40 and 100 Gigabit Ethernet Consortium

Clause 86 40GBASE-SR4 and 100GBASE-SR10
PMD Test Suite v0.1
Technical Document

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40 and 100 Gigabit Ethernet Consortium

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MODIFICATION RECORD

- March 26, 2013 Version 0.1 Released
  - Initial version of test suite to be published on website

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INTRODUCTION

Overview

The University of New Hampshire's InterOperability Laboratory (UNH–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 suite of tests has been developed to help implementers identify problems that 40GBASE-SR4 and 100GBASE-SR10 devices may have in establishing link and exchanging packets with each other. The tests do not determine if a product fully conforms to IEEE Std. 802.3 2012. Rather, they provide a reasonable level of assurance that a device does or does not pass the tests set forward in this document.

Note: successful completion of tests contained in this suite does not guarantee that the tested device is fully compliant or that it will operate with all other compliant devices.

Organization of tests

The tests contained in this document are organized to simplify the identification of information related to a test and to facilitate in the actual testing process. Each test contains an identification section that describes the test and provides cross-reference information. The discussion section covers background information and specifies why the test is to be performed. Tests are grouped in order to reduce setup time in the lab environment. Each test contains the following information:

Test number

The Test Number associated with each test follows a simple grouping structure. Listed first is the Test Group Number followed by the test's number within the group. This allows for the addition of future tests to the appropriate groups of the test suite without requiring the renumbering of the subsequent tests.

Purpose

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

References

The references section lists cross-references to the appropriate standards and other documentation that might be helpful in understanding and evaluating the test and results.

Resource requirements

The requirements section specifies the hardware, and test equipment that will be needed to perform the test. The items contained in this section are special test devices or other facilities, which may not be available on all devices.

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.

Test Setup
The setup section describes the configuration of the test environment. Small changes in the configuration should be included in the test procedure.

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

Observable results
The observable results section lists specific items that can be examined by the tester to verify that the Device Under Test (DUT) is operating properly. When multiple values are possible for an observable result, this section provides a short discussion on how to interpret them. The determination of a pass or fail for a certain test is often based on the successful (or unsuccessful) detection of a certain observable result.

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

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GROUP 1: Transmitter verification

Overview: The following group of tests pertains to the operation of the transmitter and the determination of various parametric values as defined in IEEE Std. 802.3 2012 Clause 86. Note, successfully passing these tests, or failing these tests, does not necessarily indicate that the device under test will, or will not, be interoperable. Devices that pass these tests are more inclined to be interoperable with existing and future standard compliant devices.

Scope: The scope of these tests, unless otherwise indicated, cover IEEE 802.3 2012 Clause 86 serial optical devices including 40GBASE-SR4 and 100GBASE-SR10.

Test # 52.1.1 – Signaling speed range

Purpose: To verify that the baud rate of the DUT is within the conformance limits

References:
[1] IEEE Std. 802.3 2012, subclause 86.1, Table 86-2
[2] IEEE Std. 802.3 2012, subclause 86.7

Resource requirements:
- Digital oscilloscope capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength of 850nm..
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope

Last modification: March 26, 2013

Discussion: The reference above indicates a table that specifies the transmit characteristics for 40GBASE-SR4 and 100GBASE-SR10 devices. The specifications for these signaling speeds are shown in Table 1. This translates to 10.3125 GBd +/-1.03125 MBd, with a nominal Unit Interval (UI) of 96.97 ps.

	Nominal	Variation
40GBASE-SR4 or 100GBASE-SR10	10.3125 GBd	± 100 ppm

Table 1 – Signaling speeds

Test Setup: In this test, the signaling speed is measured while the DUT is connected to the measurement system as described in the resource requirements, or its functional equivalent. The signal being transmitted by the DUT may be any valid 40GBASE-SR4 or 100GBASE-SR10 signal.

Procedure:
1. Configure the DUT to transmit a valid signal at the appropriate speed and wavelength.
2. Measure the average TX signaling speed. The measurement can be obtained from an eye-diagram obtained from the scope or by other means. When an eye diagram is used, the histograms should include at least 10,000 hits.

Observable results:
a. The average signaling speed should lie within the limits shown in Table 1.

Possible problems: None

Test # 52.1.2 – Center wavelength

Purpose: To verify that the center wavelength of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.4.1

Resource requirements:

- Optical spectrum analyzer capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelengths.
- Fiber cable 2m-5m in length used to connect the DUT to the oscilloscope

Last modification: March 26, 2013

Discussion: The reference above indicates a table that specifies the transmit characteristics for 40GBASE-SR4 and 100GBASE-SR10 devices. The specifications for center wavelength is shown in Table 2.

	Range
40GBASE-SR4 or 100GBASE-SR10	840 to 860 nm

Table 2 - Center wavelength

Test Setup: In this test, the center wavelength is measured while the DUT is connected to the measurement system as described in the resource requirements, or its functional equivalent. The signal being transmitted by the DUT may be any valid 40GBASE-SR4 and 100GBASE-SR10 signal.

Procedure:

1. Configure the DUT to transmit a valid signal at the appropriate speed and wavelength.
2. Measure the center wavelength of the optical transmission.

Observable results:

[1] The center wavelength of each lane should lie within the limits shown in Table 2.

Possible problems: None

Test # 52.1.3 – RMS spectral width

Purpose: To verify that the RMS spectral width of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.4.1

Resource requirements:

- Optical spectrum analyzer capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength of 850nm..
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope

Last modification: March 26, 2013

Discussion: The reference above indicates a table that specifies the transmit characteristics for 40GBASE-SR4 and 100GBASE-SR10 devices. The specifications for the RMS spectral width is shown in Table 3.

	Maximum
40GBASE-SR4 or 100GBASE-SR10	0.65 nm

Table 3 - RMS spectral width

Test Setup: In this test, the RMS spectral width is measured while the DUT is connected to the measurement system as described in the resource requirements, or its functional equivalent. The signal being transmitted by the DUT may be any valid 40GBASE-SR4 and 100GBASE-SR10 signal.

Procedure:

1. Configure the DUT to transmit a valid signal at the appropriate speed and wavelength.
2. Measure the RMS spectral width. The measurement can be obtained by taking the standard deviation of the spectral curve.

Observable results:

[1] The RMS spectral width for each lane should lie within the limits shown in Table 3.

Possible problems: None

Test # 52.1.4 – Average optical launch power

Purpose: To verify that the average optical launch power of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.2
[3] IEEE Std. 802.3 2012, subclause 86.8.4

Resource requirements:

- Optical power meter capable of indicating power over a range for wavelengths of 850nm.
- Fiber cable 2m-5m in length used to connect the DUT to the power meter

Last modification: March 26, 2013

Discussion: Clause 86 defines the maximum average launch power, minimum average launch power, and average launch power of the laser when turned off. Table 4 shows these powers for 40GBASE-SR4 and 100GBASE-SR10..

	SR4 or SR10
Max	2.4 dBm
Min	-7.6 dBm
OFF	–30 dBm

Table 4 – Average launch powers

Test Setup: Connect the DUT to a power meter through a fiber cable 2m-5m in length.

Procedure:

1. Configure the DUT to transmit test pattern 3 or 5, as described in reference [2].
2. Measure the average launch power of the DUT.
3. Repeat steps 1 and 2 after turning the laser OFF
4. Repeat all steps for all lanes.

Observable results:

a. The average launch power for each lane of the DUT should fall between the appropriate maximum and minimum limits shown in Table 4.
b. The average OFF launch power for each lane of the DUT should be less than –30dBm.

Possible problems: None

Test # 52.1.5 – Extinction ratio

Purpose: To verify that the extinction ratio of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.2
[3] IEEE Std. 802.3 2012, subclause 86.8.4

Resource requirements:

- Digital oscilloscope capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: March 26, 2013

Discussion: The minimum extinction ratio for 40GBASE-S4R or 100GBASE-SR10 is shown below in Table 5. Per reference [2] the measurement is made with the DUT transmitting test pattern 3 or 5. The extinction ratio is defined as the ratio of the average optical energy in a ONE to the average optical energy in a ZERO.

	SR4 or SR10
Min	3 dB

Table 5 – Extinction ratio values

Test Setup: Connect the DUT to the oscilloscope through a fiber cable 2m-5m in length.

Procedure:

1. Configure the DUT to transmit test pattern 3 or 5, as described in reference [2].
2. Configure the oscilloscope to capture the transmissions from the DUT.
3. Process the captured waveform, measuring the extinction ratio.
4. Repeat all steps for all lanes.

Observable results:

a. The measured extinction ratio for all lanes should fall above the limits shown in Table 5.

Possible problems: None

Test # 52.1.6 – Peak power

Purpose: To verify that the peak power of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)

Resource requirements:

- Digital oscilloscope capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength of 850nm..
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope

Last modification: March 26, 2013

Discussion: The reference above indicates a table that specifies the transmit characteristics for 40GBASE-SR4 and 100GBASE-SR10 devices. The specifications for the peak power is shown in Table 6.

	Max
40GBASE-SR4 or 100GBASE-SR10	4.0 dBm

Table 6 – Peak Power

Test Setup: In this test, the peak power is measured while the DUT is connected to the measurement system as described in the resource requirements, or its functional equivalent. The signal being transmitted by the DUT may be any valid 40GBASE-SR4 and 100GBASE-SR10 signal.

Procedure:

1. Configure the DUT to transmit a valid signal at the appropriate speed and wavelength.
2. Measure the peak power transmitted by the DUT.

Observable results:

a. The peak power for each lane should lie within the limits shown in Table 6.

Possible problems: None

Test # 52.1.7 – Optical modulation amplitude

Purpose: To verify that the optical modulation amplitude (OMA) of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.2
[3] IEEE Std. 802.3 2012, subclause 86.8.4

Resource requirements:

- Digital oscilloscope capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: March 26, 2013

Discussion: The maximum and minimum OMA for 40GBASE-S4R or 100GBASE-SR10 is shown below in Table 7. Per reference [2] the measurement is made with either the DUT transmitting a square wave that has 8 ones followed by an equal number of zeros or test pattern 4. The OMA is defined as the difference in optical power for the nominal "1" and "0" levels of the signal. The mean optical "1" and "0" powers are measured over the center 20% of the unit interval. The difference of these two values determines the OMA.

	SR4 or SR10
Min	-5.6 dBm
Max	3 dBm

Table 7 – OMA values

Test Setup: Connect the DUT to the oscilloscope through a fiber cable 2m-5m in length.

Procedure:

1. Configure the DUT to transmit the square wave pattern, as described in reference [2].
2. Configure the oscilloscope to capture the transmissions from the DUT.
3. Process the captured waveform, measuring the OMA.
4. Repeat all steps for all lanes.

Observable results:

a. The measured OMA for each lane should fall above the limits shown in Table 7.

Possible problems: None

Test # 52.1.8 – Optical modulation amplitude variation per lane

Purpose: To verify that the optical modulation amplitude (OMA) for each lane of the DUT is within the conformance limits.

References:

[4] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[5] IEEE Std. 802.3 2012, subclause 86.8.2
[6] IEEE Std. 802.3 2012, subclause 86.8.4

Resource requirements:

- Digital oscilloscope capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: March 26, 2013

Discussion: The maximum variation in OMA for each lane is shown below in Table 8. Per reference [2] the measurement is made with either the DUT transmitting a square wave that has 8 ones followed by an equal number of zeros or test pattern 4. The OMA is defined as the difference in optical power for the nominal “1” and “0” levels of the signal. The mean optical “1” and “0” powers are measured over the center 20% of the unit interval. The difference of these two values determines the OMA.

	SR4 or SR10
Max	4 dB

Table 8 - OMA variation values

Test Setup: Connect the DUT to the oscilloscope through a fiber cable 2m-5m in length.

Procedure:

1. Configure the DUT to transmit the square wave pattern, as described in reference [2].
2. Configure the oscilloscope to capture the transmissions from the DUT.
3. Process the captured waveform, measuring the OMA of each lane.

Observable results:

a. The measured OMA for each lane should not vary by more than the amount allowed in Table 8.

Possible problems: None

Test # 52.1.9 – Transmitter eye mask

Purpose: To verify that transmissions from the DUT meet the defined transmitter eye mask.

References:

[1] IEEE Std. 802.3 2012, subclause 86.7.1, Table 86-6 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.2
[3] IEEE Std. 802.3 2012, subclause 86.8.3.2
[4] IEEE Std. 802.3 2012, subclause 86.8.4.6.1

Resource requirements:

- Digital oscilloscope capable of sampling a 40GBASE-S4R or 100GBASE-SR10 signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: March 26, 2013

Discussion: The specified transmitter eye mask definition is contained within references [3] and [4], and the points used to create this mask are specified for each technology in references [1]. Per reference [2] the measurement is made with the DUT transmitting test pattern 3 or 5.

Test Setup: Connect the DUT to the oscilloscope through a fiber cable 2m-5m in length.

Procedure:

1. Configure the DUT to transmit the appropriate pattern, as described in reference [2].
2. Configure the oscilloscope to capture the transmissions from the DUT and to place these waveforms into the mask definition.
3. Process the captured waveform, observing the number of mask violations.

Observable results:

a. The captured waveform should have a Hit ratio of no more than 5×10–5 hits per sample

Possible problems: None

GROUP 2: Receiver verification

Overview: The following group of tests pertains to the operation of the receiver and the determination of various parametric values as defined in IEEE Std. 802.3 2012 Clause 86. Note, successfully passing these tests, or failing these tests, does not necessarily indicate that the device under test will, or will not, be interoperable. Devices that pass these tests are more inclined to be interoperable with existing and future standard compliant devices.

Scope: The scope of these tests, unless otherwise indicated, covers all IEEE 802.3 2012 serial optical devices including: 40GBASE-S4R or 100GBASE-SR10.

Test #52.2.1 – Stressed Receiver Sensitivity

Purpose:
To ensure compliant receivers operate with BER 10^{-12} or less when subjected a to conditioned input signal that combine vertical eye closure and jitter as described in clause 86.7.3.

References:

[1] [1] IEEE Std. 802.3 2012, subclause 86.7.3, Table 86-8 (optical transmit characteristics)
[2] IEEE Std. 802.3 2012, subclause 86.8.2
[3] IEEE Std. 802.3 2012, subclause 86.8.4
[4] IEEE Std. 802.3 2012, subclause 86.8.3.3

Resource Requirements:
Refer to Block diagram illustration in figure 86-3 below.

- System capable of creating a test signal that meets the requirements of reference [1].
- Fiber cable 2m-5m in length used to connect DUT to test system.

Last modification: March 26, 2013

Discussion: The Stressed Receiver Sensitivity Test defines a conditioned signal to test and evaluate receivers. A receiver that meets the requirements of this test is guaranteed to operate with the worst-case optical input. Per reference [2] the measurement is made with the DUT transmitting test pattern 3 or 5. Table 9 shows the maximum stressed receiver sensitivity values for each technology. As the test signal is applied to the DUT at these values, the DUT must be able to receive the signal with a BER of 10^{-12} or better.

	SR4 or SR10
Sensitivity in OMA	–5.4 dBm
Vertical eye closure penalty (VECP)c	1.9 dB
Stressed eye J2 Jitterc	0.3 UI
Stressed eye J9 Jitterc	0.47 UI
OMA of each aggressor lane	-0.4 dBm

Table 9 - Stressed sensitivity values

The Stressed Receiver Sensitivity Test defines a conditioned signal to test and evaluate receivers. The IEEE 802.3 2012 specifications define signals for receiver tests at TP3 as shown in the PMD block diagram below.

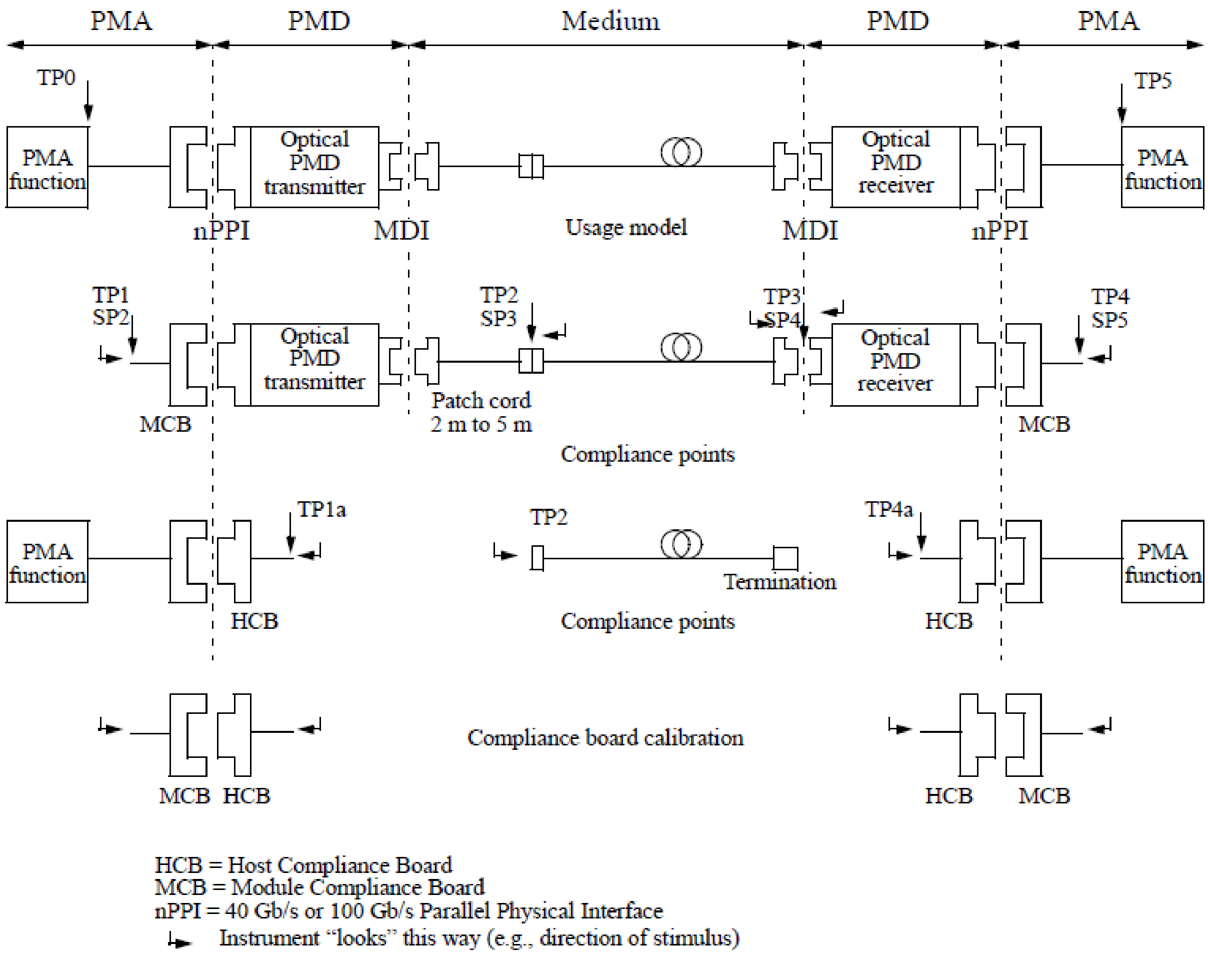

Figure 86–3—Test points for 40GBASE-SR4 and 100GBASE-SR10

Conformance Test Signal Characteristics

The conditioned test signal applied at TP3 simulates a worst-case waveform that includes pulse width shrinkage, channel impairments, and swept frequency sinusoidal jitter and is calibrated to meet the requirements of Table 86-8 found in reference [1]

Procedure:
1. Calibrate the test signal per the defined specifications.
2. Apply the test signal to the DUT.
3. Observe the BER at the receiver of the DUT.

Observable results:

a. The DUT should meet a 10^{-12} BER when it receives the stressed conformance signal at the values shown in Table 9.

Possible problems: None