UNH IOL SERIAL ATTACHED SCSI (SAS) CONSORTIUM

Clause 5
SAS Phy Layer Sync Test Suite
Version 3.3

Technical Document

Last Updated March 21, 2013

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MODIFICATION RECORD

[1]Oct 30, 2003 (Version 1.0) DRAFT RELEASE
David Woolf: Initial draft release
[2]Nov 13, 2003 (Version 1.1) DRAFT RELEASE
David Woolf: Added test cases 6.2.8 – 6.2.19
[3]May 4, 2004 (Version 1.2) DRAFT RELEASE
David Woolf Added test cases 6.1.6 – 6.1.9
[4]June 21, 2004 (Version 1.3) DRAFT RELEASE
David Woolf Adjusted test procedures to reflect UNH-IOL test capabilities.
[5]July 19, 2004 (Version 1.4) DRAFT RELEASE
David Woolf Adjusted test procedures to reflect UNH-IOL test capabilities.
[6]Oct 25, 2004 (Version 1.5) DRAFT RELEASE
David Woolf Modified Synchronization tests, Adjusted test procedures to reflect UNH-IOL test capabilities.
[7]Dec 6, 2004 (Version 1.6) FINAL RELEASE
David Woolf Added tests 6.1.11-13, 6.5.10-13
[8]January 17, 2006 (Version 1.61) FINAL RELEASE
David Woolf Edited tests 6.1.13-16
[9] March 6th 2006 (Version 1.7) FINAL RELEASE
Leon Cyril Updated the test suite to reflect the SAS 1.1 Standard (Revision 10). Added references page, Numbered references.
[10] July 10th 2006 (Version 2.0) FINAL RELEASE
Michael Davidson Rearranged tests, Added 6.1.18-6.1.21, Split Clause 6 into two Suite
[11] August 14th 2006 (Version 2.1) FINAL RELEASE
Michael Davidson Rearranged tests, added test 6.1.1, removed RCC References.
[12] August 22nd 2006 (Version 2.11) FINAL RELEASE
Michael Davidson Minor edits and revisions
[12] August 15th 2007 (Version 3.0) FINAL RELEASE
Michael Davidson Updated to reflect changes in SAS 2.0
[13] August 12th 2011 (Version 3.1) FINAL RELEASE
Michael Klempa Updated to reflect changes in SAS SPL
[14] July 9th 2012 (Version 3.2) FINAL RELEASE
Evice Bolton Updated the observable results section of tests 5.2.9 through 5.2.12
[15] March 21st 2013 (Version 3.3) FINAL RELEASE
Joshua Beaudet Updated the observable results section of tests 5.2.9 through 5.2.12

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ACKNOWLEDGMENTS

The University of New Hampshire would like to acknowledge the efforts of the following individuals in the development of this test suite.

David Woolf	UNH InterOperability Laboratory (UNH – IOL)
Leon Cyril	UNH InterOperability Laboratory (UNH – IOL)
Michael Davidson	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 to help implementers evaluate the Phy Layer functionality of their Serial Attached SCSI (SAS) products. Specifically this Test Suite is directed at verifying the 8B/10B encoding, Out of Band sequences, Speed Negotiation, and synchronization of the Phy Layer of SAS products in support of the work being directed by the SCSI Trade Association SAS Plugfest Committee.

These tests are designed to determine if a SAS product conforms to specifications defined in Clause 6 of **T10/Project 1601-D/Rev 10 – Serial Attached SCSI 1.1 – (SAS – 1.1)** (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 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 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 07 – Information technology – SAS Protocol Layer (SPL)

GROUP 1: CHARACTER ENCODING AND DECODING

Overview:

This group of tests verifies the 8B/10B encoding specifications of the SAS phy layer defined in Clause 5 of the SAS SPL. Comments and questions regarding the implementation of these tests are welcome, and may be forwarded to David Woolf, UNH InterOperability Lab (djwoolf@iol.unh.edu).

Test 5.1.1 – All Possible 8b/10b Codes in a Frame

Purpose: To determine that the DUT can correctly encode and decode all possible 8b/10b codes.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters.

Test Setup: The DUT and the Testing Station are powered on and physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit a frame to the DUT with a data body consisting of every possible 8b/10b code.

Alternative Procedure:
1. The Testing Station should complete the OOB sequence with the DUT.
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequences with the DUT.
4. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit a SCSI Write command to the DUT. The Testing station should write a frame consisting of every possible 8b/10b code to a sector of the disk.
6. The Testing Station should transmit a SCSI Read command to the DUT. The Testing Station should attempt to read the same sector previously written.

Observable Results: Verify that the DUT loops back the frame with the exact same contents. If the alternative procedure is used, verify that the data received during the Read command is the same as the data sent during the Write command.

Possible Problems: This test only works on devices that support a loop back mode. The alternative test procedure will have to be used on devices that do not support a loop back mode. The alternative test procedure will only work for targets that support writing to the medium. The alternative testing method can be used to test a SAS Initiator or Expander Device that is attached to a target device that supports reading and writing to the medium.

GROUP 2: DWORD SYNCHRONIZATION STATE MACHINE

Overview:

This group of tests verifies the SAS physical layer Synchronization state machine specifications defined in Clause 6 of the SAS Standard. Comments and questions regarding the implementation of these tests are welcome, and may be forwarded to David Woolf, UNH InterOperability Lab (djwoolf@iol.unh.edu).

Test 5.2.1 - Continuous Invalid Dwords Received - Invalid Transmission Characters Received

Purpose: To determine that the DUT can correctly identify and react to a received dword containing an invalid character.

References:

[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Any 10B character that does not occur in Table 54 or 55 is considered an invalid character. Any dword containing an invalid character is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. If the DWS Reset timer expires, the DUT may send a DWS Reset message to the SP state machine. If the DUT chooses to do so, the SP state machine will transition from SP15:SAS_PHY_Ready to SP0:OOB_COMINIT and begin sending COMINT. This transition is optional. The DUT cannot make this transition before the DW S Reset timer expires.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:

1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following invalid dword continuously for more than 1 msec:

   D21.5 0000111111 D21.5 D21.5

Observable Results: The SP state machine may restart the OOB sequence. If so the SP cannot do this until at least 1 msec after the Testing Station begins transmitting errors. Transitioning to SP0 is optional. If the DUT does not implement this transition, this test is not applicable.

Possible Problems: None.

Test 5.2.2 - Continuous Invalid Dwords Received - Running Disparity Errors Received

Purpose: To determine that the DUT can correctly identify and react to a received running disparity error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. All characters have a starting and ending running disparity. Running disparity between words must match. Non-matching running disparity in a word, or on a word boundary constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. If the DWS Reset timer expires, the DUT may send a DWS Reset message to the SP state machine. If the DUT chooses to do so, the SP state machine will transition from SP15:SAS_PHY_Ready to SP0:OOB_COMINIT and begin sending COMINT. This transition is optional. The DUT cannot make this transition before the DW S Reset timer expires.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following invalid dword continuously for more than 1 msec:
   /-D21.5-/(RD ERROR) +D00.5-/ -D21.5-/ -D21.5-

Observable Results: The SP state machine may restart the OOB sequence. If so the SP cannot do this until at least 1 msec after the Testing Station begins transmitting errors. Transitioning to SP0 is optional. If the DUT does not implement this transition, this test is not applicable.

Possible Problems: None.

Test 5.2.3 - Continuous Invalid Dwords Received - Incorrect Special Character Errors Received

Purpose: To determine that the DUT can correctly identify and react to a received incorrect special character error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. In SAS only the K28.5, K28.6, and K28.3 special characters are used. Detection of any other special character constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. If the DWS Reset timer expires, the DUT may send a DWS Reset message to the SP state machine. If the DUT chooses to do so, the SP state machine will transition from SP15:SAS_PHY_Ready to SP0:OOB_COMINIT and begin sending COMINT. This transition is optional. The DUT cannot make this transition before the DW S Reset timer expires.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following invalid dword continuously for more than 1 msec:
   K28.7/D21.5/D21.5/D21.5

Observable Results: The SP state machine may restart the OOB sequence. If so the SP cannot do this until at least 1 msec after the Testing Station begins transmitting errors. Transitioning to SP0 is optional. If the DUT does not implement this transition, this test is not applicable.

Possible Problems: None.

Test 5.2.4 - Continuous Invalid Dwords Received - Misaligned Special Character Errors Received

Purpose: To determine that the DUT can correctly identify and react to a received misaligned special character error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Table 31 describes the appropriate use of these special characters. Special characters should always be in the first position of a 40b word. Any SAS primitive received with the special character misaligned is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. If the DWS Reset timer expires, the DUT may send a DWS Reset message to the SP state machine. If the DUT chooses to do so, the SP state machine will transition from SP15:SAS_PHY_Ready to SP0:OOB_COMINIT and begin sending COMINT. This transition is optional. The DUT cannot make this transition before the DW S Reset timer expires.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following invalid dwords continuously for more than 1 msec:

   D21.5/K28.5/D21.5/D21.5
   D21.5/D21.5/K28.5/D21.5
   K28.5/D21.5/D21.5/D21.5
   D21.5/K28.5/D21.5/D21.5

Observable Results: The SP state machine may restart the OOB sequence. If so the SP cannot do this until at least 1 msec after the Testing Station begins transmitting errors. Transitioning to SP0 is optional. If the DUT does not implement this transition, this test is not applicable.

Possible Problems: None.

Test 5.2.5 - Invalid Dwords Received Followed by Continuous Idle - Invalid Characters

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 or more invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcquireSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have an invalid character error. After this the DUT receives only Idle dwords. The DUT is expected to transmit COMINIT after 1 msec, although this is not required.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords.
   Invalid Dwords (12)
   Continuous Idle Dwords

Observable Results: Determine whether the DUT transmits COMINIT or not.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.6 - Invalid Dwords Received Followed by Continuous Idle - Running Disparity Errors

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 or more invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have a running disparity error. After this the DUT receives only Idle dwords. The DUT is expected to transmit COMINIT after 1 msec, although this is not required.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords.

   Invalid Dword (12)
   Continuous Idle Dwords

Observable Results: Determine whether the DUT transmits COMINIT or not.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.7 - Invalid Dwords Received Followed by Continuous Idle - Incorrect Special Character

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 or more invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have an incorrect special character error. After this the DUT receives only Idle dwords. The DUT is expected to transmit COMINIT after 1 msec, although this is not required.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords.

   Invalid Dword (12)
   Continuous Idle Dwords

Observable Results: Determine whether the DUT transmits COMINIT or not.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.8 - Invalid Dwords Received Followed by Continuous Idle - Misaligned Special Character

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 or more invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have a misaligned special character error. After this the DUT receives only Idle dwords. The DUT is expected to transmit COMINIT after 1 msec, although this is not required.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords.

   Invalid Dword (12)
   Continuous Idle Dwords

Observable Results: Determine whether the DUT transmits COMINIT or not.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.9 - Invalid Dwords Interspersed with Idle Received - Invalid Transmission Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing an invalid character.

References:
[1] Table 40,41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: March 21, 2013

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Any 10B character that does not occur in Table 54 or 55 is considered an invalid character. Any dword containing an invalid character is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. Once the device loses synchronization, it can only regain synchronization if 3 primitives are receiving without intervening invalid dwords.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following pattern of invalid dwords and Idle dwords continuously for more than 1 msec:
   D21.5 0000111111 D21.5 D21.5 (500)
   Idle dwords (30)

Observable Results: If in the previous subgroup of tests (5.2.5 through 5.2.8) the DUT sent COMINIT then the DUT shall send OOB. If the DUT did not send COMINIT in the previous subgroup then the test is not applicable.

Possible Problems: None.

Test 5.2.10 - Invalid Dwords Interspersed with Idle Received - Running Disparity Errors

Purpose: To determine that the DUT can correctly identify and react to a received running disparity error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: March 21, 2013

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. All characters have a starting and ending running disparity. Running disparity between words must match. Non-matching running disparity in a word, or on a word boundary constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. Once the device loses synchronization, it can only regain synchronization if 3 primitives are receiving without intervening invalid dwords.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following pattern of invalid dwords and Idle dwords continuously for more than 1 msec:

   /-D21.5-/(RD ERROR) +D00.5-/ -D21.5-/ -D21.5- (500)
   Idle dwords (30)

Observable Results: If in the previous subgroup of tests (5.2.5 through 5.2.8) the DUT sent COMINIT then the DUT shall send OOB. If the DUT did not send COMINIT in the previous subgroup then the test is not applicable.

Possible Problems: None.

Test 5.2.11- Invalid Dwords Interspersed with Idle Received - Incorrect Special Character

Purpose: To determine that the DUT can correctly identify and react to a received incorrect special character error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] Table 58 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: March 21, 2013

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. In SAS only the K28.5, K28.6, and K28.3 special characters are used. Detection of any other special character constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. Once the device loses synchronization, it can only regain synchronization if 3 primitives are receiving without intervening invalid dwords.

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following pattern invalid dwords and Idle dwords continuously for more than 1 msec:

   K28.7/D21.5/D21.5/D21.5 (500)
   Idle dwords (30)

Observable Results: If in the previous subgroup of tests (5.2.5 through 5.2.8) the DUT sent COMINIT then the DUT shall send OOB. If the DUT did not send COMINIT in the previous subgroup then the test is not applicable.

Possible Problems: None.

Test 5.2.12 - Invalid Dwords Interspersed with Idle Received - Misaligned Special Character

Purpose: To determine that the DUT can correctly identify and react to a received misaligned special character error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: March 21, 2013

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Special characters should always be in the first position of a 40b word. Any SAS primitive received with the special character misaligned is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. Once the device loses synchronization, it can only regain synchronization if 3 primitives are receiving without intervening invalid dwords..

Test Setup: The DUT and the Testing Station are powered on, but not connected.

Test Procedure:
1. Connect the Testing Station to the DUT.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following pattern of invalid dwords and Idle dwords continuously for more than 1 msec:

(D21.5/K28.5/D21.5/D21.5
D21.5/D21.5/K28.5/D21.5
K28.5/D21.5/D21.5/D21.5
D21.5/K28.5/D21.5/D21.5) repeat 100 times
Idle dwords (30)

Observable Results: If in the previous subgroup of tests (5.2.5 through 5.2.8) the DUT sent COMINIT then the DUT shall send OOB. If the DUT did not send COMINIT in the previous subgroup then the test is not applicable.

Possible Problems: None.

Test 5.2.13 - Recover Sync on Consecutive Primitives - Invalid Transmission Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing an invalid character.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Any 10B character that does not occur in Table 54 or 55 is considered an invalid character. Any dword containing an invalid character is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:
1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords, ALIGN (0) primitives, and Open Address Frames followed by continuous valid Idle dwords interspersed with ALIGNs:

   D21.5 0000111111 D21.5 D21.5
   D21.5 0000111111 D21.5 D21.5
   D21.5 0000111111 D21.5 D21.5
   D21.5 0000111111 D21.5 D21.5
   Two consecutive ALIGN (0) primitives
   OPEN address frame addressed to DUT

Observable Results: Verify that the DUT responded to the OPEN ADDRESS frame.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the ALIGN (0) primitives.

Test 5.2.15 - Recover Sync on Consecutive Primitives - Incorrect Special Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing a running disparity error.

References:

[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. All characters have a starting and ending running disparity. Running disparity between words must match. Non-matching running disparity in a word, or on a word boundary constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:

1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords, ALIGN (0) primitives, and Open Address Frames followed by continuous valid Idle dwords interspersed with ALIGNs:

   K28.7/D21.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   Two consecutive ALIGN (0) primitives
   OPEN address frame addressed to DUT

Observable Results: Verify that the DUT responded to the OPEN ADDRESS frame.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the ALIGN (0) primitives.

Test 5.2.16 - Recover Sync on Consecutive Primitives - Misaligned Special Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing a running disparity error.

References:

[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. All characters have a starting and ending running disparity. Running disparity between words must match. Non-matching running disparity in a word, or on a word boundary constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:

1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords, ALIGN (0) primitives, and Open Address Frames followed by continuous valid Idle dwords interspersed with ALIGNs:

   D21.5/K28.5/D21.5/D21.5
   D21.5/K28.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   D21.5/K28.5/D21.5/D21.5
   Two consecutive ALIGN (0) primitives
   OPEN address frame addressed to DUT

Observable Results: Verify that the DUT responded to the OPEN ADDRESS frame.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the ALIGN (0) primitives.

Test 5.2.17 - 1 Cycle AcquireSync then Recover Sync on Non-Consecutive Primitives - Invalid Transmission Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing an invalid character.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Any 10B character that does not occur in Table 54 or 55 is considered an invalid character. Any dword containing an invalid character is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:
1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords and OPEN ADDRESS frames followed by continuous valid Idle dwords interspersed with ALIGNs:
   D21.5 0000111111 D21.5 D21.5
   D21.5 0000111111 D21.5 D21.5
   D21.5 0000111111 D21.5 D21.5
   D21.5 0000111111 D21.5 D21.5
   OPEN address frame with source address matching destination address
   OPEN address frame addressed to DUT.

Observable Results: Verify that the DUT responded only to the second OPEN ADDRESS frame and did not respond to the first.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the SOAF of the first OPEN ADDRESS frame.

Test 5.2.18 - 1 Cycle AcquireSync then Recover Sync on Non-Consecutive Primitives - Running Disparity Errors

Purpose: To determine that the DUT can correctly identify and react to a received dword containing a running disparity error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. All characters have a starting and ending running disparity. Running disparity between words must match. Non-matching running disparity in a word, or on a word boundary constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:
1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords and OPEN ADDRESS frames followed by continuous valid Idle dwords interspersed with ALIGNs:
   /-D21.5-/(RD ERROR) +D00.5-/ -D21.5-/ -D21.5-
   /-D21.5-/(RD ERROR) +D00.5-/ -D21.5-/ -D21.5-
   /-D21.5-/(RD ERROR) +D00.5-/ -D21.5-/ -D21.5-
   /-D21.5-/(RD ERROR) +D00.5-/ -D21.5-/ -D21.5-
   OPEN address frame with source address matching destination address
   OPEN address frame addressed to DUT.

Observable Results: Verify that the DUT responded only to the second OPEN ADDRESS frame and did not respond to the first.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the SOAF of the first OPEN ADDRESS frame.

Test 5.2.19 - 1 Cycle AcquireSync then Recover Sync on Non-Consecutive Primitives - Incorrect Special Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing an incorrect special character error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. In SAS only the K28.5, K28.6, and K28.3 special characters are used. Detection of any other special character constitutes an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:
1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords and OPEN ADDRESS frames followed by continuous valid Idle dwords interspersed with ALIGNs:
   K28.7/D21.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   K28.7/D21.5/D21.5/D21.5
   OPEN address frame with source address matching destination address
   OPEN address frame addressed to DUT.

Observable Results: Verify that the DUT responded only to the second OPEN ADDRESS frame and did not respond to the first.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the SOAF of the first OPEN ADDRESS frame.

Test 5.2.20 - 1 Cycle AcquireSync then Recover Sync on Non-Consecutive Primitives - Misaligned Special Characters

Purpose: To determine that the DUT can correctly identify and react to a received dword containing a misaligned special character error.

References:
[1] Table 40, 41 SAS Standard
[2] 5.3 SAS Standard
[3] 5.9.1 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. The mapping from 8B to 10B characters is shown in Table 54 of the SAS spec. Table 55 describes the 10B special or K characters. Special characters should always be in the first position of a 40b word. Any SAS primitive received with the special character misaligned is considered an invalid dword. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy will be in the SP_DWS0: AcquireSync state. At this point dword synchronization is lost. When dword synchronization is lost, the data stream is considered invalid and dwords shall not be passed to the link layer.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:
1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit the following sequence of 4 invalid dwords and OPEN ADDRESS frames followed by continuous valid Idle dwords interspersed with ALIGNs:
   D21.5/K28.5/D21.5/D21.5
   D21.5/D21.5/K28.5/D21.5
   K28.5/D21.5/D21.5/D21.5
   D21.5/K28.5/D21.5/D21.5
   OPEN address frame with source address matching destination address
   OPEN address frame addressed to DUT.

Observable Results: Verify that the DUT responded only to the second OPEN ADDRESS frame and did not respond to the first.

Possible Problems: It is important that no Idle dwords are transmitted by the testing station between the invalid dwords and the SOAF of the first OPEN ADDRESS frame.

A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy must send a DWS Lost message to the SP state machine. This will cause the Phy to return to the SP0:OOB_COMINIT state and restart the OOB sequence.

Test 5.2.21 - Multiple Cycles AcuireSync then Recover Sync on Non-Consecutive Primitives - Invalid Characters

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 o rmore invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have a invalid character error. After this the DUT receives 2 OPEN_ADDRESS frames. It is expected that the first SOAF of the second OPEN_ADDRESS frame will be the third primitve received by the DUT and will be forwarded to the link layer for processing. The DUT is expected to respond to the second received OPEN_ADDRESS frame.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
10 Idle Dwords
OPEN_ADDRESS Frame
10 Idle Dwords
OPEN_ADDRESS Frame

Observable Results: Verify that the DUT responds to the second OPEN_ADDRESS frame. Verify that the DUT does not transmit COMINIT.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.22 - Multiple Cycles AcuireSync then Recover Sync on Non-Consecutive Primitives - Running Disparity Errors

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 o rmore invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have a running disparity error. After this the DUT receives 2 OPEN_ADDRESS frames. It is expected that the first SOAF of the second OPEN_ADDRESS frame will be the third primitve received by the DUT and will be forwarded to the link layer for processing. The DUT is expected to respond to the second received OPEN_ADDRESS frame.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
10 Idle Dwords
OPEN_ADDRESS Frame
10 Idle Dwords
OPEN_ADDRESS Frame

Observable Results: Verify that the DUT responds to the second OPEN_ADDRESS frame. Verify that the DUT does not transmit COMINIT.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.23 - Multiple Cycles AcuireSync then Recover Sync on Non-Consecutive Primitives - Incorrect Special Character

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 o rmore invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have a incorrect special character error. After this the DUT receives 2 OPEN_ADDRESS frames. It is expected that the first SOAF of the second OPEN_ADDRESS frame will be the third primitve received by the DUT and will be forwarded to the link layer for processing. The DUT is expected to respond to the second received OPEN_ADDRESS frame.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
10 Idle Dwords
OPEN_ADDRESS Frame
10 Idle Dwords
OPEN_ADDRESS Frame

Observable Results: Verify that the DUT responds to the second OPEN_ADDRESS frame. Verify that the DUT does not transmit COMINIT.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.24 - Multiple Cycles AcuireSync then Recover Sync on Non-Consecutive Primitives - Misaligned Special Character

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the AcquireSync state if 4 o rmore invalid dwords are received. While in the AcquireSync state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when it has received 3 valid primitives, without receiving any intervening invalid dwords. If the DUT remains in the AcqurieSync state for more than 1 msec it may choose to transmit COMINIT. In this test the DUT is transmitted a pattern of 12 invalid dwords, which each have a misaligned special character error. After this the DUT receives 2 OPEN_ADDRESS frames. It is expected that the first SOAF of the second OPEN_ADDRESS frame will be the third primitve received by the DUT and will be forwarded to the link layer for processing. The DUT is expected to respond to the second received OPEN_ADDRESS frame.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
Invalid Dword
10 Idle Dwords
OPEN_ADDRESS Frame
10 Idle Dwords
OPEN_ADDRESS Frame

Observable Results: Verify that the DUT responds to the second OPEN_ADDRESS frame. Verify that the DUT does not transmit COMINIT.

Possible Problems: The DUT is not required to transmit COMINIT.

Test 5.2.25 - Respond to Frame in SyncAcquired-Lost1

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost1 state if 1 invalid dword is received. While in the Lost1 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid word is nullified by the reception of a valid dword. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.26 - Respond to Frame in SyncAcquired-Lost2

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost2 state if 2 invalid dwords are received. While in the Lost2 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Invalid Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.27 - Respond to Frame in SyncAcquired-Lost3

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Invalid Dword
   Invalid Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.28 - Respond to Frame in SyncAcquired-Lost1Recovered

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Valid Idle Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.29 - Respond to Frame in SyncAcquired-Lost2Recovered

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Invalid Dword
   Valid Idle Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.30 - Respond to Frame in SyncAcquired-Lost3Recovered

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Invalid Dword
   Invalid Dword
   Valid Idle Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.31 - Maintain Synchronization, Respond to Frame

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Invalid Dword
   Invalid Dword
   Valid Idle Dword
   Valid Idle Dword
   Invalid Dword
   Valid Idle Dword
   Valid Idle Dword
   Invalid Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.32 - Maintain Synchronization, Respond to Frame

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Valid Idle Dword
   Invalid Dword
   Valid Idle Dword
   Invalid Dword
   Valid Idle Dword
   Valid Idle Dword
   Valid Idle Dword
   Valid Idle Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.33 - Maintain Synchronization, Respond to Frame

Purpose: To determine that the DUT can correctly navigate the Synchronization State Machine for SAS.

References:
[1] Figure 85 SAS Standard
[2] 5.10.2 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: A SAS Device in the SyncAcquired state should move to the Lost3 state if 3 invalid dwords are received. While in the Lost3 state the SAS Phy should not forward dwords to the link layer for processing. A SAS Phy should return to the SyncAcquired state when the received invalid words are nullified by the reception of valid dwords. An OPEN address frame received when a SAS Phy was not in the SyncAcquired state would not be forwarded to the link layer in its entirety, and therefore not responded to by the link layer.

Test Setup: The DUT and Testing Station are physically connected.

Test Procedure:
1. The Testing Station should complete the OOB sequence with the DUT
2. The Testing Station should complete the Speed Negotiation sequence with the DUT.
3. The Testing Station should complete the IDENTIFY sequence with the DUT.
4. The Testing Station should 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
5. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs:

   Invalid Dword
   Invalid Dword
   Valid Idle Dword
   Valid Idle Dword
   Invalid Dword
   Invalid Dword
   Valid Idle Dword
   Valid Idle Dword
   Invalid Dword
   Valid Idle Dword
   Valid Idle Dword
   Valid Idle Dword
   Valid Idle Dword
   Invalid Dword
   Invalid Dword
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN address frame with either OPEN_ACCEPT, OPEN_REJECT, or BREAK primitives.

Possible Problems: None.

Test 5.2.34 - Calculate RD After Error Received

Purpose: To determine that the DUT can correctly calculate the Running Disparity after an invalid dword was received.

References:
[1] 5.3 SAS Standard

Resource Requirements: SAS Traffic Analyzer and Generator capable of creating and observing 10b errors.

Last Modification: August 12, 2011

Discussion: SAS uses 8B/10B encoding on its characters for higher transition density and better error detection. A SAS Phy will calculate running disparity for each received character. Beginning running disparity on a received character must match the ending running disparity of the previously received character. Any SAS primitive received with a running disparity error is considered an invalid dword. A received transmission character, valid or invalid, will be used to calculate the new value of running disparity. A SAS Phy in the SP_DWS3: SyncAcquired state will lose synchronization if 4 consecutive invalid dwords are received. At this point the SAS Phy must send a DWS Lost message to the SP state machine. This will cause the Phy to return to the SP0:OOB_COMINIT state and restart the OOB sequence.

Test Setup: The DUT and Testing Station are powered on but not connected.

Test Procedure:

1. Connect the DUT to the Testing Station.
2. The Testing Station should complete the OOB sequence with the DUT
3. The Testing Station should complete the Speed Negotiation sequence with the DUT.
4. The Testing Station should complete the IDENTIFY sequence with the DUT.
5. The Testing Station should transmit 1000 Idle dwords interspersed with ALIGNs. This should ensure that the DUT is in the SP_DWS3: SyncAcquired state.
6. The Testing Station should transmit idle dwords such that the ending running disparity is negative.
7. The Testing Station should transmit the following sequence followed by continuous valid Idle dwords interspersed with ALIGNs without creating a running disparity error on the first character.

   -D21.5- -0000111111+ +D21.5+ +D21.5+
   +D21.5+ -0000110001- -D21.5- -D21.5-
   -D21.5- -0000111111+ +D21.5+ +D21.5+
   valid Idle Dword with + beginning Running Disparity
   OPEN address frame

Observable Results: Verify that the DUT responds to the received OPEN ADDRESS frame. The three consecutive invalid characters should cause the DUT to move to the SPDWS8:Lost3 state. If the DUT sees the valid Idle dword as an RD Error it will transition to the SP_DWS0 state and not respond to the subsequent frame. If the DUT correctly recalculates Running Disparity it will properly respond to the OPEN ADDRESS frame.

Possible Problems: None.