2.5G/5G/10G ETHERNET
Testing Service

Clause 126
2.5G/5GBASE-T PMA Test Plan

Version 1.3
Technical Document

Last Updated: February 4, 2019

2.5, 5 and 10 Gigabit Ethernet Testing Service
University of New Hampshire
InterOperability Laboratory

21 Madbury Road, Suite 100
Durham, NH 03824
Phone: (603) 862-0090
Fax: (603) 862-4181

TABLE OF CONTENTS

MODIFICATION RECORD

- March 25, 2016 — v1.0
  Mike Klempa, Curtis Donahue — Initial Draft Release.

- July 8, 2016 — v1.1
  Mike Klempa — Updated to D3.2 standard, fixed alien test bandwidth, added new setup diagrams.

- March 15, 2017 — v1.2
  Hayden Haynes — Updated to IEEE Std. 802.3-2018, fixed miscellaneous text and formatting errors.

- February 4, 2019 — v1.3
  Mike Klempa — Formatting edits. Corrected references. Corrected some result limits. Fixed MDI Return Loss

ACKNOWLEDGMENTS

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

Mike Klempa	University of New Hampshire
Curtis Donahue	University of New Hampshire
Jeff Lapak	University of New Hampshire
Hayden Haynes	University of New Hampshire

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 test plan has been developed to help implementers evaluate the functionality of the Physical Medium Attachment (PMA) sublayer of their 2.5G/5GBASE-T 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 plan 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 2.5G/5GBASE-T 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 plan 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 plan 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 plan appendices and/or whitepapers that may provide more detail regarding these issues.

GROUP 1: PMA TRANSMITTER ELECTRICAL SPECIFICATIONS

Overview:

This group of tests verifies several of the electrical specifications of the 2.5G/5GBASE-T Physical Medium Attachment sublayer outlined in Clause 126 of the IEEE Std. 802.3-2018.

Scope:

All of the tests described in this section are currently under development at the University of New Hampshire InterOperability Laboratory.

Test 126.1.1 – Maximum Output Droop

Purpose: To verify that the transmitter output level does not droop more than the maximum specified amount.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.2 - Test modes
[2] IEEE Std. 802.3-2018, subclause 126.5.2.1 - Test fixtures
[3] IEEE Std. 802.3-2018, subclause 126.5.3.1 - Maximum output droop

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 15, 2017

Discussion:

Reference [1] states that a 2.5G/5GBASE-T device shall implement 7 test modes. These test modes are provided to measure electrical characteristics and verify compliance. Reference [2] defines the test fixture to be used to perform the test. Reference [3] provides a specification for the maximum allowable droop for the transmitter.

This test requires the device under test (DUT) to operate in transmitter test mode 6. While in test mode 6, the DUT shall generate a sequence of 128 + 16 symbols followed by 128 – 16 symbols continually from all four transmitters with the THP turned off.

Test Setup: Refer to test plan appendix.

Test Procedure:

1. Configure the DUT so that it is operating in transmitter test mode 6.
2. Connect pair BI_DA from the MDI to test fixture 1.
3. Find a rising-edge zero-crossing in the waveform (the reference).
4. Measure the amplitude of the waveform at 10 ns after the reference zero-crossing (V_{10}).
5. For 2.5GBASE-T operation, measure the amplitude of the waveform at 330 ns after the reference zero-crossing (V_{90}).
   For 5GBASE-T operation, measure the amplitude of the waveform at 170 ns after the reference zero-crossing (V_{90}).
6. Compute the droop between V_{10} and V_{90}.
7. Repeat using a falling edge reference.
8. Repeat steps 2 through 7 for pairs BI_DB, BI_DC, and BI_DD.

Observable Results:

For 2.5GBASE-T operation

a. The magnitude of both the positive droop shall be less than 17.5 % for all pairs.
b. The magnitude of both the negative droop shall be less than 17.5 % for all pairs.

For 5GBASE-T operation

a. The magnitude of both the positive droop shall be less than 12.5 % for all pairs.
b. The magnitude of both the negative droop shall be less than 12.5 % for all pairs.

Possible Problems: None.

Test 126.1.2 – Transmitter Nonlinear Distortion

Purpose: To verify that the output of the transmitter conforms to the transmitter linearity mask.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.2 - Test Modes
[2] IEEE Std. 802.3-2018, subclause 126.5.2.1 - Test Fixtures
[3] IEEE Std. 802.3-2018, subclause 126.5.3.2 - Transmitter nonlinear distortion

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 15, 2017

Discussion:

Reference [1] states that a 2.5G/5GBASE-T device shall implement 7 test modes. These test modes are provided to measure electrical characteristics and verify compliance. Reference [2] defines the test fixture to be used to perform the test. For both 2.5GBASE-T and 5GBASE-T operation the transmitter nonlinear distortion shall be greater than:

$$SFDR \geq 2.5 + \min\{52, 58 - 20log_{10}\left(\frac{f}{25}\right)\} \qquad \textit{Eq. 126 - 6}$$

Where f is the maximum frequency of the two test tones in MHz and SFDR is the ratio in dB of the minimum RMS value of either input tone to the RMS value of the worst intermodulation product in the frequency range of 1 to 100 MHz for 2.5GBASE-T and 1 to 200 MHz for 5GBASE-T. Reference [3] provides a specification for the linearity of the transmitter. 2.5GBASE-T operational devices are required to meet an extra requirement:

$$SFDR \geq -5.5 + \min\{52, 58 - 20log_{10}\left(\frac{f}{25}\right)\} \qquad \textit{Eq. 126 - 7}$$

Where f is the maximum frequency of the two test tones in MHz and SFDR is the ratio in dB of the minimum RMS value of either input tone to the RMS value of the worst intermodulation product in the frequency range of 1 to 100 MHz.

Test Setup: Refer to test plan appendix.

Test Procedure:

1. Configure the DUT so that it is operating in transmitter test mode 4.
2. Connect pair BI_DA from the MDI to test fixture 2.
3. Capture the spectrum of the transmitted test mode waveform using a spectrum analyzer.
4. Compute the SFDR of the waveform.
5. Repeat steps 3 through 4 for the remainder of the test tones as specified in reference [1].
6. Repeat steps 2 through 5 for pairs BI_DB, BI_DC, and BI_DD.

Observable Results:

For 2.5GBASE-T operation

a. The SFDR of the transmitter shall meet Equation 126 – 6 for frequencies of 1 to 100 MHz.
b. In Transmitter Nonlinear Distortion Setup 2, while at 0 dB PBO, the SFDR of the transmitter shall also meet Equation 126 – 7 for frequencies of 1 to 100 MHz.

For 5GBASE-T operation

a. The SFDR of the transmitter shall meet Equation 126 – 6 for frequencies of 1 to 200 MHz.

Possible Problems: None.

Test 126.1.3 – Transmitter Timing Jitter

Purpose: To verify that the transmitter timing jitter of the PMA is within the conformance limits.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.2 - Test modes
[2] IEEE Std. 802.3-2018, subclause 126.5.2.1 - Test Fixtures
[3] IEEE Std. 802.3-2018, subclause 126.5.3.3 - Transmitter timing jitter

Resource Requirements:

- Refer to test plan appendix

Last Modification: March 29, 2018

Discussion:

Reference [1] states that a 2.5G/5GBASE-T device shall implement 7 test modes. These test modes are provided to measure electrical characteristics and verify compliance. Reference [2] define the test fixture to be used to perform the test. Reference [3] provides a specification for the transmitter timing jitter.

Case 1 – MASTER transmitter timing jitter

When in test mode 2, the PHY transmits 2 + 16 symbols followed by 2 – 16 symbols continually with the THP turned off and with no power backoff. In this mode, the transmitter output should be a 50 MHz signal for 2.5GBASE-T operation or a 100 MHz signal for 5GBASE-T operation, and the RMS period jitter measured at the PHY MDI output shall be less than 10.0 ps for 2.5GBASE-T operation and 7.2 ps for 5GBASE-T operation. The RMS period jitter is measured as per the test configuration shown in Figure 126-30 over an integration time interval of 4 ms +/- 10 % for 2.5GBASE-T operation and 2 ms +/- 10 % for 5GBASE-T operation.

Case 2 – SLAVE transmitter timing jitter

For a PHY supporting loop timing mode, the MASTER PHY is set to test mode 1 and the SLAVE PHY is in test mode 3. The MASTER PHY transmits the PMA training pattern (PRBS 33) to the SLAVE PHY on pairs A, B and C, and the SLAVE must synchronize its transmit clock to the signals received from the MASTER PHY. The RMS period jitter measured at the SLAVE PHY MDI output shall be less than 10.0 ps for 2.5GBASE-T operation and 7.2 ps for 5GBASE-T operation. The RMS period jitter is measured as per the test configuration shown in Figure 126-30 over an integration time interval of 4 ms +/- 10 % for 2.5GBASE-T operation and 2 ms +/- 10% for 5GBASE-T operation.

Test Setup: Refer to test plan appendix.

Test Procedure:

1. Configure the DUT so that it is operating in transmitter test mode 2.
2. Connect pair BI_DA from the MDI to test fixture 3.
3. For 2.5GBASE-T operation, capture 4 ms ± 10 % using a sample size of 200,000 ± 20,000.
   For 5GBASE-T operation, capture 2 ms ± 10 % using a sample size of 200,000 ± 20,000.
4. Calculate the RMS period jitter according to equation 126-8 in reference [3].
5. Repeat steps 2 through 4 for pairs BI_DB, BI_DC, and BI_DD.
6. If PHY supports loop timing, configure the DUT so that the MASTER PHY is operating in transmitter test mode 1, SLAVE PHY is operating in transmitter test mode 3, and repeat steps 2 through 5.

Observable Results:

Case 1 – MASTER transmitter timing jitter

For 2.5GBASE-T operation

a. The RMS period jitter measured at the MDI output should not exceed 10.0 ps for all pairs.

For 5GBASE-T operation

a. The RMS period jitter measured at the MDI output should not exceed 7.2 ps for all pairs.

Case 2 – SLAVE transmitter timing jitter

For 2.5GBASE-T operation

b. The RMS period jitter measured at the MDI output should not exceed 10.0 ps.

For 5GBASE-T operation

b. The RMS period jitter measured at the MDI output should not exceed 7.2 ps.

Possible Problems: None.

Test 126.1.4 – Transmitter Power Spectral Density and Power Level

Purpose: To verify the transmitter power level and power spectral density are within the conformance limits.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.2 - Test modes
[2] IEEE Std. 802.3-2018, subclause 126.5.2.1 - Test Fixtures
[3] IEEE Std. 802.3-2018, subclause 126.5.3.4 - Transmitter PSD and power level
[4] IEEE Std. 802.3-2018, Figure 126-36 - Transmitter PSD mask

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 29, 2018

Discussion:

Reference [1] defines the 7 test modes that a 2.5G/5GBASE-T PHY shall implement. These test modes are provided to measure electrical characteristics and verify compliance. Reference [2] defines the test fixture to be used to perform the test. Reference [3] discusses the operation of a device while in test mode 5 and provides a specification for the transmitter power spectral density and power level. Reference [4] provides the transmitter power spectral density mask.

In test mode 5, the device shall transmit as normal with power backoff disabled. The transmit power shall be between 1.0 dBm and 3.0 dBm and the power spectral density, measured into 100 Ω, shall fit within the upper and lower masks of reference [4].

Test Setup: Refer to test plan appendix.

Test Procedure:

1. Configure the DUT so that it is operating in transmitter test mode 5.
2. Connect pair BI-DA to transmitter test fixture 2.
3. Capture the spectrum of the transmitted test mode waveform using a spectrum analyzer.
4. Compute the transmit power and power spectral density.
5. Repeat steps 2 through 4 for pairs BI_DB, BI_DC, and BI_DD.

Observable Results:

For 2.5GBASE-T operation

a. The transmit power shall be between 1.0 dBm and 3.0 dBm for all pairs.
b. The power spectral density of the transmitter output while operating in test mode 5 shall fit within the transmitter power spectral density mask shown in reference [4] for all pairs.

For 5GBASE-T operation

a. The transmit power shall be between 1.0 dBm and 3.0 dBm for all pairs.
b. The power spectral density of the transmitter output while operating in test mode 5 shall fit within the transmitter power spectral density mask shown in reference [4] for all pairs.

Possible Problems: None.

Test 126.1.5– Transmit Clock Frequency

Purpose: To verify that the frequency of the transmit clock is within the conformance limits.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.3.5 - Transmit clock frequency

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 15, 2017

Discussion:

Reference [1] states that all 2.5GBASE-T devices must have a symbol transmission rate of 200.00 MHz ± 50 ppm and all 5GBASE-T devices must have a symbol transmission rate of 400.00 MHz ± 50 ppm while operating in Master timing mode. When the transmitter is in the LPI transmit mode or when the receiver is in the LPI receive mode the transmitter clock short term rate variation shall be less than 0.1 ppm/second.

The reference clock used in this test is the one obtained in test 126.5.3.3, Transmitter Timing Jitter. The frequency of this clock extracted from the transmitted waveform shall have a base frequency of 200 MHz ± 50 ppm for 2.5GBASE-T devices and 400 MHz ± 50 ppm for 5GBASE-T devices.

Test Setup: Refer to test plan appendix.

Procedure:

1. Configure the DUT for test mode 2 operation.
2. Using a narrow-bandwidth PLL, extract the clock frequency from the transmitted symbols.
3. Measure the frequency of the transmit clock.

Observable Results:

For 2.5GBASE-T operation

a. The transmit clock generated by the DUT shall have a frequency of 200 MHz ± 50 ppm.

For 5GBASE-T operation

a. The transmit clock generated by the DUT shall have a frequency of 400 MHz ± 50 ppm.

Possible Problems: None.

GROUP 2: PMA RECEIVER ELECTRICAL SPECIFICATIONS

Overview:

This group of tests verifies several of the electrical specifications of the 2.5G/5GBASE-T Physical Medium Attachment sublayer outlined in Clause 126 of the IEEE Std. 802.3-2018.

Scope:

All of the tests described in this section are currently under development at the University of New Hampshire InterOperability Laboratory.

Test 126.2.1 – Bit Error Rate Verification

Purpose: To verify that the device under test (DUT) can maintain a low bit error rate in the presence of the worst-case input signal-to-noise ratio.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.4 – Receiver electrical specifications
[2] IEEE Std. 802.3-2018, subclause 126.5.4.1 - Receiver differential input signals
[3] IEEE Std. 802.3-2018, subclause 126.7 - Link segment characteristics
[4] IEEE Std. 802.3-2018, subclause 126.5.3 - Transmitter electrical specifications

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 29, 2018

Discussion:

The operation of the 2.5G/5GBASE-T PMA sublayer is defined in reference [1]. Reference [2] specifies that signals from a valid transmitter shall be received with a BER of less than 10^{-12} over a cable assembly as defined in reference [3]. This test shall verify a $7.8x10^{-9}$ Frame Error Rate using the maximum cable length of 100 m.

The transmit station is configured to meet the requirements set in reference [4]. The transmit settings utilize the lowest transmit amplitude possible. The device shall operate over both cable types as defined in [3].

Test Setup: Refer to test plan appendix.

Procedure:

1. Connect the transmit station to the DUT across a 100 m Category 5e cable plant.
2. Configure the transmit station such that it is configured to the lowest amplitude settings while still meeting the requirements defined in [4].
3. The test station shall send 800 octet frames (for a $7.8x10^{-9}$ FER) and the monitor will count the number of packet errors.

Observable Results: The DUT shall operate at a FER of $7.8x10^{-9}$ for any iteration.

Possible Problems: None.

Test 126.2.2 – Receiver Frequency Tolerance

Purpose: To verify that the device under test (DUT) can maintain low bit error rate in the presence of the worst-case input signal-to-noise ratio.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.4 – Receiver electrical specifications
[2] IEEE Std. 802.3-2018, subclause 126.5.4.1 - Receiver differential input signals
[3] IEEE Std. 802.3-2018, subclause 126.7 - Link Segment Characteristics
[4] IEEE Std. 802.3-2018, subclause 126.5.3 - Transmitter Electrical Specifications
[5] IEEE Std. 802.3-2018, subclause 126.5.4.2 - Receiver frequency tolerance

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 29, 2018

Discussion:

The operation of the 2.5G/5GBASE-T PMA sublayer is defined in reference [1]. Reference [2] specifies that signals from a valid transmitter shall be received with a BER of less than 10^{-12} over a cable assembly as defined in reference [3]. This test shall verify a $7.8x10^{-9}$ Frame Error Rate using the maximum cable length of 100 m.

For 2.5GBASE-T, devices are required to properly receive incoming data with symbol rates ranging from 200 MHz ± 50 ppm. For 5GBASE-T, devices are required to properly receive incoming data with symbol rates ranging from 400 MHz ± 50 ppm as defined in [5].

Test Setup: Refer to test plan appendix.

Procedure:

1. Connect the transmit station to the DUT across a 100m Category 5e cable plant.
2. For 2.5GBASE-T Operation:
   Configure the transmit station to the lowest amplitude settings while still meeting the requirements defined in reference [4] and sending frames at a symbol rate of 200 MHz + 50 ppm.
   For 5GBASE-T Operation:
   Configure the transmit station such that it is configured to the lowest amplitude settings while still meeting the requirements defined in [4] and sending frames at a symbol rate of 400 MHz + 50 ppm.
3. For 2.5GBASE-T Operation:
   Repeat steps 1 and 2 with the transmit station sending frames at a symbol rate of 200 MHz - 50 ppm.
   For 5GBASE-T Operation:
   Repeat steps 1 and 2 with the transmit station sending frames at a symbol rate of 400 MHz - 50 ppm.
4. The test station shall send 800 octet frames (for a $7.8x10^{-9}$ FER) and the monitor will count the number of packet errors.

Observable Results: The DUT shall operate at a FER of $7.8x10^{-9}$ for any iteration.

Test 126.2.3 – Alien Crosstalk Noise Rejection

Purpose: To verify that the device under test (DUT) can maintain low bit error rate in the presence of the worst-case input signal-to-noise ratio.

References:

[1] IEEE Std. 802.3-2018, subclause 126.5.4.1 - Receiver differential input signals
[2] IEEE Std. 802.3-2018, subclause 126.7 - Link Segment Characteristics
[3] IEEE Std. 802.3-2018, subclause 126.5.3 - Transmitter Electrical Specifications
[4] IEEE Std. 802.3-2018, subclause 126.5.4.4 - Alien crosstalk noise rejection

Resource Requirements:

- Refer to test plan appendix.

Last Modification: March 15, 2017

Discussion:

The operation of the 2.5G/5GBASE-T PMA sublayer is defined in reference [1]. Reference [2] specifies that signals from a valid transmitter shall be received with a BER of less than 10^{-12} over a cable assembly as defined in reference [3]. This test shall verify a 7.8×10^{-9} Frame Error Rate using a cable length of up to 100 meters.

The transmit station is configured to transmit the worst-case rise time and output amplitude, while still meeting the requirements set in [3]. The transmit settings utilize the lowest transmit amplitude possible. In addition to the worst-case transmitter and channel settings, 2.5G/5GBASE-T devices are required to reject alien crosstalk noise introduced with couplers at the MDI inputs. The test channel shall be shortened to compensate for the insertion loss introduced by the couplers and baluns required for the test.

Test Setup: Refer to test plan appendix.

Procedure:

1. Configure the transmit station such that it generates the slowest worst-case rise time and output amplitude, while maintaining the minimum electrical requirements discussed in [3] with wideband Gaussian noise sources introduced as defined in [4].
2. The test station shall send 800 octet frames (for a 7.8×10^{-9} FER) and the monitor will count the number of packet errors.

Observable Results:

For 2.5GBASE-T operation:

a. The DUT shall operate at a FER of 7.8×10^{-9} for all pairs with a noise source whose power spectral density is -125 dBm/Hz from 10 to 100 MHz.

For 5GBASE-T operation:

a. The DUT shall operate at a FER of 7.8×10^{-9} for all pairs with a noise source whose power spectral density is -137 dBm/Hz from 10 to 200 MHz.

Possible Problems: None.

GROUP 3: PMA IMPEDANCE SPECIFICATIONS

Overview:

This group of tests verifies several of the electrical specifications of the 2.5G/5GBASE-T Physical Medium Attachment sublayer outlined in Clause 126 of the IEEE Std. 802.3-2018.

Scope:

All of the tests described in this section are currently under development at the University of New Hampshire InterOperability Laboratory.

Test 126.3.1 – MDI Return Loss

Purpose: To measure the return loss at the MDI for all four channels.

References:

[1] IEEE Std. 802.3-2018, subclause 126.8.2.2 – MDI return loss
[2] IEEE Std. 802.3-2018, subclause 126.5.2 – Test modes

Resource Requirements:

- Refer to test plan appendix.

Last Modification: February 4, 2019

Discussion:

The MDI on a 2.5G/5GBASE-T device compliant with the IEEE Std. 802.3-2018 shall ideally have a differential impedance of 100 Ω. Any difference between the impedance of the MDI and the impedance of the connector and cable results in reflections of the transmitted signals. Because the impedances can never be precisely 100Ω, and because the termination impedance varies with frequency, some limited amount of reflections must be allowed.

Return loss is a measure of the signal power that is reflected due to the impedance mismatch. Reference [1] specifies that the reflected power at the MDI must be at least:

$$RL \geq \begin{cases} 16 & 1 \leq f \leq 40 \\ 16 - 10\,log_{10}(f/40) & 40 < f \leq fmax \end{cases} \quad (dB) \qquad Eq.126-38$$

This return loss must be maintained when connected to cabling with a characteristic impedance of 100Ω, and while transmitting data or control symbols.

Test Setup: Refer to test plan appendix.

Procedure:

1. Configure the DUT for test mode 5 operation.
2. Connect pair BI_DA to the reflection port of a network analyzer.
3. Measure the reflection coefficient at the transmitter in the frequency range of 1.0 MHz to fmax where fmax is 125MHz for 2.5GBASE-T and 250 MHz for 5GBASE-T.
4. Compute the Return Loss for a Z_S of 100 Ω.
5. Repeat above steps for the BI_DB, BI_DC, and BI_DD pairs.

Observable Results:

a. The return loss measured at each MDI shall abide by Equation 126-38.

Test 126.3.2 – MDI impedance balance

Purpose: To verify that the common-mode to differential-mode impedance balance of the TD circuit is greater than the specified limit.

References:

[1] IEEE Std. 802.3-2018, subclause 126.8.2.3 – MDI impedance balance
[2] IEEE Std. 802.3-2018, subclause 126.5.2 – Test modes

Resource Requirements:

- Refer to test plan appendix

Last Modification: March 30, 2018

Discussion:

The impedance balance is defined in reference [1] as the S parameter measurement of Sdc11, measured in dB at the MDI. The impedance balance may be measured with a mixed mode four-port network analyzer capable of measuring the common-mode voltage and differential mode voltage of a balanced port. Impedance balance is the S parameter measurement of Sdc11 in dB at the MDI where two ports of the four-port network analyzer are connected between two MDI contacts used by a duplex link channel. The two ports are configured as a single balanced port. For this test the PHY ground is connected to the network analyzer ground. The other two ports of the network analyzer are unconnected. Reference [1] suggests using test mode 5 defined in reference [2] as the transmitter output.

The network analyzer should be capable of measuring Sdc11 to at least –60 dB. The differential input impedance shall be 100 Ω with a common-mode impedance of 75 Ω. During this test, the PHY is connected to the MDI as in normal operation. The resulting impedance balance shall meet the following criteria:

For 2.5GBASE-T:

$$Bal(f) \geq \begin{cases} 48 & 1 \leq f < 10 \\ 48 - 20\log_{10}(f/10) & 10 \leq f < 20 \\ 42 - 15\log_{10}(f/20) & 20 \leq f \leq 250 \end{cases} \quad (dB) \qquad Eq.126-39$$

For 5GBASE-T:

$$Bal(f) \geq \begin{cases} 48 & 1 \leq f \leq 30 \\ 44 - 19.2\log_{10}(f/50) & 30 < f \leq 250 \end{cases} \quad (dB) \qquad Eq.126-39$$

Test Setup: Refer to test plan appendix.

Procedure:

1. Configure the DUT for test mode 5 operation.
2. Connect pair BI_DA to the reflection port of a network analyzer.
3. Measure the reflection coefficient at the transmitter in the frequency range of 1.0 MHz to 250 MHz.
4. Compute the Return Loss for a Z_S of 100 Ω.
5. Repeat above steps for the BI_DB, BI_DC, and BI_DD pairs.

Observable Results:

a. The impedance balance (Sdc11) shall abide by Equation 126 – 39.

APPENDIX: TEST SETUPS

Overview:

The appendices contained in this section are intended to provide additional low-level technical details pertinent to specific tests defined in this test plan. Test plan 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 plan appendices are considered informative, and pertain only to tests contained in this test plan. This is considered a work in progress.

Test Setup #1

- Test 126.5.3.1 – Maximum Output Droop
- Test 126.5.3.3 – Transmit Timing Jitter – Master Jitter
- Test 126.5.3.5 – Transmit Clock Frequency

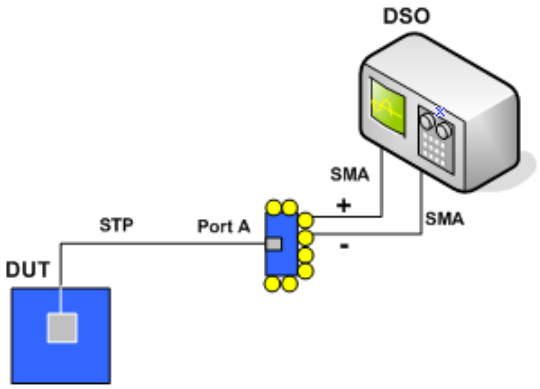

Figure 126.5.A-1: Test Setup #1

Test Setup #2

- Test 126.5.3.2 – Transmitter Linearity
- Test 126.5.3.4 – Transmitter Power Spectral Density

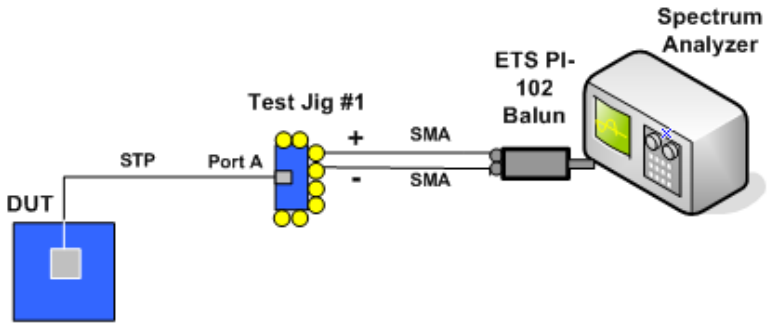

Figure 126.5.A-2: Test Setup #2

Test Setup #3

- Test 126.5.3.3 – Transmit Timing Jitter – Slave Jitter

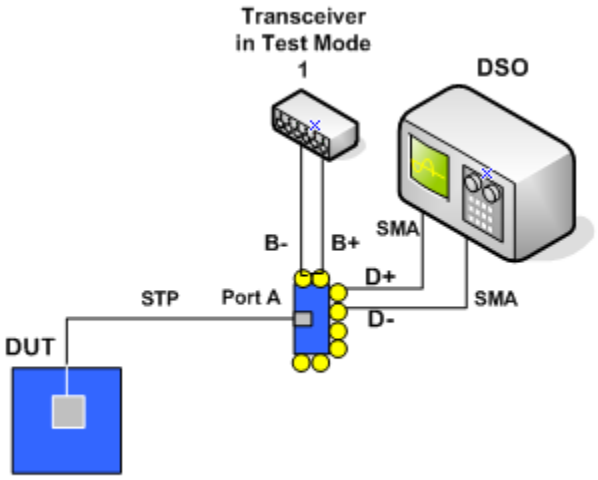

Figure 126.5.A-3: Test Setup #3

Test Setup #4

- Test 126.5.8.1 – MDI Return Loss

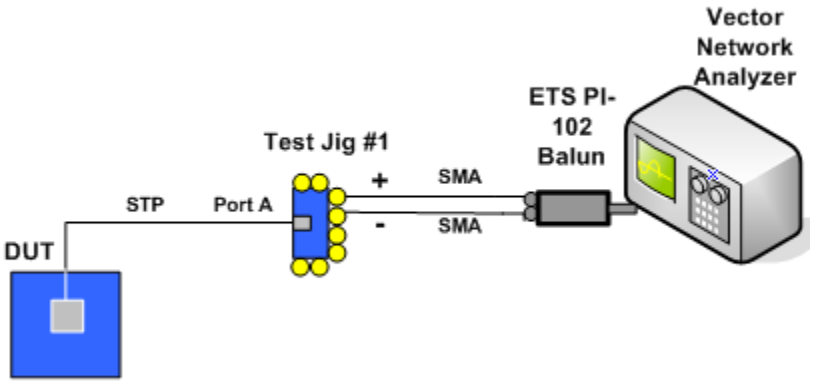

Figure 126.5.A-4: Test Setup #4

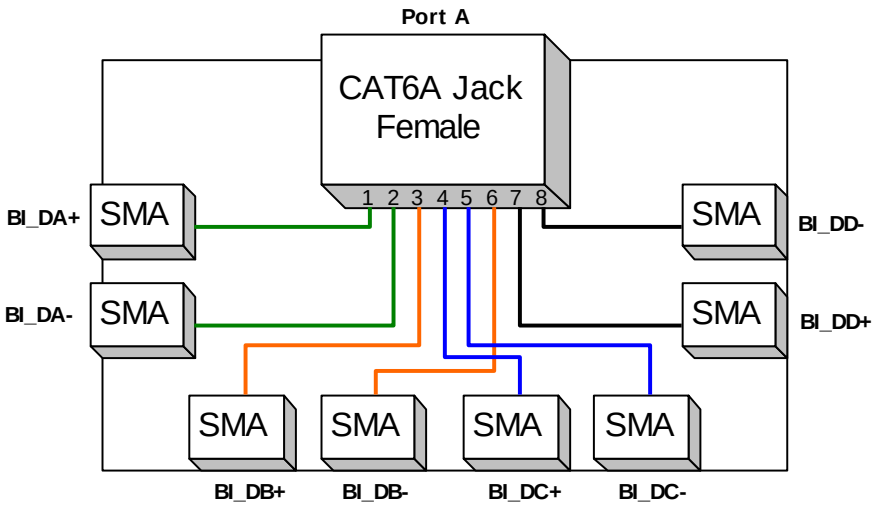

Figure 126.5.A-5: Test Jig #1

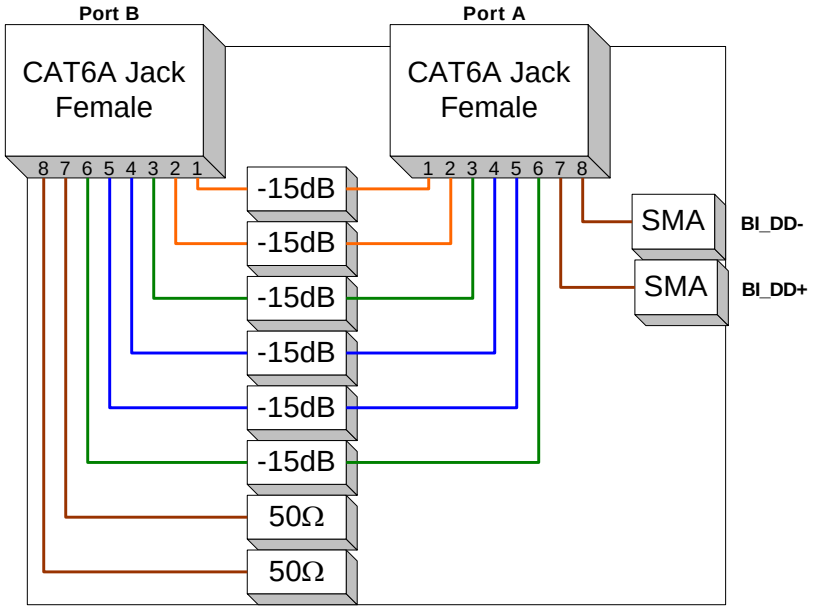

Figure 126.5.A-6: Test Jig #2