UNH-IOL
SAS CONSORTIUM

September 2014 SAS Plugfest Test Plan v0.13

Technical Document

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The University of New Hampshire
InterOperability Laboratory
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MODIFICATION RECORD

March 20, 2014 (Version 0.1) DRAFT RELEASE
        David Woolf: Initial Version.

March 25, 2014 (Version 0.11) DRAFT RELEASE
        David Woolf: Editorial fixes. Notes added to test 1.1 and Appendix A to indicate that cable tests may not be necessary for cables previously tested.

April 3, 2014 (Version 0.12) DRAFT RELEASE
        David Woolf: Editorial fixes to update specification references in Group 2 and Group 5 to SAS-3.

April 15, 2014 (Version 0.13) DRAFT RELEASE
        David Woolf: Removed Group 2 tests. Added notes for how to handle Group 1 tests.

ACKNOWLEDGMENTS

INTRODUCTION

The SCSI Trade Association and the University of New Hampshire InterOperability Laboratory have partnered to coordinate a series of SAS plugfests since 2003. This document is intended to outline tests that will be performed during the latest SAS Plugfest scheduled for September 2014.

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 interoperability of their Serial Attached SCSI (SAS) products, including SAS Hosts, Expanders, Enclosures, Disk Drives, and Passive and Active cables.

These tests are designed to determine if a SAS product designed to specifications defined in *Serial Attached SCSI-3 (SAS-3) standard* **T10/2212-D** (hereafter referred to as the "SAS Standard") with be interoperable with other products designed to the same 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 SAS Target 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.

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 subclauses 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.

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 SAS target 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: CABLE MANAGEMENT

Overview:

This group of tests verifies the interoperability of a small SAS system using various interconnects, such as active or passive cables, and backplanes.

Scope:

Comments and questions regarding the implementation of these tests are welcome, and may be forwarded to David Woolf, UNH InterOperability Lab (david@iol.unh.edu).

Test #1.1: EEPROM Reading

Purpose: To determine if a SAS Transceiver can properly read the EEPROM of a SAS cable and adjust transmitter settings accordingly.

References: SAS-3 Standard, SFF-8636 Chapter 6

Resource Requirements:
- SAS Cable implementing SFF 8636
- SAS Device Pair

Last Modification: March 25, 2014

Discussion: The EEPROM of a SAS cable may contain information essential for the SAS device pair to properly configure for in order to operate the link. This test is primarily intended for cables that have not been tested at previous SAS Plugfest events.

Test Setup: A device pair is connected through a reference test channel.

Procedure:
1. Allow the SAS device to read the following addresses of Lower Page 00 Memory Map of the EEPROM of the SAS Cable:
   a. 0 Identifier
   b. 1 Revision Compliance
   c. 2
      i. Bit 2, Flat_mem,
      ii. Bit 1 IntL (optional for PC (Passive Cable), AC (Active Cable), AO (Active Optical Cable), required for SM (separate Module))
      iii. Bit 0, Data_Not_Ready
   d. 108 Propagation Delay MSB
   e. 109 Propagation Delay LSB
   f. 110
      i. Bits 7-4 Advanced Low Power Mode
      ii. Bit 3 Far Side managed
      iii. Bits 2-0 Min Operating Voltage
2. Allow the SAS device to read the following addresses of Upper Page 00 Memory Map of the EEPROM of the SAS Cable:
   a. 128 Identifier
   b. 129 Power Class
   c. 129 CDR in TX
   d. 129 CDR in RX
   e. 130 Connector Type
   f. 133 SAS Speed
   g. 140, BR Nominal (bit rate in units of 100 Mbps)
   h. 148-163 Vendor Name
   i. 165-167 Vendor OUI
   j. 168-183 Vendor PN
   k. 184-185 Vendor Rev
   l. 194 RX Squelch Disable implemented
   m. 194 RX Output Disable Capable
   n. 194 TX Squelch Disable implemented
   o. 194 TX Squelch implemented
   p. 196-211 Vendor SN
   q. 212-213 Date Code Year
   r. 214-215 Date Code Month
   s. 216-217 Date Code Day

         t.   218-219 Date Code Lot code
         u.   223 CC_EXT
3. Remove the cable, then reinsert the cable. Repeat steps 1 and 2 and verify that all parameters are correctly read a second time.

Observable Results:
- Verify that the DUT is able to properly read each of the addresses above and correctly retrieve data from the EEPROM.

Possible Problems: None known.

Test #1.2: Cable Management

Purpose: To determine if a SAS Transceiver can properly read the EEPROM of an Optical SAS cable and adjust transmitter settings accordingly.

References: SAS-3 Standard

Resource Requirements:
- SAS Optical Cable
- SAS Device Pair

Last Modification: April 15, 2014

Discussion: TBD – This Test may reveal results that can be fed back to T10. Specific result recording will be essential.

Test Setup: A device pair is connected through an optical SAS cable.

Case 1 – Passive Copper Cables

Case 2 – Active Copper Cables

Case 3 – Optical Cables

Procedure:
1. TBD

Observable Results:
- TBD

Possible Problems: None known.

GROUP 2: DATA PROTECTION

Overview:

      This group of tests verifies the interoperability of a system implementing DIF.

Scope: Comments and questions regarding the implementation of these tests are welcome, and may be forwarded to David Woolf, UNH InterOperability Lab (david@iol.unh.edu).

Test #2.1: - Type 0 Protection – RDPROTECT, WRPROTECT, VRPROTECT, or ORPROTECT field is a non-zero value

Purpose: To determine if the DUT properly handles commands while formatted with Type 0 protection

References: SCSI Block Commands – 3 (SBC-3)

Resource Requirements:
- SAS Host
- SAS Analyzer

Last Modification: July 7, 2011

Discussion: Type 0 is the equivalent of no data protection. If the RDPROTECT, WRPROTECT, VRPROTECT, or ORPROTECT field is not equal to zero then medium access commands defined in SBC-3 4.20.2.1, may be terminated by the device with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB. See Appendix C for a list of disallowed medium access commands for each Data Protection Level.

Test Setup: The DUT and the SAS Host are physically connected with the SAS Analyzer between them.

Test Procedure:
1. Format the DUT to have Type 0 protection and set the RDPROTECT, WRPROTECT, VRPROTECT, or ORPROTECT field to a non-zero value.
2. Attempt the "medium access commands" on the formatted DUT.

Observable Results: The DUT may terminate the attempted "medium access commands" defined in SBC-3 4.20.2.1 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

Test #2.2: - Type 0 Protection – RDPROTECT, WRPROTECT, VRPROTECT, or ORPROTECT field is a zero value

Purpose: To determine if the DUT properly handles commands while formatted with Type 0 protection

References: SCSI Block Commands – 3 (SBC-3)

Resource Requirements:
- SAS Host
- SAS Analyzer

Last Modification: July 7, 2011

Discussion: Type 0 is the equivalent of no data protection. If the RDPROTECT, WRPROTECT, VRPROTECT, or ORPROTECT field is equal to zero then medium access commands defined in SBC-3 4.20.2.2, may be terminated by the device with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. See Appendix C for a list of disallowed medium access commands for each Data Protection Level.

Test Setup: The DUT and the SAS Host are physically connected with the SAS Analyzer between them.

Test Procedure:
1. Format the DUT to have Type 0 protection and set the RDPROTECT, WRPROTECT, VRPROTECT, or ORPROTECT field to a zero value.
2. Attempt the "medium access commands" on the formatted DUT.

Observable Results: The DUT may terminate the attempted "medium access commands" defined in SBC-3 4.20.2.2 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.

Test #2.3: - Type 1 Protection

Purpose: To determine if the DUT properly handles commands while formatted with Type 1 protection

References: SCSI Block Commands – 3 (SBC-3)

Resource Requirements:
- SAS Host
- SAS Analyzer

Last Modification: July 7, 2011

Discussion: Type 1 defines the content of each LOGICAL BLOCK GUARD field; does not define the content of and LOGICAL BLOCK APPLICATION TAG field; and defines the content each LOGICAL BLOCK REFERENCE TAG field. A device formatted with type 1 shall be terminate the "medium access commands" defined in SBC-3 4.20.2.3 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. See Appendix C for a list of disallowed medium access commands for each Data Protection Level.

Test Setup: The DUT and the SAS Host are physically connected with the SAS Analyzer between them.

Test Procedure:
1. Format the DUT to have Type 1 protection.
2. Attempt the "medium access commands" on the formatted DUT.

Observable Results: The DUT shall be terminate the "medium access commands" defined in SBC-3 4.20.2.3 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.

Test #2.4: - Type 2 Protection

Purpose: To determine if the DUT properly handles commands while formatted with Type 2 protection

References: SCSI Block Commands – 3 (SBC-3)

Resource Requirements:
- SAS Host
- SAS Analyzer

Last Modification: July 7, 2011

Discussion: Type 2 defines the content of each LOGICAL BLOCK GUARD field; does not define the content of and LOGICAL BLOCK APPLICATION TAG field; and defines, except for the first logical block addressed by the command, the content each LOGICAL BLOCK REFERENCE TAG field. A device formatted with type 2 shall be terminate the "medium access commands" defined in SBC-3 4.20.2.4 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. See Appendix C for a list of disallowed medium access commands for each Data Protection Level.

Test Setup: The DUT and the SAS Host are physically connected with the SAS Analyzer between them.

Test Procedure:
1. Format the DUT to have Type 2 protection.
2. Attempt the "medium access commands" on the formatted DUT.

Observable Results: The DUT shall be terminate the "medium access commands" defined in SBC-3 4.20.2.4 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.

Test #2.5: - Type 3 Protection

Purpose: To determine if the DUT properly handles commands while formatted with Type 3 protection

References: SCSI Block Commands – 3 (SBC-3)

Resource Requirements:
- SAS Host
- SAS Analyzer

Last Modification: July 7, 2011

Discussion: Type 3 defines the content of each LOGICAL BLOCK GUARD field; does not define the content of and LOGICAL BLOCK APPLICATION TAG field; and does not define the content of any LOGICAL BLOCK REFERENCE TAG field. A device formatted with type 3 shall be terminate the "medium access commands" defined in SBC-3 4.20.2.5 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE. See Appendix C for a list of disallowed medium access commands for each Data Protection Level.

Test Setup: The DUT and the SAS Host are physically connected with the SAS Analyzer between them.

Test Procedure:
1. Format the DUT to have Type 3 protection.
2. Attempt the "medium access commands" on the formatted DUT.

Observable Results: The DUT shall be terminate the "medium access commands" defined in SBC-3 4.20.2.5 with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID COMMAND OPERATION CODE.

Test #2.6: - Power Loss/ Hard Reset Test

Purpose: To determine if the DUT properly handles power loss/hard reset/logical unit reset.

References: SCSI Block Commands – 3 (SBC-3)

Resource Requirements:
- SAS Host
- SAS Analyzer

Last Modification: July 11, 2011

Discussion: Protection information is retained by the device server until overwritten. Power loss, hard reset, logical unit reset, and I_T nexus loss shall have no effect on the retention of protection information. See Appendix C for a list of disallowed medium access commands for each Data Protection Level.

Test Setup: The DUT and the SAS Host are physically connected with the SAS Analyzer between them.

Test Procedure:
1. Format the DUT to have Type 0 protection.
2. Reset DUT
3. Make sure Type 0 protection is still enabled by attempting a medium access command.
4. Repeat for Type 1,2 and 3.

Observable Results: The DUT should keep its data protection information even after power loss/hard reset.

GROUP 3: POWER MANAGEMENT

Overview:
  This group of tests verifies the interoperability of a system implementing SAS Power Management.

Scope: Comments and questions regarding the implementation of these tests are welcome, and may be forwarded to David Woolf, UNH InterOperability Lab (david@iol.unh.edu).

Test #3.1: - Partial Power State – Enter Low Phy State

Purpose: To verify the Device accepts PS_REQ(PARTIAL) and goes into the Partial power state

References:
    [1] 6.2.6.13 SAS Protocol Layer
    [2] 5.9.5.1 SAS Protocol Layer

Resource Requirements:
- SAS Power Management test fixture
- Lab Grade DC Power Supply
- Multimeter
- SAS Host

Last Modification: June 22, 2011

Discussion: To enter a Low Phy Power state the DUT must accept a PS_REQ(PARTIAL) primitive and send a PS_ACK.

Test Setup: The DUT and the SAS Host are physically connected. The DUT is in the active power state.

Test Procedure:
1. The Host is instructed to transmit 6 PS_REQ(PARTIAL) to the DUT.

Observable Results: Verify that the DUT will send a PS_ACK and enter the partial phy state.

Possible Problems: None

Test #3.2 - Partial Power State – Exit To Active State COMWAKE

Purpose: To determine that the DUT properly exits the partial power state after receiving COMWAKE.

References:
    [1] 5.9.5 SAS Protocol Layer
    [2] Table 44 SAS Protocol Layer

Resource Requirements:
- SAS Power Management test fixture
- Lab Grade DC Power Supply
- Multimeter
- SAS Host

Last Modification: June 22, 2011

Discussion: The device must go back to active state from partial power state before going into any other state. It can only process COMINIT or COMWAKE while in a low phy state. The DUT must respond to the COMINIT or COMWAKE within the HOTPLUG TIMEOUT timer. Then send ALIGN(0) followed by ALIGN(1) to get into the active state and regain sync.

Test Setup: The DUT and the SAS Host are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT into the partial power state.
2. The device will be in the partial power state. After receiving COMWAKE, the DUT must respond to the COMWAKE within the HOTPLUG TIMEOUT timer.
3. Measure the time it takes the DUT to go into active power state and make sure it is within 10 usec.
4. The DUT sends at least 3 ALIGN(0) before the SNLT timer expires, at the speed saved from the last Speed negotiation.
5. The SAS Host transmits 3 ALIGN(1) in response.
6. The DUT sends at least 3 ALIGN(1) before the SNTT timer expires.
7. The SAS Host transmits ALIGN(1) received message.
8. The DUT sets SASPhyPwrCond state machine variable to Active and ends the SNTT and SNLT timers.

Observable Results: Verify that the DUT goes into the active power state within 10 usec.

Possible Problems: None

Test #3.3 - Slumber Power State – Enter Low Phy State

Purpose: To verify the Device accepts PS_REQ(PARTIAL) and goes into the slumber power state.

References:
       [1] 6.2.1 SAS Protocol Layer
       [2] 4.10.1.1 SAS Protocol Layer
       [3] 6.2.6.11-13 SAS Protocol Layer

Resource Requirements:
- SAS Power Management test fixture
- Lab Grade DC Power Supply
- Multimeter
- SAS Host

Last Modification: June 22, 2011

Discussion: To enter a Low Phy Power state the DUT must accept the PS_REQ(SLUMBER) primitive and send a PS_ACK.

Test Setup: The DUT and the SAS Host are physically connected. The DUT is in the active power state.

Test Procedure:
         1.   The SAS Host is instructed to transmit 6 PS_REQ(SLUMBER) to the DUT.

Observable Results: Verify that the DUT will send a PS_ACK and enter the slumber phy state.

Possible Problems: None

Test #3.4 - Slumber Power State – Exit To Active State COMWAKE

Purpose: To determine that the DUT properly exits the partial power state after receiving COMWAKE.

References:
      [1] 5.9.5 SAS Protocol Layer
      [2] Table 44 SAS Protocol Layer

Resource Requirements:
- SAS Power Management test fixture
- Lab Grade DC Power Supply
- Multimeter
- SAS Host

Last Modification: June 22, 2011

Discussion: The device must go back to active state from partial power state before going into any other state. It can only process COMINIT or COMWAKE while in a low phy state. The DUT must respond to the COMINIT or COMWAKE within the HOTPLUG TIMEOUT timer.

Test Setup: The DUT and the SAS Host are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT into slumber power state.
2. The device will be in the slumber power state. After receiving COMWAKE, the DUT must respond to the COMWAKE within the HOTPLUG TIMEOUT timer.
3. Measure the time it takes the DUT to go into active power state and make sure it is within 10 msec.
4. The DUT sends at least 3 ALIGN(0) before the SNLT timer expires, at the speed saved from the last Speed negotiation.
5. The SAS Host transmits 3 ALIGN(1) in response.
6. The DUT sends at least 3 ALIGN(1) before the SNTT timer expires.
7. The SAS Host transmits ALIGN(1) received message.
8. The DUT sets SASPhyPwrCond state machine variable to Active and ends the SNTT and SNLT timers.

Observable Results: Verify that the DUT goes into the active power state within 10 msec.

Possible Problems: None

Test #3.5 - Partial Power State – Exit To Active State COMINIT

Purpose: To determine that the DUT properly exits the partial power state after receiving COMINIT.

References:
    [1] 5.9.5.2.2 SAS Protocol Layer
    [2] 5.9.3.2.1 SAS Protocol Layer

Resource Requirements:
- SAS Power Management test fixture
- Lab Grade DC Power Supply
- Multimeter
- SAS Host

Last Modification: June 22, 2011

Discussion: The device must go back to active state from partial power state before going into any other state. It can only process COMINIT or COMWAKE while in a low phy state. The DUT must respond to the COMINIT or COMWAKE within the HOTPLUG TIMEOUT timer.

Test Setup: The DUT and the SAS Host are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT to partial power state.
2. The SAS Host is instructed to send COMINIT to the DUT. After receiving COMINIT, the DUT must respond to the COMINIT within the HOTPLUG TIMEOUT timer.
3. The DUT will go through speed negotiation with the SAS Host.

Observable Results: Verify that the DUT goes through speed negotiation and negotiates to the highest supported speed.

Possible Problems: None

Test #3.6 - Slumber Power State – Exit To Active State COMINIT

Purpose: To determine that the DUT properly exits the partial power state after receiving COMINIT.

References:
    [1] 5.9.5.2.2 SAS Protocol Layer
    [2] 5.9.3.2.1 SAS Protocol Layer

Resource Requirements:
- SAS Power Management test fixture
- Lab Grade DC Power Supply
- Multimeter
- SAS Host

Last Modification: June 22, 2011

Discussion: The device must go back to active state from partial power state before going into any other state. It can only process COMINIT or COMWAKE while in a low phy state. The DUT must respond to the COMINIT or COMWAKE within the HOTPLUG TIMEOUT timer.

Test Setup: The DUT and the SAS Host are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT to slumber power state.
2. The SAS Host is instructed to send COMINIT to the DUT. After receiving COMINIT, the DUT must respond to the COMINIT within the HOTPLUG TIMEOUT timer.
3. The DUT will go through speed negotiation with the SAS Host.

Observable Results: Verify that the DUT goes through speed negotiation and negotiates to the highest supported speed.

Possible Problems: None

GROUP 4: LARGE BUILD INTEROPERABILITY

Overview:

This group of tests verifies the interoperability of a system of multiple SAS end devices connected through multiple SAS expanders.

Scope: Comments and questions regarding the implementation of these tests are welcome, and may be forwarded to David Woolf, UNH InterOperability Lab (david@iol.unh.edu).

Test #4.1: Large Build Latency

Purpose: To determine whether transmission latency will affect SAS operation in large SAS topologies

References: SAS-3 Standard

Resource Requirements:
- SAS Test channel with known properties (i.e. SAS cable or backplane).
- Local management indicators on the devices within SAS System that indicate the state of the link as perceived by the different devices, and the ability to measure average round-trip time for IO.

**Last Modification:** August 24, 2010

Discussion: As SAS Fabrics increase in size, the possibility arises that delays caused by long cascades of SAS Expanders/Enclosures may interfere with the SAS protocol. This test is designed to see how latency increases as expanders are added to a cascaded series of SAS expanders.

Test Setup: A single initiator and target system is connected through a single expander, then through a series of cascaded expanders. See Appendix B for one method for measuring latency.

Setup 1 using a single expander:
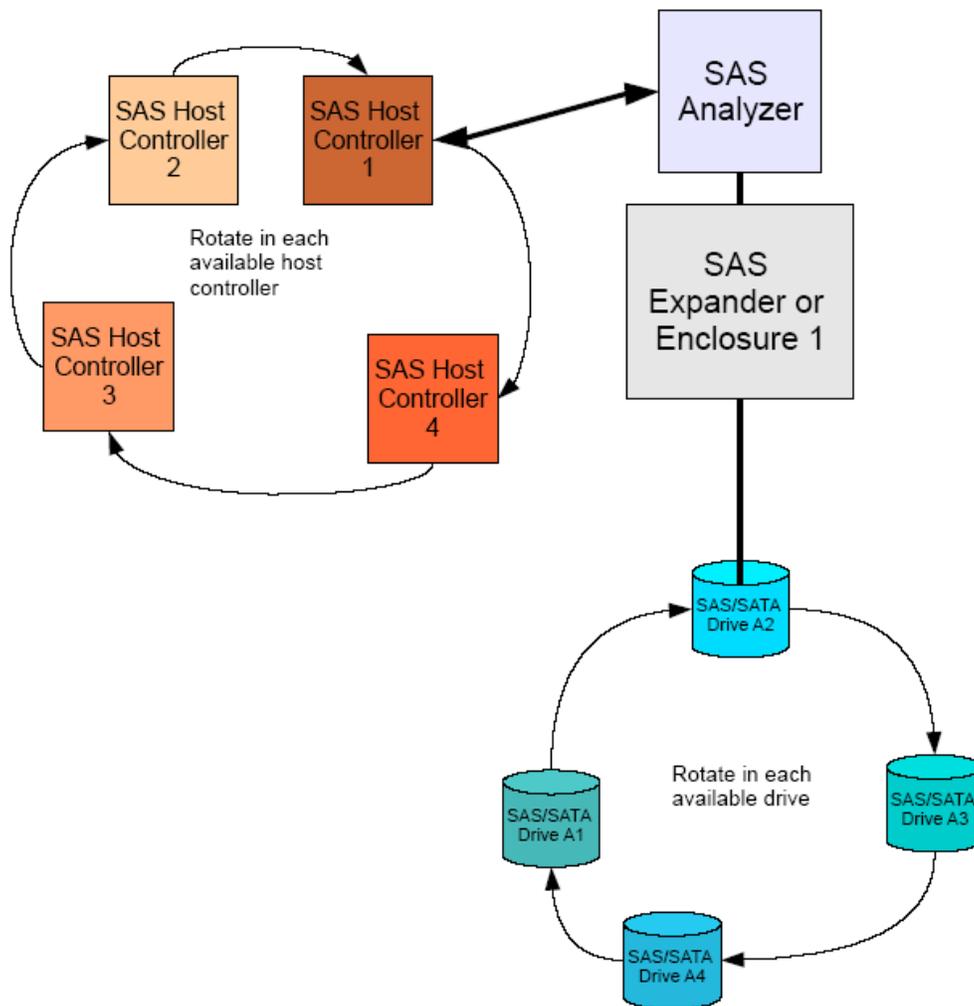
Setup 2 using a series of Cascaded expanders:
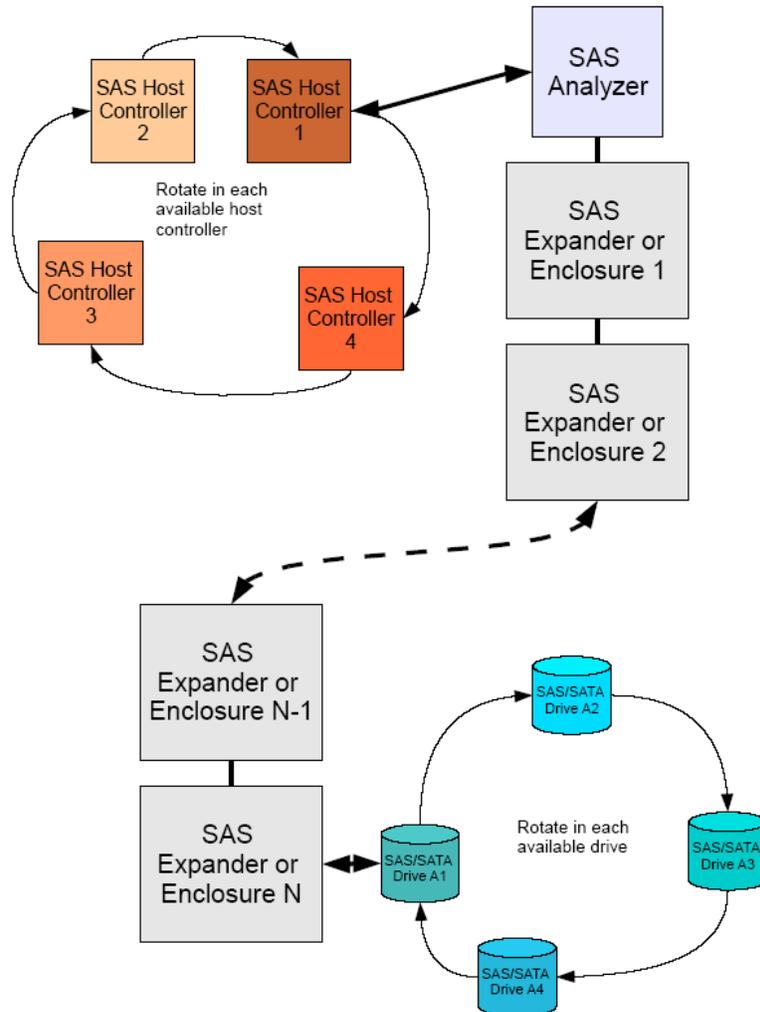
Procedure:
1. Connect devices together in Setup 1 as shown above with a single Host, Expander, and Disk.
2. Using either the analyzer, or software running on the Host system, measure latency on IO from the Host to the Disk.
3. Rotate in each available Disk Drive and Host Controller and repeat steps 1 and 2 until all combinations have been checked.
4. Connect devices together in Setup 2 as shown above with a single Host, N Expanders, and Disk.
5. Using either the analyzer, or software running on the Host system, measure latency on IO from the Host to the Disk.
6. Rotate in each available Disk Drive and Host Controller and repeat steps 1 and 2 until all combinations have been checked.

Observable Results:
- Compare latency on IO measured in the single and multi expander setups.

Possible Problems: None Known.

Test #4.2: Large System Build for Single Initiator Systems

Purpose: To determine if a SAS system consisting of a single initiator, multiple expanders, and multiple targets, can link and exchange data.

References: SAS-3 Standard

Resource Requirements:
- A reference set of stations that can be used as expanders, targets, SCSI initiators.
- Link monitoring facilities that are able to monitor primitives on the link.
- Local management indicators on the SAS target and reference set that indicate the state of the link as perceived by the different stations.

**Last Modification:** October 6, 2009

Discussion:
      SAS is designed to allow many phys within one domain. Thus it is necessary to test how individual phys will interoperate within a large system. One difficulty in testing large systems is isolating problem devices. Hence in this test, devices are added one at a time to the system, and a series of tests are performed before another device is added. In this way problem isolation is made easier.

      This test builds a large SAS system starting with one SAS Initiator, and adding a SAS expander, and then SAS targets until the expander is full. Then additional expanders are daisy chained to the first expander and the process of adding targets begins again.

      Once a set of tests has been performed on an added device, a traffic stream is started from the Initiator to the added device. This traffic stream stays active throughout the rest of the test as other devices are added.

      This test is an interoperability test. Failure of this test does not mean that a SAS target is necessarily non-conformant. It does suggest that a problem in the ability of the devices to work properly together exists and further work should be done to isolate the cause of the failure.

Test Setup: Initiator 1, and selected targets are connected through Expander 1.
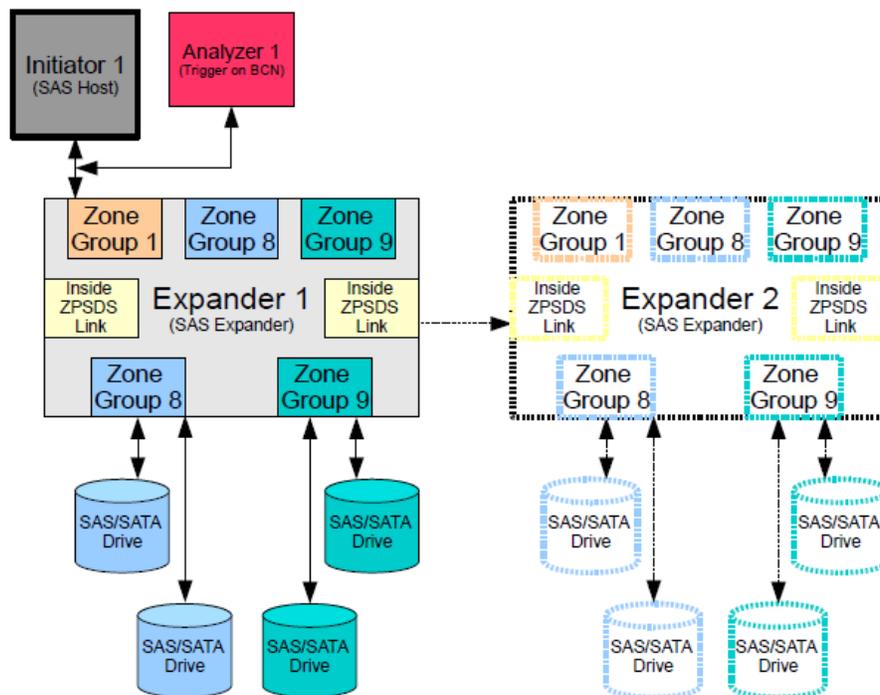
Procedure:

1. Configure the SAS Initiator, SAS Expander, and SAS/SATA Drives to use a phy configuration that was proven to be successful in tests 1.1. and 1.2.
2. Attach Initiator 1 to the Phy configured for Zone Group 1.
    a. Using local management information verify that all targets are visible from Expander 1 and Initiator 1.
    b. From Initiator 1, perform a brief (less than 1 minute) data transaction to all attached targets. Verify that all data arrived without error.
    c. Disconnect a target from the system. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was removed. An analyzer set to trigger on BCN can be used to verify this.
    d. Reconnect the removed target. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was reconnected. An analyzer set to trigger on BCN can be used to verify this.
3. Move Initiator 1 to the Phy configured for Zone Group 8.
    a. Using local management information verify that Initiator 1 can only access target devices also in Zone Group 8 and cannot access target devices in Zone Group 9.
    b. From Initiator 1, perform a brief (less than 1 minute) data transaction to all attached targets in the zone. Verify that all data arrived without error.
    c. Disconnect a target from the system. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was removed. An analyzer set to trigger on BCN can be used to verify this.
    d. Reconnect the removed target. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was reconnected. An analyzer set to trigger on BCN can be used to verify this.
4. Repeat Step 3 for Initiator 1 attached to the Phy configured for Zone Group 9. Verify that Initiator 1 only has access to target devices in Zone Group 9.
5. Add Expander 2 to one of the 'Inside ZPSDS Link' Phys on Expander 1. Expander 2 should have Phys configured for access to Zone Group 1, 8, and 9, just like Expander 1. Connect Targets to Zone Group 8 and 9 on Expander 2.
6. Repeat steps 1-5 with the new Expander added to the system. At each step verify that Initiator 1 has access to target devices in its same zone on Expander 1 and 2 simultaneously.

Observable Results:

- As devices are added to the system use local management information to verify that added devices are visible from all other devices in the system.
- Verify SCSI traffic resumes when devices are disconnected and reconnected from the system.

Possible Problems: Local management information may not be available, depending on the device. Daisy chained expanders need to be configured to use interoperable routing methods.

Test #4.3: Large System Build for Multi Initiator Systems

Purpose: To determine if a SAS system consisting of multiple initiators, multiple expanders, and multiple targets, can link and exchange data.

References: SAS-3 Standard

Resource Requirements:
- A reference set of stations that can be used as expanders, targets, SCSI initiators.
- Link monitoring facilities that are able to monitor primitives on the link.
- Local management indicators on the SAS target and reference set that indicate the state of the link as perceived by the different stations.

**Last Modification:** October 19, 2009

Discussion:

SAS is designed to allow many phys within one domain. Thus it is necessary to test how individual phys will interoperate within a large system. One difficulty in testing large systems is isolating problem devices. Hence in this test, devices are added one at a time to the system, and a series of tests are performed before another device is added. In this way problem isolation is made easier.

This test builds a large SAS system starting with several SAS Initiators, and adding a SAS expander, and then SAS targets until the expander is full. Then additional expanders are daisy chained to the first expander and the process of adding targets begins again.

Once a set of tests has been performed on an added device, a traffic stream is started from the Initiator to the added device. This traffic stream stays active throughout the rest of the test as other devices are added.

This test is an interoperability test. Failure of this test does not mean that a SAS target is necessarily non-conformant. It does suggest that a problem in the ability of the devices to work properly together exists and further work should be done to isolate the cause of the failure.

Test Setup: Initiator 1 and 2, and selected targets are connected through Expander 1 as illustrated below.
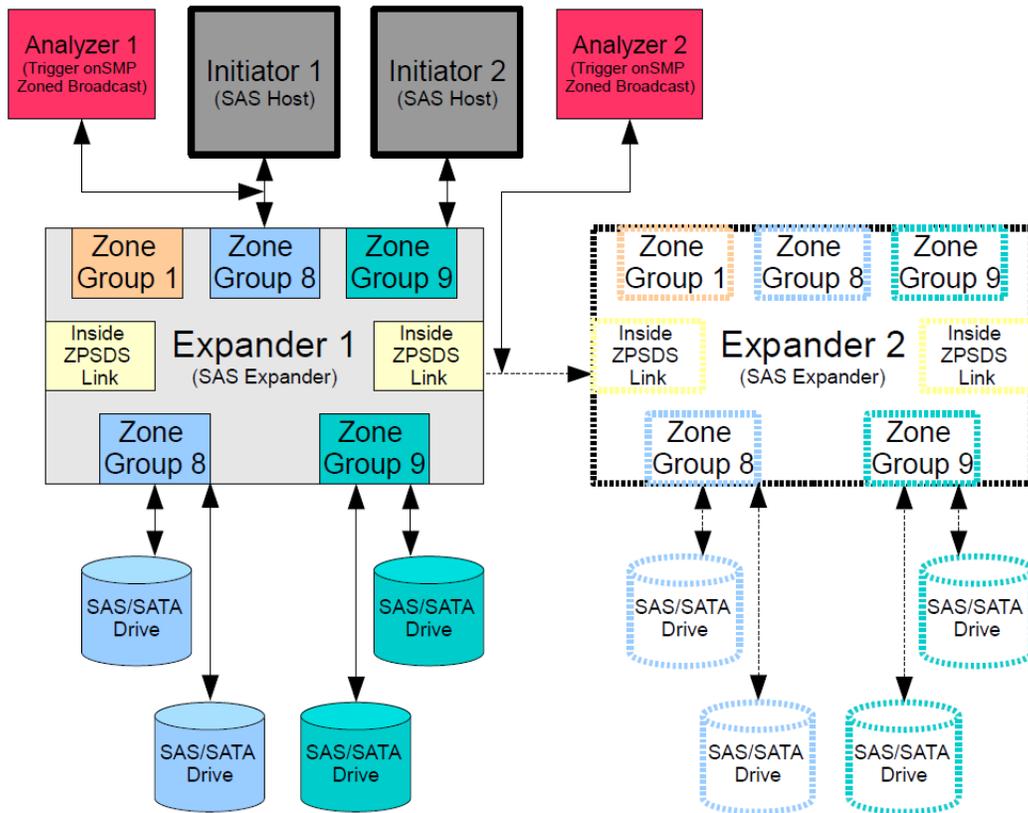
Procedure:
1. Configure the SAS Initiator, SAS Expander, and SAS/SATA Drives to use a phy configuration that was proven to be successful in tests 1.1. and 1.2.
2. Attach Initiator 1 to the Expander 1Phy configured for Zone Group 8. Attached Initiator 2 to the Expander 1 Phy configured for Zone Group 9.
   a. Using local management information verify that all targets are visible from Expander 1, targets in Zone Group 8 are visible to Initiator 1, targets in Zone Group 9 are visible to Initiator 2.
   b. From each Initiator , perform a brief (less than 1 minute) data transaction to all attached targets. Verify that all data arrived without error.
   c. Disconnect a target from each zone in the system. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was removed. An analyzer set to trigger on BCN can be used to verify this.
   d. Reconnect the removed targets. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was reconnected. An analyzer set to trigger on BCN can be used to verify this.
3. Swap Initiator 1 and 2 such that Initiator 1 is in Zone Group 9 and Initiator 2 is in Zone Group 8.
   a. Using local management information verify that all targets are visible from Expander 1, targets in Zone Group 9 are visible to Initiator 1, targets in Zone Group 8 are visible to Initiator 2.
   b. From each Initiator, perform a brief (less than 1 minute) data transaction to all attached targets in the zone. Verify that all data arrived without error.
   c. Disconnect a target from the system. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was removed. An analyzer set to trigger on BCN can be used to verify this.

d. Reconnect the removed target. Verify that only the Initiator and Expander in the same zone as the disconnected target recognized that the target was reconnected. An analyzer set to trigger on BCN can be used to verify this.

4. Add Expander 2 to one of the 'Inside ZPSDS Link' Phys on Expander 1. Expander 2 should have Phys configured for access to Zone Group 1, 8, and 9, just like Expander 1. Connect Targets to Zone Group 8 and 9 on Expander 2.
5. Repeat steps 1-4 with the new Expander added to the system. At each step verify that Initiator 1 has access to target devices in its same zone on Expander 1 and 2 simultaneously.
6. Add additional Zones and Initiators as equipment and time allows.

Observable Results:
- As devices are added to the system use local management information to verify that added devices are visible from all other devices in the system.
- Verify SCSI traffic resumes when devices are disconnected and reconnected from the system.

Possible Problems: None known.

APPENDICES

Overview:

Test suite appendices are intended to provide additional low-level technical detail pertinent to specific tests contained in this test suite. These appendices often cover topics that are outside of the scope of the standard, and are specific to the methodologies used for performing the measurements in this test suite. Appendix topics may also include discussion regarding a specific interpretation of the standard (for the purposes of this test suite), for cases where a particular specification may appear unclear or otherwise open to multiple interpretations.

Scope:

Test suite appendices are considered informative supplements, and pertain solely to the test definitions and procedures contained in this test suite.

Appendix A: Cable Measurement Preparation

1.0 Purpose
To standardize the test procedure for interoperability testing of SAS 12Gb/s passive cable assembly. Although the test event will not include measurement of passive copper cables, this procedure is a good preparatory step for cable manufacturers to understand the characteristics of their product prior to attending the plugfest event. It's expected that cable vendors will perform these tests prior to arriving at the SAS Plugfest event.

2.0 Test Equipment List
- 4-Port VNA 20GHz
- VNA Calibration Kit
- 2 Module Compliance Boards (MCB#1 and MCB#2)
- Host Compliance Board (HCB)
- BertScope BSA260C or equivalent
- Power Supply 3.3V, 5W max.

3.0 Test Setup and Calibration Procedure
VNA Setup for S-parameter testing:
- Sweep frequency: 10MHz – 20GHz
- Resolution: 2000 points
- IF BW: 1 KHz Max.
- Power Level: 0dBm

The SOLT shall be performed at the end of VNA's launch cable. Port 1 and port 2 is the positive; port 3 and port 4 is the negative.

The same calibration procedure can be used for measuring Module Compliance Boards prior to the plugfest.

4.0 Test Parameters and Procedure
- Label each cable assembly's connectors as P1 and P2
- All test parameters are reference to the IEEE SAS-3 Rev. 02a (26 July, 2012)

4.1 Differential Insertion Loss ($\left|Sdd21\right|$)

1. Connect port 1 to Tx+ and port 3 to Tx- of the MCB #1; connect port 2 to Rx+ and port port 4 to Rx- of the MCB #2.
2. Connect P1 connector of the cable assembly to the MCB #1 and P2 connector to the MCB #2
3. Sweep the VNA over the defined frequency range as defined in the Test Setup
4. Export the results as an *.s4p file
5. Export the results as a *.csv data file which needs to include the magnitude of all balanced signals such as Sdd21, Sdd22, Scd21, and Scd22.
6. Label the file as the following format:

(Vendor_Name)_(Transmitter Channel ID)_(Cable End ID)_(Receiver Channel_ID)_(Cable End ID)_(CableLength_AWG_ Description).s4p or .csv

*i.e. **Amphenol_Tx1_P1_Rx1_P2_3m 30awg.s4p** and **Amphenol_Tx1_P1_Rx1_P2_3m 30awg.csv***

7. Repeat for all other TxRx connection pairs
8. Reverse the cable assembly's end by connecting P2 connector to MCB #1 and P1 connector to MCB #2
9. Repeat steps 3-7

4.2 Differential Output Return Loss ($\left|Sdd22\right|$)
1. Since the test in Section 4.1 has been performed, this parameter testing is not required

2. The differential output return loss │Sdd22│ of each TxRx connection's receive signal pair can be obtained from the data file in Section 4.1

3. The │Sdd22│ of each receive signal pair shall not exceed the limit specified in Table 25 of the reference standard.

4.3 Mode Conversion Insertion Loss (│Scd21│)

1. Since the test in Section 4.1 has been performed, this parameter testing is not required

2. The mode conversion insertion loss │Scd21│ of each TxRx connection's receive signal pair can be obtained from the data file in Section 4.1

3. The │Scd21│ of each TxRx connection pair shall not exceed the limit specified in Table 25 of the reference standard.

4.4 Mode Conversion – Insertion Loss (│Scd21│ - │Sdd21│)

The computation of this SI parameter of each TxRx connection can be obtained by using the │Scd21│ and │Sdd21│ data obtained in Section 4.1. The computed value shall not exceed the limit specified in Table 25 of the reference standard.

4.5 Mode Conversion Output Return Loss (│Scd22│)

1. Since the test in Section 4.1 has been performed, this parameter testing is not required

2. The mode conversion output return loss │Scd22│ of each TxRx connection's receive signal pair can be obtained from the data file in Section 4.1

3. The │Scd22│ of each receive signal pair shall not exceed the limit specified in Table 25 of the reference standard.

4.6 Pair-Pair Near-end Crosstalk (NEXT│Sdd21│)) and TotalNEXT

The pair-pair NEXT can be obtained as followings:

1. Connect port 1 to Tx+ and port 3 to Tx- of the MCB #1; connect port 2 to Rx+ and port port 4 to Rx- of the same MCB #1; terminate all unused SMA ports with 50 Ohm terminations.

2. Terminate all SMA ports of MCB # 2 with 50 Ohm loads

3. For pair-pair NEXT @ P1 connector, connect P1 connector of the cable assembly to the MCB #1 and P2 connector to the MCB #2

4. Sweep the VNA over the defined frequency range as defined in the Test Setup

5. Export the results as an *.s4p file

6. Export the results as a *.csv data file which includes the magnitude of the balanced signal Sdd21.

7. Label the file as the following format:

(Vendor_Name)_(Transmitter Channel ID)_(Cable End ID)_(Receiver Channel_ID)_(Cable End ID)_(CableLength_AWG_ Description).s4p or .csv

*i.e. **Amphenol_Tx1_P1_Rx1_P1_3m 30awg.s4p** and*
Amphenol_Tx1_P1_Rx1_P1_3m 30awg.csv

8. Repeat the same test for the remaining aggressor pairs to each receive (victim) signal pair. There are 16 pair-pair NEXT combination for each 4X connector

9. For pair-pair NEXT @ P2 connector, reverse the cable assembly's end by connecting P2 connector to MCB #1 and P1 connector to MCB #2

10. Repeat steps 4-8 to complete the pair-pair NEXT │Sdd21│ measurement. The TotalNEXT to each receive signal pair is calculated per the following equation:

$$TotalNEXT(f) = 10 * \log \sum_{1}^{n} 10^{NEXT(f)/10}$$

Where f = frequency and n is equal to the number of aggressor pairs.

The TotalNEXT to each victim pair shall not exceed in the limit specified in Table 25 of the reference standard.

4.7 Eye Mask Compliance

1. Connect differential Tx Data input to transmitter channel on MCB #1
2. Connect the differential Rx Data output to the receiver channel on the MCB #2
3. Set frequency to 12Gbps (TBD) and set data pattern to PBS31 (TBD)
4. Set differential output of generator to 500mVp-p (nominal peak-peak)
5. Verify that the j2 and J9 jitter values at TP1a are within the maximum specified values
6. Measure and record BER contour to 10-12 and verify that the BER contour passes the Eye Mask Compliance
7. Capture of the BER contour measured including the eye height and eye width of the contour
8. The BER contour should satisfy the eye mask requirements