BACKPLANE CONSORTIUM

Clause 71
10GBASE-KX4 PMD Test Suite
Version 0.2

Technical Document

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Backplane Consortium

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MODIFICATION RECORD

Revision	Release Date	Author	Comments
0.1	11/30/2007	Jon Beckwith	• Initial Template Release
0.2	02/12/2008	Jon Beckwith	• Added test 73.3.1 • Changed all “Ibid” references to “802.3ap-2007” • Other minor editorial changes
0.3			•
0.4			•
0.5			•

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Jon Beckwith	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 10GBASE-KX4 products.

These tests are designed to determine if a product conforms to specifications defined in Clause 71 of the IEEE 802.3ap-2007 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 10GBASE-KX4 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: ELECTRICAL SIGNALING REQUIREMENTS

Overview:

The tests defined in this section verify the electrical signaling characteristics of the Physical Medium Dependent (PMD) layer for 10GBASE-KX4 devices defined in Clause 71 of IEEE 802.3ap-2007.

Test 71.1.1 - Signaling Speed Range

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

References:

[1] IEEE Std 802.3ap-2007, subclause 71.7.1 – Transmitter characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.1.3 – Signaling speed range
[3] IEEE Std 802.3ap-2007, subclause 71.7.1.1 – Test fixtures
[4] IEEE Std 802.3-2005, Annex 48A.2 – Low-frequency test pattern

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007

Discussion:

Reference [1] specifies the transmitter characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the per-lane signaling speed, which are defined in [2].

Reference [2] states that the 10GBASE-KX4 MDI signaling speed shall be 3.125 Gbaud +/- 100 ppm. This translates to 3.125 Gbaud +/- 312.5 Kbaud, with a nominal Unit Interval (UI) of 320 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 10GBASE-KX4 signal. However, the low-frequency jitter test pattern 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 71.A

Test Procedure:

1. Configure the DUT to transmit the low-frequency jitter test pattern.
2. Connect the DUT's Lane 0 transmitter to the test fixture.
3. Measure the average TX signaling speed for Lane 0.
4. Repeat steps 2 and 3 for Lanes 1, 2, and 3.

Observable Results:

a. For all lanes, the average signaling speed shall be 3.125 Gbaud +/- 312.5 Kbaud.

Possible Problems: None

Test 71.1.2 - 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 802.3ap-2007, subclause 71.7.1 – Transmitter characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.1.4 – Output amplitude
[3] IEEE Std 802.3ap-2007, subclause 71.7.1.1 – Test fixtures
[4] IEEE Std 802.3-2005, Annex 48A.2 – Low-frequency test pattern

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007 (Version 1.0)

Discussion:

Reference [1] specifies the transmitter characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the per-lane common mode output voltage, which are defined in [2].

In this test, the DC common mode output voltage is measured at the V_{com} test point 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 10GBASE-KX4 signal. However, the low-frequency jitter test pattern 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 71.A

Test Procedure:

1. Configure the DUT so that it is sourcing the low-frequency jitter test pattern.
2. Connect the DUT's Lane 0 transmitter to the test fixture.
3. Measure the DC common mode output voltage at the V_{com} test point.
4. Repeat steps 2 and 3 for Lanes 1, 2, and 3.

Observable Results:

a. For all lanes, the DC common mode output voltage shall be between -0.4 V and 1.9 V with respect to signal shield.

Possible Problems: None

Test 71.1.3 - Differential Output Amplitude

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

References:

[1] IEEE Std 802.3ap-2007, subclause 71.7.1 – Transmitter characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.1.4 – Output amplitude
[3] IEEE Std 802.3ap-2007, subclause 71.7.1.1 – Test fixtures
[4] IEEE Std 802.3-2005, Annex 48A.2 – Low-frequency test pattern

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007

Discussion:

Reference [1] specifies the transmitter characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the differential output amplitude, which are 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. Reference [2] also requires that the DUT be transmitting the low-frequency jitter test pattern defined in [4] during this test.

Test Setup: See Appendix 71.A

Test Procedure:

1. Configure the DUT so that it is sourcing the low-frequency jitter test pattern.
2. Connect the DUT's Lane 0 transmitter to the test fixture.
3. Measure the maximum peak-to-peak differential output voltage.
4. Repeat steps 2 and 3 for Lanes 1, 2, and 3.

Observable Results:

a. For each lane, the maximum differential peak-to-peak output voltage shall be between 800 mV and 1200 mV.
b. The maximum difference between any two lanes' differential peak-to-peak output voltage shall be less than or equal to 150 mV.

Possible Problems: None

Test 71.1.4 - Differential Output Template

Purpose: To verify that the DUT's transmitter provides equalization such that the output waveform falls within the specified template

References:

[1] IEEE Std 802.3ap-2007, subclause 71.7.1 – Transmitter characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.1.6 – Differential output template
[3] IEEE Std 802.3ap-2007, subclause 71.7.1.1 – Test fixtures
[4] IEEE Std 802.3-2005, Annex 48A.2 – Low-frequency test pattern

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007

Discussion:

Reference [1] specifies the transmitter characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the amount of transmitter equalization present on the DUT's output signal. This is expressed in terms of a differential output template, which is specified in [2]. This reference also defines the procedure for normalizing and fitting the measured waveform to the template.

In this test, conformance to the differential output template is measured while the DUT is connected to the test fixture defined in [3], or its functional equivalent. Reference [2] also requires that the DUT be transmitting the low-frequency jitter test pattern defined in [4] during this test.

Test Setup: See Appendix 71.A

Test Procedure:

1. Configure the DUT so that it is sourcing the low-frequency jitter test pattern.
2. Connect the DUT's Lane 0 transmitter to the test fixture.
3. Ensure all other transmitters are active and terminated.
4. Capture, normalize, and fit the output waveform to the differential output template.
5. Repeat steps 2, 3, and 4 for Lanes 1, 2, and 3.

Observable Results:

a. For all lanes, the normalized output waveform shall fit within the specified template.

Possible Problems: None

Test 71.1.5 - Transmit Jitter

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

References:

[1] IEEE Std 802.3ap-2007, subclause 71.1.1 – Transmitter characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.1.8 – Transmit jitter
[3] IEEE Std 802.3ap-2007, subclause 71.7.1.9 – Transmit jitter test requirements
[4] IEEE Std 802.3ap-2007, subclause 71.7.1.1 – Test fixtures
[5] IEEE Std 802.3-2005, Annex 48A.5 – Continuous jitter test pattern (CJPAT)

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007

Discussion:

Reference [1] specifies the transmitter characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the peak-to-peak transmit jitter, which are defined in [2] and [3].

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

Test Setup: See Appendix 71.A

Test Procedure:

1. Configure the DUT so that it is sourcing the CJPAT test pattern.
2. Connect the DUT's Lane 0 transmitter to the test fixture.
3. Ensure all other transmitters are active and terminated.
4. Measure the random, deterministic, and total transmit jitter.
5. Repeat steps 2, 3, and 4 for Lanes 1, 2, and 3.

Observable Results:

a. For all lanes, the Random Jitter value shall not exceed 0.27 UI.
b. For all lanes, the Deterministic Jitter value shall not exceed 0.17 UI.
c. For all lanes, the Total Jitter value shall not exceed 0.35 UI.

Possible Problems: None

GROUP 2: IMPEDANCE REQUIREMENTS

Overview:

The tests defined in this section verify the impedance characteristics of the Physical Medium Dependent (PMD) layer for 10GBASE-KX4 devices defined in Clause 71 of IEEE 802.3ap-2007.

Test 71.2.1 - Output Return Loss

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

References:
[1] IEEE Std 802.3ap-2007, subclause 71.7.1 – Transmitter characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.1.5 – Output return loss

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007

Discussion:
Reference [1] specifies the transmitter characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the differential output return loss, which are defined 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. 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 100 MHz to 2.0 GHz, the differential return loss of the driver shall exceed Equation 71-1 and 71-2:

$$\text{ReturnLoss}(f) \geq 10 \text{ dB} \quad (\text{for } 100 \text{ MHz} \leq f < 625 \text{ MHz}) \quad (\text{EQ. } 71\text{-}1)$$

$$\text{ReturnLoss}(f) \geq 10 - 10\log(f/625) \text{ dB} \quad (\text{for } 625 \text{ MHz} \leq f \leq 2.0 \text{ GHz}) \quad (\text{EQ. } 71\text{-}2)$$

This value is to be verified for each of the four DUT TX lanes, which are identified as Lane 0, Lane 1, Lane 2, and Lane 3.

Test Setup: See Appendix 71.A

Test Procedure:
1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing normal IDLE signaling.
3. Connect the DUT’s Lane 0 transmitter to the VNA.
4. Measure the reflection coefficient at the DUT’s transmitter from 100 MHz to 2.0 GHz.
5. Compute the return loss from the reflection coefficient values.
6. Repeat steps 3 through 5 for Lanes 1, 2, and 3.

Observable Results:
a. For all lanes, the differential return loss shall exceed the limits described by Equations 71-1 and 71-2.

Possible Problems: None

Test 71.2.2 - Input Return Loss

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

References:

[1] IEEE Std 802.3ap-2007, subclause 71.7.2 – Receiver characteristics
[2] IEEE Std 802.3ap-2007, subclause 71.7.2.5 – Differential Input return loss

Resource Requirements: See Appendix 71.A

Last Modification: November 30, 2007

Discussion:

Reference [1] specifies the receiver characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the differential input return loss, which are defined in [2].

Note that because the same conformance limits are used in both the input and output return loss specifications, this test is almost identical to Test 71.2.1 (Output Return Loss), except the measurement is now performed on the DUT's receiver instead of the transmitter.

Test Setup: See Appendix 71.A

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing normal IDLE signaling.
3. Connect the DUT's Lane 0 receiver to the VNA.
4. Measure the reflection coefficient at the DUT's receiver from 100 MHz to 2.0 GHz.
5. Compute the return loss from the reflection coefficient values.
6. Repeat steps 3 through 5 for Lanes 1, 2, and 3.

Observable Results:

a. For all lanes, the differential return loss shall exceed the limits described by Equations 71-1 and 71-2 (see previous test, 71.2.1).

Possible Problems: None

GROUP 3: RECEIVE FUNCTIONALITY TESTS

Overview:

The tests defined in this section verify the receive functionality characteristics of the Physical Medium Dependent (PMD) layer for 10GBASE-KX4 devices defined in Clause 71 of IEEE 802.3ap-2007.

Test 71.3.1 – Interference Tolerance Test

Purpose: To verify that the DUT can operate to a specified BER under worst-case interference conditions.

References:

[1] IEEE Std 802.3ap-2007, subclause 71.7.2.1 – Receiver Interference Tolerance
[2] IEEE Std 802.3ap-2007, Table 71-7 – 10GBASE-KX4 interference tolerance parameters
[3] IEEE Std 802.3ap-2007, Annex 69A
[4] IEEE Std 802.3ap-2007, Annex 69B
[5] IEEE Std 802.3ap-2007, Figure 69A-1
[6] IEEE Std 802.3-2005, Annex 48A.5 – Continuous jitter test pattern (CJPAT)
[7] UNH-IOL 100Base-Tx TP-PMD Test Suite, Appendix 25.D

Resource Requirements: See Appendix 71.A

Last Modification: January 25, 2008

Discussion:

Reference [1] specifies the receiver characteristics for 10GBASE-KX4 devices. This specification includes conformance requirements for the receiver interference tolerance, which are defined in [2].

Reference [3] outlines a procedure to inject interference onto the channel by coupling onto the receive pair of the DUT. This is done while using a lossy channel in order to create a low signal-to-noise environment. An informative description of the test channel is provided in reference [4], and a block diagram of the entire test setup is shown in reference [5]. The continuous jitter test pattern, specified in reference [6], is used for this test.

Reference [1] states that the target BER of a 10GBASE-KX4 device is 10^{-12}. Based on the analysis in reference [7], if more than 7 errors are observed out of $3x10^{12}$ bits (about 247,100,000 1518-byte packets), it can be concluded that the bit error rate of the device is greater than 10^{-12} with less than a 5% chance of error.

Test Setup: See Appendix 71.A

Test Procedure:

1. Connect the DUT to the interference tolerance setup shown in [5]
2. Turn on the interference source
3. Turn on the pattern generator, configured for CJPAT
4. Send $3x10^{12}$ bits (or 247,100,000 1518-byte packets) to the DUT

Observable Results:

a. The measured BER shall be less than 10^{-12} under all test conditions.

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 71.A - Test Fixtures and Setups

Purpose: To specify the measurement hardware, test fixtures, and setups used in this test suite

References:

[1] IEEE Std 802.3ap-2007, subclause 71.7.1.1 – Test Fixtures
[2] IEEE Std 802.3ap-2007, subclause

Last Modification: January 24, 2008

Discussion:

Reference [1] defines the test fixture used in 10GBASE-KX4.

To perform the tests specified in Group 1, the following is needed:

1. Test Fixture
2. DSO
3. Other

To perform the tests specified in Group 2, the following is needed:

1. Test Fixture
2. VNA

To perform the tests specified in Group 3, the following is needed:

1. Test Pattern Generator
2. Test Channel
3. AWGN