UNH IOL SERIAL ATTACHED SCSI (SAS) CONSORTIUM

SAS 3.0 Receiver Physical Layer Test Suite
Version 1.00

Technical Document

Last Updated: September 29, 2014

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Joshua Beaudet: Minor edits and release

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Pat Kennedy: Initial Draft

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Michael Klempa	UNH InterOperability Laboratory
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Joel Nkounkou	UNH InterOperability Laboratory
Pat Kennedy	UNH InterOperability Laboratory

INTRODUCTION

The University of New Hampshire's InterOperability Laboratory (IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard. This particular suite of tests has been developed to help implementers evaluate the Physical Layer functionality of their Serial Attached SCSI (SAS) products.

These tests are designed to determine if a SAS product conforms to specifications defined in Clause 5 of **ISO/IEC 14776-154:201x, *Serial Attached SCSI-3 (SAS-3) Standard* T10/2212-D, Revision 06** (hereafter referred to as the "SAS-3 Standard", or "the Standard"). Successful completion of all tests contained in this suite does not guarantee that the tested device will successfully operate with other SAS products. However, when combined with satisfactory operation in the IOL's interoperability test bed, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function properly in many SAS environments.

The tests contained in this document are organized in order to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are separated into groups, primarily in order to reduce setup time in the lab environment, however the different groups typically also tend to focus on specific aspects of device functionality. A three-number, dot-notated naming system is used to catalog the tests, where the first number always indicates the specific clause of the reference standard on which the test suite is based. The second and third numbers indicate the test's group number and test number within that group, respectively. This format allows for the addition of future tests in the appropriate groups without requiring the renumbering of the subsequent tests.

The test definitions themselves are intended to provide a high-level description of the motivation, resources, procedures, and methodologies specific to each test. Formally, each test description contains the following sections:

Purpose

The purpose is a brief statement outlining what the test attempts to achieve. The test is written at the functional level.

References

This section specifies all reference material *external* to the test suite, including the specific sub-clauses references for the test in question, and any other references that might be helpful in understanding the test methodology and/or test results. External sources are always referenced by a bracketed number (e.g., [1]) when mentioned in the test description. Any other references in the test description that are not indicated in this manner refer to elements within the test suite document itself (e.g., "Appendix 5.A", or "Table 5.1.1-1")

Resource Requirements

The requirements section specifies the test hardware and/or software needed to perform the test. This is generally expressed in terms of minimum requirements, however in some cases specific equipment manufacturer/model information may be provided.

Last Modification

This specifies the date of the last modification to this test. Editorial modifications (e.g., updated table/figure numbers) and/or conformance limit changes due to an updated version of the standard will be denoted by a decimal increase in version number (e.g., 'version 1.1'). Modifications to the test procedure will be denoted by an integer number version increment (e.g., 'version 2.0').

Discussion

The discussion covers the assumptions made in the design or implementation of the test, as well as known limitations. Other items specific to the test are covered here as well.

Test Setup

The setup section describes the initial configuration of the test environment. Small changes in the configuration should not be included here, and are generally covered in the test procedure section (next).

Procedure

The procedure section of the test description contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing, and may be interspersed with observable results.

Observable Results

This section lists the specific observables that can be examined by the tester in order to verify that the DUT is operating properly. When multiple values for an observable are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail outcome for a particular test is generally based on the successful (or unsuccessful) detection of a specific observable.

Possible Problems

This section contains a description of known issues with the test procedure, which may affect test results in certain situations. It may also refer the reader to test suite appendices and/or other external sources that may provide more detail regarding these issues.

GROUP 1: RX Testing

Overview:

This group of tests verifies the RX electrical signaling requirements for SAS signals, as defined in Clause 5 of the SAS-3 Standard.

Scope:

All of the tests described in this section are implemented and currently active through the UNH IOL SAS Consortium. Comments and questions are welcome, and may be forwarded to the SAS Lab (saslab@iol.unh.edu).

Test 1.1 - Stressed Receiver Device Jitter Tolerance Test Procedure for Trained 12 Gbit/s

Purpose: To verify that the receiver device shall operate within the required BER of 10^{-12} when a signal with valid voltage and timing characteristics is delivered to the receiver device compliance point from a nominal 100 Ω source. The received signal shall be considered valid if it meets the voltage and timing limits specified in the SAS Standard [7].

References:

[1] SAS Standard, Table 64 - ISI generator characteristics for trained 12 Gbit/s at ET and ER
[2] Ibid., Table 65 - RJ characteristics for trained 12 Gbit/s stressed receiver device tolerance test
[3] Ibid., Table D.5-S-parameter files for stressed receiver device delivered signal calibration
[4] Ibid., Table 66- f_{min}, f_c, and f_{max} for trained 12 Gbit/s without SSC support
[5] Ibid., Table 67- f_{min}, f_c, and f_{max} for trained 12 Gbit/s with SSC support
[6] Ibid., Section 5.8.5.7.6.5 Stressed receiver device jitter tolerance test procedure for trained 12 Gbit/s
[7] Ibid., Table 59 Delivered signal characteristics for trained 1.5 Gbit/s, 3 Gbit/s, 6 Gbit/s, and 12 Gbit/s at IR and CR

Resource Requirements: See Appendix 1.A

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Discussion:

Reference [1] specifies the general inter-symbol interface characteristics for 12Gbps SAS receivers. This specification includes conformance limits for the maximum voltage specifications permitted at the ISI channel output, as well as the conditions under which these measurements shall be made. Reference [2] specifies the random jitter characteristics to be applied to the signal before the ISI channel. Random jitter shall be measured from the output of the ISI channel. The crosstalk amplitude characteristics are defined in reference [3], and shall be applied before the input of the ISI channel. The sinusoidal jitter frequency characteristics are outlined in reference [4] for devices without SSC support, and reference [5] for devices with SSC support.

At the output of the ISI channel containing a 12Gbs signal as defined by the above characteristics, a 12G SAS DUT in loopback shall return the signal with a BER no greater than 10^{-12}[6] across a range of sinusoidal jitter values.

Test Setup: See Appendix 5.A

Test Procedure:

1. Configure the test setup with the ISI channel active but at 0%.
2. Calibrate only the amplitude characteristics of the output voltage at the end of the ISI channel according to reference [1].
3. Calibrate the crosstalk amplitude according to reference [3].
4. Adjust the ISI characteristics as outlined in reference [1].
5. Configure the random jitter according to reference [2].
6. Configure loopback on the DUT.
7. Apply the sinusoidal jitter characteristics in references [4] (SSC off) or [5] (SSC on).
8. With the device in loopback and connected to an error detector with appropriate bandwidth characteristics, ensure a bit error rate of 10^{-12}.

Observable Results:

a. The receiver device has a maximum BER of 10^{-12} with a confidence level of 95% above the jitter tolerance curve defined in appendix 1.A.

Possible Problems: **None.**

Appendix 1.A

Figure 1: Stressed Receiver Device Jitter Tolerance Test Procedure for Trained 12 Gbit/s Setup

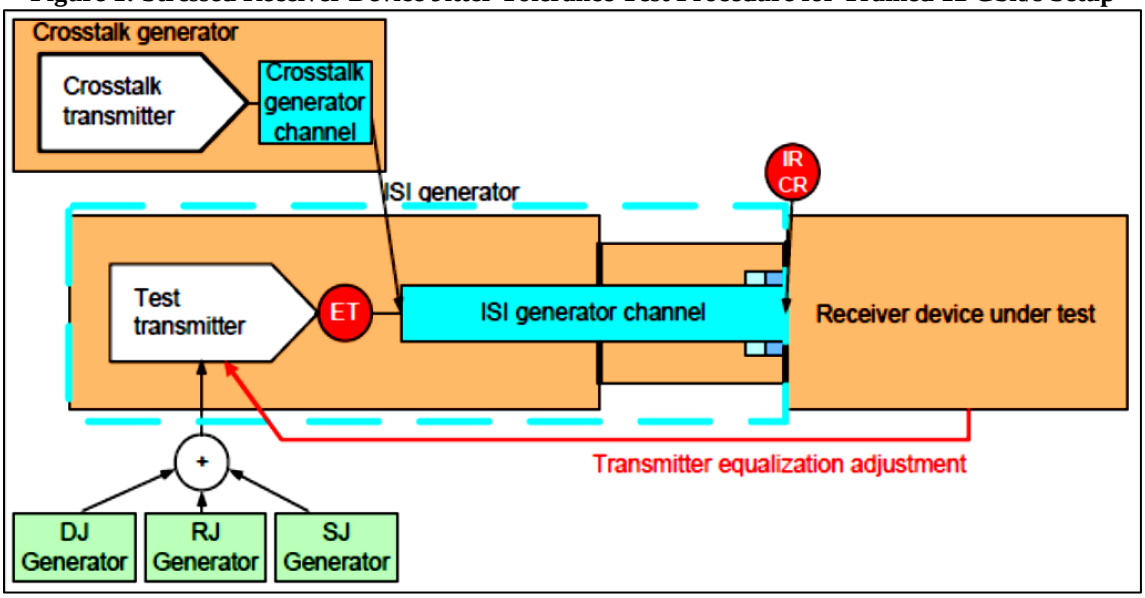

Figure 2: Stressed Receiver Device SJ Curve for Trained 12 Gbit/s without SSC Support

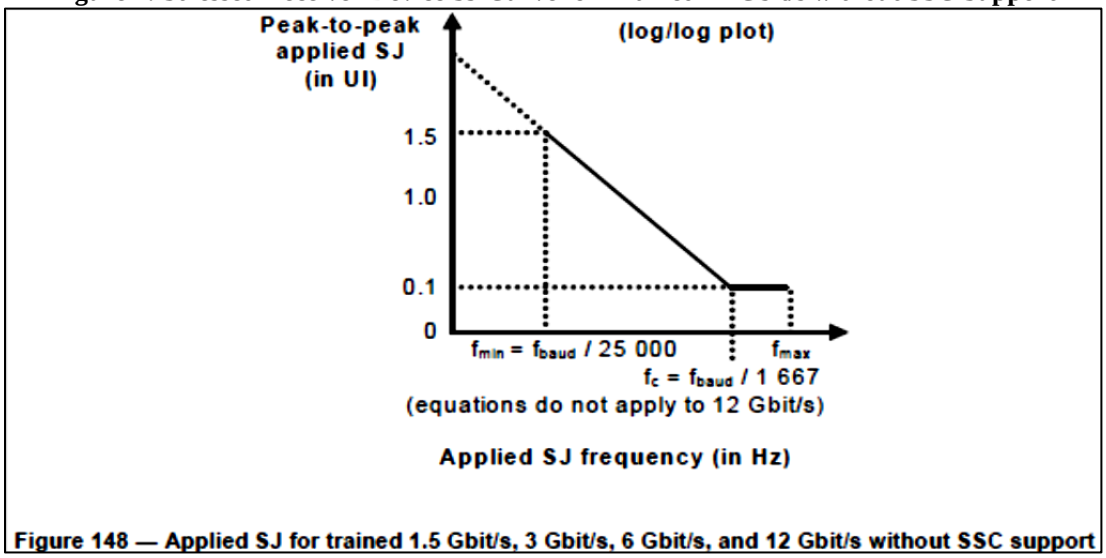

Figure 3: Stressed Receiver Device SJ Values for Trained 12 Gbit/s without SSC Support

Table 66 — f_{min}, f_c, and f_{max} for trained 1.5 Gbit/s, 3 Gbit/s, 6 Gbit/s, and 12 Gbit/s without SSC support

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

Figure 4: Stressed Receiver Device SJ Curve for Trained 12 Gbit/s with SSC Support

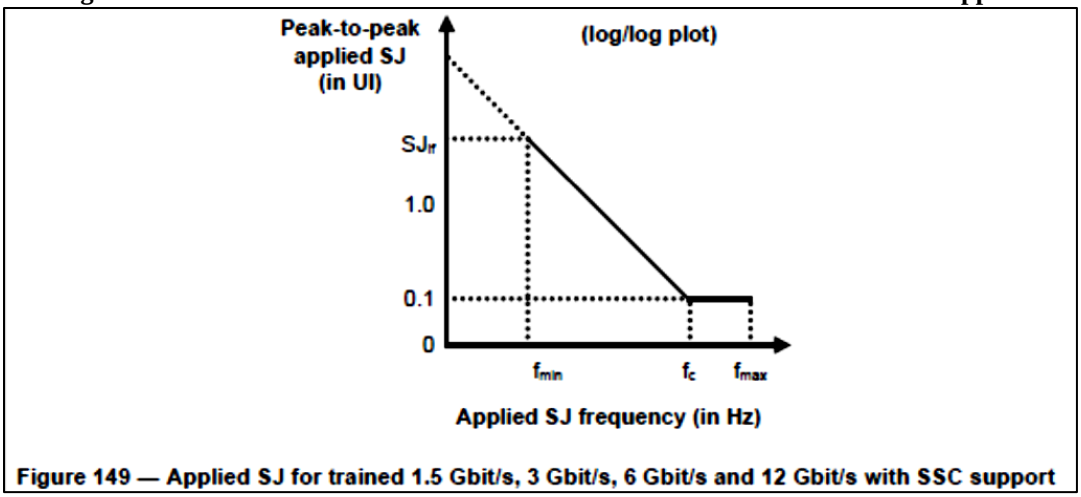

Figure 149 — Applied SJ for trained 1.5 Gbit/s, 3 Gbit/s, 6 Gbit/s and 12 Gbit/s with SSC support

Figure 5: Stressed Receiver Device SJ Values for Trained 12 Gbit/s with SSC Support

Table 67 — f_{min}, f_c, f_{max}, and SJ_{lf} for trained 1.5 Gbit/s, 3 Gbit/s, 6 Gbit/s, and 12 Gbit/s with SSC support

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