40 AND 100 GIGABIT ETHERNET CONSORTIUM

Clause 85
40GBASE-CR4 and
100GBASE-CR10 PMD Test Suite
Version 1.0
Technical Document

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40 and 100 Gigabit Ethernet Consortium

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TABLE OF CONTENTS

TABLE OF CONTENTS **2**
MODIFICATION RECORD **3**
ACKNOWLEDGMENTS **4**
INTRODUCTION **5**
GROUP 1: TRANSMITTER ELECTRICAL SIGNALING REQUIREMENTS **7**
TEST 85.1.1 – SIGNALING SPEED 8
TEST 85.1.2 – COMMON MODE OUTPUT VOLTAGE 9
TEST 85.1.3 – DIFFERENTIAL OUTPUT AMPLITUDE 10
TEST 85.1.4 – COMMON-MODE AC OUTPUT VOLTAGE RMS 11
TEST 85.1.5 – FAR-END TRANSMIT OUTPUT NOISE 12
TEST 85.1.6 – TRANSMIT JITTER 13
GROUP 2: TRANSMITTED WAVEFORM **14**
TEST 85.2.1 – TRANSMITTER OUTPUT WAVEFORM 15
TEST 85.2.2 – COEFFICIENT STEP SIZE 16
TEST 85.2.3 – COEFFICIENT INITIALIZATION 17
TEST 85.2.4 – COEFFICIENT RANGE 18
GROUP 3: IMPEDANCE REQUIREMENTS **19**
TEST 85.3.1 – DIFFERENTIAL OUTPUT RETURN LOSS 20
TEST 85.3.2 – DIFFERENTIAL INPUT RETURN LOSS 21
TEST 85.3.3 – DIFFERENTIAL TO COMMON-MODE INPUT RETURN LOSS 22
GROUP 4: RECIEVER ELECTRICAL SIGNALING REQUIREMENTS **23**
TEST 85.4.1 – RECEIVER INTERFERENCE TOLERANCE 24
APPENDICES **26**
APPENDIX I – TEST FIXTURES AND SETUPS 27

MODIFICATION RECORD

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Michael Klempa: Minor edits.

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Michael Klempa	UNH InterOperability Laboratory
Jeff Lapak	UNH InterOperability Laboratory
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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 functionality of the Physical Medium Dependent (PMD) sublayer of their 40GBASE-CR4 and 100GBASE-CR10 products.

These tests are designed to determine if a product conforms to specifications defined in Clause 85 of the IEEE 802.3-2012 Standard. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other devices. However, 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 40GBASE-CR4 and 100GBASE-CR10 environments.

The tests contained in this document are organized in such a manner as to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are organized 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-part numbering system is used to organize the tests, where the first number indicates the clause of the IEEE 802.3 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 to 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 pertinent to each test. Specifically, each test description consists of 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 source material *external* to the test suite, including specific subclauses pertinent to the test definition, or any other references that might be helpful in understanding the test methodology and/or test results. External sources are always referenced by number when mentioned in the test description. Any other references not specified by number are stated with respect to the test suite document itself.

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.

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, below.

Test 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 whitepapers that may provide more detail regarding these issues.

GROUP 1: TRANSMITTER ELECTRICAL SIGNALING REQUIREMENTS

Overview:

The tests defined in this section verify the transmitter's electrical signaling characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 85 of IEEE 802.3-2012.

Test 85.1.1 – Signaling Speed

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

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.9 – Signaling Speed
[3] IEEE Std. 802.3-2012, subclause 85.8.3.5 – Test fixture

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the signaling speed, which is specified in [2].

Reference [2] states that the 40GBASE-CR4 and 100GBASE-CR10 signaling speed should be 10.3125 Gbaud +/- 100 ppm per lane. This translates to 10.3125 Gbaud +/- 1.03125 Mbaud, with a nominal Unit Interval (UI) of 97 ps.

In this test, the signaling speed is measured while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT may be any valid 40GBASE-CR4 or 100GBASE-CR10 signal.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send a valid signal or test pattern.
2. Connect the DUT's transmitter to the DSO.
3. Measure the average TX signaling speed.
4. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The signaling speed should be within 10.3125 Gbaud +/- 1.03125 Mbaud

Possible Problems: None.

Test 85.1.2 – Common Mode Output Voltage

Purpose: To verify that the DC common mode output voltage of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2008, subclause 72.7.1.4 – Output amplitude
[3] IEEE Std. 802.3-2012, subclause 85.8.3.5 – Test fixture
[4] IEEE Std. 802.3-2012, subclause 86.8.2 – Test-patterns and related sub clauses

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the common mode output voltage defined in [2].

In this test, the DC common mode output voltage is measured at TP2 while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT may be any valid 40GBASE-CR4 or 100GBASE-CR10 signal, however the test pattern 3 (PRBS31) defined in [4] will be used, primarily out of convenience, as this pattern is also used for several other tests in this group.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send test pattern 3 (PRBS31).
2. Connect the DUT's transmitter to the DSO.
3. Measure the common mode output voltage of SL<p> and SL<n> at TP2.
4. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The common mode output voltage should be between 0 V and 1.9 V with respect to the signal shield.

Possible Problems: None

Test 85.1.3 – Differential Output Amplitude

Purpose: To verify that the differential output amplitude of the DUT transmitter is within the conformance limits.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2008, subclause 72.7.1.4 – Output amplitude
[3] IEEE Std. 802.3-2012, subclause 85.8.3.5 – Test fixture

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the differential output amplitude defined in [2].

In this test, the maximum differential peak-to-peak output voltage is measured while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT will be a high frequency test pattern (1010) consisting of no fewer than eight symbols.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send a high frequency test pattern (1010).
2. Connect the DUT's transmitter to the DSO.
3. Measure the maximum peak-to-peak differential output voltage.
4. Disable the transmitter and measure the peak-to-peak output voltage.
5. Repeat steps 1-4 for each transmit lane.

Observable Results:

a. The maximum differential peak-to-peak output voltage should be less than 1200 mV, regardless of equalization setting.
b. The transmitter output voltage should be less than or equal to 30 mV peak-to-peak when disabled.

Possible Problems: None

Test 85.1.4 – Common-mode AC output voltage RMS

Purpose: To verify that the maximum AC common-mode output voltages are within the conformance limits.

References:

[1] IEEE Std. 802.3-2012, Table 85 – 5 – Transmitter characteristics at TP2 summary
[2] IEEE Std. 802.3-2012, subclause 86A.5.3.1 – AC common-mode voltage

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for maximum output AC common-mode voltage defined in [2].

In this test, the differential amplitude is measured while the DUT is connected to the DSO. The common mode voltage can be found by averaging the signal+ and signal- at any time. RMS AC common-mode voltage may be calculated by applying the histogram function over 1 UI to the common mode signal.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send a test pattern 3 (PRBS31).
2. Connect the DUT's transmitter to the DSO.
3. Apply a histogram function over 1 UI of the common mode signal.
5. Measure the common mode RMS amplitude.
6. Repeat steps 1-5 for each transmit lane.

Observable Results:

a. The maximum output AC common-mode voltage should be no greater than 30mV.

Possible Problems: None

Test 85.1.5 – Far-end transmit output noise

Purpose: To verify that the far-end transmit output noise of the DUT is within the conformance limits with respect to the low and high insertion loss channels.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.2 – Transmitter noise parameter measurements
[3] IEEE Std. 802.3-2012, subclause 85.10.7 – Cable assembly integrated crosstalk noise (ICN)
[4] IEEE Std. 802.3-2012, subclause 85.10.8 – Cable Assembly Test Fixture

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the transmitter output noise related to a worst case "los-loss" and "high-loss" cable assembly.

In this test, the transmitter under test is connected to one end of the reference cable assembly and the other end is connected to the cable assembly test fixture specified in [4]. All lanes of the cable assembly test fixture are terminated in the reference impedance with the lane under test (LUT) connected to the measuring instrument. The LUT of the transmitter under test sends a square wave test pattern while all other adjacent transmitter lanes send either scrambled idle or PRBS31. Denote σ_l as the far-end ICN for the "low-loss" cable assembly and σ_h as far-end ICN for the "high-loss" cable assembly.

Equation 85 – 2: $\mathrm{RMS}l_{\mathrm{dev}} \leq \sqrt{\sigma_l{}^2 + 2^2}$ (mV)

Equation 85 – 3: $\mathrm{RMS}h_{\mathrm{dev}} \leq \sqrt{\sigma_h{}^2 + 1^2}$ (mV)

Test Setup: See Appendix I

Test Procedure:

1. Measure the far-end integrated crosstalk noise into the LUT of the low-loss cable assembly.
2. Configure LUT to send a square wave test pattern.
3. Configure all adjacent transmitter lanes to send test pattern 3 (PRBS31).
4. Connect the DUT to the DSO via the low-loss cable assembly
5. $\mathrm{RMS}l_{dev}$ is measured at a chosen fixed point on the square wave test pattern.
6. Subtract the observed system noise from $\mathrm{RMS}l_{dev}$.
7. Repeat steps 1-6 for high-loss cable assembly.
8. Repeat steps 1-7 for each transmit lane.

Observable Results:

a. For the low-loss cable assembly, $\mathrm{RMS}l_{dev}$ should be less than the value determined using Equation (85–2).
b. For the high-loss cable assembly, $\mathrm{RMS}h_{dev}$ should be less than the value determined using Equation (85–3).

Possible Problems: None

Test 85.1.6 – Transmit Jitter

Purpose: To verify that the peak-to-peak transmit jitter of the DUT is within the conformance limits

References:

[1] $IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] $IEEE Std. 802.3-2008, subclause 72.7.1.9 – Transmit jitter test requirements
[3] $IEEE Std. 802.3-2012, subclause 85.8.3.5 – Test fixture
[4] IEEE Std. 802.3-2012, subclause 83A.5.1 – Transmit jitter
[5] IEEE Std. 802.3-2012, subclause 85.8.3.8 – Data dependent jitter (DDJ)

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the peak-to-peak total transmit jitter excluding data dependent jitter (DDJ). DDJ is defined in [5] and measured using the methodology found in reference [2].

In this test, the peak-to-peak transmit jitter is measured while the DUT is transmitting test pattern 3 (PRBS31) defined in [4] and is connected to the test fixture defined in [3] or its functional equivalent. Reference [5] also requires that the DUT be transmitting PRBS9 while measuring DDJ.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT so that it is sourcing a PRBS9 pattern.
2. Connect the DUT’s transmitter to the DSO.
3. Measure the DDJ.
4. Configure the DUT so that it is sourcing test pattern 3 (PRBS31).
5. Measure the random jitter, duty cycle distortion, and total transmit jitter.
6. Repeat steps 1-5 for each transmit lane.

Observable Results:

a. The Random Jitter value should not exceed 0.15 UI.
b. The Duty Cycle Distortion value should not exceed 0.035 UI.
c. The Total Jitter excluding DDJ should not exceed 0.25 UI.

Possible Problems: None

GROUP 2: TRANSMITTED WAVEFORM

Overview:

The tests defined in this section verify the transmitted waveform characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 85 of IEEE 802.3-2012. The point for the tests in Group 2 is to eliminate the channel that connects the chip to the transmitter. This is necessary because in order to correctly characterize the effects of the coefficient changes, the intrinsic effects of the channel need to be accounted for. This means each test below besides test 85.2.1 DC amplitude must be run 'N' times, where 'N' is the number of possible coefficient combinations.

Test 85.2.1 – Transmitter Output Waveform

Purpose: To verify that the transmitter output waveform of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[3] IEEE Std. 802.3-2012, subclause 72.6.10.2.3.1 – Preset
[4] IEEE Std. 802.3-2012, subclause 83.5.10 – PMA test patterns (optional)
[5] IEEE Std. 802.3-2012, subclause 85.8.3.3.4 – Waveform acquisition

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the transmitter output waveform related to transmitter DC amplitude defined in [2].

In this test, the DUT's equalizer is manipulated to every coefficient conmbination, including preset as specified in [3]. For each combination one complete cycle of the PRBS9 test pattern, specified in [4], is captured. This data is then post-processed using the procedure defined in [2] to compute the least mean square fit of the captured waveform. Additional parameters such as the DC amplitude, linear fit pulse response, and RMS normalized error are derived from captured data and the fitting process.

Test Setup: See Appendix I

Test Procedure:

1. Force the DUT transmitter equalizer to preset.
2. Configure the DUT so that it is sourcing a PRBS9 pattern.
3. Capture at least one complete cycle of the test pattern using the acquisition settings defined in [5].
4. Calculate the linear fit pulse response $p(k)$ and RMS normalized error.
5. Repeat steps 1-4 for all combination of equalizer coefficients.
6. Repeat steps 1-5 for each transmit lane.

Observable Results:

a. The transmitter's DC amplitude, the sum of $p(k)$ divided by M, should be no less than 0.34 V and not exceed 0.6 V.
b. The peak of $p(k)$ should be no less than the transmitter DC amplitude multiplied by 0.63.
c. The RMS normalized error should be no greater than 0.037.

Possible Problems: None

Test 85.2.2 – Coefficient Step Size

Purpose: To verify that the change in the normalized amplitude of each equalizer coefficient is within the conformance limits when responding to an increment or decrement request.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[3] IEEE Std. 802.3-2012, subclause 85.8.3.3.2 – Coefficient step size

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the transmitter output equalizer coefficients related to absolute coefficient step size defined in [3].

In this test, the transmit equalizer functional model shown in [2] is sent "increment" or "decrement" requests. After an "increment" request the device will have stepped up that change must be within the conformance limits. After a "decrement" request the device will have stepped down that change must be within the conformance limits.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT so that it is sourcing a low frequency test pattern.
2. Connect the DUT's transmitter to the DSO.
3. Measure the normalized amplitude of the c(-1) equalizer coefficient.
4. Send an "increment" requests to c(-1).
5. Measure the normalized amplitude of the incremented c(-1) equalizer coefficient
6. Repeat steps 3-5 with a "decrement" request.
7. Repeat steps 1-6 for c(0) and c(1).
8. Repeat steps 1-7 for each transmit lane.

Observable Results:

a. The absolute coefficient step size should be within 0.0083 and 0.05

Possible Problems: None

Test 85.2.3 – Coefficient Initialization

Purpose: To verify that the equalizer coefficient value is within the conformance limits when entering the INITIALIZE state.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[3] IEEE Std. 802.3-2012, subclause 85.8.3.3.1 – Coefficient initialization

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the transmitter output equalizer coefficients related to absolute coefficient step size defined in [3].

In this test, the transmit equalizer functional model shown in [2] is sent an "initialize" request. Once the DUT has responded to the initialize request the equalizer coefficient values should satisfy the ratios provided below in (85.2.3 – 1) and (85.2.3 – 2), as defined in [3].

$$\frac{c(0)+c(1)-c(-1)}{c(0)+c(1)+c(-1)} = 1.54 \pm 10\% \quad (85.2.3-1)$$

$$\frac{c(0)-c(1)+c(-1)}{c(0)+c(1)+c(-1)} = 2.57 \pm 10\% \quad (85.2.3-2)$$

Test Setup: See Appendix I

Test Procedure:

1. Force the DUT transmitter equalizer to initialize.
2. Record the c(-1), c(0), and c(1) equalizer coefficient values from the DUT management settings.
3. Repeat for each transmit lane.

Observable Results:

a. The DUT equalizer coefficient values should satisfy (85.2.3 – 1) and (85.2.3 – 2).

Possible Problems: None

Test 85.2.4 – Coefficient Range

Purpose: To verify that the post cursor fullscale range of the DUT is within the conformance limits with respect to the coefficient range.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[3] IEEE Std. 802.3-2012, subclause 85.8.3.3.3 – Coefficient range

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the transmitter output equalizer coefficients related to minimum precursor and post cursor fullscale range defined in [3].

In this test, the transmit equalizer functional model shown in [2] is sent sufficient "decrement" requests such that the coefficient will reach the minimum value. With c(-1) set to zero and both c(0) and c(1) having received sufficient "decrement" requests, the equalizer coefficient values should satisfy the ratio provided below in (85.2.4 – 1). With c(1) set to zero and both c(-1) and c(0) having received sufficient "decrement" requests, the equalizer coefficient values should satisfy the ratio provided below in (85.2.4 – 2).

$$\frac{c(0) - c(1)}{c(0) + c(1)} \geq 4 \quad (85.2.4 - 1)$$

$$\frac{c(0) - c(-1)}{c(0) + c(-1)} \geq 1.54 \quad (85.2.4 - 2)$$

Test Setup: See Appendix I

Test Procedure:

1. Force the DUT c(-1) transmitter equalizer coefficient to preset.
2. Send "decrement" requests to c(0) and c(1).
3. Repeat step 2 until a sufficient amount of requests make the c(0) and c(1) coefficients the minimum value.
4. Record the c(0) and c(1) equalizer coefficient values from the DUT management settings.
5. Force the DUT c(1) transmitter equalizer coefficient to preset.
6. Send "decrement" requests to c(0) and c(-1).
7. Repeat step 6 until a sufficient amount of requests make the c(0) and c(-1) coefficients the minimum value.
8. Record the c(0) and c(-1) equalizer coefficient values from the DUT management settings.
9. Repeat for each transmit lane.

Observable Results:

a. The minimum post cursor fullscale range, as defined by (85.2.4 – 1), should be greater than or equal to 4.
b. The minimum precursor fullscale range, as defined by (85.2.4 – 2), should be greater than or equal to 1.54.

Possible Problems: None

GROUP 3: IMPEDANCE REQUIREMENTS

Overview:

The tests defined in this section verify the impedance characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 85 of IEEE 802.3-2012.

Test 85.3.1 – Differential Output Return Loss

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

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[2] IEEE Std. 802.3-2012, subclause 85.8.3.1 – Differential output return loss

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the differential output return loss, which are specified in [2].

For the purpose of this test, the differential output return loss is defined as the magnitude of the reflection coefficient expressed in decibels of the DUT's transmitter. 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 S_{DD22} scattering parameter (s-parameter). For frequencies from 50 MHz to 10 GHz, the differential return loss of the driver should exceed (85-1). The reference impedance for differential return loss measurements shall be 100 Ω.

$$Return\_loss(f) \geq \left\{ \begin{matrix} 12 - 2\sqrt{f} & 0.05 \leq f \leq 4.11 \\ 6.3 - 13\log_{10}\left(\frac{f}{5.5}\right) & 4.11 \leq f \leq 10 \end{matrix} \right\} (dB) \qquad (85-1)$$

Test Setup: See Appendix I

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing a PRBS31 pattern.
3. Connect the DUT's transmitter to the VNA.
4. Measure the reflection coefficient at the DUT transmitter from 50 MHz to 10 GHz.
5. Compute the return loss from the reflection coefficient values.
6. Repeat steps 1-5 for each transmit lane.

Observable Results:

a. The differential output return loss should exceed the limits described by (85-1).

Possible Problems: None

Test 85.3.2 – Differential Input Return Loss

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

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.4 - Receiver characteristics at TP3 summary
[2] IEEE Std. 802.3-2012, subclause 85.8.4.1 - Receiver differential input return loss

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the receiver characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. This specification includes conformance requirements for the differential output return loss, which are specified in [2].

For the purpose of this test, the differential input return loss is defined as the magnitude of the reflection coefficient expressed in decibels of the DUT's receiver. 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 S_{DD11} scattering parameter (s-parameter). For frequencies from 10 MHz to 10 GHz, the differential return loss of the driver should exceed (85-17). The reference impedance for differential return loss measurements shall be 100 Ω.

$$Return\_loss(f) \geq \begin{Bmatrix} 12 - 2\sqrt{f} & 0.01 \leq f \leq 4.11 \\ 6.3 - 13\log_{10}\left(\frac{f}{5.5}\right) & 4.11 \leq f \leq 10 \end{Bmatrix} (dB) \qquad (85-17)$$

Test Setup: See Appendix I

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing a PRBS31 pattern.
3. Connect the DUT's receiver to the VNA.
4. Measure the reflection coefficient at the DUT receiver from 10 MHz to 10 GHz.
5. Compute the return loss from the reflection coefficient values.
6. Repeat steps 1-5 for each receive lane.

Observable Results:

a. The differential return loss should exceed the limits described by (85-17).

Possible Problems: None

Test 85.3.3 – Differential to common-mode input return loss

Purpose: To verify that the differential to common-mode input return loss of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.4 - Receiver characteristics at TP3 summary

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the receiver characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices, including conformance requirements for the differential to common-mode input return loss.

For the purpose of this test, the differential to common-mode input return loss is defined as the magnitude of the reflected differential to common-mode conversion expressed in decibels of the DUT's receiver. Note that this is also known as the S_{CD11} scattering parameter (s-parameter). For frequencies from 10 MHz to 10 GHz, the differential to common-mode input return loss of the driver should exceed 10 dB. The reference impedance for differential return loss measurements shall be 100 Ω.

Test Setup: See Appendix I

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing a PRBS31 pattern.
3. Connect the DUT's receiver to the VNA.
4. Measure the reflected differential to common-mode conversion at the DUT receiver from 10 MHz to 10 GHz.
5. Repeat steps 1-4 for each receive lane.

Observable Results:

a. The differential to common-mode input return loss should exceed 10 dB from 10 MHz to 10 GHz.

Possible Problems: None

GROUP 4: RECIEVER ELECTRICAL SIGNALING REQUIREMENTS

Overview:

The tests defined in this section verify the receiver's electrical signaling characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 85 of IEEE 802.3-2012.

Test 85.4.1 – Receiver Interference Tolerance

Purpose: To verify that the bit error ratio (BER) of the DUT's receiver is within the conformance limits while communicating over a lossy channel with coupled interference.

References:

[1] IEEE Std. 802.3-2012, subclause 85.8.4 - Receiver characteristics at TP3 summary
[2] IEEE Std. 802.3-2012, 85.8.4.2 - Receiver interference tolerance test
[3] IEEE Std. 802.3-2012, 85.8.4.2.4 – Pattern generator
[4] IEEE Std. 802.3-2012, 85.8.4.2.3 - Test channel calibration

Resource Requirements: See Appendix I

Last Modification: May 23, 2014

Discussion:

Reference [1] specifies the receiver tolerance characteristics for 40GBASE-CR4 and 100GBASE-CR10 devices. A major problem in the communication of multi-channel transceivers is interference. The interfering signal can come from a variety of sources including: a) Crosstalk from other data channels running the same kind of signals as the channel of interest. This type of interference is usually subdivided into:1) Far-end crosstalk (FEXT) coming from data traveling in the same general direction as the channel of interest.2) Near-end crosstalk (NEXT) originating from a channel with a transmitter near the receiver of the channel of interest. b) Self interference caused by reflections due to impedance discontinuities, stubs, etc. This is a form of intersymbol interference (ISI) that is beyond what a reasonable equalizer can compensate. c) Alien crosstalk which is defined to be interference from unrelated sources such as clocks, other kinds of data, power supply noise, etc. For the channel to work, the receiver must be able to extract correct data from the lossy channel in the presences of interference. The ability of the receiver to extract data in the presence of interference is an important characteristic of the receiver and needs to be measured. This ability is called interference tolerance.

In this test, BER is measured while the DUT is subjected to an input victim signal defined in [2] and [3], with far-end crosstalk disturber interference as specified in [4]. Table 85-8 found in [2] specifies two cable assemblies which will be referred to 'low loss' and 'high loss'. The additive jitter applied to the input victim signal consists of sinusoidal jitter (SJ), random jitter (RJ), and duty cycle distortion (DCD). The added SJ component should be fixed at a frequency greater than 15 MHz.

Test Setup: See Appendix I

Test Procedure:

1. Configure the victim pattern generator output to transmit a jittered test pattern 3 (PRBS31) waveform with a signaling rate of 10.3125Gbd compliant with [2] and [3].
2. Configure the disturber pattern generator outputs to transmit test pattern 3 (PRBS31) with a signaling rate of 10.3125Gbd compliant with [4].
3. Using low loss cable assembly, connect the victim pattern generator to the LUT receiver while all adjacent receive lanes are connected to the disturber pattern generator.
4. Connect the LUT transmitter to an error detector.
5. Enable an externally facing loopback on the DUT.
6. Transmit at least $3x10^{12}$ bits from the victim pattern generator and calculate the BER from the number of errors on the error detector.
7. Repeat steps 1-6 with the high loss cable assembly.
8. Repeat steps 1-7 with signaling speed of 10.3125Gbd - 100ppm and 10.3125Gbd + 100ppm.
9. Repeat steps 1-8 for each receive lane.

Observable Results:

a. The receiver shall operate with a BER of 10^{-12} or better.

Possible Problems: None

APPENDICES

Overview:

Test suite appendices are intended to provide additional low-level technical detail pertinent to specific tests contained in this test suite. These appendices often cover topics that are outside of the scope of the standard, and are specific to the methodologies used for performing the measurements in this test suite. Appendix topics may also include discussion regarding a specific interpretation of the standard (for the purposes of this test suite), for cases where a particular specification may appear unclear or otherwise open to multiple interpretations.

Scope:

Test suite appendices are considered informative supplements, and pertain solely to the test definitions and procedures contained in this test suite.

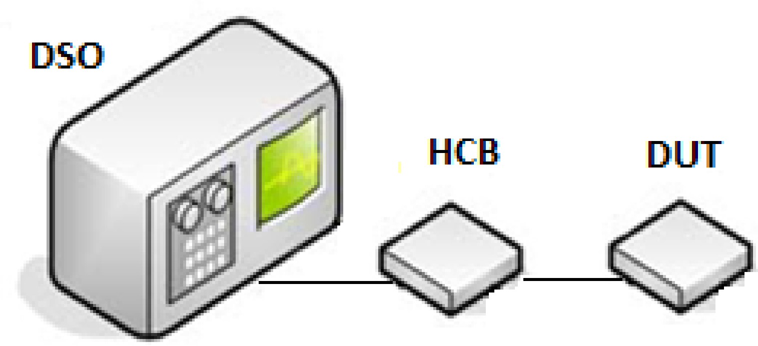
Appendix I – Test Fixtures and Setups

Purpose: To specify the test equipment and setup used to test all electrical characteristic as well as waveform characteristics in this test suite.

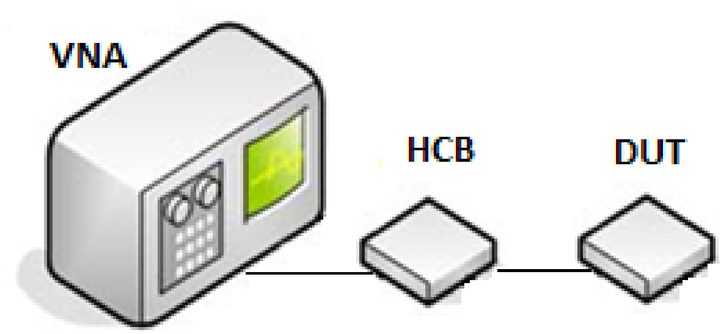
Last Modification: May 23, 2014

Equipment List:

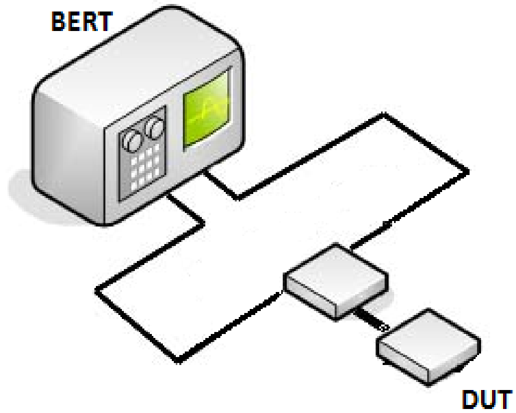
1. Digital Storage Oscilloscope, 20 GHz bandwidth (minimum)
2. Vector Network Analyzer, capable of measuring up to 10 GHz (minimum)
3. Bit Error Rate Tester (BERT)
4. 50Ω matched coax cables
5. Host compliance board (HCB)



85.I – 1: Setup used for Group 1: Transmitter Electrical testing



85.I – 2: Setup used for Group 3: Impedance Requirements testing



85.I – 3: Setup used for Group 4: Receiver Electrical Requirements testing