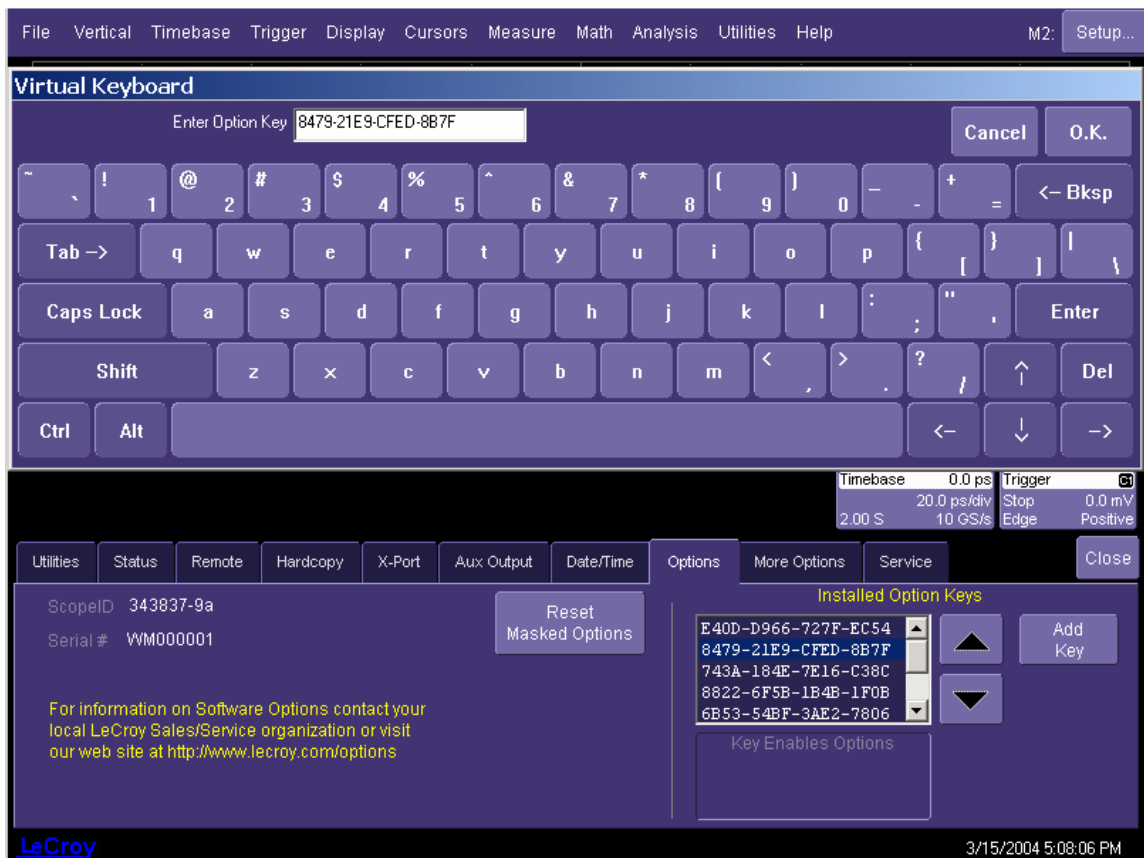
SOFTWARE INSTALLATION AND SYSTEM CONFIGURATION

Option Key Installation

When ordered as an option for a new instrument, no installation is necessary. Installation is required, however, when the option is ordered after the oscilloscope is purchased. An option key will be issued at the time the option is purchased.

To enter the option key code,

1. Touch **Utilities** in the menu bar, then **Utilities Setup...** in the drop-down menu.
2. Select the "Options" tab from the utilities dialog.
3. In the Options dialog, touch the **Add Key** button and enter the option key in the dialog box, using the on-screen keyboard.



Entering the option key code for the SDA-SAS software option

CD-ROM Installation

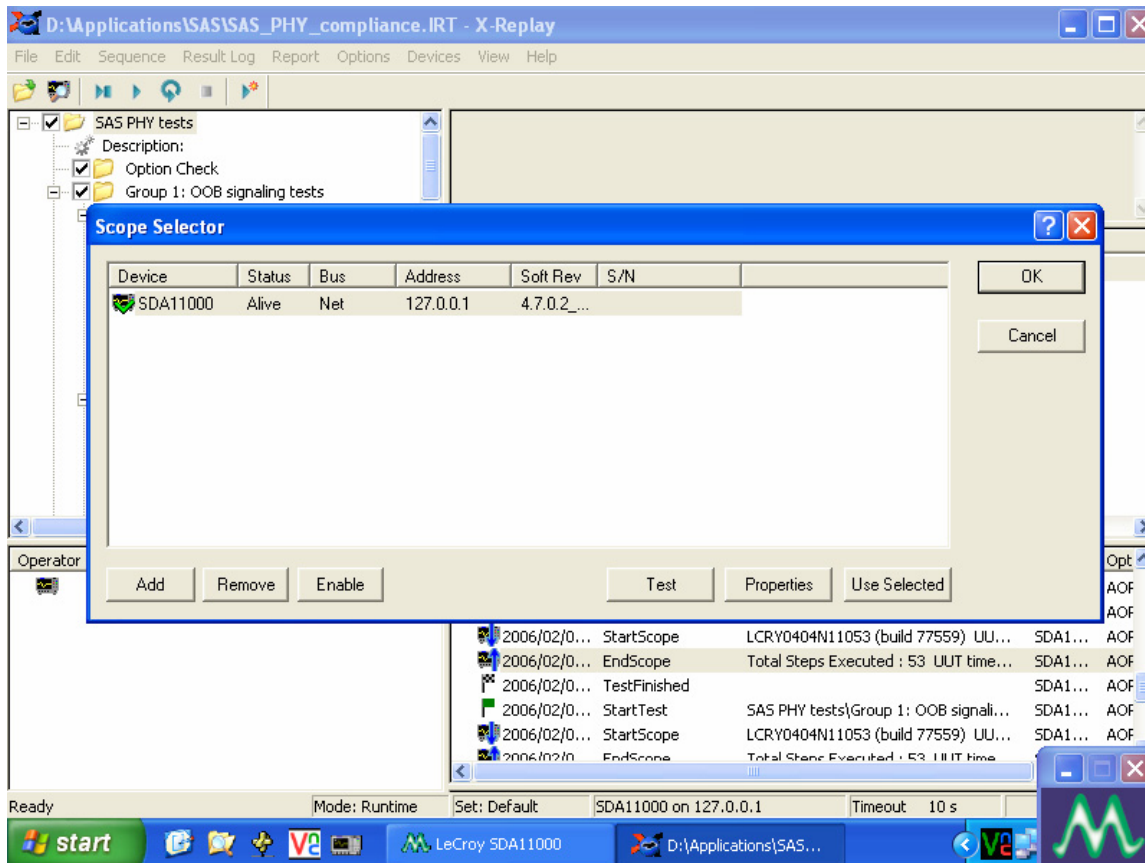
When ordered as an upgrade to an existing X-Stream instrument, an Application Software CD-ROM is supplied containing X-Replay and other software installation files. Follow the specific instructions in the Installer application. When necessary, the installation process will prompt you for storage locations for data files and test results, reports, scripts, etc.

X-Replay Configuration

Typical Configuration (Recommended)

SDA-SAS software can be executed from the scope PC or from a Host PC. By default, a new scope will come equipped with X-Replay installed in the scope. LeCroy recommends running SDA-SAS in a scope equipped with Dual Monitor Display capability (Option DMD-1), such that the waveform and measurements are displayed in the scope LCD display, whereas the X-Replay application and test results are displayed on a second monitor. When X-Replay is executed in the scope, the scope will appear as a local host (IP address is 127.0.0.1). To verify its correct operation, the following steps must be taken once the scope is turned on:

1. Minimize the X-Stream scope window
2. Run X-Replay
3. Select Scope Manager. The scope selector window will display the ID of the scope attached (in this case, an SDA 11000)



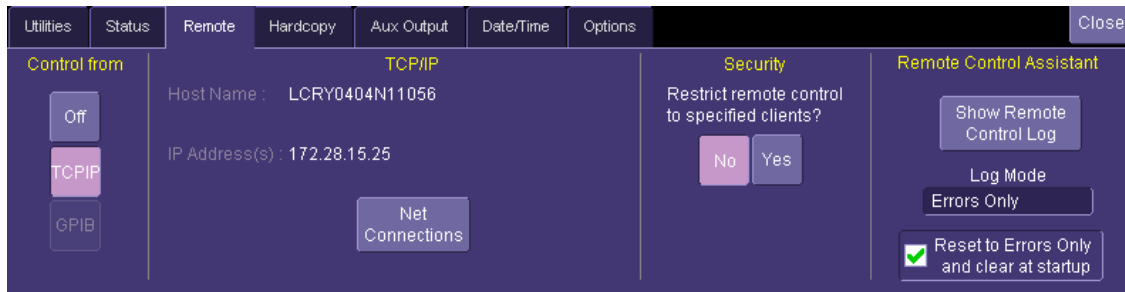
4. Press the **Test** button. When the scope is detected, a message box will indicate that the device is OK. X-Replay is now ready for use.

Remote Configuration (GPIB or TCP/IP)

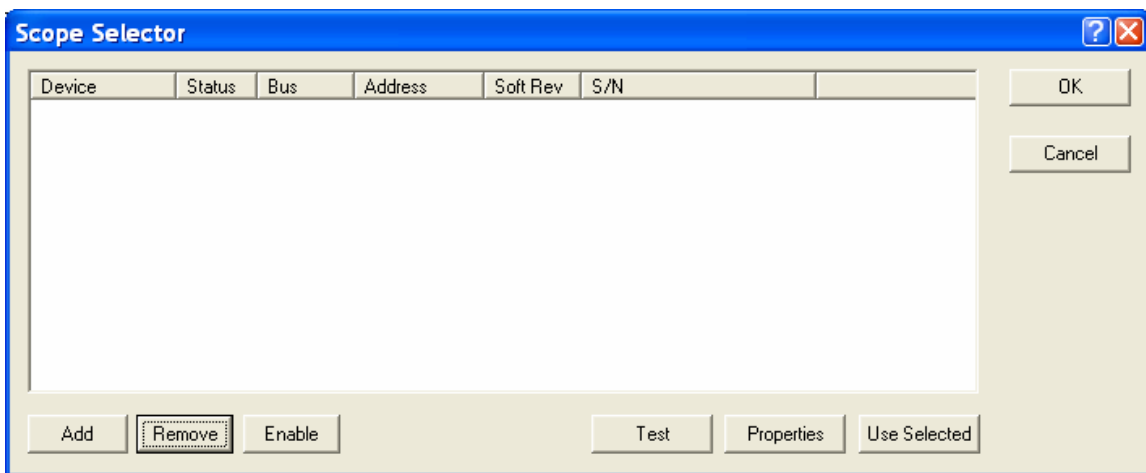
Of course, it is also possible to run SDA-SAS by installing X-Replay in a remote host PC, controlling the scope via a GPIB/LAN Connection, which allows you to control other instruments or run applications from the host PC (for example, setting up and configuring more than one LeCroy instrument). The scope selected must already be configured with an IP address (fixed or network-assigned) or a GPIB address.

As an example of setting up a scope using X-Replay over a LAN (Local Area Network), follow these steps:

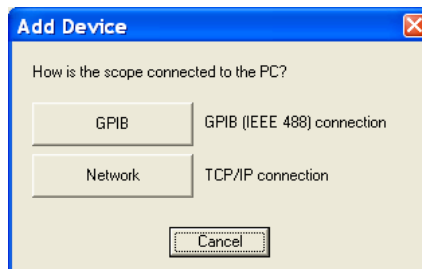
1. Verify in the **Utilities, Remote** dialog that the scope has an assigned IP address, control is set to TCP/IP as shown below.



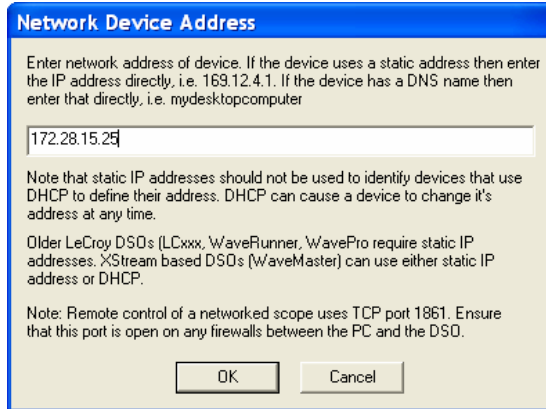
2. Make sure that the host PC is connected to the same LAN as the scope. If unsure, contact your system administrator.
3. Run **X-Replay** in the host PC and select the **Devices** menu, then **Scope Selector**. The screen should have no devices enabled at this time:



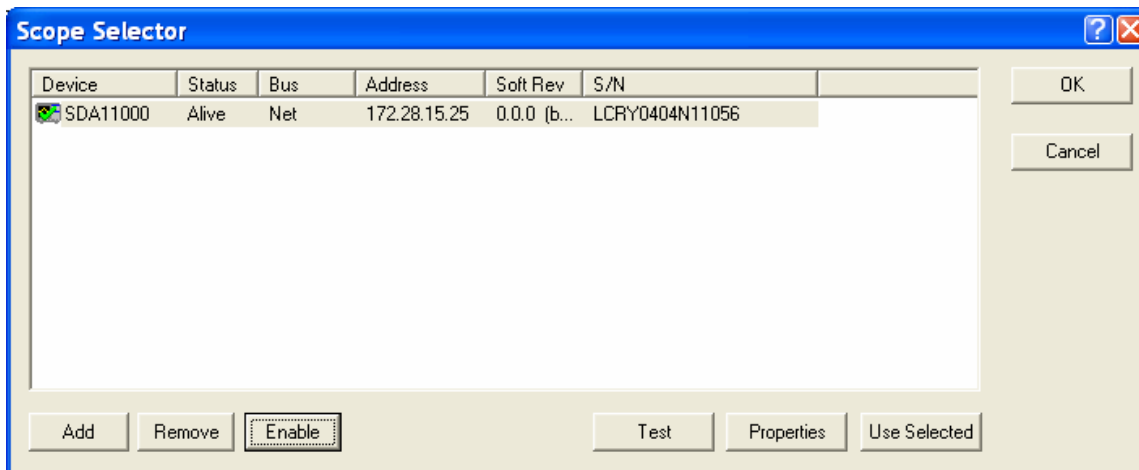
4. Click the **Add** button. Select the connection method (**GPIB** or **Network**):



5. In our case, we'll select **Network**, then enter the **IP address** from step #1



- Click **OK**. The Scope Selector window will display the correct information about the scope connected to the LAN. In our example, an SDA 11000 is connected as shown below:



- Repeat Steps 4 through 6 to add other devices.

Note: Every scope configured to operate over the LAN, using X-Replay, must have the SAS option key installed. If the option key is not installed, the application will not work.

PREPARING TO MAKE SAS MEASUREMENTS

Channel Deskew (SMA Cables)

SAS signals are properly probed using two separate channels on the oscilloscope connected to the appropriate SMA jacks on the test fixture. The highest measurement accuracy is achieved when the timing skew between the two channels is calibrated. This is performed using the “Deskew” control on one of the two channels to which the differential signal is connected, as follows:

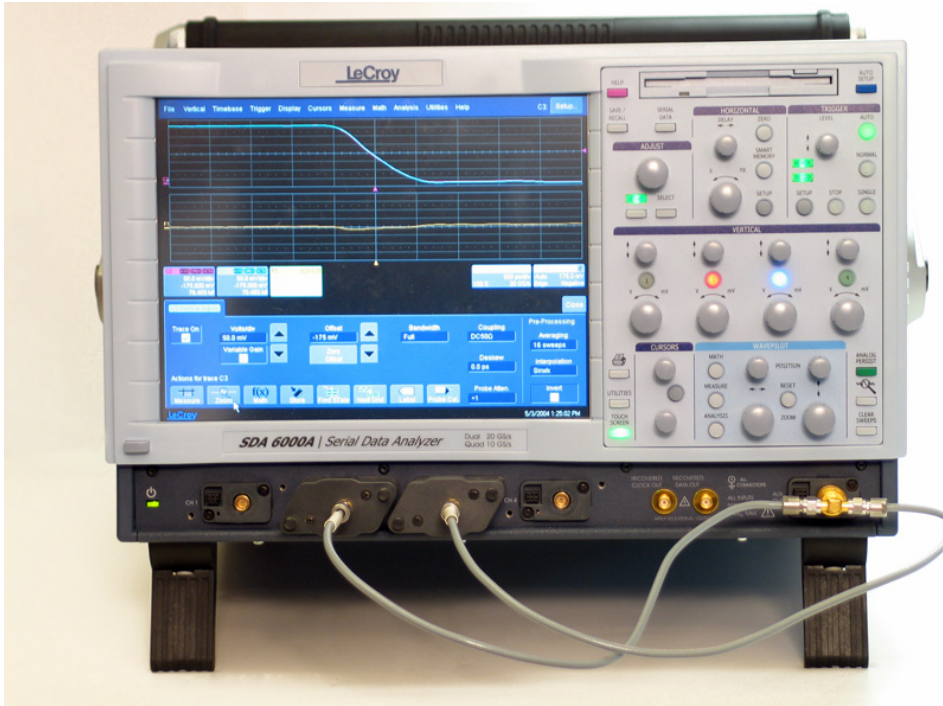
1. Attach the calibrator signal to both input channels using a “T” connector to rout the calibrator signal on the SDA front panel through the same cables that will be connected to the fixture.
2. Set interpolation of both channels to **Sinx/x**, using the **Interpolation** control in the “Vertical Adjust” dialog for each channel.
3. Check the **Invert** checkbox on one channel.
4. Create a Difference math waveform by selecting **Math** in the menu bar, then **Math Setup...** in the drop-down menu. Enter the channels to which your signal is connected in the **Source1** and **Source2** fields, and select **Difference** from the **Operator1** menu. The math function is thus defined as the difference between the 2 channels probing the D⁺ and D⁻ signals.
5. While viewing the math trace, adjust the **Deskew** control in one of the channels until the math trace is as flat as possible.

Note: With the **Deskew** control highlighted, you can use the front panel **ADJUST** knob to make the adjustment.

The best accuracy is achieved by setting the level of the calibrator signal to match the expected levels of the signal under test, and with the calibrator set to its maximum frequency (5 MHz). The calibrator settings can be found in the “Utilities” dialog under the **Aux Output** tab.



Deskew control in channel menu. Adjust this value to achieve minimum skew.



Deskew cable setup. The calibrator signal is connected to the cables using a “T” connector or resistive divider. The calibrator peak voltage should be set to the same value as the nominal voltage of D+ and D-.

X-REPLAY OPERATION

This section covers use of X-Replay and the supplied “SAS_PHY_Compliance.irt” script to perform tests described in the UNH-IOL document, and generation of a test results report from X-Replay.

X-Replay allows you to test SAS functionality in several ways:

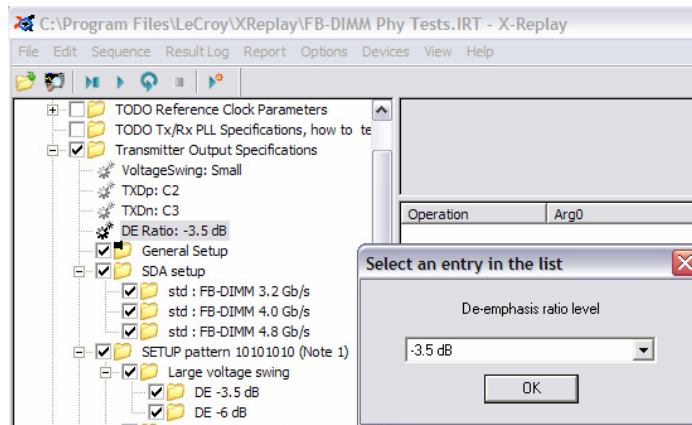
- Select, repeat, and skip tests, as required, to demonstrate or develop different PHY functions
- Establish Test Limits for each of the versions of the SAS specification, and modify, create, or delete entire test limit sets
- Generate Test Reports based on the tests actually run
- For XML-formatted reports, query a database using test results generated in prior test sessions or experiment runs

X-Replay application display is divided into several windows (clockwise, from upper left hand):

- Test Sequence Window
- Test Description Window
- Commands Window
- Activity Log Window
- Session Window

Use of Configuration Variables in Test Sequences

Configuration Variables allow you to define system inputs such as signal sources, probe types, a specification parameter set to be used for testing, form factors, and other global conditions. These variables can be set prior to beginning tests, or changed between test runs.



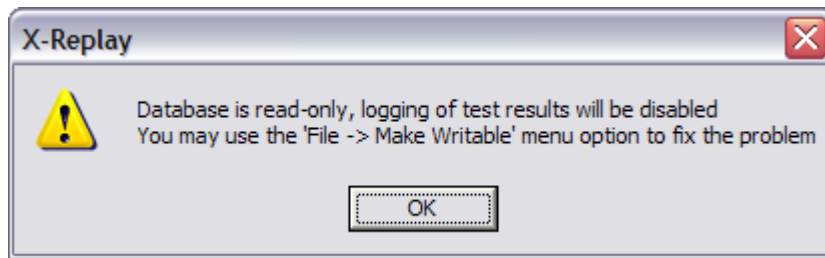
Right-clicking on any variable allows you to reset the variable to its default setting, or to change the value to be used for subsequent tests.

Menu Structure

File

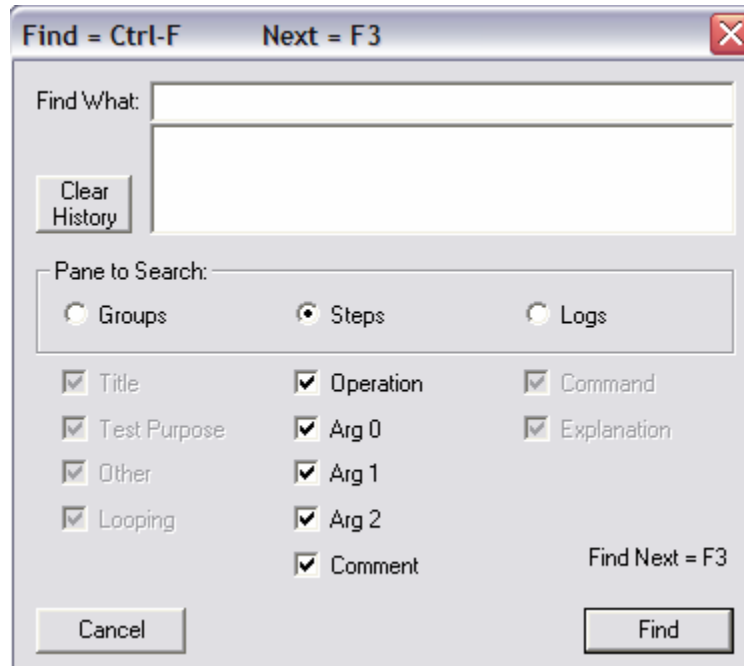
Open Test File (Test Database). The file extension is *.irt

Make Read Only disables writing test results into session log. *Make Writable* reverses the action.



Edit

Performs the find function to locate specific measurements or actions in the program sequence



Sequence

Execute program items starting at the designated point. The Menu Toolbar displays the available choices, from left to right:



- *Single Step [F10]* executes one instruction at a time
- *Play Selected Group and Children [F5]* executes all the checked items in the selected group,
- *Play selected group Continuously* executes all checked items in the selected group until *Stop*
- *Stop* stops execution (active when Play has been pressed)

Result Log

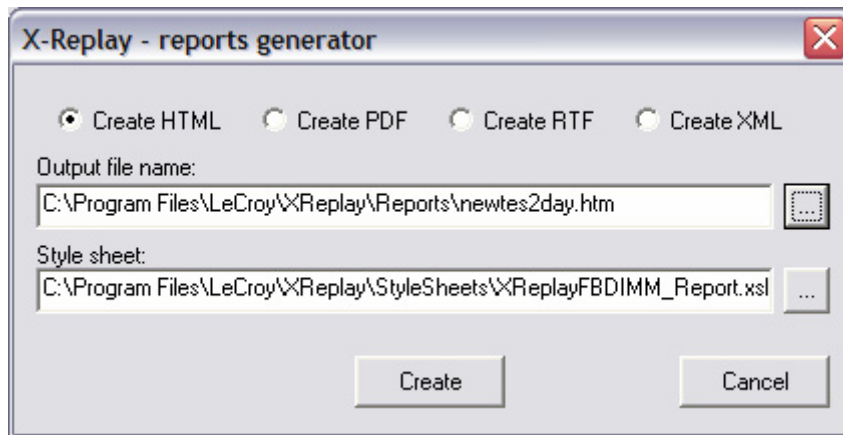
Clear Log removes all the previously recorded activity

Export to File (ASCII) creates a comma-separated-values set of activity records

Export to File (ASCII) Standard creates a text file PHY tests checklist.logdump.txt

Report

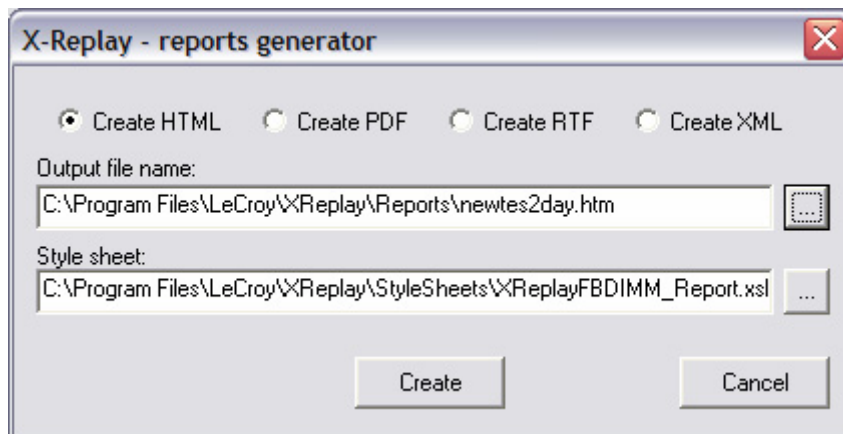
Creates a report with one of three formats (html, pdf or rtf) based on the specified report template Style Sheet (*.xsl or *.xslt). For Style sheet, please select the supplied "XReplay_Report.xslt". The "..." button to the right of the text entry field can be used to browse and find that file. On an SDA, it can be found in D:\Applications\SAS.



Export to *.XML file – Database Access

X-Replay allows you to export entire test sessions to XML file for subsequent access by database programs such as Microsoft Access. Most database programs have built-in XML import data capability. Please note that test sessions appear at the lower left portion of the X-Replay screen.

In order to create an XML record of the session data, select Create XML on the Report Generation window:



Saving test results to *.xml format

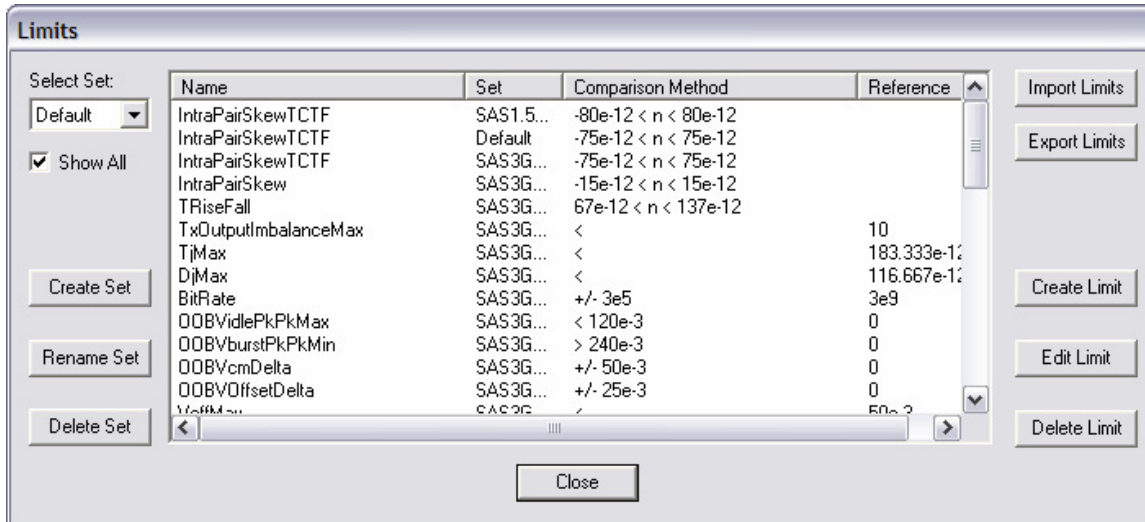
Options

Select the **Limits** option to allow the configuration of individual parameters pass/fail criteria, or edit, rename, and save complete parameter sets.

Create Set: You can create a new, named set of limits. Initially, the new set is the same as the set selected when pressing "Create Set".

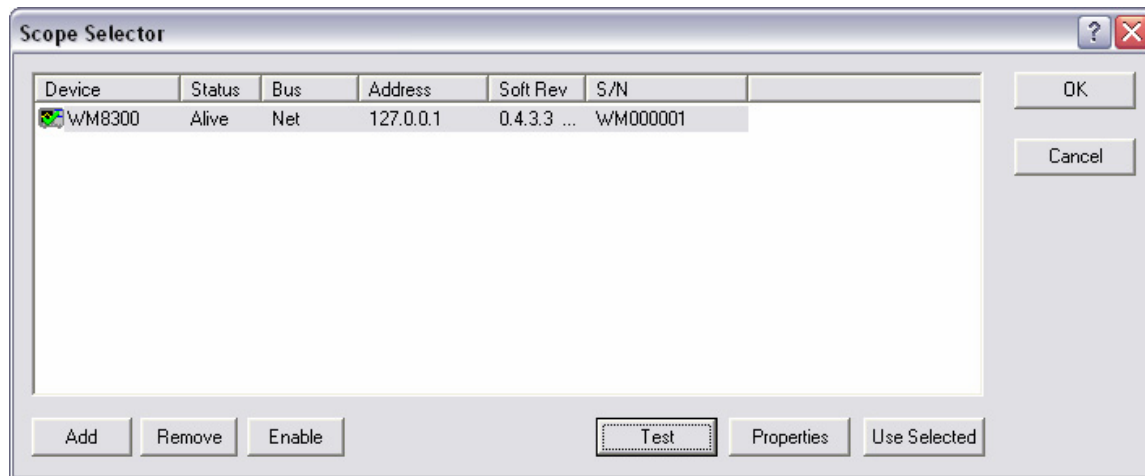
Edit Limit: **Using Edit** Limit allows limits to be changed to meet specific pass/fail criteria.

Import/Export Limits allow you to transfer entire parameter sets to csv-formatted (MS Excel) files.

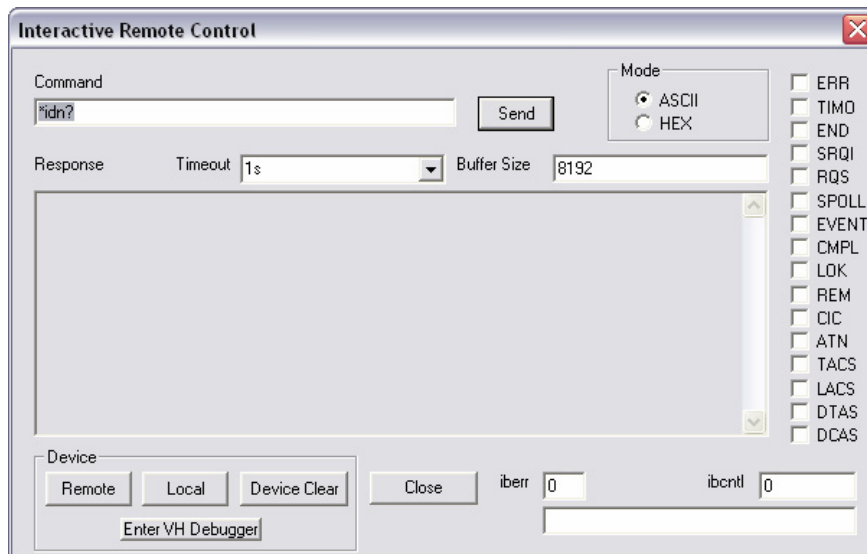


Devices

Scope Manager displays the devices connected to the host computer. There are two supported modes of attaching a device: GPIB or LAN.



Interactive Dialog supports sending and receiving of single line commands to the devices on the list.



View

Enables/Disables Toolbar and Status bars

Help

Help Topics

Running SAS Tests

1. Verify proper signal input and observe all deskew and calibration procedures.
2. Run X-Replay application.
3. Open The SAS PHY Tests Checklist database.
4. Select the test groups to be executed.
5. Set up ***Configuration Variables*** as required for the selected tests.
6. Press **Play** and follow script prompt(s) as required.

SAS TEST SUITE DESCRIPTION

Note: All the tests covered by this Manual refer to the ISO/IEC 14776-151, *Serial Attached SCSI-1.1 (SAS-1.1) Standard T10/1601-D*, Revision 10. For reference purposes, the test procedure descriptions are reproduced from the UNH-IOL Clause 5 document.

GROUP 1: OOB SIGNALING TESTS

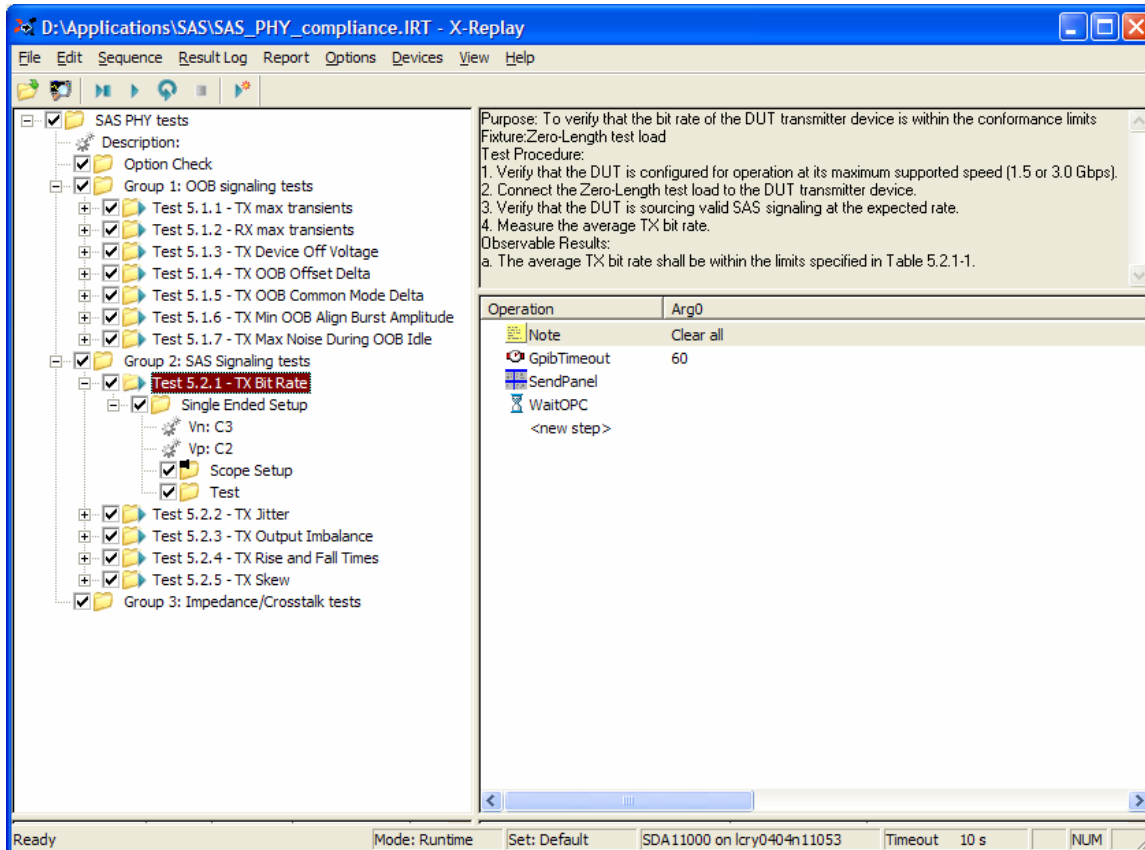
- TEST 5.1.1 - TX MAXIMUM TRANSIENTS
- TEST 5.1.2 - RX MAXIMUM TRANSIENTS
- TEST 5.1.3 - TX DEVICE OFF VOLTAGE
- TEST 5.1.4 - TX OOB OFFSET DELTA
- TEST 5.1.5 - TX OOB COMMON MODE DELTA
- TEST 5.1.6 - TX MINIMUM OOB ALIGN BURST AMPLITUDE
- TEST 5.1.7 - TX MAXIMUM NOISE DURING OOB IDLE

GROUP 2: SAS SIGNALING TESTS

- TEST 5.2.1 - TX BIT RATE
- TEST 5.2.2 - TX JITTER
- TEST 5.2.3 - TX OUTPUT IMBALANCE
- TEST 5.2.4 - TX RISE AND FALL TIMES
- TEST 5.2.5 - TX SKEW

GROUP 3: IMPEDANCE/CROSSTALK TESTS

- TEST 5.3.1 - RX DIFFERENTIAL IMPEDANCE
- TEST 5.3.2 - RX DIFFERENTIAL IMPEDANCE IMBALANCE
- TEST 5.3.3 - RX COMMON MODE IMPEDANCE
- TEST 5.3.4 - RX TERMINATION TIME CONSTANT
- TEST 5.3.5 - RX MAXIMUM NEAR-END CROSSTALK
- TEST 5.3.6 - TX DIFFERENTIAL IMPEDANCE
- TEST 5.3.7 - TX DIFFERENTIAL IMPEDANCE IMBALANCE
- TEST 5.3.8 - TX COMMON MODE IMPEDANCE



Group 1 – OOB tests

Test 5.1.1: Tx maximum transients

Purpose: To verify that the peak voltage transients on the DUT transmitter device are below the conformance limit

Fixture: SAS Transmitter device transient test circuit

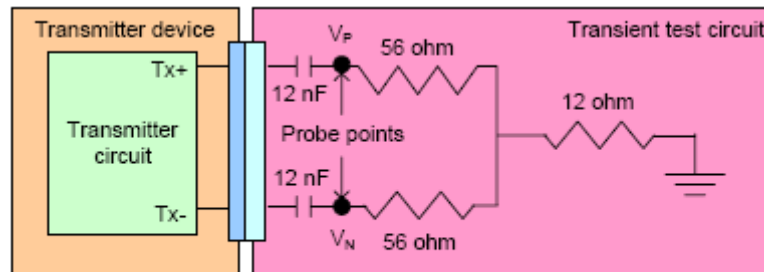


Figure 103 — Transmitter device transient test circuit

Test Procedure:

1. Connect the transmitter transient test circuit to the DUT.
2. Cycle the DUT from the power OFF state to the power ON state.
3. Measure the maximum transmitter transients.
4. Cycle the DUT from the power ON state to the power OFF state.

5. Measure the maximum transmitter transients.
6. Repeat steps 2 through 4 as necessary to determine that the peak transient value is observed.
7. Capture and save the worst-case observed transient waveform.

Observable Results:

- a. The peak magnitude of all transients shall be less than 1.2 volts.

Actual Measurement Setup: 100 μ s/div, 4 MS maximum memory. Two waveforms captured (ON \rightarrow OFF and OFF \rightarrow ON). Measure min and max on two waveforms.

Test 5.1.2: Rx maximum transients

Purpose: To verify that the peak voltage transients on the DUT receiver device are below the conformance limit

Fixture: SAS Receiver device transient test circuit

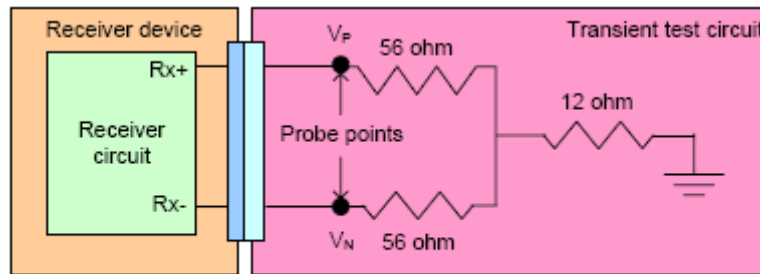


Figure 104 — Receiver device transient test circuit

Test Procedure:

1. Connect the receiver transient test circuit to the DUT.
2. Cycle the DUT from the power OFF state to the power ON state.
3. Measure the maximum receiver transients.
4. Cycle the DUT from the power ON state to the power OFF state.
5. Measure the maximum receiver transients.
6. Repeat steps 2 through 4 as necessary to determine that the peak transient value is observed.
7. Capture and save the worst-case observed transient waveform.

Observable Results:

- a. The peak magnitude of all transients shall be less than 1.2 volts.

Actual Measurement Setup: 100 μ s/div, 4 MS maximum memory. Two waveforms captured (ON \rightarrow OFF and OFF \rightarrow ON). Measure min and max on two waveforms.

Test 5.1.3: Tx Device OFF Voltage

Purpose: To verify that the TX device off voltage of the DUT transmitter device is below the conformance limit

Fixture: Zero-Length test fixture with SMA

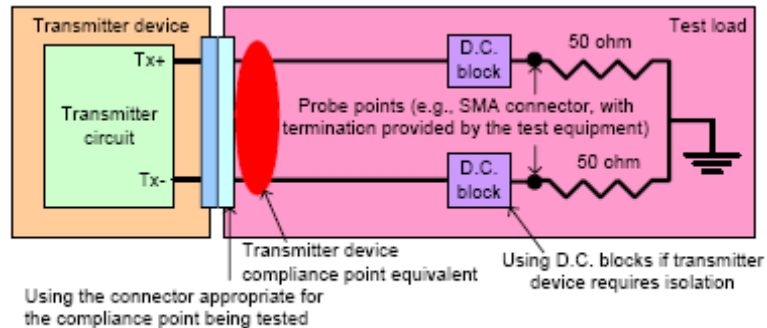


Figure 96 — Zero-length test load for transmitter device compliance point

Test Procedure:

1. Configure the DUT so that it is sourcing OOB signaling.
2. Connect the Zero-Length test load to the DUT transmitter device.
3. Measure the TX device off voltage during the idle period of the OOB signal.

Observable Results:

- a. The peak-to-peak TX device off voltage shall be less than 50 mV.

Actual Measurement Setup: Waveform acquisition settings are 20 μ s/div at fixed sample rate 20GS/s.

Test 5.1.4: Tx OOB Offset Delta

Purpose: To verify that the OOB offset delta of the DUT transmitter device is within the conformance limits

Fixture: Zero-Length test fixture with SMA (see Test 5.1.3 above)

Test Procedure:

1. Configure the DUT so that it is sourcing OOB signaling.
2. Connect the Zero-Length test load to the DUT transmitter device.
3. Capture a single SAS OOB burst waveform.
4. Compute the OOB offset delta as specified in [1].

Observable Results:

- a. The OOB offset delta shall not exceed +/- 25 mV.

Actual Measurement Setup: Waveform capture 2 μ s: 400 kS acquisition at 20 GS/s

Test 5.1.5: Tx OOB Common Mode Delta

Purpose: To verify that the OOB common mode delta of the DUT transmitter device is within the conformance limits

Fixture: Zero-Length test fixture with SMA (see Test 5.1.3 above)

Test Procedure:

1. Configure the DUT so that it is sourcing OOB signaling.
2. Connect the Zero-Length test load to the DUT transmitter device.
3. Capture a single SAS OOB burst waveform.

4. Compute the OOB common mode delta as specified in [1].

Observable Results:

- a. The OOB common mode delta shall not exceed +/- 50 mV.

Actual Measurement Setup: Waveform capture 2 μ s: 400 kS acquisition at 20 GS/s

Test 5.1.6: Tx Minimum OOB ALIGN Burst Amplitude

Purpose: To verify that the minimum OOB ALIGN burst amplitude of the DUT transmitter device is above the conformance limit.

Fixtures: Both the Zero-Length (see Test 5.1.3 above) and TCTF test load:

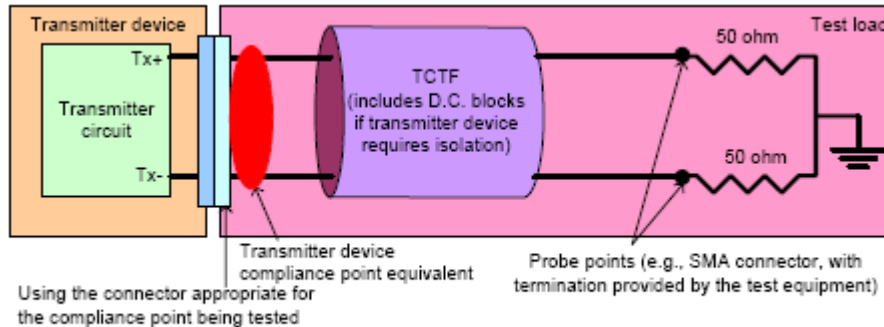


Figure 98 — TCTF test load

Test Procedure:

1. Configure the DUT so that it is sourcing valid OOB signaling.
2. Connect the Zero-Length test load to the DUT transmitter device.
3. Capture a single SAS OOB burst waveform.
4. Compute the minimum OOB ALIGN burst amplitude.
5. Replace the Zero-Length test load with the TCTF test load, and repeat steps 3 and 4.

Observable Results:

- a. For both test load cases, the minimum peak-to-peak OOB ALIGN burst amplitude shall be greater than 240 mV.

Actual Measurement Setup: Minimum OOB burst amplitude is measured as follows: "With a measurement bandwidth of 1,5 times the highest supported baud rate (e.g., 4.5 GHz for 3.0 Gb/s), each signal level during the OOB burst shall exceed the specified minimum differential amplitude before transitioning to the opposite bit value or before termination of the OOB burst."

Test 5.1.7: Tx Maximum Noise during OOB Idle

Purpose: To verify that the maximum OOB idle noise of the DUT transmitter device is below the conformance limit

Fixtures: Both the Zero-Length and TCTF test load (see Tests 5.1.3 and 5.1.6 above)

Test Procedure:

1. Configure the DUT so that it is sourcing valid OOB signaling.
2. Configure the DSO for persistence mode, edge trigger on OOB burst.
3. Connect the Zero-Length test load to the DUT transmitter device.
4. Measure the maximum noise spikes observed during OOB idle.
5. Replace the Zero-Length test load with the TCTF test load, and repeat step 4.

Observable Results:

- a. For both test load cases, the maximum peak-to-peak OOB idle noise shall be less than 120 mV.

Actual Measurement Setup: We measure max sample value - min sample value in any one sweep, the largest measurement result in your set “measureCount” sweeps is the result.

Group 2 – SAS Signaling Tests

Test 5.2.1: TX Bit Rate

Purpose: To verify that the bit rate of the DUT transmitter device is within the conformance limits

Fixture: Zero-Length test fixture with SMA (see Test 5.1.3 above)

Test Procedure:

1. Verify that the DUT is configured for operation at its maximum supported speed (1.5 or 3.0 Gb/s).
2. Connect the Zero-Length test load to the DUT transmitter device.
3. Verify that the DUT is sourcing valid SAS signaling at the expected rate.
4. Measure the average TX bit rate.

Observable Results:

- a. The average TX bit rate shall be within the limits specified in Table 5.2.1-1.

Actual Measurement Setup: Measure bit rate parameter. Scope setup is 5 μ s/div at fixed sample rate of 20 GS/s, 1 MS acquisition.

Test 5.2.2: TX Jitter

Purpose: To verify that the transmit jitter of the DUT transmitter device is within the conformance limits

Fixtures: Both the Zero-Length and TCTF test load (see Tests 5.1.3 and 5.1.6 above) or the Low-Loss TCTF test load

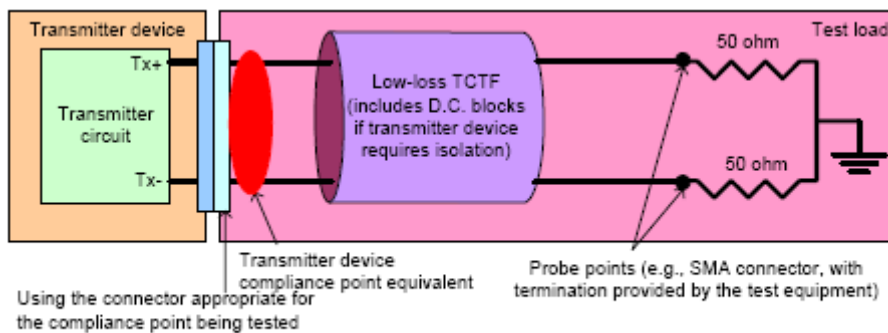


Figure 101 — Low-loss TCTF test load

Test Procedure:

1. Verify that the DUT is configured for operation at its maximum supported speed (1.5 or 3.0 Gb/s).
2. Configure the DUT so that it is sourcing the CJTPAT test pattern (see Appendix A for details).
3. Connect the Zero Length test load to the DUT transmitter device.
4. (Optional) Configure the optimal amplitude and emphasis settings to maximize the eye opening.
5. Measure the deterministic and total jitter.
6. Perform the asymmetry computation, and adjust the total jitter value if necessary.
7. Replace the Zero-Length test load with the TCTF test load or the Low-Loss TCTF test load, and repeat steps 5 and 6.

Observable Results:

- a. For both test load cases, the total peak-to-peak jitter shall not exceed 0.55 UI.
- b. For both test load cases, the peak-to-peak deterministic component of the total jitter shall not exceed 0.35 UI.

Actual Measurement Setup: Measure Basic jitter breakdown (produce TJ, RJ, DJ) using MJSQ method. TJ and DJ are tested.

Test 5.2.3: TX Output Imbalance

Purpose: To verify that the RMS imbalance of the DUT transmitter device is within the conformance limits

Fixture: Zero-Length test fixture with SMA (see Test 5.1.3 above)

Test Procedure:

1. Verify that the DUT is configured for operation at its maximum supported speed (1.5 or 3.0 Gb/s).
2. Configure the DUT so that it is sourcing the CJTPAT test pattern (see Appendix A for details).
3. Connect the Zero-Length test load to the DUT transmitter device.
4. Measure the maximum transmitter device output imbalance.

Observable Results:

- a. The maximum transmitter device output imbalance shall be no greater than 10%.

Actual Measurement Setup: The imbalance is computed for each acquisition over your specified number of acquisitions (measureCount). The largest value is tested.

Test 5.2.4: TX Rise and Fall Times

Purpose: To verify that the rise and fall times of the DUT transmitter device are within the conformance limits

Fixture: Zero-Length test fixture with SMA (see Test 5.1.3 above)

Test Procedure:

1. Verify that the DUT is configured for operation at its maximum supported speed (1.5 or 3.0 Gb/s).
2. Configure the DUT so that it is sourcing the CJTPAT test pattern (see Appendix A for details).
3. Connect the Zero-Length test load to the DUT transmitter device.
4. Measure the rise/fall times, isolating only the edges corresponding to the high-frequency (1010b) portion of the CJTPAT pattern.

Observable Results:

- a. The measured rise/fall times shall be between 67 and 137 ps for 3.0 Gb/s devices, and between 67 and 273 ps for 1.5 Gb/s devices.

Actual Measurement Setup: Measure rise and fall times in the 1010b regions of CJTPAT test pattern.

Test 5.2.5: TX Skew

Purpose: To verify that the skew on the DUT transmitter is below the conformance limits

Fixtures: Both the Zero-Length and TCTF test load (see Tests 5.1.3 and 5.1.6 above)

Test Procedure:

1. Verify that the DUT is configured for operation at its maximum supported speed (1.5 or 3.0 Gb/s).
2. Configure the DUT so that it is sourcing a repeating 0101b test pattern.
3. Connect the Zero-Length test load to the DUT transmitter device.
4. Measure the skew on the DUT output.

5. Replace the Zero-Length test load with the TCTF test load.
6. Measure the skew at the TCTF test load output.

Observable Results:

- a. For both test load cases, the skew shall be below the limits specified in Table 5.2.5-1.

Actual Measurement Setup: Measurement is only made on 0101b pattern isolated from the input. The user-specified measureCount number of sweeps are taken. The statistic mean of Skew is tested.

Group 3: Impedance/Crosstalk tests

These tests all require a VNA (or a sampling scope with normalized TDR capability). We do not plan to implement them in the first SAS release.

TEST 5.3.1 - RX DIFFERENTIAL IMPEDANCE

TEST 5.3.2 - RX DIFFERENTIAL IMPEDANCE IMBALANCE

TEST 5.3.3 - RX COMMON MODE IMPEDANCE

TEST 5.3.4 - RX TERMINATION TIME CONSTANT

TEST 5.3.5 - RX MAXIMUM NEAR-END CROSSTALK

TEST 5.3.6 - TX DIFFERENTIAL IMPEDANCE

TEST 5.3.7 - TX DIFFERENTIAL IMPEDANCE IMBALANCE

TEST 5.3.8 - TX COMMON MODE IMPEDANCE

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APPENDIX A - TEST PATTERN GENERATION

Test Pattern Generation Using LeCroy SASTracer/Trainer

Running the SAS test scripts requires the generation of test patterns to determine DUT compliance to SAS specifications. Any method that causes the DUT to produce the required patterns is acceptable. LeCroy uses a Protocol Analysis solution to exercise DUT test patterns. LeCroy's (formerly CATC's) SASTracer software allows you to load individual scripts to cause the Host (in this case, the SAS exerciser) to initiate SAS traffic. These scripts use the Protocol-Specific diagnostic page for SAS; the DUT must support this feature. The following section describes the specific actions required to successfully generate test patterns from a DUT connected to the LeCroy SASTracer/Trainer. It is assumed that you have started SASTracer/Trainer software in the host computer and established communication with the Tracer/Trainer instrument via USB. When you are prompted to generate a specific test pattern during the execution of an SAS script, the requested pattern can be created by using the following steps:

1. Connect an SAS device cable between the DUT and the "Target" port of the LeCroy Protocol Analyzer.
2. Load the GenFile for the desired test pattern. There are GenFiles (*.ssg) available to generate CJTPAT at both 1.5 Gb/s and 3.0 Gb/s data rates:
 - LeCroy SAS CJTPAT.ssg (1.5 Gb/s)
 - LeCroy 3G SAS CJTPAT.ssg (3.0 Gb/s)
3. Modify the script to communicate with the DUT by replacing the values of SAS_DEST and HashedDest with those of the DUT. To determine the SAS_DEST address, configure the Bus Analyzer to trigger on Identify Address Frames. Then begin recording and run the script. Examine the recorded trace and copy the DUT's address from the Identify Address Frame. Use the Hash Address Utility located on the Tools menu to determine the value for HashedDest. Replace the values of SAS_DEST and HashedDest in the script. Note, both ports have different addresses.
4. Press Start Generation. The script should run and successfully communicate with the device to generate the test pattern.
5. Disconnect the SAS cable from the DUT and connect SAS test fixture to the scope via SMA cables and directly into the DUT.
6. These SAS exerciser scripts have been verified to work on production disk drives from several companies. However, not all devices implement the protocol-specific diagnostic page for SAS.

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