40 AND 100 GIGABIT ETHERNET CONSORTIUM

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

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40 and 100 Gigabit Ethernet Consortium

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MODIFICATION RECORD

December 19, 2013 Version 0.1

Christopher Bridges: Informal preliminary draft. Internal IOL use only.

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Michael Klempa: Initial draft.

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Christopher Bridges	UNH InterOperability Laboratory
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 40GBASE-CR4 and 100GBASE-CR10 cable assemblies.

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: CABLE ASSEMBLY CHARACTERISTICS

Overview:

The tests defined in this section verify the electrical signaling characteristics of 40GBASE-CR4 and 100GBASE-CR10 cable assemblies as defined in Clause 85 of IEEE 802.3-2012.

Test 85.1.1 – Insertion Loss

Purpose: To verify that the insertion loss of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3-2012, Table 85-9 – Cable assembly insertion loss characteristics

Resource Requirements: See Appendix I

Last Modification: December 19, 2013

Discussion:

Reference [1] states that the insertion loss at 5.15625 GHz shall be no less than 3 dB and no greater than 17.04 dB.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT as specified in Appendix I.
2. Measure the insertion loss at 5.15625 GHz

Observable Results:

a. The insertion loss at 5.15625 GHz shall be no less than 3 dB and no greater than 17.04dB

Possible Problems: None.

Test 85.1.2 – Fitted Insertion Loss Coefficients

Purpose: To verify that the insertion loss coefficients of the DUT are within the conformance limits.

References:

[1] IEEE Std. 802.3-2012, subclause 85.10.2 – Cable assembly insertion loss
[2] IEEE Std. 802.3-2012, table 85-10 – Maximum cable assembly insertion loss characteristics

Resource Requirements: See Appendix I

Last Modification: December 19, 2013

Discussion:

Reference [1] describes the equations necessary for calculating the fitted insertion loss.

Reference [2] states that the insertion loss coefficients a_1, a_2, and a_4, shall be no greater than $6\frac{dB}{\sqrt{GHz}}$, $1\frac{dB}{GHz}$, and $0.08\frac{dB}{GHz^2}$ respectively.

The insertion loss coefficients are calculated using the following equations:

$$F = \begin{bmatrix} \sqrt{f_1} & f_1 & f_1^2 \\ \sqrt{f_2} & f_2 & f_2^2 \\ \cdots & \cdots & \cdots \\ \sqrt{f_N} & f_N & f_N^2 \end{bmatrix} \quad (85\text{-}20)$$

$$\begin{bmatrix} a_1 \\ a_2 \\ a_4 \end{bmatrix} = (F^T F)^{-1} F^T IL \quad (85\text{-}21)$$

Where f is the frequency from 50MHz to 7.5GHz measured at intervals of 10MHz and IL is the column vector of insertion loss IL_n measured at frequency f_n.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT as specified in Appendix I.
2. Measure the insertion loss over the range of 50MHZ to 7.5GHz in 10MHz steps
3. Calculate the insertion loss coefficients using equations 85-20 and 85-21.

Observable Results:

a. The value of coefficient a_1 shall be no greater than $6\frac{dB}{\sqrt{GHz}}$
b. The value of coefficient a_2 shall be no greater than $1\frac{dB}{GHz}$
c. The value of coefficient a_4 shall be no greater than $0.08\frac{dB}{GHz^2}$

Possible Problems: None.

Test 85.1.3 – Insertion Loss Deviation

Purpose: To verify that the insertion loss deviation (ILD) of the DUT is within the conformance limits

References:

[1] IEEE Std. 802.3-2012, subclause 85.10.2 – Cable assembly insertion loss
[2] IEEE Std. 802.3-2012, subclause 85.10.3 – Cable assembly insertion loss deviation (ILD)

Resource Requirements: See Appendix I

Last Modification: December 19, 2013

Discussion:

Reference [1] specifies the methods for calculating the fitted insertion loss which is needed to find the insertion loss deviation.

Reference [2] specifies the calculation and limits for the ILD. It states that for a given frequency f the ILD shall fall between $-0.7 - 0.2 * 10^{-3} f(dB)$ and $0.7 + 0.2 * 10^{-3} f(dB)$ for a frequency range of 50MHz to 7.5GHz.

In this test, the ILD is found as a function of frequency by the following equation:

$$ILD(f) = IL(f) - IL_{\text{fitted}}(f) \qquad (85\text{-}22)$$

IL(f) is the insertion loss at a given frequency and $IL_{fitted}(f)$ is the fitted insertion loss for a given frequency calculated by the following equation:

$$IL_{\text{fitted}}(f) = a_1\sqrt{f} + a_2 f + a_4 f^2 \quad \text{(dB)} \qquad (85\text{-}19)$$

This equation uses the insertion loss coefficients calculated in test 85.1.2

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT as specified in figure 1.
2. Measure the insertion loss for frequencies between 50MHz and 7.5GHz in 10MHz steps.
3. Find the fitted insertion loss as specified in test
4. Calculate the ILD using equation 85-22.

Observable Results:

a. The ILD shall fall between the limits set by the equations $-0.7 - 0.2 * 10^{-3} f(dB)$ and $0.7 + 0.2 * 10^{-3} f(dB)$

Possible Problems: None

Test 85.1.4 – Return Loss

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

References:

[1] IEEE Std. 802.3-2012, subclause 85.10.4 – Cable assembly return loss

Resource Requirements: See Appendix I

Last Modification: December 19, 2013

Discussion:

Reference [1] specifies the return loss limits for 40GBASE-CR4 and 100GBASE-CR10 cable assemblies. The return loss limits are defined by the following equation:

$$Return\_loss(f) \geq \begin{Bmatrix} 12 - 2\sqrt{f} & 0.05 \leq f < 4.1 \\ 6.3 - 13\log_{10}(f/5.5) & 4.1 \leq f \leq 10 \end{Bmatrix} \text{ (dB)} \qquad (85\text{-}25)$$

Where f is the frequency in GHz.

Test Setup: See Appendix I

Test Procedure:

1. Configure the DUT as specified in Appendix 1.
2. Measure the return loss of the DUT.

Observable Results:

a. The return loss of the DUT shall not exceed the values as stated in equation 85-25.

Possible Problems: None

Test 85.1.5– Integrated Crosstalk Noise

Purpose: To verify that the integrated crosstalk noise (ICN) of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3-2012, subclause 85.10.7 – Cable assembly integrated crosstalk noise (ICN)
[2] IEEE Std. 802.3-2012, subclause 86.10.5 – Cable assembly multiple disturber near-end crosstalk (MDNEXT) loss
[3] IEEE Std. 802.3-2012, subclause 86.10.5 – Cable assembly multiple disturber far-end crosstalk (MDFEXT) loss
[4] IEEE Std. 802.3-2012, table 85-11 – Cable assembly integrated crosstalk parameters

Resource Requirements: See Appendix II

Last Modification: December 19, 2013

Discussion:

Reference [1] specifies integrated crosstalk noise characteristics for 40GBASE-CR4 and 100GBASE-CR10 cable assembly devices. This specification includes references to the multiple disturber near-end crosstalk (MDNEXT) and multiple disturber far-end crosstalk (MDFEXT) values calculated in [2] and [3]. This specification also uses parameter values found in [4].

Reference [2] defines MDNEXT using the following equation:

$$MDNEXT\_loss(f) = -10\log_{10}\left(\sum_{i=0}^{i=3\text{ or }9} 10^{-NLi(f)/10}\right)\text{ (dB)} \qquad (85\text{-}26)$$

Where f is the frequency in MHz, $NL_i(f)$ is the NEXT loss at frequency f for pair i and I is the pair to pair combination.

Reference [3] defines MDFEXT using the following equation:

$$MDFEXT\_loss(f) = -10\log_{10}\left(\sum_{i=0}^{i=2\text{ or }8} 10^{-NLi(f)/10}\right)\text{ (dB)} \qquad (85\text{-}27)$$

Where f is the frequency in MHz, $NL_i(f)$ is the FEXT loss at frequency f for pair i and I is the pair to pair combination.

ICN is calculated using the following series of equations:

$$W_{nt}(f_n) = (A_{nt}^2/f_b)\operatorname{sinc}(f_n/f_b)^2\left[\frac{1}{1+(f_n/f_{nt})^4}\right]\left[\frac{1}{1+(f_n/f_r)^8}\right] \qquad (85\text{-}28)$$

$$W_{ft}(f_n) = (A_{ft}^2/f_b)\operatorname{sinc}(f_n/f_b)^2\left[\frac{1}{1+(f_n/f_{ft})^4}\right]\left[\frac{1}{1+(f_n/f_r)^8}\right] \qquad (85\text{-}29)$$

$$\sigma_{nx} = \left[2\Delta f\sum_n W_{nt}(f_n)10^{-MDNEXT_{loss}(f_n)/10}\right]^{1/2} \qquad (85\text{-}30)$$

$$\sigma_{fx} = \left[2\Delta f\sum_n W_{ft}(f_n)10^{-MDFEXT_{loss}(f_n)/10}\right]^{1/2} \qquad (85\text{-}31)$$

$$\sigma_x = \sqrt{\sigma_{nx}^{\;2} + \sigma_{fx}^{\;2}} \qquad (85\text{-}32)$$

$$\sigma_{x,\,ca} \leq \left\{ \begin{array}{ll} 10 & 3 \leq IL \leq 5.3 \\ 12.4 - 0.45IL & 5.3 < IL \leq 17.04 \end{array} \right\} \quad (\mathrm{mV})$$

(85-33)

f_n is the range of frequencies between 50MHz and 10GHz taken at intervals of 10MHz, f_r is 7.5GHz, f_{nt} is $\frac{T_{nt}}{0.2365}$, f_{ft} is $\frac{T_{ft}}{0.2365}$, and Δf is 10MHz. f_b, A_{nt}, A_{ft}, T_{nt}, and T_{ft} are defined in [4].

Test Setup: See Appendix II

Test Procedure:

1. Configure the DUT as specified in Appendix II
2. Measure the MDNEXT and MDFEXT for all lanes of the DUT using equations 85-26 and 85-27.
3. Calculate the ICN of the DUT using equations 85-28 through 85-32.

Observable Results:

a. The integrated crosstalk noise of the DUT shall not exceed the limits stated in 85-33.

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 – Victim Test Setup

Purpose: To specify the test equipment and setup used to test insertion loss, insertion loss deviation, and return loss in this test suite.

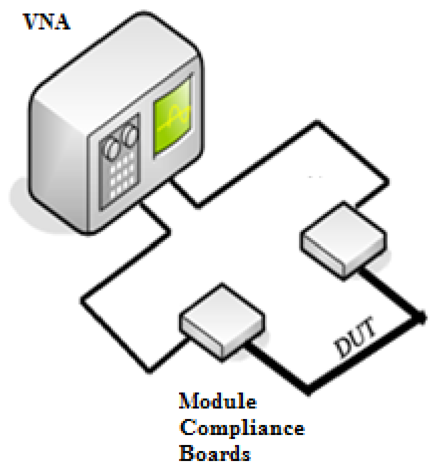
Last Modification: December 19, 2013

Resource Requirements:

- VNA
- Two module compliance boards (MCB)

Discussion:

For the purpose of these tests the testing equipment should be configured in the following manner:



The DUT is connected between two module compliance boards. The VNA is connected to the victim transmit pair on one MCB and the victim receive pair on the other. The VAN shall be properly calibrated before use.

Appendix II – Crosstalk Test Setup

Purpose: To specify the test equipment and setup used to crosstalk in this test suite.

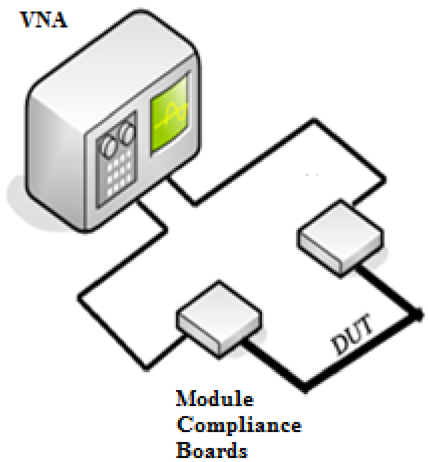
Last Modification: December 19, 2013

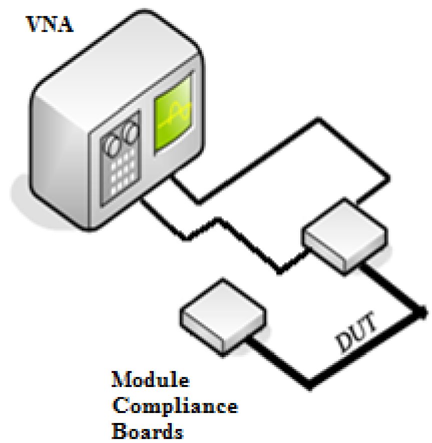
Resource Requirements:

- VNA
- Two module compliance boards (MCB)

Discussion:

For the purpose of these tests the testing equipment should be configured in the following manner:





The DUT is connected between two module compliance boards. In order to test near-end crosstalk the VNA is connected to the victim receive pair on one MCB and to all transmit pairs on the same MCB. In order to test far-end crosstalk the VNA is connected to the victim receive pair of one MCB and to each non-victim transmit pair on the other MCB. The VAN shall be properly calibrated before use.