

**BACKPLANE INTEROPERABILITY
CONSORTIUM**

**Clause 70
1000BASE-KX PMD Test Suite
Version 1.0**

Technical Document



Last Updated: 12 May 2008 2:34 PM

Backplane Interoperability Consortium

*University of New Hampshire
InterOperability Laboratory*

*121 Technology Drive, Suite 2
Durham, NH 03824*

Phone: +1-603-862-0090

Fax: +1-603-862-4181

<http://www.iol.unh.edu/consortiums/bp>

The University of New Hampshire
InterOperability Laboratory
TABLE OF CONTENTS

TABLE OF CONTENTS	2
MODIFICATION RECORD	3
ACKNOWLEDGMENTS	4
INTRODUCTION	5
GROUP 1: PMD ELECTRICAL SPECIFICATIONS	6
TEST 70.1.1 – SIGNALING SPEED	7
TEST 70.1.2 – COMMON MODE OUTPUT VOLTAGE	8
TEST 70.1.3 – DIFFERENTIAL OUTPUT AMPLITUDE	9
TEST 70.1.4 – DIFFERENTIAL OUTPUT EYE MASK.....	10
TEST 70.1.5 – TRANSITION TIME	11
TEST 70.1.6 – TRANSMIT JITTER.....	12
GROUP 2: IMPEDANCE REQUIREMENTS	13
TEST 70.2.1 – DIFFERENTIAL OUTPUT RETURN LOSS	14
TEST 70.2.2 – DIFFERENTIAL INPUT RETURN LOSS	15
GROUP 3: PMA RECEIVE TESTS	16
TEST 70.3.1 – INTERFERENCE TOLERANCE TEST	17
TEST SUITE APPENDICES	18
APPENDIX 70.A - TEST FIXTURES AND SETUPS	19

The University of New Hampshire
InterOperability Laboratory
MODIFICATION RECORD

- **May 12, 2008 (Version 1.0)**
Jon Beckwith Compiled individual tests into a cohesive test suite
Initial release
- **January 31, 2008 (Version 0.1)**
Zach Clifton Wrote individual tests

The University of New Hampshire
InterOperability Laboratory
ACKNOWLEDGMENTS

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

Jon Beckwith	University of New Hampshire
Zach Clifton	University of New Hampshire
Bob Noseworthy	University of New Hampshire

The University of New Hampshire 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 1000BASE-KX products.

These tests are designed to determine if a product conforms to specifications defined in the IEEE 802.3 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 1000BASE-KX 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.

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.

*The University of New Hampshire
InterOperability Laboratory*

GROUP 1: PMD ELECTRICAL SPECIFICATIONS

Overview:

This group of tests verifies several of the electrical specifications of the 1000BASE-KX Physical Medium Dependent sublayer outlined in Clause 70 of the IEEE 802.3ap-2007™ standard.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.1.1 – Signaling Speed

Purpose: To verify that the signaling speed of a 1000BASE-KX device is within the conformance limits.

References:

- [1] IEEE Std. 802.3ap-2007, subclause 70.7.1 – Transmitter Electrical Characteristics
- [2] IEEE Std. 802.3ap-2007, subclause 70.7.1.3 – Signaling Speed
- [3] IEEE Std. 802.3ap-2007, subclause 70.7.1.1 – Test fixtures
- [4] IEEE Std. 802.3-2005, subclause 59.7.1 – Test Patterns

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: February 8, 2007

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the signaling speed defined in [2].

Reference [2] defines the signaling speed for a 1000BASE-KX device to be 1.25GBd +/- 100ppm. This translates to 1.25GBd +/- 125KBd with a nominal UI of 800 ps. The signaling speed is tested using the setup defined in [3], or its functional equivalent. The testing is performed using the jitter test pattern defined in [4].

Test Setup: Refer to test suite appendix 70.7.A.

Test Procedure:

1. Connect the DUT to the setup as defined in [3]
2. Set up the DUT to source the test pattern defined in [4].
3. Measure the average signaling speed.

Observable Results:

- a. The signaling speed shall be within 1.25GBd +/- 125KBd.

Possible Problems: None.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.1.2 – Common Mode Output Voltage

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

References:

- [1] IEEE Std 802.3ap-2007, subclause 70.7.1 – Transmitter characteristics
- [2] IEEE Std 802.3ap-2007, subclause 70.7.1.5 – Output amplitude
- [3] IEEE Std 802.3ap-2007, subclause 70.7.1.1 – Test fixtures
- [4] IEEE Std. 802.3-2005, subclause 36A.2 – Test Patterns

Resource Requirements:

- Refer to test suite Appendix 70.A

Last Modification: March 7, 2008

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the common mode output voltage, which are defined in [2].

In this test, the 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 low-frequency test pattern defined in [4] will be used during the test.

Test Setup: See Appendix 70.A

Test Procedure:

1. Configure the DUT so that it is sourcing the low-frequency test pattern defined in [4].
2. Connect the DUT's transmitter to the V_{com} test point the test fixture.
3. Measure the DC common mode output voltage at the V_{com} test point.

Observable Results:

- a. The common mode output voltage shall be between -0.4 V and 1.9 V with respect to signal ground as measured at V_{com} .

Possible Problems: None

*The University of New Hampshire
InterOperability Laboratory*

Test 70.1.3 – Differential Output Amplitude

Purpose: To verify that the output amplitude of a 1000BASE-KX device is within the conformance limits.

References:

- [1] IEEE Std. 802.3ap-2007, subclause 70.7.1 – Transmitter Electrical Characteristics
- [2] IEEE Std. 802.3ap-2007, subclause 70.7.1.5 – Output Amplitude
- [3] IEEE Std. 802.3ap-2007, subclause 70.7.1.1 – Test fixtures
- [4] IEEE Std. 802.3-2005, subclause 36A.2 – Test Patterns

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: March 7, 2008

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the output amplitude defined in [2].

Reference [2] defines the differential peak-to-peak output voltage for 1000BASE-KX devices. Reference [3] defines the test setup. Both tests are run while transmitting the low-frequency test pattern defined in [4].

Test Setup: Refer to test suite appendix 70-A.

Test Procedure:

1. Connect the DUT to the setup defined in [3].
2. Set up the DUT to source the low-frequency test pattern defined in [4].
3. Measure the peak-to-peak differential output voltage.
4. Measure the common mode output voltage.

Observable Results:

- a. The transmitter differential peak-to-peak voltage shall be between 800 mV and 1600 mV.
- b. The common mode voltage of SL<p> and SL<n> shall be between –0.4 V and 1.9 V with respect to signal ground as measured at V_{COM} from [3].

Possible Problems: None.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.1.4 – Differential Output Eye Mask

Purpose: To verify that the output waveform of a 1000BASE-KX device is within the conformance limits.

References:

- [1] IEEE Std. 802.3ap-2007, subclause 70.7.1 – Transmitter Electrical Characteristics
- [2] IEEE Std. 802.3ap-2007, subclause 70.7.1.4 – Differential output eye mask
- [3] IEEE Std. 802.3ap-2007, subclause 70.7.1.1 – Test fixtures
- [4] IEEE Std. 802.3-2005, subclause 59.7.1 – Test Patterns

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: March 7, 2008

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the output waveform defined in [2].

Reference [2] defines the output waveform template for a compliant 1000BASE-KX device. The output waveform is tested using the setup defined in [3] and with the jitter test pattern as defined in [4].

Test Setup: Refer to test suite appendix 70-A.

Test Procedure:

1. Connect the DUT to the setup as defined in [3]
2. Set up the DUT to source the test pattern defined in [4].
3. Measure the average output waveform of the DUT.

Observable Results:

- a. The observed waveform shall be contained within the template defined in [2].

Possible Problems: None.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.1.5 – Transition Time

Purpose: To verify that the transition time of a 1000BASE-KX device is within the recommended limits.

References:

- [1] IEEE Std 802.3ap-2007, subclause 70.7.1 – Transmitter Electrical Characteristics
- [2] IEEE Std. 802.3ap-2007, subclause 70.7.1.7 – Transition Time
- [3] IEEE Std. 802.3ap-2007, subclause 70.7.1.1 – Test fixtures
- [4] IEEE Std. 802.3ap-2007, subclause 36A.1 – High Frequency Test Pattern

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: March 5, 2007

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the transmitter transition time defined in [2].

This test is conducted for *informative purposes only* as the standard does not mandate any transition time, but only recommends transition times for implementers. Likewise, this test should help implementers to understand whether their 1000BASE-KX device is within acceptable or normal operating condition.

Test Setup: Refer to test suite appendix 70-A.

Test Procedure:

1. Connect the DUT to the setup as shown in figure 70-2 as in [3].
2. Force the DUT to send the high frequency test pattern found in [4]
3. Measure the transition time for the rising edge.
4. Measure the transition time for the falling edge.

Observable Results:

- a. The rising edge transition time is recommended to be no less than 60 ps as measured at the 20% and 80% levels of the peak-to-peak differential value of the waveform.
- b. The falling edge transition time is recommended to be no less than 60 ps as measured at the 20% and 80% levels of the peak-to-peak differential value of the waveform.
- c. The maximum transition time is recommended to be no more than 320 ps.

Possible Problems: None.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.1.6 – Transmit Jitter

Purpose: To verify that the transmit jitter of a 1000BASE-KX device is within the conformant limits.

References:

- [1] IEEE standard 802.3ap-2007, subclause 70.7.1 – Transmitter Electrical Characteristics
- [2] IEEE standard 802.3ap-2007, Subclause 70.7.1.8 – Transmit Jitter
- [3] IEEE standard 802.3ap-2007, subclause 70.7.1.9 – Transmit Jitter Test Setup Requirements
- [4] IEEE standard 802.3ap-2007, subclause 59.7.1 – Test Patterns

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: January 4, 2008

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the transmitter jitter defined in [2].

This specification includes conformance requirements for the peak-to-peak transmit jitter, which is detailed in [2]. In this test, the peak-to-peak transmit jitter is measured with the assumption that crossing times are defined with respect to the mid-point (0 V) of the AC-coupled differential signal.

Test Setup: See Appendix 70-A

Test Procedure:

1. Connect the DUT to the setup as defined in [3].
2. Configure the DUT so that it is sourcing the jitter pattern defined in [3].
3. Measure the random and deterministic transmit jitter.

Observable Results:

- a. The total deterministic jitter shall be less than 0.1 UI.
- b. The total random jitter shall be less than 0.15 UI.
- c. The total jitter shall be less than 0.25 UI with a BER less than 10^{-12} .

Possible Problems: None

The University of New Hampshire
InterOperability Laboratory
GROUP 2: IMPEDANCE REQUIREMENTS

Overview:

The tests defined in this section verify the impedance characteristics of the Physical Medium Dependent (PMD) layer for 1000BASE-KX devices defined in Clause 70 of IEEE 802.3ap-2007.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.2.1 – Differential Output Return Loss

Purpose: To verify that the output return loss of a 1000BASE-KX device is within the conformance limits.

References:

- [1] IEEE standard 802.3ap-2007, subclause 70.7.1, Transmitter Electrical Characteristics
- [2] IEEE standard 802.3ap-2007, subclause 70.7.1.6, Output Return Loss
- [3] Test suite appendix 70.7.A – Transmitter Test Setups

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: March 7, 2008

Discussion:

Reference [1] specifies the transmitter characteristics for 1000BASE-KX 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). The differential return loss of the driver shall exceed Equation 70-1 and 70-2:

$$\text{ReturnLoss}(f) \geq 10 \text{ dB} \quad (\text{for } 50 \text{ MHz} \leq f < 625 \text{ MHz}) \quad (\text{EQ. 70-1})$$

$$\text{ReturnLoss}(f) \geq 10 - 10\log(f/625) \text{ dB} \quad (\text{for } 625 \text{ MHz} \leq f \leq 1250 \text{ MHz}) \quad (\text{EQ. 70-2})$$

Test Setup: Refer to test suite appendix 70-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 transmitter to the VNA.
4. Measure the reflection coefficient at the DUT's transmitter from 50 MHz to 1250 MHz.
5. Compute the return loss from the reflection coefficient values.

Observable Results:

- a. The measured return loss shall exceed the minimum values defined by Eq. 70-1 and Eq. 70-2.

Possible Problems: None.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.2.2 – Differential Input Return Loss

Purpose: To verify that the input return loss of a 1000BASE-KX device is within the conformance limits.

References:

- [1] IEEE standard 802.3ap-2007, subclause 70.7.2, Receiver Electrical Characteristics
- [2] IEEE standard 802.3ap-2007, subclause 70.7.2.5, Differential Input Return Loss
- [3] Test suite appendix 70.7.A – Transmitter Test Setups

Resource Requirements:

- Refer to test suite appendix 70-A.

Last Modification: March 7, 2008

Discussion:

Reference [1] specifies the receiver characteristics for 1000BASE-KX devices. This specification includes conformance requirements for the differential input 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_{DD11} scattering parameter (s-parameter). The differential return loss of the driver shall exceed Equation 70-1 and 70-2:

$$\text{ReturnLoss}(f) \geq 10 \text{ dB} \quad (\text{for } 50 \text{ MHz} \leq f < 625 \text{ MHz}) \quad (\text{EQ. 70-1})$$

$$\text{ReturnLoss}(f) \geq 10 - 10\log(f/625) \text{ dB} \quad (\text{for } 625 \text{ MHz} \leq f \leq 1250 \text{ MHz}) \quad (\text{EQ. 70-2})$$

Test Setup: Refer to test suite appendix 70-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 transmitter to the VNA.
4. Measure the reflection coefficient at the DUT's transmitter from 50 MHz to 1250 MHz.
5. Compute the return loss from the reflection coefficient values.

Observable Results:

- a. The measured return loss shall exceed the minimum values defined by Eq. 70-1 and Eq. 70-2.

Possible Problems: None.

The University of New Hampshire
InterOperability Laboratory
GROUP 3: PMA RECEIVE TESTS

Overview:

This section verifies the integrity of the 1000BASE-KX PMD Receiver through frame reception tests.

Scope:

The test contained in this section is in development.

*The University of New Hampshire
InterOperability Laboratory*

Test 70.3.1 – Interference Tolerance Test

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

References:

- [1] IEEE Std 802.3ap-2007, subclause 70.7.2.1 – Receiver Interference Tolerance
- [2] IEEE Std 802.3ap-2007, Table 70-7 – 1000BASE-KX 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, subclause 59.7.1 – Test Patterns
- [7] UNH-IOL 100Base-Tx TP-PMD Test Suite, Appendix 25.D

Resource Requirements:

- Refer to test suite Appendix 70-A

Last Modification: February 1, 2008

Discussion:

Reference [1] specifies the receiver characteristics for 1000BASE-KX devices. This specification includes conformance requirements for interference tolerance 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 test pattern specified in reference [6] is used for this test.

Reference [1] states that the target BER of a 1000BASE-KX device is 10^{-12} . Based on the analysis in reference [7], if more than 7 errors are observed out of 3×10^{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 70-A.

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 the pattern defined in [6]
4. Send 3×10^{12} bits (or 247,100,000 1518-byte packets) to the DUT

Observable Results: The measured BER shall be less than 10^{-12}

Possible Problems: None

The University of New Hampshire
InterOperability Laboratory
TEST SUITE APPENDICES

Overview:

The appendices contained in this section are intended to provide additional low-level technical details pertinent to specific tests defined in this test suite. Test suite appendices often cover topics that are beyond the scope of the standard, but are specific to the methodologies used for performing the measurements covered in this test suite. This may also include details regarding a specific interpretation of the standard (for the purposes of this test suite), in cases where a specification may appear unclear or otherwise open to multiple interpretations.

Scope:

Test suite appendices are considered informative, and pertain only to tests contained in this test suite.

*The University of New Hampshire
InterOperability Laboratory*

Appendix 70.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 70.7.1.1 – Test Fixtures
- [2] Ibid., subclause - Input return loss

Last Modification: January 3, 2008 (Version 1.0)

Discussion:

Reference [1] includes a standard test fixture defined to perform electrical signal characterization for 1000BASE-KX Physical Layer Dependent devices. It also specifies that the measurement shall be performed before the backplane connector at a test point referred to as TP1. An entire setup of the link block diagram is given in figure 70-1.

If any fixtures are used during testing, they should be compensated for. If compensation is not performed, the results will be affected and this should be taken into consideration.