40 AND 100 GIGABIT ETHERNET CONSORTIUM

Clause 92
100GBASE-CR4 PMD Test Suite
Version 1.0
Technical Document

Last Updated: October 2, 2014

40 and 100 Gigabit Ethernet Consortium

University of New Hampshire
InterOperability Laboratory

121 Technology Drive, Suite 2
Durham, NH 03824
Phone: (603) 862-0090
Fax: (603) 862-4181
http://www.iol.unh.edu/consortiums/bp

TABLE OF CONTENTS

The University of New Hampshire
InterOperability Laboratory

MODIFICATION RECORD

October 2, 2014 Version 1.0

Michael Klempa: Preliminary release. First draft.

ACKNOWLEDGMENTS

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

Michael Klempa	UNH InterOperability Laboratory
Jeff Lapak	UNH InterOperability Laboratory
Curtis Donahue	UNH InterOperability Laboratory

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 100GBASE- CR4 products.

These tests are designed to determine if a product conforms to specifications defined in Clause 92 of the IEEE Std. 802.3bj. 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 100GBASE- CR4 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 92 of the IEEE Std. 802.3b.

Test 92.1.1 – Signaling Speed

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

References:

[1] IEEE Std. 802.3bj, Table 92 - 6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.11.1.1 – Transmitter Test fixture
[3] IEEE Std. 802.3bj, subclause 92.8.3.9 – Signaling Rate Range

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for the signaling speed which states that the signaling speed should be 25.78125 Gbaud +/- 100 ppm per lane. This translates to 25.78125 Gbaud +/- 2.578125 Mbaud, with a nominal Unit Interval (UI) of 38.7878 ps.

In this test, the signaling speed is measured while the DUT is connected to the test fixture defined in [2], or its functional equivalent. The signal being transmitted by the DUT may be any valid 100GBASE-CR4 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 25.78125 Gbaud +/- 100 ppm per lane

Possible Problems: None.

Test 92.1.2 – 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. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.1 – Signal Levels
[3] IEEE Std. 802.3bj, subclause 92.11.1.1 – Transmitter Test fixture

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 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 while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT shall be PRBS9 as defined in [2]. The limits shall be met regardless of the transmit equalization setting.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send PRBS9.
2. Connect the DUT's transmitter to the DSO.
3. Measure the common mode output voltage of SL<p> and SL<n>.
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 ground.

Possible Problems: None

Test 92.1.3 – Differential Output Amplitude

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

References:

[1] IEEE Std. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.1 – Signal Levels
[3] IEEE Std. 802.3bj, subclause 92.11.1.1 – Transmitter Test fixture
[4] IEEE Std. 802.3bj, subclause 92.7.6 – Transmit disable function
[5] IEEE Std. 802.3bj, subclause 92.7.7 – Lane by lane disable function

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 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 PRBS9 as defined in [2].

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send PRBS9.
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 35 mV peak-to-peak when disabled as defined in [4] and [5].

Possible Problems: None

Test 92.1.4 – 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. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.1 – Signal Levels
[3] IEEE Std. 802.3bj, subclause 92.8.1.1 – Transmitter Test fixture

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 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. The signal being transmitted by the DUT will be PRBS9 as defined in [2].

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to send PRBS9.
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 92.1.5 – Transmit Jitter

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

References:

[1] IEEE Std. 802.3bj, Table 92-4 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.8 – Transmitter Output Jitter
[3] IEEE Std. 802.3bj, subclause 92.8.3.8.1 – Even Odd Jitter
[4] IEEE Std. 802.3bj, subclause 92.8.3.8.2 – Effective bounded uncorrelated jitter and effective total uncorrelated jitter

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for even-odd jitter, effective bounded uncorrelated jitter peak-peak and effective total uncorrelated jitter.

In this test, there are three components of jitter that are measured. Even-Odd Jitter is measured while the DUT is transmitting PRBS9 and is the difference between the average deviation of all even-numbered transitions and the average deviation of all odd-numbered transitions. Effective bounded uncorrelated jitter (BUJ) and effective total uncorrelated jitter (TUJ) are also measured, also while the DUT is sourcing a PRBS9 pattern. The procedure will performed as defined in [5]. All measurements will be performed with the DUT connected to the test fixture defined in [3] or its functional equivalent.

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 Even-Odd Jitter.
4. Measure the even-odd jitter, effective bounded uncorrelated jitter peak-peak and effective total uncorrelated jitter.
5. Repeat steps 1-5 for each transmit lane.

Observable Results:

a. The Even-Odd Jitter value should not exceed 0.35 UI.
b. The BUJ value should not exceed 0.10 UI.
c. The TUJ value should not exceed 0.18 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 92 of IEEE Std. 802.3bj. 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 92.2.1 steady state voltage must be run 'N' times, where 'N' is the number of possible coefficient combinations.

Test 92.2.1 – Transmitter Output Waveform

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

References:

[1] IEEE Std. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.5.2 – Steady state voltage and linear fit pulse peak
[3] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[4] IEEE Std. 802.3-2012, subclause 72.6.10.2.3.1 – Preset
[5] IEEE Std. 802.3-2012, subclause 83.5.10 – PMA test patterns (optional)
[6] IEEE Std. 802.3-2012, subclause 85.8.3.3.4 – Waveform acquisition

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for the transmitter output waveform related to transmitter steady state voltage defined in [2].

In this test, the DUT's equalizer is manipulated to every coefficient combination, including preset as specified in [4]. For each combination one complete cycle of the PRBS9 test pattern, specified in [5], is captured. This data is then post-processed using the procedure defined in [3] to compute the least mean square fit of the captured waveform. Additional parameters such as the steady state voltage and linear fit pulse response 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 $p(\mathrm{k})$.
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 steady state voltage, the sum of $p(\mathrm{k})$ divided by M, should be no less than 0.34 V and not exceed 0.6 V.
b. The peak of $p(\mathrm{k})$ should be no less than the transmitter steady state voltage multiplied by 0.45.

Possible Problems: None

Test 92.2.2 – 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. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.5.4 – Coefficient Step Size
[3] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[4] IEEE Std. 802.3-2012, subclause 85.8.3.3.2 – Coefficient step size

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for the transmitter output equalizer coefficients related to absolute coefficient step size defined in [2].

In this test, the transmit equalizer functional model shown in [3] 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 92.2.3 – Coefficient Initialization

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

References:

[1] IEEE Std. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.5.3 – Coefficient initialization
[3] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[4] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[5] IEEE Std. 802.3-2012, subclause 85.8.3.3.1 – Coefficient initialization

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for the transmitter output equalizer coefficients related to absolute coefficient step size defined in [2].

In this test, the transmit equalizer functional model shown in [4] is sent an "initialize" request. Once the DUT has responded to the initialize request the equalizer coefficient values should satisfy the ratios provided below as defined in [2].

$$\frac{c(0) + c(1) - c(-1)}{c(0) + c(1) + c(-1)} = 1.29 \pm 10\%$$

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

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 the equations defined in [2].

Possible Problems: None

Test 92.2.4 – 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. 802.3bj, Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.5.3 – Coefficient range
[3] IEEE Std. 802.3-2012, subclause 85.8.3 – Transmitter Characteristics
[4] IEEE Std. 802.3-2012, subclause 85.8.3.3 – Transmitter output waveform
[5] IEEE Std. 802.3-2012, subclause 85.8.3.3.3 – Coefficient range

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for the transmitter output equalizer coefficients related to minimum precursor and post cursor fullscale range defined in [2].

In this test, the transmit equalizer functional model shown in [4] 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.

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

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

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 in [2] should be greater than or equal to 4.
b. The minimum precursor fullscale range, as defined in [2] should be greater than or equal to 1.54.

Possible Problems: None

Test 92.2.5 – Signal to Noise and Distortion Ratio

Purpose: To verify that the transmit signal to noise ratio of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3bj, Table 92-4 – Transmitter Characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.3.7 – Transmitter output noise and distortion

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for signal to noise and distortion ratio (SNDR).

In this test, the RMS deviation error will be measured while each lane is sourcing PRBS9 as defined in [3]. The RMS deviation from the mean voltage will be measured at a fixed point in a run of at least 8 consecutive identical bits in PRBS9. The deviation is measured within the flattest portion of the waveform at a point where the slope is closest to zero. The RMS deviation is measured for a run of zeros and also a run of ones. The average of the two measurements is denoted as σn. The peak value of the linear interpolated waveform will also be used in this measurement. SNDR is found with Equation 92-9:

$$SNDR = 10\log_{10}\frac{pmax^2}{\sigma e^2 + \sigma n^2} \qquad \text{Eq. 92-9}$$

Test Setup: See Appendix I

Test Procedure:

1. From the transmitter output waveform test, find the peak of the interpolated waveform as well as the RMS standard deviation error.
2. Configure the DUT to source PRBS9 on all lanes.
3. Connect the DUT to the DSO.
4. Measure the RMS deviation on PRBS9 with at least eight consecutive identical bits in a single pattern.
5. Use equation 92-9 to find SNDR.

Observable Results:

a. The SNDR shall be greater than 26 dB regardless of transmitter equalization setting.

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 92 of IEEE Std. 802.3bj.

Test 92.3.1 – 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. 802.3bj., Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj., subclause 92.8.3.2 – Differential output return loss

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the transmitter characteristics for 100GBASE-CR4 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. The differential output return loss of the driver should exceed (92-1). The reference impedance for differential return loss measurements shall be 100 Ω.

$$Return\_loss(f) \geq \begin{Bmatrix} 9.5 - 0.37f & 0.01 \leq f \leq 8 \\ 4.75 - 7.4\log_{10}(f/14) & 8 \leq f \leq 19 \end{Bmatrix} (dB) \qquad (92-1)$$

Test Setup: See Appendix I

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Connect the DUT's transmitter to the VNA.
3. Measure the differential output return loss of the DUT.
4. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The differential output return loss should exceed the limits described by (92-1).

Possible Problems: None

Test 92.3.2 – Common Mode to Differential Mode Output Return Loss

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

References:

[1] IEEE Std. 802.3bj., Table 92-6 – Transmitter Characteristics
[2] IEEE Std. 802.3bj., subclause 92.8.3.3 – Common mode to differential mode output return loss

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

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

For the purpose of this test, the common mode 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. The common mode output return loss of the driver should exceed (92-2). The reference impedance for common mode return loss measurements shall be 25 Ω.

$$Return\_loss(f) \geq \begin{Bmatrix} 22 - (\frac{20}{25.78})f & 0.01 \leq f \leq 12.89 \\ 15 - (\frac{6}{25.78})f & 12.89 \leq f \leq 19 \end{Bmatrix} (dB) \qquad (92-2)$$

Test Setup: See Appendix I

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Connect the DUT's transmitter to the VNA.
3. Measure the common mode output return loss of the DUT.
4. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The differential output return loss should exceed the limits described by (92-2).

Possible Problems: None

Test 92.3.3 – Common Mode to Common Mode Output Return Loss

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

References:

[3] IEEE Std. 802.3bj., Table 92-6 – Transmitter Characteristics
[4] IEEE Std. 802.3bj., subclause 92.8.3.4 – Common mode to common mode output return loss

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

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

For the purpose of this test, the common mode 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. The common mode output return loss of the driver should exceed (92-3). The reference impedance for common mode return loss measurements shall be 25 Ω.

$$Return\_loss(f) \geq \{2 \quad 0.02 \leq f \leq 19\}\,(dB) \qquad (92-3)$$

Test Setup: See Appendix I

Test Procedure:

5. Calibrate the VNA to remove the effects of the coaxial cables.
6. Connect the DUT's transmitter to the VNA.
7. Measure the common mode output return loss of the DUT.
8. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The differential output return loss should exceed the limits described by (92-3).

Possible Problems: None

Test 92.3.4 – Differential Input Return Loss

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

References:

[1] IEEE Std. 802.3bj., Table 92-7 – Receiver Characteristics
[2] IEEE Std. 802.3bj., subclause 92.8.4.2 – Receiver input return loss

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [1] specifies the receiver characteristics for 100GBASE-CR4 devices. This specification includes conformance requirements for the differential input 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. The differential input return loss of the driver should exceed (92-20). The reference impedance for differential return loss measurements shall be 100 Ω.

$$Return\_loss(f) \geq \begin{Bmatrix} 9.5 - 0.37f & 0.01 \leq f \leq 8 \\ 4.75 - 7.410\log_{10}(f/14) & 8 \leq f \leq 19 \end{Bmatrix} (dB) \qquad (92-20)$$

Test Setup: See Appendix I

Test Procedure:

5. Calibrate the VNA to remove the effects of the coaxial cables.
6. Connect the DUT's transmitter to the VNA.
7. Measure the differential input return loss of the DUT.
8. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The differential input return loss should exceed the limits described by (92-20).

Possible Problems: None

Test 92.3.5 – Differential to Common Mode Return Loss

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

References:

[5] IEEE Std. 802.3bj., Table 92-7 – Transmitter Characteristics
[6] IEEE Std. 802.3bj., subclause 92.8.4.2 – Receiver input return loss

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

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

For the purpose of this test, the differential to common mode 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. The differential to common mode return loss of the driver should exceed (92-21).

$$Return\_loss(f) \geq \left\{ \begin{matrix} 22 - (\frac{20}{25.78})f & 0.01 \leq f \leq 12.89 \\ 15 - \left(\frac{6}{25.78}\right)f & 12.89 \leq f \leq 19 \end{matrix} \right\} (dB) \qquad (92-21)$$

Test Setup: See Appendix I

Test Procedure:

9. Calibrate the VNA to remove the effects of the coaxial cables.
10. Connect the DUT's receiver to the VNA.
11. Measure the differential to common mode return loss of the DUT.
12. Repeat steps 1-3 for each transmit lane.

Observable Results:

a. The differential to common mode return loss should exceed the limits described by (92-21).

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 92 of IEEE Std. 802.3bj.

Test 92.4.1 – 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. 802.3bj, table 92- 7 Receiver characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.4.4 - Receiver interference tolerance
[3] IEEE Std. 802.3bj, subclause 92.4.4.1 – Test Setup
[4] IEEE Std. 802.3bj, table 92- 8 Receiver interference tolerance parameters
[5] IEEE Std. 802.3bj, Table 94 – 17 COM parameter values

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [2] specifies the receiver tolerance characteristics for 100GBASE-CR4 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 with far-end crosstalk disturber interference as specified in [3]. Reference [4] specifies four sets of test values which describe the setup parameters for the test. The test channel will be calibrated using COM as described in [5].

Test Setup: See Appendix I

Test Procedure:

1. Configure the victim, far end and near end pattern generator output to transmit a jittered PRBS9 waveform
2. Connect the lane under test's transmitter to an error detector.
3. Enable an externally facing loopback on the DUT.
4. Transmit at least $3x10^{12}$ bits from the victim pattern generator and calculate the BER from the number of errors on the error detector.
5. Repeat steps 1-4 for all test values in [4].
6. Repeat steps 1-5 with signaling speed of 25.78125 Gbd - 100ppm and 25.78125 Gbd + 100ppm.
7. 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

Test 92.4.2 – Receiver jitter Tolerance

Purpose: To verify that the RS-FEC symbol error ratio of the DUT's receiver is within the conformance limits while communicating over a lossy channel.

References:

[1] IEEE Std. 802.3bj, table 92- 4 Receiver characteristics
[2] IEEE Std. 802.3bj, subclause 92.8.4.5 - Receiver jitter tolerance
[3] IEEE Std. 802.3bj, Figure 92-12 – Jitter Tolerance Setup
[4] IEEE Std. 802.3bj, table 92- 8 Receiver interference tolerance parameters
[5] IEEE Std. 802.3bj, Table 94 – 17 COM parameter values
[6] IEEE Std. 802.3bj, Table 92 – 9 Receiver jitter tolerance parameters

Resource Requirements: See Appendix I

Last Modification: October 2, 2014

Discussion:

Reference [2] specifies the receiver tolerance characteristics for 100GBASE-CR4 devices. A major problem in the communication of multi-channel transceivers is jitter. 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, RS-FEC symbol error ratio is measured while the DUT is subjected to a lossy channel as specified in [3]. Reference [2] specifies test value four will be sued to describe the setup parameters for the test in reference [4]. The test will be run for both cases as described in [6].

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT to have an optimized equalization register settings.
2. Configure the test transmitter to source a scrambled idle pattern.
3. Configure the test channel to meet the requirements described in [2].
4. Measure the symbol error rate.
5. Repeat steps 1-4 for all test values in [6].
6. Repeat steps 1-5 with signaling speed of 25.78125 Gbd - 100ppm and 25.78125 Gbd + 100ppm.
7. Repeat steps 1-6 for each receive lane.

Observable Results:

a. The receiver shall operate with a RS-FEC symbol error ratio of 10^{-4} or better for each case.

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.

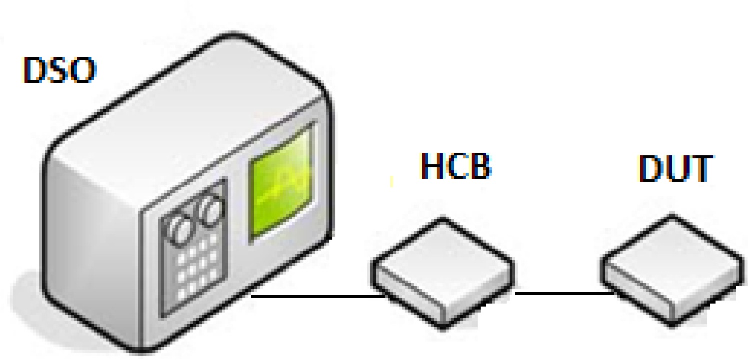
Appendix I – Test Fixtures and Setups

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

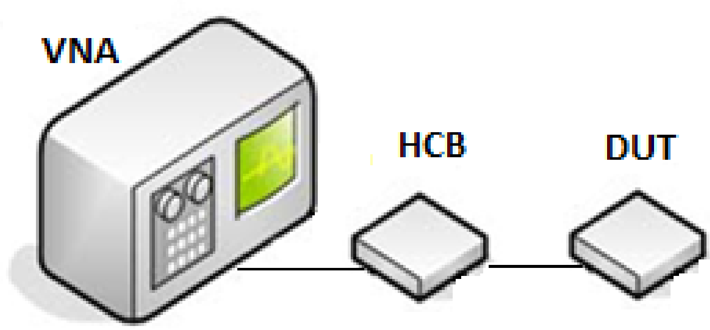
Last Modification: May 23, 2014

Equipment List:

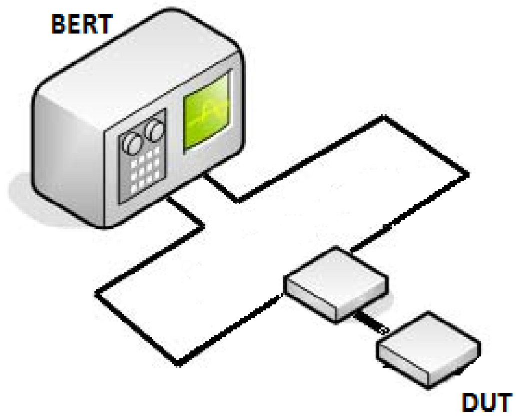
1. Digital Storage Oscilloscope, 35 GHz bandwidth (minimum)
2. Vector Network Analyzer, capable of measuring up to 19 GHz (minimum)
3. Bit Error Rate Tester (BERT)
4. 50Ω matched coax cables
5. Host compliance board (HCB)



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



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



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