10GEC THE 10 GIGABIT ETHERNET CONSORTIUM

Clause 52 Optical PMD Test Suite v0.1

Technical Document

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10 Gigabit Ethernet Consortium

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MODIFICATION RECORD

- February 11, 2004 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 10GBASE-R 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. 802.3ae-2002. 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. 802.3ae-2002 Clause 52. 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, not only existing products, but also future standard compliant devices.

Scope: The scope of these tests, unless otherwise indicated, covers all IEEE 802.3ae serial optical devices including: SR, SW, LR, LW, ER, and EW.

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. 802.3ae-2002, subclause 52.5.1, Table 52-7 (10GBASE-SR/SW)
[2] IEEE Std. 802.3ae-2002, subclause 52.6.1, Table 52-12 (10GBASE-LR/LW)
[3] IEEE Std. 802.3ae-2002, subclause 52.7.1, Table 52-16 (10GBASE-ER/EW)

Resource requirements:

- Digital oscilloscope capable of sampling a 10GBASE-R or 10GBASE-W signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope

Last modification: February 11, 2004

Discussion: Each of the first four references above indicate a table that specifies the transmit characteristics for 10GBASE-R and 10GBASE-W devices. The specifications for these signaling speeds are shown in Table 1. For a 10GBASE-R device, this translates to 10.3125 GBd +/-1.03125 MBd, with a nominal Unit Interval (UI) of 96.97 ps. For a 10GBASE-W device, this translates to 9.95328 GBd +/- 995.328 KBd with a nominal Unit Interval (UI) of 100.4694 ps.

	Nominal	Variation
10GBASE-R	10.3125 GBd	± 100 ppm
10GBASE-W	9.95328 GBd	± 20 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 10GBASE-R or 10GBASE-W 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 in 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 – 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. 802.3ae-2002, subclause 52.5.1, Table 52-7 (10GBASE-SR/SW)
[2] IEEE Std. 802.3ae-2002, subclause 52.6.1, Table 52-12 (10GBASE-LR/LW)
[3] IEEE Std. 802.3ae-2002, subclause 52.7.1, Table 52-16 (10GBASE-ER/EW)
[4] IEEE Std. 802.3ae-2002, subclause 52.9.1
[5] IEEE Std. 802.3ae-2002, subclause 52.9.3

Resource requirements:

- Optical power meter capable of indicating power over a range of wavelengths from 850nm to 1550nm.
- Fiber cable 2m-5m in length used to connect DUT to power meter

Last modification: February 11, 2004

Discussion: There are three sets of average launch powers that are specified in Clause 52 for each of the technologies: maximum average launch power, minimum average launch power, and average launch power of the laser when turned off. Table 2 shows these powers for each technology.

	SR/SW	LR/LW	ER/EW
Max	–1.0 dBm	+0.5 dBm	+4.0 dBm
Min	–7.3 dBm	–8.2 dBm	–4.7 dBm
OFF	–30 dBm	–30 dBm	–30 dBm

Table 2 – 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 1 or 3, as described in reference [4].
2. Measure the average launch power of the DUT.
3. Repeat steps 1 and 2 after turning the laser OFF.

Observable results:

a. The average launch power of the DUT should fall between the appropriate maximum and minimum limits shown in Table 2.
b. The average OFF launch power of the DUT should be less than –30dBm.

Possible problems: None

Test # 52.1.3 – Extinction ratio

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

References:

[1] IEEE Std. 802.3ae-2002, subclause 52.5.1, Table 52-7 (10GBASE-SR/SW)
[2] IEEE Std. 802.3ae-2002, subclause 52.6.1, Table 52-12 (10GBASE-LR/LW)
[3] IEEE Std. 802.3ae-2002, subclause 52.7.1, Table 52-16 (10GBASE-ER/EW)
[4] IEEE Std. 802.3ae-2002, subclause 52.9.1
[5] IEEE Std. 802.3ae-2002, subclause 52.9.4

Resource requirements:

- Digital oscilloscope capable of sampling a 10GBASE-R or 10GBASE-W signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: February 11, 2004

Discussion: The minimum extinction ratio for each technology is shown below in Table 3. Per reference [4] the measurement is made with the DUT transmitting test pattern 1 or 3. The extinction ratio is defined as the ratio of the average optical energy in a ONE to the average optical energy in a ZERO.

	SR/SW	LR/LW	ER/EW
Min	–3 dB	–3.5 dB	–3 dB

Table 3 – 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 1 or 3, as described in reference [4].
2. Configure the oscilloscope to capture the transmissions from the DUT.
3. Process the captured waveform, measuring the extinction ratio.

Observable results:

a. The measured extinction ratio should fall above the limits shown in Table 3.

Possible problems: None

Test # 52.1.4 – Optical modulation amplitude

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

References:

[1] IEEE Std. 802.3ae-2002, subclause 52.5.1, Table 52-7, Figure 52-3 (10GBASE-SR/SW)
[2] IEEE Std. 802.3ae-2002, subclause 52.6.1, Table 52-12 (10GBASE-LR/LW)
[3] IEEE Std. 802.3ae-2002, subclause 52.7.1, Table 52-16 (10GBASE-ER/EW)
[4] IEEE Std. 802.3ae-2002, subclause 52.9.1
[5] IEEE Std. 802.3ae-2002, subclause 52.9.5

Resource requirements:

- Digital oscilloscope capable of sampling a 10GBASE-R or 10GBASE-W signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: February 11, 2004

Discussion: The minimum extinction ratio for each technology is shown below in Table 4. Per reference [4] the measurement is made with the DUT transmitting a square wave that has 4 – 11 ones followed by an equal number of zeros. 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.

	SR/SW	LR/LW	ER/EW
Min	Taken from Figure 52-3	–5.2 dBm	–1.7 dBm

Table 4 – 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 [4].
2. Configure the oscilloscope to capture the transmissions from the DUT.
3. Process the captured waveform, measuring the OMA.

Observable results:

a. The measured OMA should fall above the limits shown in Table 4.

Possible problems: None

Test # 52.1.5 – Transmitter eye mask

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

References:

[1] IEEE Std. 802.3ae-2002, subclause 52.5.1, Table 52-7 (10GBASE-SR/SW)
[2] IEEE Std. 802.3ae-2002, subclause 52.6.1, Table 52-12 (10GBASE-LR/LW)
[3] IEEE Std. 802.3ae-2002, subclause 52.7.1, Table 52-16 (10GBASE-ER/EW)
[4] IEEE Std. 802.3ae-2002, subclause 52.9.1
[5] IEEE Std. 802.3ae-2002, subclause 52.9.7

Resource requirements:

- Digital oscilloscope capable of sampling a 10GBASE-R or 10GBASE-W signal at the appropriate wavelength.
- Fiber cable 2m-5m in length used to connect DUT to oscilloscope.

Last modification: February 11, 2004

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

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 [4].
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 no mask violations.

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. 802.3ae-2002 Clause 52. 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, not only existing products, but also future standard compliant devices.

Scope: The scope of these tests, unless otherwise indicated, covers all IEEE 802.3ae serial optical devices including: SR, SW, LR, LW, ER, and EW.

Test # 52.2.1 – Stressed receiver

Purpose: To verify that the receiver of the DUT can operate with a BER of 10^{-12} or less when subject to the stressed receiver conformance test signal.

References:

[1] IEEE Std. 802.3ae-2002, subclause 52.5.2, Table 52-9 (10GBASE-SR/SW)
[2] IEEE Std. 802.3ae-2002, subclause 52.6.2, Table 52-13 (10GBASE-LR/LW)
[3] IEEE Std. 802.3ae-2002, subclause 52.7.2, Table 52-17 (10GBASE-ER/EW)
[4] IEEE Std. 802.3ae-2002, subclause 52.9.1
[5] IEEE Std. 802.3ae-2002, subclause 52.9.9

Resource requirements:

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

Last modification: February 11, 2004

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 [4] the measurement is made with the DUT transmitting test pattern 2 or 3. Table 5 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.

	SR/SW	LR/LW	ER/EW
Sensitivity in OMA	–11.1 dBm	–10.3 dBm	–11.3 dBm

Table 5 – Stressed sensitivity values

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

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 5.

Possible problems: None