SERIAL ATTACHED SCSI (SAS) CONSORTIUM

Clause 4
SAS Power Management Test Suite
Version 0.5

Technical Document

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MODIFICATION RECORD

[1] Initial Draft v0.1
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[2] Edited Draft v0.2
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[3] Edited Draft v0.3
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[4] Edited Draft v0.4
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[5] Edited Draft v0.5
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David Woolf	UNH InterOperability Laboratory (UNH-IOL)

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 in junction with CATC to help implementers evaluate the functionality of their Serial Attached SCSI (SAS) products. Specifically this Test Suite is directed at verifying the Link layer of SAS Targets, Initiators, and Expanders.

These tests are designed to determine if a SAS product conforms to specifications defined in **T10/Project 2124-D/Rev 7 – Information Technology – SAS Protocol Layer (SPL)** (hereafter referred to as the "SAS 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.

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.

REFERENCES

The following document is referenced in this text:

[1] T10/Project 2124-D/Rev 7 – Information Technology – SAS Protocol Layer (SPL)

GROUP 1: Power Measurement

Overview:

This group of tests measures the power drawn by a device in each Phy Power Condition and verifies that the device conforms to the Power Management Protocol defined in the SAS Spec

Test 4.1.1 - Active Power State – Power Measurement

Purpose: To determine the amount of power drawn by a device, to serve as benchmark for the Low Power Phy states

References:
[1] 4.10.1.2 SAS Standard

Resource Requirements: Lab Grade DC Power Supply, Multimeter, Traffic Generator, Traffic Generator Software

Last Modification: June 22, 2011

Discussion: The device will draw more power in an active state. This will be measure to serve as a benchmark for analyzing the Partial and Slumber power states.

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

Test Procedure:
1. The DUT is powered on and connected to the Testing Station.
2. The Testing Station sends a 50/50 mix of read/write to the DUT for 5 minutes.
3. Measure the current and voltage drawn by the DUT. Calculate power consumption.

Observable Results: The Average Power Consumption should be greater than the average power consumption of the Partial and Slumber power states. This test is informative.

Possible Problems: None.

Test 4.1.2 - 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 Standard
[2] 5.9.5.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 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 Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:

1. The Testing Station 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 4.1.3 - Partial Power State – Power Measurement

Purpose: To determine the amount of power drawn by a device, to verify the DUT power consumption is conformant.

References:

[1] 4.10.1.3 SAS Standard

Resource Requirements: Lab Grade DC Power Supply, Multimeter

Last Modification: June 15, 2011

Discussion: A device in the Partial power state shall consume more power than the slumber power state but less than the active power state

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

Test Procedure:

1. Send the DUT into the partial power state.
2. Measure the current and voltage drawn by the DUT. Calculate power consumption.

Observable Results: The Average Power Consumption should be greater than the average power consumption of the slumber power state but less than the active power state.

Possible Problems: None

Test 4.1.4 - 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 Standard
[2] Table 44 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

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 Testing Station 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. The DUT sends at least 3 ALIGN(0) before the SNLT timer expires, at the speed saved from the last Speed negotiation.
4. The testing station transmits 3 ALIGN(1) in response.
5. The DUT sends at least 3 ALIGN(1) before the SNTT timer expires.
6. The testing station transmits ALIGN(1) received message.
7. 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 μsec.

Possible Problems: None

Test 4.1.5 - 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 Standard
[2] 4.10.1.1 SAS Standard
[3] 6.2.6.11-13 SAS Standard

Resource Requirements: Lab Grade DC Power Supply, Multimeter

Last Modification: June 15, 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 Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:

1. The Testing Station 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 4.1.6 - Slumber Power State – Power Measurement

Purpose: To determine the amount of power drawn by a device, to verify the DUT power consumption is conformant.

References:

[1] 4.10.1.4 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 22, 2011

Discussion: A device in the slumber power state shall consume less power than the slumber power state and less than the active power state

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

Test Procedure:

1. Send the DUT is in the slumber power state.
2. Measure the current and voltage drawn by the DUT. Calculate power consumption.

Observable Results: The Average Power Consumption should be less than the average power consumption of the partial power state and less than the active power state.

Possible Problems: None

Test 4.1.7 - 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 Standard
[2] Table 44 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 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 Testing Station 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. The DUT sends at least 3 ALIGN(0) before the SNLT timer expires, at the speed saved from the last Speed negotiation.
4. The testing station transmits 3 ALIGN(1) in response.
5. The DUT sends at least 3 ALIGN(1) before the SNTT timer expires.
6. The testing station transmits ALIGN(1) received message.
7. 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 4.1.8 - 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 Standard
[2] 5.9.3.2.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 15, 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 Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:

1. Send the DUT to partial power state.
2. The Testing station 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 Testing station.

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

Possible Problems: None

Test 4.1.9 - 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 Standard
[2] 5.9.3.2.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 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 Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:

1. Send the DUT to slumber power state.
2. The Testing station 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 Testing station.

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

Possible Problems: None

GROUP 2: Power Management State Machine

Overview:

This group of tests verifies the Power Management state machine specified in the SAS 2.1 standard.

Test 4.2.1 - Partial Power State - NOTIFY

Purpose: To determine that the DUT will not forward NOTIFY when in a low phy state.

References:
[1] 4.10.1.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 15, 2011

Discussion: [1] A SAS phy or expander phy is in a low phy power condition and that phy is requested to transmit a NOTIFY, then that phy shall not transmit the NOTIFY and shall remain in the same low phy power condition.

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

Test Procedure:
1. Send the DUT into partial power state.
2. The Testing Station is instructed to transmit NOTIFY to the DUT.

Observable Results: Verify that if the DUT is a target or initiator, it does not forward the NOTIFY and remains in the partial power state. If DUT is an expander, it should go to the active phy state and forward the NOTIFY.

Possible Problems: None

Test 4.2.2 - Slumber Power State - NOTIFY

Purpose: To determine that the DUT will not forward NOTIFY when in a low phy state.

References:
[1] 4.10.1.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 15, 2011

Discussion: [1] A SAS phy or expander phy is in a low phy power condition and that phy is requested to transmit a NOTIFY, then that phy shall not transmit the NOTIFY and shall remain in the same low phy power condition.

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

Test Procedure:
1. Send the DUT into slumber power state.
2. The Testing Station is instructed to transmit NOTIFY to the DUT.

Observable Results: Verify that if the DUT is a target or initiator, it does not forward the NOTIFY and remains in the partial power state. If DUT is an expander, it should go to the active phy state and forward the NOTIFY.

Possible Problems: None

Test 4.2.3 - Partial Power State – 5 PS_REQ(PARTIAL) Received

Purpose: To determine that the DUT properly handles a received PS_REQ(PARTIAL).

References:

[1] 6.2.1- Table 60 SAS Standard
[2] 4.10.1.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 2011

Discussion: PS_REQ(PARTIAL) is a redundant primitive. After receiving 6 the DUT should enter the partial power state.
Test Setup: The DUT and the Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:

1. Send the DUT into partial power state.
2. The Testing Station is instructed to 5 PS_REQ(PARTIAL) primitives to the DUT.

Observable Results: Verify that the DUT does not send a PS_ACK and does not enter the partial power state.

Possible Problems: None

Test 4.2.4 - Slumber Power State – 5 PS_REQ(SLUMBER) Received

Purpose: To determine that the DUT properly handles a received PS_REQ(SLUMBER).

References:
[1] 6.2.1- Table 60 SAS Standard
[2] 4.10.1.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 2011

Discussion: PS_REQ(SLUMBER) is a redundant primitive. After receiving 6 the DUT should enter the partial power state.
Test Setup: The DUT and the Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT into slumber power state.
2. The Testing Station is instructed to 5 PS_REQ(SLUMBER) primitives to the DUT.

Observable Results: Verify that the DUT does not send a PS_ACK and does not enter the slumber power state.

Possible Problems: None

Test 4.2.5 - Partial Power State – 7 PS_REQ(PARTIAL) Received

Purpose: To determine that the DUT properly handles a received PS_REQ(PARTIAL).

References:
[1] 6.2.1- Table 60 SAS Standard
[2] 4.10.1.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 2011

Discussion: PS_REQ(PARTIAL) is a redundant primitive. After receiving 6 the DUT should enter the partial power state.
Test Setup: The DUT and the Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT into partial power state.
2. The Testing Station is instructed to 7 PS_REQ(PARTIAL) primitives to the DUT.

Observable Results: Verify that the DUT sends a PS_ACK and enters the partial power state.

Possible Problems: None

Test 4.2.6 - Slumber Power State – 7 PS_REQ(SLUMBER) Received

Purpose: To determine that the DUT properly handles a received PS_REQ(SLUMBER).

References:
[1] 6.2.1- Table 60 SAS Standard
[2] 4.10.1.1 SAS Standard

Resource Requirements: SAS Protocol Analyzer and Generator

Last Modification: June 9, 2011

Discussion: PS_REQ(SLUMBER) is a redundant primitive. After receiving 6 the DUT should enter the slumber power state.
Test Setup: The DUT and the Testing Station are physically connected. The DUT is in the active power state.

Test Procedure:
1. Send the DUT into slumber power state.
2. The Testing Station is instructed to 7 PS_REQ(PARTIAL) primitives to the DUT.

Observable Results: Verify that the DUT sends a PS_ACK and enters the SLUMBER power state.

Possible Problems: None

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 defined 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 5.A - Hardware Requirements, Test Fixtures, and Setups

Purpose: To specify the measurement hardware, test fixtures, and setups used in this test suite.

Last Modification: June 21, 2011 (version 0.3)

Setup: