Open Network Systems Interoperability Test Plan [DRAFT] Rev. 5

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Table of Contents

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 test plan was designed to validate the multi-vendor compatibility of optical transceivers and cables with bare-metal open switches running Networking Operating Systems (NOS) software. The aim is to validate the operation of open network systems, giving end users confidence that the individual components can be combined to create strong alternatives to traditional closed solutions.

The tests do not determine if a product conforms to standards, nor are they purely interoperability tests. Rather, they provide one method to isolate problems within Open Network Systems . Successful completion of all tests contained in this suite does not guarantee that the tested Open Network Module will operate with other Open Network Modules. However, combined with satisfactory operation in the IOL's semi-production environment, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function well with other Open Network Modules that have been subjected to similar tests.

References

The following documents were referenced in this text:

- IEEE 802.3 - 2008
- IEEE 802.1Q - 2011
- SFF-8431
- SFF-8432
- SFF-8435
- SFF-8436
- SFF-8472
- SFF-8479
- OCP http://www.opencompute.org/wiki/Networking/SpecsAndDesigns
- ONIE https://github.com/opencomputeproject/onie/wiki

Abbreviations and Acronyms

CLI	Command Line Interface
DOM	Digital Optical Monitoring
DSO	Digital Storage Oscilloscope
DUT	Device Under Test
EEPROM	Electrically Erasable Programmable Read-Only Memory
I^2C	Inter-Integrated Circuit
LP	Link Partner
IPG	Inter-Packet Gap
ONIE	Open Network Install Environment
PHY	Abbreviation for Physical Layer
PVID	Port VLAN ID
QSFP+	Quad Small Form-factor Pluggable
RMS	Root Mean Square
SFP+	Enhanced Small Form-factor Pluggable
VLAN	Virtual Local Area Network

Test Organization

This document organizes tests by group based on related test methodology or goals. Each group begins with a brief set of comments pertaining to all tests within group. This is followed by a series of description blocks; each block describes a single test. The format of the description block is as follows:

Test Label: The Test Label and title comprise the first line of the test block. The Test Label is the concatenation of the short test suite name, group number, and the test number within the group, separated by periods. The test label DCBX.1.2 refers to the second test of the first group in the DCB Capability Exchange Protocol Test Suite.

Purpose: The Purpose is a short statement describing what the test attempts to achieve. It is usually phrased as a simple assertion of the feature or capability to be tested.

References: The Reference section lists cross-references to the specifications and documentation that might be helpful in understanding and evaluating the test and results**.**

Resource Requirements: The Resource Requirements section specifies the software, hardware, and test equipment that will be needed to perform the test.

Discussion: The Discussion is a general discussion of the test and relevant sections of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

Test Setup: The Default Test Setup section describes the configuration of the DUT prior to the start of the test. The procedure may involve configuration steps that deviate from what is given in the test setup. If a value is not provided for a protocol parameter, then the protocol's default is used for that parameter.

Test This section of the test description contains the step-by-step instructions for carrying out the test.

Procedure: These steps include such things as enabling interfaces, disconnecting links between devices, and sending MAC frames from a Test Station. The test procedure may also instruct the test to make observations, which are interpreted in accordance with the observable results given for that test part.

Observable Results: This section lists observable results that can be examined by the tester to verify that the DUT is operating properly. When multiple observable results are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail for each test is usually based on how the behavior of the DUT compares to the results described in this section.

Possible Problems: This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

Requirements

Modules covered by this test plan

Pluggable Form Factors
SFP+ (10G)
QSFP+ (10G per lane)
Link Technologies (Transceivers and active cable assemblies)
Short Reach (SR) Optics (Multi-mode fiber using 850 nm light)
Long Reach (LR) Optics (Single-mode fiber using 1300 nm light)
Copper Cables (passive and active)
Host Module Complex

- 10G
- 40G

Group 1: Management of NOS through ONIE

Overview: The tests defined in this section verify that the NOS can be uninstalled and reinstalled through ONIE.

1.1 Installing and uninstalling a NOS through ONIE via HTTP server

Purpose: To verify that a NOS can be successfully installed through ONIE**.**

Resource Requirements: A switch with ONIE pre-installed. An HTTP server running on port 80 and hosting the NOS image. A DHCP server. A hub or switch.

Discussion: The Open Network Install Environment (ONIE) is a Linux based OS and boot loader which runs on Bare Metal Switches and designed to discover Network Operating Systems (NOS) on a network, transfer the NOS to the switch, then install it. ONIE also provides the means to uninstall the NOS. Once ONIE has installed a NOS, the switch will boot directly into the NOS and not ONIE, but ONIE is still able to be called upon to uninstall or reinstall a NOS.

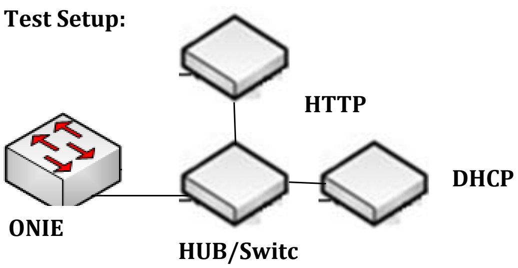
These tests may be omitted if all of the following apply:

1) The switch has been ONIE HW Certified
2) The NOS has been certified through ONIE NOS Validation with the switch

In the event that the switch has not been through ONIE HW Certification, a random sampling of tests from ONIE Compliance Environment (OCE) will be used. The exact tests will be chosen from one of the following (https://github.com/opencomputeproject/onie/wiki/Testing-Overview):

* Installation: Tests 2 - 37
* Uninstallation: Tests 74 - 76

Test Setup:



Test Procedure:

Part A. Installing a NOS

1. Power on the DUT and ensure that it boots into ONIE.
2. Ensure that ONIE has established an IP address from the DHCP server.
3. From ONIE, issue the command " install_url http://<ipAddress>/<fileName>"
4. Wait for ONIE to finish installing the NOS.
5. Reboot the DUT

Part B. Uninstalling a NOS

1. Power on the DUT and ensure that it boots into the NOS.
2. Reboot the DUT and interrupt the boot process such that GRUB appears.
3. Select ONIE from GRUB.
4. From ONIE list in GRUB, select "uninstall"

5. Wait for ONIE to finish installing the NOS.
6. Reboot the DUT

Observable results:
In Part A, step 5, the DUT should boot directly into the NOS that was just installed.
In Part B, step 6, the DUT should boot directly into ONIE. No NOS should be installed on the DUT.

Possible Problem:
In the event that a switch/NOS combination has not been through ONIE NOS Validation, NOS validation will take place during ONIE HW testing.

Group 2: Management of Optical Module

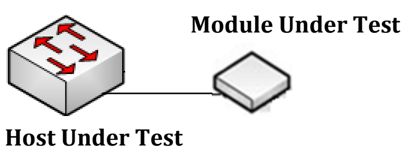
Overview: The tests defined in this section verify that the modules under test are physically compatible with the hosts under tests and that the modules read-only data is accessible.

2.1 Physical Compatibility with Supporting Devices

Purpose: To verify that the mechanical form factor is compatible with devices for interoperability purposes

Resource requirements:
Known good host
Known good cable with appropriate connector assembly

Test Setup:



Test Procedure:
1. Record Optical Module number and serial number.
2. Verify Optical Module is capable of being inserted into known good host.
3. Verify DUT is capable of attaching to known good Cable with respective appropriate connector.

Observable results:
All modules should insert and connect to the Host

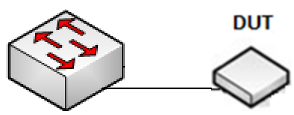
2.2 Host Management of Optical Module

Purpose: To verify that the Optical Module(SFP+ or QSFP) is manageable via the Host complex

Resource requirements:

- Known good host module
- Known good cable with appropriate connector assembly
- EEPROM Reader (details to be added in for this resource)
- Evaluation board (details added later)

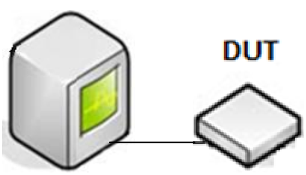
Test Setup:
For part A and B, the DUT is connected to the Host



Host Under Test

For parts C and D, the DUT is inserted into an evaluation board and

EEPROM reader



Test Procedure:

Part A. Host OS recognizes Optical Module

1. Record Optical Module part number and serial number
2. Insert Optical Module in Host
3. Verify Host recognizes Optical Module type and manufacturer via CLI interface of Host Record

Part B. EEPROM is accessible via Host

1. Record Optical Module part number and serial number
2. Insert Optical Module in Host
3. Via CLI Interface extract hexdump

Part C. EEPROM is accessible via EEPROM Reader

1. Record Optical Module part number and serial number
2. Insert Optical Module in evaluation board
3. Connect EEPROM reader to EEPROM via I²C interface
4. Record Serial ID info
5. Record Vendor specific information

Part C. Extract all data from EEPROM via EEPROM Reader

1. Record Optical Module part number and serial number

2. Insert Optical Module in evaluation Board
3. Connect EEPROM reader to EEPROM via I^{2}C interface
4. Extract hexdump and store in specified file format

Observable results:
Host CLI should recognize module and accurately reflect Optical Module information
EEPROM Read Only data shall accurately reflect Optical Module information and coincide with CLI

Possible Problems:
EEPROM Data can be organized in a paginated format.

Group 3: Cable Assembly

Overview: <update needed>

Section 3.1 10G Actve Optical Cables Measurements

3.1.1 10G Active Optical Cable Electrical Baseline

Purpose: To establish Electrical input baseline of the optical cable modules.

NOTE: This measurement needs to only to be done at the beginning of module testing and not for every DUT.

Resource Requirements:

Tektronix BERTscope BSA260C
Agilent DCA-X86100D Wide Bandwidth Oscilloscope
Agilent DCA-86108B 50 GHz Precision Waveform analyzer

Discussion: Establishing a baseline allows a reference for all other optical cable measurements**.**

Test Setup: BERT=> HCB/MCB => DCA (will insert Diagram before finalized)

Measurements:

1. Screen Capture Eye Diagram
2. Verify Eye Mask Margin: 10.3125 Gbps

Observable Results:
Informational - this is a baseline measurement to reference all other 10 G optical cable measurements from**.**

3.1.2 Receiver Eye Diagram - 10G Active Optical Cable

Purpose: To verify that the DUT's transmitter meets the specified requirements**.**

Resource Requirements:

Tektronix BERTscope BSA260C
Agilent DCA-X86100D Wide Bandwidth Oscilloscope
Agilent DCA-86108B 50 GHz Precision Waveform analyzer

Discussion: A Receiver Eye Diagram can indicate significant information about the health of the DUT.

Test Setup: BERT => MCB => DUT => MCB => DCA-X <Diagram will be inserted>

Test Procedure

1. Record Optical Module part number and serial number
2. Instruct the Test Station to begin sourcing PRBS31 using setting calibrated in test 3.1.1.
3. Observe Receiver Eye.
4. Verify that the Eye Diagram is compliant with the 10.3125Gbps Eye Mask Margin.

Observable results:

The eye mask is limited to a hit ratio of ___________.

Comment [D1]: Need to do more research on this value.

Section 3.2 40G Active Optical Cable Measurements

3.2.1 40G Active Optical Cable Electrical Baseline

Purpose: To establish Electrical input baseline of the optical cable modules.

NOTE: This measurement needs to only to be done at the beginning of module testing and not for every DUT

Resource Requirements:

Tektronix BERTscope BSA260C
Agilent DCA-X86100D Wide Bandwidth Oscilloscope
Agilent DCA-86108B 50 GHz Precision Waveform analyzer

Discussion: Establishing a baseline allows a reference for all other optical cable measurements.

Test Setup: BERT=> HCB/MCB => DCA (will insert Diagram before finalized)

Measurements:

1. Screen Capture Eye Diagram.
2. Verify the Eye Mask Margin: 10.3125 Gbps

Observable Results:
Informational - this is a baseline measurement to reference all other 10 G optical cable measurements from.

3.2.2 Receiver Eye Diagram - 40G Active Optical Cable

Purpose: To verify that the DUT's transmitter meets the specified requirements.

Resource Requirements:

Tektronix BERTscope BSA260C
Agilent DCA-X86100D plug-in
Agilent DCA-86108B 50 GHz Precision Waveform analyzer

Discussion: A Receiver Eye Diagram can indicate significant information about the health of the DUT.

Test Setup: BERT => MCB => DUT => MCB => DCA-X **<Diagram will be inserted>**

Test Procedure

1. Record Optical Module part number and serial number
2. Instruct the Test Station to begin sourcing PRBS31 using setting calibrated in test 3.1.1.
3. Observe Receiver Eye on Lane 2.
4. Verify that the Eye Diagram is compliant with the 10.3125Gbps Eye Mask Margin.

Comment [D2]: Is this the procedure we are looking for? I believe we discussed only testing one lane, and then verifying others if there was a failure on a specific DUT?

Observable results:

The eye mask is limited to a hit ratio of ___________.

Comment [D3]: Need to do more research on this value.

Section 3.3 Passive Cable Measurements

3.3.1 Return loss for 10G Passive Cable

Purpose: To verify that the return loss of the DUT is within the conformance limits provided by SFF-8431 Appendix E, Table 37.

Resource Requirements:
VNA
Two MCB fixtures

Discussion:
SFF-8431 Appendix E, Table 37, defines the return loss limits for cable assemblies by the following equation:

$$\begin{Bmatrix} -12 + 2\sqrt{f} & 0.01 \le f < 4.1GHz \\ -6.3 + 13log_{10}\left(\frac{f}{5.5}\right) & 4.1GHz < f \le 11.1GHz \end{Bmatrix} (dB)$$

Where *f* is frequency in GHz

Test Setup: See Appendix

Comment [D4]: To be added: VNA → MCB → DUT → MCB → VNA. See Ethernets Clause 85 Cable assembly test suite v1.0 Appendix I: Victim Test Setup. This visual setup works for both This test and the 40G test that follows.

Test Procedure:
1. Record Cable Assembly part number and serial number
2. Configure DUT as specified in the Test Setup.
3. Measure the return loss of the DUT.

Observable results:
The return loss of the DUT shall not exceed the values as stated in SFF-8431 Appendix E for passive cable assemblies.

Comment [CD5]: need more exact terms. Verify this is in the references at the top of the test plan.

3.3.2 Return loss for 40G Passive Cable

Purpose: To verify that the return loss of the DUT is within the conformance limits provided by IEEE Std. 802.3-2012, subclause 85.10.4

Resource Requirements:
Vector Analyzer
Two MCB fixtures

Discussion:
IEEE Std. 802.3-2012, 85.10.4 states that return loss limits for 40GBASE-CR4 cable assemblies are defined by the following equation:

$$\begin{Bmatrix} -12 + 2\sqrt{f} & 0.01 \leq f < 4.1GHz \\ -6.3 + 13log_{10}\left(\frac{f}{5.5}\right) & 4.1GHz < f \leq 11.1GHz \end{Bmatrix} (dB)$$

Where *f* is frequency in GHz.

Test Setup: **See Appendix**

Comment [D6]: To be added:
VNA → MCB → DUT → MCB → VNA
Same as Test 3.1.2

Test Procedure:
1. Record Cable Assembly part number and serial number
2. Configure DUT as specified in the Test Setup.
3. Measure the return loss of the DUT.

Observable results:
The return loss of the DUT shall not exceed the values as stated in IEEE Std. 802.3-2012, subclause 85.10.4.

Group 4: Transceiver Electrical

Overview: These tests establish a baseline of the test equipment/test environment for results of the other tests to be referenced from. A small set of transceiver electrical tests to establish confidence in the transceiver modules prior to the interoperability tests.

Section 4.1. Electrical characteristics of 10G Transceiver Modules

4.1.1 10G SFP/SFP+ Transceiver Electrical Baseline

Purpose: To establish Electrical input baseline of the SFP+ optical modules.
NOTE: This measurement needs to only to be done at the beginning of module testing and not for every DUT

Resource Requirements:

Tek BERTscope BSA260C
Agilent DCA-X86100D
Agilent 86105C Waveform Analyzer
Agilent 83496A Clock Recovery Module
Module Compliance Board <details added later>
Host Compliance Board <details added later>

Discussion: A transmitter Eye Diagram can indicate significant information about the health of a transmitter.

Test Setup: BERT => Module Compliance Board => Host Compliance Board => DCA (will insert Diagram before finalized)

Test Procedure

1. Electrical Eye Screen Capture.
2. Verify Electrical Eye Mask Margin.

Observable results:

Informational - to establish baseline of test equipment as reference for additional tests

4.1.2 Transmitter eye diagram for 10G SFP/SFP+

Purpose: To verify that the DUT's optical transmitter meets the specified requirements.

Discussion: A transmitter Eye Diagram can indicate significant information about the health of a transmitter.

Test Setup:

BERT => Module Compliance Board => DUT (optical output) = DCA (optical plug in)

Resource Requirements:

Tek BERTscope BSA260C
Agilent DCA-X86100D
Agilent 86105C Waveform Analyzer
Agilent 83496A Clock Recovery Module
Fiber cable 2m-5m in length used to connect DUT to DCA

Test Procedure

1. Record Optical Module part number and serial number
2. Use the board setup and input signal measured in section "4.1.1"
3. Insert Module under test (DUT) into the Evaluation Board, connect the optical fiber to the DCA and capture the following information:
    a. Optical Eye (screen capture) over 1
    b. Transmitter Eye Mask definition X1, X2, X3, Y1, Y2, Y3 = 0.235, 0.395, 0.45, 0.235, 0.265, 0.40 10.3125Gbps. IEEE 802.3ae Clause 52 compliant
4. Process the captured waveform.

Observable results:

Hit ratio shall not exceed 5×10^{-5} per sample.

Section 4.2 Electrical characteristics of 40G QSFP+Transceiver Modules

4.2.1 40G QSFP+ Transceiver Transmitter Baseline

Purpose: To establish Electrical input baseline of the40 G QSFP+ optical modules.
NOTE: This measurement needs to only to be done at the beginning of module testing and not for every DUT

Resource Requirements:

Tek BERTscope BSA260C
Agilent DCA-X86100D
Agilent 86105C Waveform Analyzer
Agilent 83496A Clock Recovery Module

Discussion: A transmitter Eye Diagram can indicate significant information about the health of a transmitter.

Test Setup: BERT => Module Compliance Board => Host Compliance Board => DCA (will insert Diagram before finalized)

Test Procedure

1. Perform screen capture of Electrical Eye
2. Electrical Eye Mask Margin using PRBS31.
3. Process the captured waveform

Observable results:

Informational - to establish baseline of test equipment as reference for additional tests

4.2.2 Transmitter Eye diagram - 40G QSFP+

Purpose: To verify that the DUT's optical transmitter meets the specified requirements.

Resource Requirements:

Tek BERTscope BSA260C
Agilent DCA-X86100D
Agilent 86105C Waveform Analyzer
Agilent 83496A Clock Recovery Module
Fiber Cable 2m-5m in length used to connect DUT to DCA

Discussion: A transmitter Eye Diagram can indicate significant information about the health of a transmitter.

Test Setup: BERT => Module Compliance Board => DUT (optical output) = DCA (optical plug in)

Test Procedure

1. Record Optical Module part number and serial number
2. Use the board setup and input signals measured in Test 4.2.1
3. Test lane #2 out of four lanes
4. Note: If there is an issue during Link Functionality or Interoperability testing, re-run this test with all four channels
5. Insert Module under test (DUT) into the Evaluation Board, connect the optical fiber (breakout cable) to the DCA and capture the following information using test pattern PRBS31:
    a. Optical Eye (screen capture)
    b. Optical Mask Margin: PRBS31, 10.3125Gbps, TP2: X1, X2, X3, Y1, Y2, Y3 = 0.23, 0.34, 0.43, 0.27, 0.35, 0.4 UI. Hit Ratio = 5e-5.
6. Process the captured waveform.

Observable results:

Hit ratio shall not exceed 5 x 10^{-5} per sample.

Group 5: Host Module Electrical Verification

Overview: The tests defined in this section verify the electrical signaling characteristics of the host module. These tests are distinguished based on speed and are represented as sections of such.

Section 5.1 Electrical Verification of 10G Host

The tests defined in this section verify the transmitter electrical signaling characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 52 (SR and LR) of IEEE 802.3-2012 as well as requirements mandated through SFF-8431.

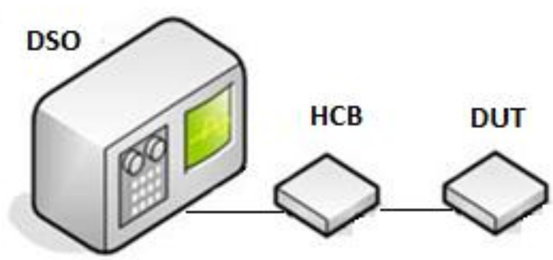
Resources for Section 5.1
FC16-TPA-HCB-P by Wilder Technologies (Test Fixture, HCB)
Tektronix MSO73304DX 33GHz Mixed Signal Oscilloscope
ENA E5071C Series Network Analyzer 300kHz – 20GHz

5.1.1 Output Rise and Fall Times for 10G Host

Purpose: To verify that the Output Rise and Fall Times are within the conformance limits.
Reference: SFF8431

Discussion: In this test, the transition time is measured while the DUT is connected to the DSO. The transition times are to be measured at the 20% and 80% levels. The measurement is done using the square wave test pattern defined.

Test Setup: The DUT output is connected to the host compliance board which is then connected to the DSO. The DSO should be properly calibrated before use.



Test Procedure:

1. Configure the DUT so that it is sourcing a square wave with no equalization.
2. Connect the DUT's transmitter to the DSO.
3. Measure the rising and falling edge transition times.

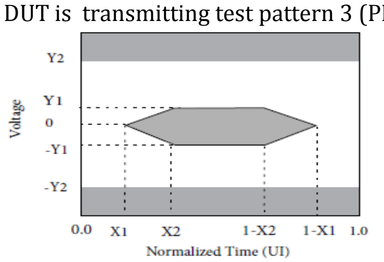
Observable Results:

The rising and falling edge transition times should not be less than 34ps.

5.1.2 – Transmitter Eye Mask for 10G Host

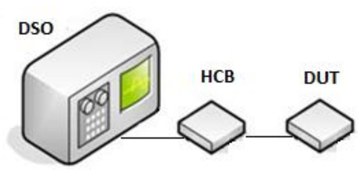
Purpose: To verify that the Eye Mask Hit Ratio is within the conformance limits.

Reference: IEEE 802.3-2012 Clause 52
Resource Requirements: DSO, SFP+ Host Compliance Boards
Discussion: In this test, the eye diagram is measured while the DUT is connected to DSO. The DUT is transmitting test pattern 3 (PRBS31).



X1=0.12 UI X2=0.33 UI Y1=95 mV Y2=350 mV

Test Setup: The DUT output is connected to the host compliance board which is then connected to the DSO. The DSO should be properly calibrated before use.



Test Procedure:
1. Configure the DUT so that it is sourcing test pattern 3 (PRBS31).
2. Connect the DUT's transmitter to DSO.
3. Capture the eye diagram.

Comment [D7]: Would remove this, leave PRBS31.

Comment [CD8R7]: Add to Appendix

Observable Results:
The eye mask hit ratio should not exceed $5x10^{-5}$

5.1.3 – Total Jitter for 10G Host

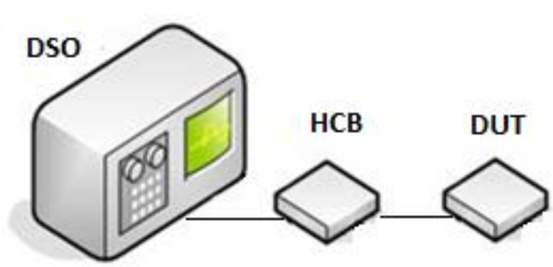
Purpose: To verify that the Total Jitter (TJ) is within the conformance limits.

Reference: SFF-8431

Resource Requirements:
DSO
SFP+ Host Compliance Boards

Discussion: Total jitter is defined as the sum of the deterministic jitter and random jitter. Test pattern PRBS31 will be used.

Test Setup: The DUT output is connected to the host compliance board which is then connected to the DSO. The DSO should be properly calibrated before use.



Test Procedure:
1. Set the DUT to transmit test pattern 3 (PRBS31).
2. Connect the DUT's transmitter to DSO.
3. Measure the total jitter.

Comment [D9]: Same as above.

Observable Results:
The total jitter should not exceed 0. 28 UI(p-p)

5.1.4 Host Input and Output Return Loss (10G)

Purpose: To verify that the differential input and output return loss of the DUT is within the conformance limits.

Resource Requirements:
FC16-TPA-HCB-P by Wilder Technologies (Test Fixture, HCB)
Tektronix MSO73304DX 33GHz Mixed Signal Oscilloscope,
ENA E5071C Series Network Analyzer 300kHz – 20GHz

Discussion: For the purpose of this test, the differential output return loss is defined as the magnitude of the reflection coefficient expressed in decibles. The reflection coefficient is the ratio of the voltage in the reflected wave to the voltage in the incident wave. Note that this is also known as the SDD22 scattering parameter (s-parameter). For frequencies from 100 MHz to 2.0 GHz, the differential return loss of the driver shall exceed Equation 54.1 and 54.2:

ReturnLoss(f) ≥ 10 dB (for 100 MHz ≤ f < 625 MHz) (EQ. 54.1)
ReturnLoss(f) ≥ 10 - 10log(f/625) dB (for 625 MHz ≤ f ≤ 2.0 GHz) (EQ. 54.2)

This value is to be verified for each of the four DUT TX lanes, which are identified as Lane 0, Lane 1, Lane 2, and Lane 3.

Test Setup: <to be added>

Test Procedure:
Part A: Return Loss for 10G Host
1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing normal IDLE signaling.
3. Connect the DUT's Lane 0 transmitter to the VNA.
4. Measure the reflection coefficient at the DUT transmitter from 100 MHz to 2.0 GHz.
5. Compute the return loss from the reflection coefficient values.
6. Repeat steps 3 through 5 for Lanes 1, 2, and 3.

Observable Results:
For all lanes, the differential return loss shall exceed the limits described by Equations 54.1 and 54.2.
Possible Problems: None.

Section 5.2 Electrical Analysis of 40G Host

Resource Requirements for Section 5.2 testing:

QSFP+-TPA40G-HCB-P by Wilder Technologies (Test Fixture, HCB)
Keysight 86100D DCA-X with 86108B Precision Waveform Analyzer at 50GHz
PNA-X N5244A 10MHz – 43.5GHz Network Analyzer

5.2.1 Input and Output Return Loss on 40G Host

Purpose: To verify that the differential input and output return loss of the DUT is within the conformance limits.

Resource Requirements:
QSFP+-TPA40G-HCB-P by Wilder Technologies (Test Fixture, HCB)
Keysight 86100D DCA-X with 86108B Precision Waveform Analyzer at 50GHz
PNA-X N5244A 10MHz – 43.5GHz Network Analyzer

Discussion:

Test Setup: IEEE Std. 802.3-2012, subclause 86A.4.1.1 specifies the transmitter characteristics for 40GBASE-SR4 and 100GBASE-SR4 devices. This specification includes conformance requirements for the differential input and output return loss. For the purpose of this test, the differential return loss is defined as the magnitude of the reflection coefficient expressed in decibels. The reflection coefficient is the ratio of the voltage in the reflected wave to the voltage in the incident wave. For frequencies from 10 MHz to 11.1 GHz, the differential return loss of the driver shall not exceed the limit given in Equation 86A-1 and Equation 86A-2 (same):

$$\text{Return\_loss}(f) \geq \left\{ \begin{array}{ll} 12.2\sqrt{f} & 0.01 \leq f < 4.11 \\ 6.3 - 13\log_{10}(f/5.5) & 4.11 \leq f \leq 11.1 \end{array} \right\} \text{dB}$$

Test Procedure:
Part A: Return Loss for 40G Host
1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing normal IDLE signaling.
3. Connect the DUT's transmitter to the VNA.
4. Measure the reflection coefficient at the DUT transmitter from 10 MHz to 11.1 GHz.
5. Compute the return loss from the reflection coefficient values.

Observable Results:
Part A: The differential input return loss shall exceed the limits described by Equation 86A-2.
Possible Problems: None.

5.2.2 Output Rise and Fall on 40G Host

5.2.3 Transmitter Eye Mask on 40G Host

5.2.4 Total Jitter of 40G

Purpose: To verify that the Total Jitter (TJ) is within the conformance limits.
Reference:
Resource Requirements:
Discussion: Total jitter is defined as the sum of the deterministic jitter and random jitter.
Test Setup:

Test Procedure:

Measure the total jitter.

Observable Results:
The total jitter should not exceed

Group 6: Link Functionality

Overview: The following tests cover BER and the ability to remain functional when receiving packets at line rate for an extended period of time.

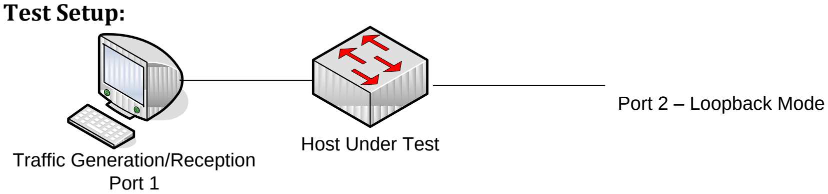
6.1 - Establish Baseline Performance Analysis

Purpose: To establish a baseline performance analysis of the host using the loopback functionality and one SFP+ module

NOTE: This baseline assessment will be performed per module to establish a baseline performance of the host with said module. The test is designed to create an understanding of performance that can translate through the remaining tests in this section.

Resource Requirements:
One SFP+ module.
Link monitoring and traffic generating capabilities.
Host with loopback capabilities.

Test Setup:



Test Procedure:
Part A. The Host

1. Insert the pluggable module into the Host and then connect a compliant cable between the Traffic Generator (TS1) and the Host.
2. Using Filtering Database capabilities program Source MAC Address 00-00-00-66-11-AA at Port 1.
3. Additional programming of switch needed.
4. From TS1, transmit the frames in Ixia Stream xyz at 1% line rate in order to verify that the link was properly established.
5. From TS1, transmit 90% <futher details needed>
6. Verify % traffic reception.
7. If frame loss occurs, throttle traffic rate to 85% and repeat.
8. Repeat reduction of 5% traffic until all frames are received.
9. Record this baseline percent an use throughout tests in this section.

6.2 – Link Detection on Power Up

Purpose: To determine if the DUT and a set of link partners establish a link while varying the power up sequence.

Resource Requirements:
A set of pluggable modules or Hosts supporting the same form factor as the DUT.
Link monitoring and traffic generating capabilities.
Local management indicators on the DUT and link partner that indicate the state of the link.

Discussion: The ability to detect and establish a link is dependent on the two devices that make up the link segment and the channel used to connect the two devices. This test procedure addresses several conditions in which link detection should work when a pluggable module is used in a Host device. There are three parts to this test.

1. The Host is fully powered up, has its drivers loaded, and then receives the pluggable module with and without a link partner connected to the pluggable module during insertion.
2. The Host is powered on with the pluggable module inserted and connected to a link partner that has not yet powered on.
3. The Host is powered on with the pluggable module inserted and connected to a link partner that has already been powered on.

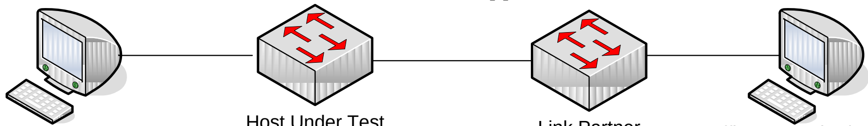
These three conditions are checked, as there may be different signals on the line during the boot up sequences of the devices, such as remote and local fault, that could cause the DUT to improperly not establish a link.

The act of verifying the link is not necessarily obvious, and difficulties arise in determining the cause of the link not being active, if problems exist. Indications such as link lights and status indicators, while they can provide very useful and visible information, may not always represent the status of the link. In addition, frames should be able to be passed from one device to the other once the link has been established.

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

Test Setup: The Host is tested against a pluggable module connected to a link partner as a traffic source. The Host connects a third station into the network, which sources and sinks packets. Connect the Host to its link partner.

The frames transmitted in these tests are defined in Appendix C.



Test Procedure:

*Part A. The Host receives the pluggable module while fully powered and operational***.**

1. Power off the Host and the link partner.
2. Remove the pluggable module from the Host and disconnect the cable connecting the pluggable module to the link partner.
3. Power both devices back on and allow them to come fully up.
4. Insert the pluggable module into the Host and then connect a compliant cable between the devices.
5. From TS1, transmit the frames in Ixia Stream A at Baseline Established in 6.1 line rate in order to verify that the link was properly established.
6. Remove the cable for a few seconds, then reinsert.
7. From TS1, transmit the frames in Ixia Stream A at Baseline Established in 6.1 line rate in order to verify that the link was properly established.
8. Remove the cable and then the pluggable module, reinsert the pluggable module and then reconnect the cable.
9. From TS1, transmit the frames in Ixia Stream A at Baseline Established in 6.1 line rate in order to verify that the link was properly established.
10. Remove the cable and then the pluggable module, reconnect the cable to the pluggable module and then reinsert the pluggable module.
11. From TS1, transmit the frames in Ixia Stream A at Baseline Established in 6.1 line rate in order to verify that the link was properly established.
12. Repeat steps 1 to 8 with several pluggable modules.

Part B. The pluggable module receives no input signal during power up.

1. Power off the Host and the link partner.
2. Ensure that the pluggable module is inserted in the Host.
3. Connect a compliant cable between the two devices.
4. Power on the Host and ensure that the device is fully up and all needed drivers are loaded.
5. Power on the link partner and ensure that the device is fully up and all needed drivers are loaded.
6. From TS1, transmit the frames in Ixia Stream A at Baseline Established in 6.1 line rate in order to verify that the link was properly established.
7. Repeat steps 1 to 5 with several pluggable modules.

Part C. The DUT receives signal from the testing station during power up.

1. Power off the Host and the link partner.
2. Ensure that the pluggable module is inserted in the Host.
3. Connect a compliant cable between the two devices.
4. Power on the link partner and ensure that the device is fully up and all needed drivers are loaded.
5. Power on the Host and ensure that the device is fully up and all needed drivers are loaded.
6. From TS1, transmit the frames in Ixia Stream A at Baseline Established in 6.1 line rate in order to verify that the link was properly established.
7. Repeat steps 1 to 5 with several pluggable modules.

Observable results: The Host and link partner must be examined for indicators of a proper link. This is typically an LED that lights when link is established. Local management may provide information about configuration and status, as well. The passing of valid frames between the two devices should serve as final validation that the link has been established. The testing stations will exchange packets with each other. The links between the testing stations and the Host must be error free.

In Part A, the DUT and link partner should establish a valid link each time the cable reconnects both devices.
In Part B, the DUT and link partner should establish a valid link when both devices are fully operational.
In Part C, the DUT and link partner should establish a valid link when both devices are fully operational.

Possible Problems: Some modules may require power that is not supplied by the Host, these combinations will not be tested. Also, care must be taken to ensure that the inputs to the receivers of the pluggable module and link partner do not exceed the power levels set by the standard if an optical PHY is used.

6.2 Packet Error Rate Estimation

Purpose: To determine if a Host can exchange packets with a pluggable module such that a bit error rate of 10^{-12} is achieved

Resource Requirements:

A set of pluggable modules or Hosts supporting the same form factor as the DUT.
Link monitoring and traffic generating capabilities.
Local management indicators on the DUT and link partner that indicate the state of the link.
A physical signaling channel with known compliant properties

Discussion: This test is designed to verify the ability of a Host to exchange packets with a pluggable module. The exchange of packets must produce a packet error rate that is low enough to meet a desired bit error rate. The bit error rate as specified in the IEEE Std 802.3ae-2012 is 10^{-12}. The number of frames to be sent depends on the module type that is used by the Host
The table below shows the number of 1518-byte frames that need to be sent with each to ensure that the bit error rate is less than 10^{-12} with 95% accuracy

Module Type	Number of 1518byte frames
10GBASE LX4	197E+6
10GBASE R	239E+6

If more than 7 packets are lost during the exchange, then the BER criteria has not been met and the test fails. In addition to packets lost, local management information may make it possible to isolate the packet loss to either the transmit side or the receive side of the test channel relative to the Host/pluggable module. If more than 7 packets are lost in either side of the channel, then the Host/pluggable module combination has violated the BER and the result is considered a failure.

The observable results in this testing process is one or more packet counters. Since a single packet contains many bits, the measurement technique does not really measure the bit error rate. The PASS/FAIL criteria assume that no more than one bit is in error in a lost packet. Thus a device may in theory pass a test with a bit error in excess of 1 in 10^{12}.

However, given that any one bit in error will corrupt the packet, multiple errors within a packet do not, in practice, make a difference in the number of packets that must be retransmitted on real links. Thus, a short-term clock deviation that causes a bit error rate of 5 bits in a stream of 10^{12} bits will, under most conditions, cause as many packet errors as a device with a bit error rate of 1 in 10^{12}.

The results obtained from this testing process should not be seen as a true measure of the bit error rate but as information that may suggest the need for further analysis.

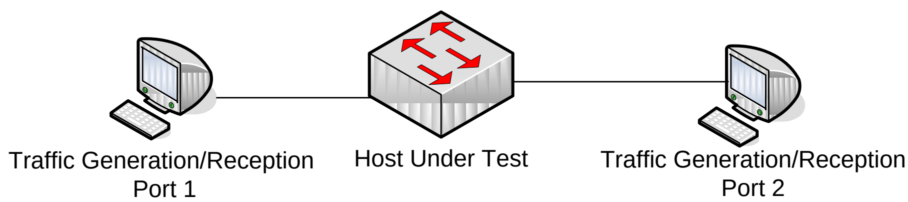
Under some circumstances, additional fiber lengths may be made available for testing.

Test Setup

The Host is tested against a pluggable module connected to a link partner as a traffic source. The Host connects a third station into the network, which sources and sinks packets.

The testing stations will exchange packets with each other. The links between the testing stations and the Host must be error free.

The frames transmitted in these tests are defined in Appendix C.



Test Procedure

Part A. Known good Cable

1. Insert the pluggable module into the Host, and connect to the testing station via a compliant cable.
2. Reset all counters that will be used to measure or monitor the exchange of packets, configure software as needed.
3. From TS1, transmit Ixia stream B at Baseline Established in 6.1 line rate.
4. If the DUT is a Host, repeat steps 1 to 3 with several pluggable modules.

Part B: Longevity

1. Insert the pluggable module into the Host, and connect to the testing station via a compliant cable.
2. Reset all counters that will be used to measure or monitor the exchange of packets, configure software as needed.
3. From TS1, transmit Ixia Stream C at Baseline Established in 6.1 line rate.
4. If the DUT is a Host, repeat steps 1 to 3 with several pluggable modules.

Note: These tests can be repeated with various data patterns in the frames transmitted to create various transmitter stress situations.

Observable results

Using the available counters, identify the number of packets received and transmitted. Compare relative to the baseline established in 6.1

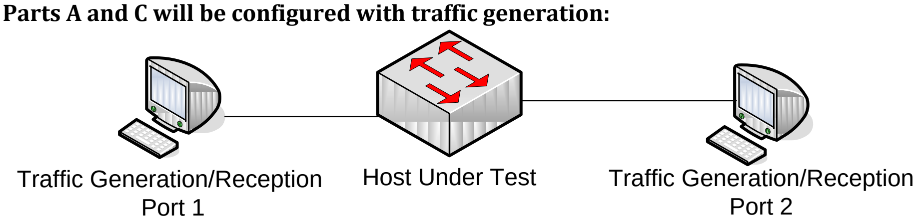
6.3 Packet Loss/Stress Test

Purpose: To verify that no obvious buffer management problems occur when directing a large volume of traffic Interpacket Gap at the Host/pluggable module combination.
Resource Requirements: Two test stations, one that can be used to source packets at minimum Interpacket Gap, and one that can be used to respond or echo the sourced packet. These stations must be able to provide detailed counts of packets transmitted, received, as well as information on errors associated with link level operation.

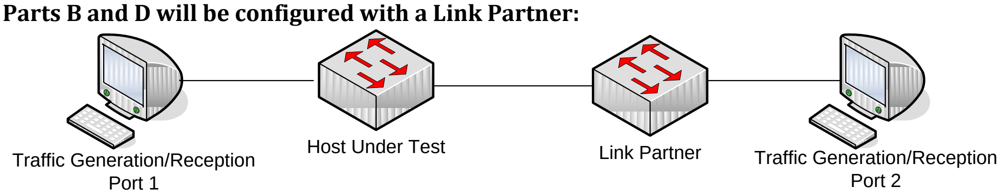
Discussion: This test is informative only and is designed to verify that the Host/Pluggable module combination has no obvious buffer management problems. The Host/Pluggable module combination is attached to a source station that is capable of sending large numbers of frames with a minimum IPG of 96BT. The Host/pluggable module combination does not have to respond to or forward all of the frames, but the test should not cause any system failures. Two sets of frame sizes are used for this test. For the first test run, 64-byte frames are used, since they are the smallest frames and therefore require the most overhead processing in the system. The second set of frames is the maximum size frame that the DUT can support.

Test Setup: A link is established between the Host/pluggable module combination and the testing station. Further description is provided in Appendix B. The frames transmitted in these tests are defined in Appendix C.

Parts A and C will be configured with traffic generation:



Parts B and D will be configured with a Link Partner:



Test Procedure:

Part A. Port X to Port Y with No Link Partner

1. Insert the pluggable module into the port X, and connect to the testing station via a compliant cable for transmittal of frames
2. Insert the pluggable module into the port Y, and connect to the testing station via a compliant cable for reception of frames
3. Reset all counters that will be used to measure or monitor the exchange of packets, configure software as needed.

4. From TS1, transmit Ixia Stream $D_{1,}$ at Baseline Established in 6.1 line rate.
5. Observe all management and status indicators of the DUT
6. From TS1, transmit Ixia Stream D_2 at Baseline Established in 6.1 line rate.
7. Observe all management and status indicators of the DUT
8. If the DUT is a Host, repeat steps 1 to 6 with several pluggable modules.

Part B. Port X to Port Y with Link Partner

1. Insert the pluggable module into the port X, and connect to the testing station via a compliant cable for transmittal of frames
2. Insert the pluggable module into the port Y, and connect to the Link Partner via a compliant cable for reception of frames
3. Connect Link Partner to testing station via a compliant cable for reception of all frames.
4. Reset all counters that will be used to measure or monitor the exchange of packets, configure software as needed.
5. From TS1, transmit Ixia Stream $D_{1,}$ at Baseline Established in 6.1 line rate.
6. Observe all management and status indicators of the DUT
7. From TS1, transmit Ixia Stream D_2 at Baseline Established in 6.1 line rate.
8. Observe all management and status indicators of the DUT
9. Repeat steps 1 to 6 with several pluggable modules.

Part C. Port X to Port Y - fully loaded Chassis - No Link Partner

1. Insert the pluggable module into the port X, and connect to the testing station via a compliant cable for transmittal of frames
2. Insert the pluggable module into the port Y, and connect to the testing station via a compliant cable for reception of frames
3. Daisy chain appropriate ports to fully load chassis.
4. Reset all counters that will be used to measure or monitor the exchange of packets, configure software as needed.
5. From TS1, transmit Ixia Stream $D_{1,}$ at Baseline Established in 6.1 line rate.
6. Observe all management and status indicators of the DUT
7. From TS1, transmit Ixia Stream D_2 at Baseline Established in 6.1 line rate.
8. Observe all management and status indicators of the DUT
9. Repeat steps 1 to 6 with several pluggable modules.

Part D. Port X to Port Y - Fully Loaded Chassis - Link Partner

1. Insert the pluggable module into the port X, and connect to the testing station via a compliant cable for transmittal of frames
2. Insert the pluggable module into the port Y, and connect to the Link Partner via a compliant cable for reception of frames
3. Fully load chassis by connecting each available port on Host Under test to Link Partner
4. Connect the link partner to the testing station via a compliant cable for reception of frames.
5. Reset all counters that will be used to measure or monitor the exchange of packets, configure software as needed.
6. From TS1, transmit Ixia Stream $D_{1,}$ at Baseline Established in 6.1 line rate.
7. Observe all management and status indicators of the DUT
8. From TS1, transmit Ixia Stream D_2 at Baseline Established in 6.1 line rate.
9. Observe all management and status indicators of the DUT
10. Repeat steps 1 to 6with several pluggable modules.

Observable results: Using the counters on the Host and testing station(s), identify the number of frames transmitted and received. The difference between the number of packets sent and the number received is the number of lost packets. These numbers should be compared against the baseline established in 6.1. The DUT should have not power cycled and/or exhibited other odd behavior.

Appendix A

SFP+ Certification Criteria:

Statement and test data from vendor assuring compliance to these specification

MSA governing specifications:

SFF-8431 – Specification for SFP+ with addendum revision 4.1
SFF-8432 – Specification for Improved Pluggable Form Factor
SFF-8472 – Rev 11.3 or later Diagnostic Monitoring Interface for Optical Transceivers
SFF-8636 – Rev. 1.7 or later (EEPROM)

Management Interface:

Serial ID EEPROM
Digital Optical Monitoring (DOM) compliance to SFF-8472, where applicable
Low speed signaling requirements

Optical or Copper Performance:

IEEE Spec compliance to 802.3 (as appropriate)

Environmental:

Data Center Environment or
Standard Environment
RoHS-6 compliant
Class 1 Eye Safety per IEC-60825-1

Reliability:

GR-468 criteria

QSFP+ Certification Criteria
Statement and test data from vendor assuring compliance to these specifications:

MSA governing specifications:
- SFF-8436 - Rev. 4.8 or later (Primary MSA, now transferred to EIA-964)
- SFF-8636 - Rev. 1.7 or later (EEPROM)
- SFF-8635 - Rev. 0.5 or later (Mechanical: Must comply with SFF-8436)
- SFF-8679 - Rev. 1.5 or later (Electrical and Optical Interfaces)

Management Interface:
- Serial ID EEPROM

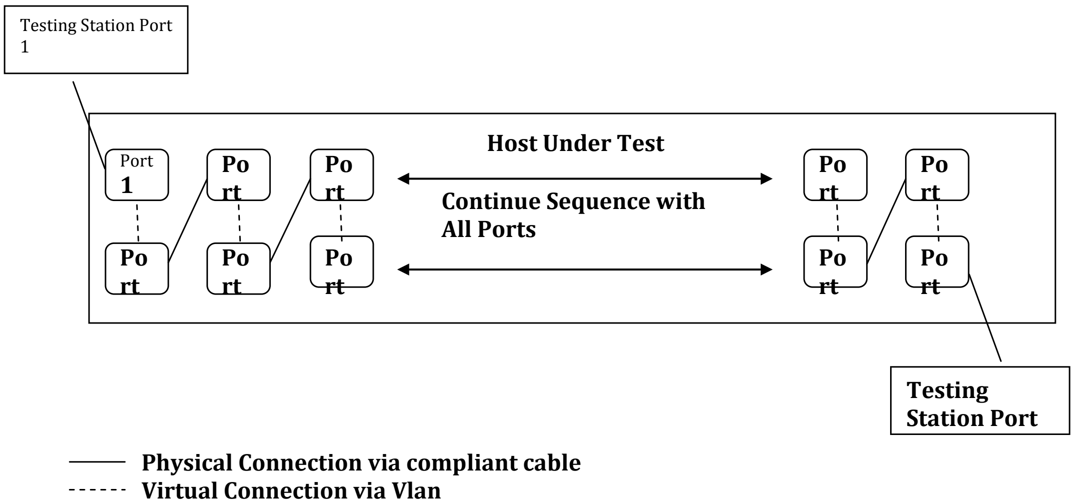
Digital Optical Monitoring (DOM) compliance to SFF-8472, where applicable
Low speed signaling requirements
Optical Performance or Copper
IEEE Spec compliance

Environmental:
- Data Center Environment or
- Standard Environment
- RoHS-6 compliant
- Class 1 Eye Safety per IEC-60825-1

Reliability:
- GR-468 criteria

Appendix B

Fully loaded Host Under Test
The following diagram describes the test layout for daisy chaining a chassis with two test stations connected to the Host Under Test.

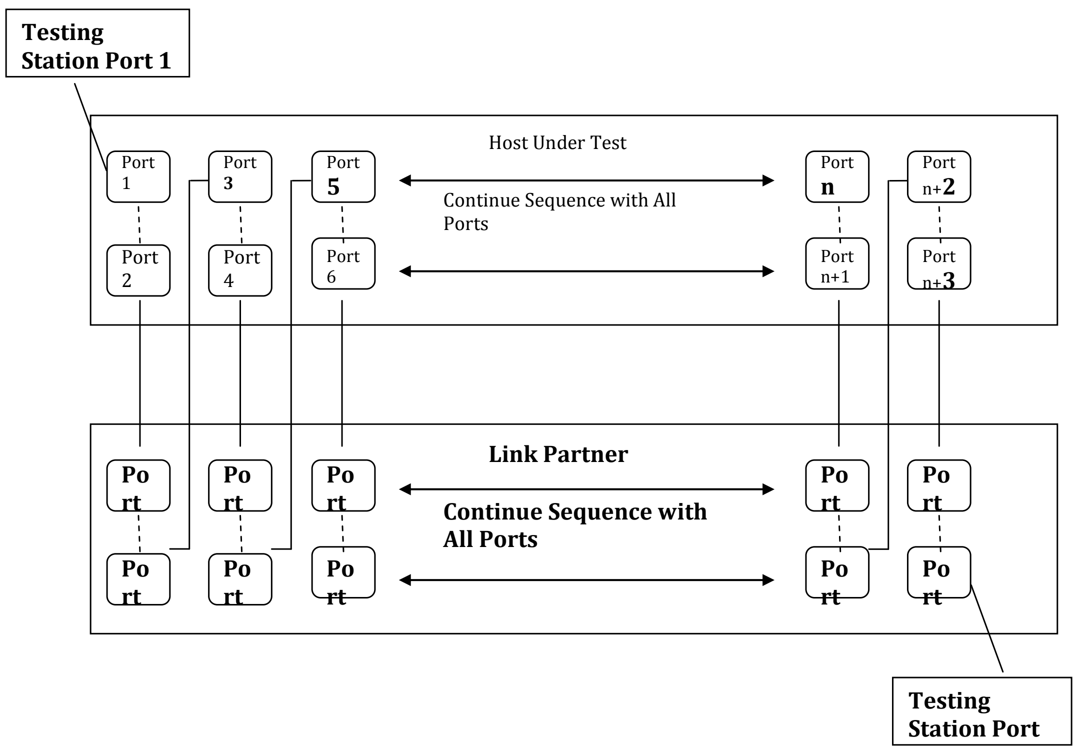


The test uses the following setup for the Host Under Test:

Disable Spanning Tree Protocol
Set Acceptable frame type parameter to admit all frames on all ports
Set Ingress Filtering to reset(disabled) on all ports
Configure Port 1 on the host to have PVID 2
Configure Port 2 on the host to be an untagged member of Vlan 2
Configure Port 3 on the host to have PVID 3
Configure Port 4 on the host to be an untagged member of Vlan 3
Continue this sequence until every port on the Host is configured
Connect Port 1 on the testing station to port 1 on the host via a compliant cable for transmittal of frames
Connect Port 2 on the testing station to the last port on the host via a compliant cable for transmittal of frames

Fully loaded Host Under Test Connected to Link Partner

The following diagram describes the test layout for daisy chaining two chassis with one test stations connected to the Host Under Test and another test station connected to the Link Partner.



~~Physi~~cal Connection via compliant cable
------ **Virtual Connection via Vlan**

The test uses the setup previously described above for the Host Under Test and the Link Partner. The only difference being: Connect Port 2 on the testing station to the last port on the *Link Partner* via a compliant cable for transmittal of frames.

Appendix C

Test Traffic Format

The following packets will be used throughout this test suite.

Ixia Stream A: 10 64-byte IP frames sent, incrementing byte data pattern,
SA: 00 00 31 00 11 11
DA: 00 00 31 00 22 22

Ixia Stream B: 239,000,000 1518-byte IP frames, incrementing byte data pattern,
TS1: TS2:
SA: 00 00 32 AB 11 11 SA: 00 00 32 AB 22 22
DA: 00 00 32 AB 22 22 DA: 00 00 32 AB 11 11

Comment [g10]: I have combined stream B and C because they were the same.

Ixia Stream C: Continuously transmit 1518-byte IP frames, incrementing byte data pattern,
TS1: TS2:
SA: 00 00 32 CC 11 11 SA: 00 00 32 CC 22 22
DA: 00 00 32 CC 22 22 DA: 00 00 32 CC 11 11

Ixia Stream D_1: 1 billion 64-byte IP frames, incrementing byte data pattern, and 96BT IPG
SA: 00 00 33 A1 11 11
DA: 00 00 33 A1 22 22

Ixia Stream D_2: 1 billion 1518-byte IP frames, incrementing byte data pattern, and 96BT IPG
SA: 00 00 33 A2 11 11
DA: 00 00 33 A2 22 22

Appendix C
Test Traffic Format

Comment [g11]: Alternative format for Appendix C.

The following packets will be used throughout this test suite.

Ixia Stream A:

Packets to send	10
Packet Size	64-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 31 00 11 11
Destination Address	00 00 31 00 22 22

Ixia Stream B:

TS1:

Packets to send	290,000,000
Packet Size	1518-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 32 AA 11 11
Destination Address	00 00 32 AA 22 22

TS2:

Packets to send	290,000,000
Packet Size	1518-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 32 AA 22 22
Destination Address	00 00 32 AA 11 11

Appendix C (continued):
Ixia Stream C:
TS1: TS2:

Packets to send	290,000,000
Packet Size	1518-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 32 BB 11 11
Destination Address	00 00 32 BB 22 22

Packets to send	290,000,000
Packet Size	1518-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 32 BB 22 22
Destination Address	00 00 32 BB 11 11

Ixia Stream D:
TS1: TS2:

Packets to send	Continuous
Packet Size	1518-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 32 CC 11 11
Destination Address	00 00 32 CC 22 22

Packets to send	Continuous
Packet Size	1518-byte
Line Rate	Baseline Established in 6.1
Data Pattern	Incrementing Byte
Source Address	00 00 32 CC 22 22
Destination Address	00 00 32 CC 11 11

Ixia Stream E_1:

TS1: TS2:

Comment [g12]: Again, not sure if this test requires bi-directional traffic.

Packets to send	**1,000,000,000**
Packet Size	**64-byte**
Line Rate	**100%**
Data Pattern	**Incrementing Byte**
Source Address	**00 00 33 AA 11 11**
Destination Address	**00 00 33 AA 22 22**

Packets to send	**1,000,000,000**
Packet Size	**64-byte**
Line Rate	**100%**
Data Pattern	**Incrementing Byte**
Source Address	**00 00 33 AA 22 22**
Destination Address	**00 00 33 AA 11 11**

Ixia Stream E_2:

TS1: TS2:

Packets to send	**1,000,000,000**
Packet Size	**1518-byte**
Line Rate	**100%**
Data Pattern	**Incrementing Byte**
Source Address	**00 00 33 AA 11 11**
Destination Address	**00 00 33 AA 22 22**

Packets to send	**1,000,000,000**
Packet Size	**1518-byte**
Line Rate	**100%**
Data Pattern	**Incrementing Byte**
Source Address	**00 00 33 AA 22 22**
Destination Address	**00 00 33 AA 11 11**

Appendix D

For physical layer tests (see Group 1.5 and Group 2), devices are required to transmit test patterns in order to sufficiently stress the electrical signal on the line, while providing measurement consistency. These test patterns are defined by IEEE 802.3 Clause 83.5. The following table lists those patterns.

Pattern
PRBS 31
Square Wave (eight ones, eight zeros)
Scrambled Idle

Comment [D13]: I can attempt to add to this should people want this expanded. There is plenty more that could be added from 802.3's various clauses, but I'm not sure if it's appropriate for this event.