

ETHERNET

Interoperability Test Suite Version 3.0

Technical Document



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Ethernet Consortia

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MODIFICATION RECORD

Revision	Release Date	Author	Comments
1.0	12/1996		<ul style="list-style-type: none"> Initial Release
2.0	7/25/2002		<ul style="list-style-type: none"> Addition of Group 2
2.1	7/31/2002	Jeremy Kent	<ul style="list-style-type: none"> Removed: Test #1.1.4 Optical Fiber Link Up/Down Values and Test # 1.1.5 Endurance Stress Test Part B, and removed all references to these tests Modified: Renumbered subsequent test names and references appropriately
2.11	3/25/2003	Jon Beckwith	<ul style="list-style-type: none"> Updated references to 802.3, 2002, fixed small typo.
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INTRODUCTION

Overview

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 suite of tests has been developed to help implementers identify problems that IEEE 802.3 devices may have in establishing link and exchanging packets with each other. The tests do not determine if a product conforms to the IEEE 802.3 standard. Rather, they provide one method to verify that the devices can exchange packets within the bit error ratio specifications established by the IEEE 802.3 standard when operating over a worst-case compliant channel. The interoperability test suite focuses on several areas of functionality to simulate a real-world environment: the exchange of packets to produce a packet error ratio that is low enough to meet a desired bit error ratio, the ability to detect and establish a link at the optimal speed between two devices that make up a link segment, an optional energy efficient mode of operation, and cable testing.

Note: Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other compliant 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 well in most environments.

Test Channels

The intent of interoperability testing is to ensure that the DUT will perform as expected in a real world network. Testing in a real world network is often variable. Each technology has a standard, which defines the allowable cable characteristics for that technology. To account for a number of the possible cable plant scenarios in the real world, ideally a "worst case cable plant" which is very close to the limit of the applicable cable standards is used. For example, the cable plants for 1000BASE-T are tuned to be between 1-5% above the margins specified in ANSI-TIA-EIA-568-B-2001. A shorter patch cable is also included in testing to ensure that short links between devices are also viable. For certain technologies other methods for either degrading the cable plant (such as an air gap attenuator for Fiber) or choosing a controlled, degraded cable plant may be used. Additional details regarding the cable plants can be found in APPENDIX C: TEST CHANNELS.

Organization of Tests

The tests contained in this document are organized to simplify the identification of information related to a test and to facilitate in the actual testing process. Each test contains an identification section that describes the test and provides cross-reference information. The discussion section covers background information and specifies why the test is to be performed. Each test contains the following information:

Test Number

The Test Number associated with each test follows a simple grouping structure. Listed first is the Test Group Number followed by the test's number within the group. This allows for the

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addition of future tests to the appropriate groups of the test suite without requiring the renumbering of the subsequent tests.

Purpose

The purpose is a brief statement outlining what the test attempts to achieve. The test is written at the functional level.

References

The references section lists cross-references to the IEEE 802.3 standards and other documentation that might be helpful in understanding and evaluating the test and results.

Resource Requirements

The requirements section specifies the hardware, and test equipment that will be needed to perform the test.

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 configuration of the test environment. Small changes in the configuration should be included in the test procedure.

Procedure

The procedure section of the test description contains the step-by-step instructions for carrying out the test. It provides a cookbook approach to testing, and may be interspersed with observable results.

Observable Results

The observable results section lists specific items that can be examined by the tester to verify that the DUT is operating properly. When multiple values are possible for an observable result, this section provides a short discussion on how to interpret them. The determination of a pass or fail for a certain test is often based on the successful (or unsuccessful) detection of a certain observable result.

Possible Problems

This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

APPLICATION TABLE

The following table denotes whether or not the listed test is applicable to the given physical layer speed.

Table 1 - Application of Tests to Given Physical Speeds

	1000BASE-SX, 1000BASE-LX, 10GBASE-SR, 10GBASE-LR, 10GBASE-ER, 10GBASE-CX4, 40GBASE-R, 100GBASE-R	100BASE-TX, 1000BASE-T, 1000BASE-KX, 10GBASE-KR, 10GBASE-KX4, 10GBASE-T, XAUI	PoE PD, PoE PSE, PoE Midspan	Direct Attached Cable, Pluggable Module	100BASE-FX
GROUP 1: Link Configuration Tests					
Test #1.1.1: Point to Point Link Configuration	√	√			√
Test #1.1.2: Link Configuration and Powering for PoE			√		
Test #1.1.3: Direct Attached Cable or Pluggable Module Link Configuration				√	
Test #1.1.4: 100BASE-FX Link Up – Receiver					√
Test #1.1.5: 100BASE-FX Link Down – Receiver					√
GROUP 2: Operational Tests					
Test #1.2.1: Packet Error Ratio Estimation	√	√	√	√	√
Test#1.2.2: Endurance Stress Test (INFORMATIVE)	√	√	√ ²	√ ²	√ ²
GROUP 3: EEE-Related Tests					
Test #1.3.1: Low-Power Idle Mode Interoperability		√ ¹			

1: Device must support EEE

2: This test is not applicable if the DUT is a passive direct attached cable or a Midspan device

GROUP 1: Link Configuration Tests

Scope: The following tests cover Link Configuration.

Overview: These tests are designed to identify problems that IEEE 802.3 compatible devices may have in establishing link and exchanging packets with each other.

Test #1.1.1: Point to Point Link Configuration

Purpose: To determine if the DUT establishes the best possible link with a reference set of stations under various startup configurations.

References:

- [1] IEEE Std. 802.3-2012, Clause 28 – Auto-Negotiation for twisted pair
- [2] IEEE Std. 802.3-2012, Clause 37 – Auto-Negotiation for 1000BASE-X
- [3] IEEE Std. 802.3-2012, Clause 73 – Auto-Negotiation for Backplane Ethernet

Resource Requirements:

- A reference set of stations that can be used as Link Partners.
- Link monitoring facilities that are able to determine the signaling being used on the link.
- Local management indicators on the DUT and reference set that indicate the state of the link as perceived by the different stations.
- A channel with known characteristics within allowable margins.
- Test Stations, if necessary, to transmit packets between the DUT and the Link Partner. These stations must be able to provide detailed counts of packets transmitted, received, as well as information on errors associated with link level operation.

Last Modification: February 12, 2013

Discussion: The ability to detect and establish a link at the optimal speed is dependent on the two devices that make up the link segment, and providing and detecting the signaling method or connection information being passed. This test procedure addresses three conditions in which proper link configuration should be established. The first procedure covers the case where the DUT is initialized before the remote station and there is no signal on the DUT's receiver. The second procedure covers the case where the DUT is initialized after the remote station and there is a signal from this remote station on the DUT's receiver. The third procedure covers the final case where the DUT is in an operational state and is connected to a station that is also in an operational state. These three conditions are checked, as there may be different signals on the line during the boot up sequences of the devices that could cause the DUT to detect and establish a link at the wrong speed.

It is also possible that the DUT may support a pluggable optical module. When a pluggable module is present (including but not limited to XENPAK, XPAK, X2, XFP, SFP+, QSFP+, CFP, and CXP) some additional test cases are performed.

Many Ethernet technologies that support multiple speeds use some form of Auto-Negotiation. If, after link has been established at the speed under test, the device links at a different speed, the device should be able to re-gain link at the speed under test. The third section of link configuration is to verify that the DUT reacquires link properly. A large majority of RJ45-based products use IEEE Std. 802.3-2012 Clause 28 Auto-Negotiation, while some use different proprietary schemes to detect the Link Partner's speed or do not detect link speed at all. 1000BASE-LX and 1000BASE-SX devices use Clause 37 Auto-Negotiation, and 1000BASE-

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KX, 10GBASE-KX4, 10GBASE-KR, and 40GBASE-KR4 devices use Clause 73 Auto-Negotiation.

This test is an interoperability test. Failure of this test does not mean that the DUT is non-conformant. It does suggest that a problem in the ability of two devices to work "properly" together exists and further work should be done to isolate the cause of the failure.

Test Setup: Connect the DUT to its Link Partner as described in APPENDIX A: INTEROPERABILITY TEST SETUPS with an appropriate high attenuation media channel as outlined in APPENDIX C: TEST CHANNELS.

Procedure:

Ideally all applicable parts are completed against multiple Link Partners.

Part A: Power on configurations

Case 1: The DUT receives no signal from the Link Partner during initialization.

1. Power off the DUT and the Link Partner.
2. Connect a compliant high attenuation media channel between the two devices.
3. Power on the DUT and ensure that the device is initialized and all needed drivers are loaded.
4. Power on the Link Partner and verify that it is initialized and all needed drivers are loaded.
5. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
6. Send the DUT a series of packets and observe whether the packets are accepted.

Case 2: The DUT receives signal from the Link Partner during initialization.

1. Power off the DUT and the Link Partner.
2. Connect a compliant high attenuation media channel between the two devices.
3. Power on the Link Partner and ensure that the device is initialized and all needed drivers are loaded.
4. Power on the DUT and verify that it is initialized and all needed drivers are loaded.
5. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
6. Send the DUT a series of packets and observe whether the packets are accepted.

Case 3: The DUT establishes link with a fully powered and operational Link Partner.

1. Power off the DUT and the Link Partner and ensure that the channel is disconnected.
2. Power both devices back on and allow them to initialize.
3. Connect a compliant high attenuation media channel between the devices.
4. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.

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5. Send the DUT a series of packets and observe whether the packets are accepted or not.
6. Remove and hold the cable for a few seconds, then reinsert. Repeat four more times. Check local management information to verify that the link came up at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices. After every reconnection send the DUT a series of packets and observe whether the packets are accepted.

Part B: Pluggable Module devices

Case 1: The DUT utilizes a pluggable module and is powered up without module present.

1. Power off the DUT and the Link Partner.
2. Remove the pluggable module from the DUT.
3. Power on both the DUT and the Link Partner and allow them to come fully up.
4. Insert the pluggable module into the DUT.
5. Connect a compliant high attenuation media channel between the devices.
6. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
7. Send the DUT a series of packets and observe whether the packets are accepted.

Case 2: The DUT has module removed during normal operation

1. Power off the DUT and the Link Partner.
2. Connect a compliant high attenuation media channel between the devices.
3. Power both devices back on and ensure that the devices are initialized and all needed drivers are loaded. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
4. Remove the pluggable module from the DUT then reinsert. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
5. Send the DUT a series of packets and observe whether the packets are accepted.

Part C: Multi-Speed devices

1. Establish a valid Highest Common Denominator (HCD) link between the DUT and Link Partner via a compliant high attenuation media channel. Verify that a valid HCD link is established.
2. Break the link and connect the DUT to a Test Station configured to establish a link at a speed other than the HCD established in step 1 and verify that a link is established. Send the DUT a series of packets and observe whether the packets are accepted or not.
3. Reconnect the DUT to the Link Partner.
4. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
5. Send the DUT a series of packets and observe whether the packets are accepted.
6. Repeat steps 1-5 for all speeds supported by the Link Partner.

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Observable Results:

- a. The DUT and the Link Partner should establish an HCD link and accept the packets in all cases. The DUT and Link Partner must be examined for indicators of proper link speed and type. This is typically an LED that indicates when a link is established. Many devices provide some indication of link speed as well. Local management may provide information about configuration such as link duplex status as well as link speed.
- b. The DUT and Link Partner should establish a valid link and accept the packets in all cases.
- c. The DUT should establish a valid link in steps 1 through 3 and accept the packets in steps 3 and 5.

Possible Problems: If management access is not provided, it may be difficult to determine if the DUT resolves a link at the proper speed. If both devices support a higher speed than the desired testing speed, the higher speed must be disabled on one or both of the devices to force the link to resolve at the desired speed.

Test #1.1.2: Link Configuration and Powering for PoE

Purpose: To determine that the PD has been powered by the PSE and to determine if the PD and its PSE, or in the case of a Midspan the non-PSE Link Partner, have established the best possible link with a reference set of stations under various startup configurations.

References:

- [1] IEEE Std. 802.3-2012, subclause 28.2.3.3 – Priority Resolution Function
- [2] IEEE Std. 802.3-2012, Annex 28B.3 – Priority resolution
- [3] IEEE Std. 802.3-2012 Clause 33

Resource Requirements:

- A reference set of stations that can be used as Link Partners.
- Link monitoring facilities that are able to determine the signaling being used on the link.
- Local management indicators on the DUT and reference set that indicate the state of the link as perceived by the different stations.
- A channel with known characteristics within allowable margins.
- Test Stations, if necessary, to transmit packets between the DUT and the Link Partner. These stations must be able to provide detailed counts of packets transmitted, received, as well as information on errors associated with link level operation.

Last Modification: February 4, 2014

Discussion: The ability to detect and establish a link at the optimal speed is dependent on the devices that make up the link segment, and providing and detecting the signaling method or connection information being passed. In this test, the PSE's ability to provide power to the PD is also confirmed.

This test procedure addresses six possible conditions in which proper link configuration should be established. The applicable conditions depend on if a Midspan is used, and are summarized in Table 2 - Application of Tests Based on Device Type.

Table 2 - Application of Tests Based on Device Type

	No Midspan	Midspan	Description
<i>Case A</i>	√		The PD is connected to a PSE while the PSE is powering on.
<i>Case B</i>	√		The PD is connected to a PSE after the PSE is fully powered.
<i>Case C</i>		√	The Midspan and PD are powered on prior to the non-PoE Link Partner.
<i>Case D</i>		√	The Midspan and PD are powered on after the non-PoE Link Partner.
<i>Case E</i>		√	The link between the non-PoE Link Partner and the Midspan is disconnected and reconnected.
<i>Case F</i>		√	The link between the PD and the Midspan is disconnected and reconnected.

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This test is an interoperability test. Failure of this test does not mean that the DUT is non-conformant. It does suggest that a problem in the ability of the devices to work "properly" together exists and further work should be done to isolate the cause of the failure.

Test Setup: Connect the DUT to its Link Partner(s) as outlined in APPENDIX A: INTEROPERABILITY TEST SETUPS with an appropriate high attenuation media channel as outlined in APPENDIX C: TEST CHANNELS.

Procedure:

Ideally all applicable parts are completed against multiple Link Partners.

Part A: The PD is connected to a PSE while the PSE is powering on.

1. Power off the PD and the PSE.
2. Connect a compliant high attenuation media channel between the two devices.
3. Power on the PSE and ensure that the device is initialized and all needed drivers are loaded. .
4. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
5. Send a series of packets between the PD and the PSE and observe whether the packets are accepted.

Part B: The PD is connected to a PSE after the PSE is fully powered.

1. Power off the PD and the PSE and ensure that the cable is disconnected.
2. Power on the PSE and ensure that the device is initialized and all needed drivers are loaded.
3. Connect a compliant high attenuation media channel between the two devices.
4. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices and that the PD has fully initialized.
5. Send a series of packets between the PD and the PSE and observe whether the packets are accepted.

Part C: The Midspan and PD are powered on prior to the non-PoE Link Partner.

1. Power off the PD, Midspan, and the non-PoE Link Partner.
2. Connect a compliant high attenuation media channel between the Midspan and the PD. Connect a compliant low attenuation media channel between the Midspan and the non-PoE Link Partner.
3. Power on the Midspan and ensure that the Midspan and PD are initialized and all needed drivers are loaded.
4. Power on the non-PoE Link Partner and ensure that the device is initialized and all needed drivers are loaded.

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5. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
6. Send a series of packets between the PD and the non-PoE Link Partner and observe whether the packets are accepted.

Part D: The Midspan and PD are powered on after the non-PoE Link Partner.

1. Power off the PD, Midspan, and the non-PoE Link Partner.
2. Connect a compliant high attenuation media channel between the Midspan and the PD. Connect a compliant low attenuation media channel between the Midspan and the non-PoE Link Partner.
3. Power on the non-PoE Link Partner and ensure that the device is initialized and all needed drivers are loaded.
4. Power on the Midspan and ensure that the Midspan and PD are initialized and all needed drivers are loaded.
5. Check local management information to verify that the link is established at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices.
6. Send a series of packets between the PD and the non-PoE Link Partner and observe whether the packets are accepted.

Part E: The link between the non-PoE Link Partner and the Midspan is disconnected and reconnected.

1. Ensure that the non-PoE Link Partner, Midspan, and PD are powered on, connected, and capable of passing traffic.
2. Remove the cable between the non-PoE Link Partner and the Midspan and hold the cable for a few seconds, then reinsert. Repeat four more times. Check local management information to verify that the link came up at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices. After every reconnection send a series of packets between the PD and the non-PoE Link Partner and observe whether the packets are accepted.

Part F: The link between the non-PoE Link Partner and the Midspan is disconnected and reconnected.

1. Ensure that the non-PoE Link Partner, Midspan, and PD are powered on, connected, and capable of passing traffic.
2. Remove the cable between the PD and the Midspan for a few seconds, then reinsert. Repeat four more times. Check local management information to verify that the link came up at the proper speed and that link Auto-Negotiation, if supported, negotiated the optimal common values for the two devices. After every reconnection send a series of packets between the PD and the non-PoE Link Partner and observe whether the packets are accepted.

Observable Results:

- a. The PD and the PSE should establish an HCD link and accept the packets.
- b. The PD and the PSE should establish an HCD link and accept the packets.

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- c. The PD and the non-PoE Link Partner should establish an HCD link and accept the packets.
- d. The PD and the non-PoE Link Partner should establish an HCD link and accept the packets.
- e. The PD and the non-PoE Link Partner should establish an HCD link and accept the packets each time the link is reconnected.
- f. The PD and the non-PoE Link Partner should establish an HCD link and accept the packets each time the link is reconnected.

Possible Problems: If management access is not provided, it may be difficult to determine if the DUT resolves a link at the proper speed. If both devices support a higher speed than the desired testing speed, the higher speed must be disabled on one or both of the devices to force the link to resolve at the desired speed.

Test #1.1.3: Direct Attached Cable or Pluggable Module Link Configuration

Purpose: To determine if the Host/Cable or Host/Module combination establishes a valid link with a reference Test Station under various startup configurations. This test can be performed with the DUT being a Host and the Link Partner being a Cable/Module, or vice versa.

References:

[1] APPENDIX A: INTEROPERABILITY TEST SETUPS

Resource Requirements:

- A reference set of Hosts or Cables/Modules that can be used as Link Partners.
- Local management indicators on the Host(s) and Test Station that indicate the state of the link as perceived by the different stations.
- Test Station(s) to transmit packets to the Host over the Cable/Module. These stations must be able to provide detailed counts of packets transmitted, received, as well as information on errors associated with link level operation.

Last Modification: February 15, 2013

Discussion: The ability to establish a link is dependent on the two devices that make up the link segment. In this test, a link segment is the connection between a Host device and a Direct Attached Cable or the connection between a Host device and a Pluggable Module (such as XENPAK, XPAK, X2, XFP, SFP+, QSFP+, CFP, or CXP). This test procedure addresses three conditions in which proper link should be established. The first procedure covers the case where the Host is initialized while the Cable/Module is inserted. The second procedure covers the case where the Host is initialized without the Cable/Module, and then the Cable/Module is inserted. The third procedure covers the final case where the Host and Cable/Module are connected and operational, and then the Cable/Module is removed and reinserted.

This test is an interoperability test. Failure of this test does not mean that the DUT is non-conformant. It does suggest that a problem in the ability of two devices to work "properly" together exists and further work should be done to isolate the cause of the failure.

Test Setup: Connect the Host/Cable or Host/Module to the Test Station(s) as outlined in APPENDIX A: INTEROPERABILITY TEST SETUPS.

Procedure:

Ideally all applicable parts are completed against multiple Link Partners.

Part A: Power on configurations

Case 1: The Cable/Module is inserted while the Host is powered off.

1. Power off the Host and ensure that the Cable/Module is inserted.
2. Power on the Host and ensure that the device is initialized and all needed drivers are loaded.

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3. Check local management information to verify that a link is established.
4. Send the Host a series of packets and observe whether the packets are accepted.

Case 2: The Cable/Module is inserted while the Host is powered on.

1. Power off the Host and remove the Cable/Module.
2. Power on the Host and ensure that the device is initialized and all needed drivers are loaded.
3. Insert the Cable/Module.
4. Check local management information to verify that the link is established.
5. Send the Host a series of packets and observe whether the packets are accepted.

Part B: The Cable/Module is removed and reinserted during operation

1. Ensure that the Host is powered on, that the Cable/Module is inserted, and that the Host is accepting packets.
2. Remove and hold the Cable/Module for a few seconds, then reinsert.
3. Check local management information to verify that the link was established.
4. Send the DUT a series of packets and observe whether the packets are accepted.
5. Repeat steps 2-4 several times.
6. If the test is using a pluggable module, repeat steps 2-5 removing the external cable while keeping the pluggable module inserted in the host.

Observable Results:

- a. The Host/Cable or Host/Module combination should establish a link and accept the packets in both cases.
- b. The Host/Cable or Host/Module should reestablish a link each time the Cable/Module is reinserted.

Possible Problems: Some Hosts may not accept all Cables or Modules due to intentionally disabling the ports when an unknown Cable or Module is connected. This behavior will be disabled if possible.

Test #1.1.4: 100BASE-FX Link Up – Receiver

Purpose: To determine if link is asserted at appropriate power levels and BER.

References:

- [1] ISO-IEC_9413-3
- [2] IEEE 802.3 2012 Clause 26

Resource Requirements:

- A set of stations to be used as link partners, at least one must be capable of sourcing frames, and one must be capable of monitoring and recording erroneous frames.
- Link monitoring facilities that are able to determine the signaling being used on the link.
- Local management indicators on the DUT and reference set that indicate the state of the link as perceived by the different stations.
- A channel with known characteristics within allowable margins.

Last Modification: February 7, 2014

Discussion: The FDDI Physical Layer Medium Dependent (PMD) standard (ISO/IEC 9413-3) section 9.1.1.1 defines that Signal_Detect will be asserted for any power level of -31dBm or higher, and that for Signal_Detect to be asserted, the BER of the receiver outputs shall be less than 0.01. This power level is defined for the transmission of a constant stream of the halt symbol (00100b). Section 9.1.1.1 also defines that the maximum allowable hysteresis between assertion and deassertion is 1.5dB. Table 4 more specifically defines that the assertion level must be at least 1.5dB above deassertion. Ideally the power level measurements would be done while the DUT is transmitting Halt Code groups (the 5 bit code group 00100). However these measurements

This test is an interoperability test. Therefore, failure against any one device does not necessarily indicate nonconformance. Rather, it indicates that the two devices are unable to work "properly" together and that further work should be done to isolate the cause of the failure.

Test Setup: Connect the DUT to another device via the appropriate media channel.

Procedure:

1. Attenuate the signal of the RX channel of the DUT until link is deasserted.
2. Deattenuate the signal of the RX channel of the DUT until link is asserted.
3. Verify that the DUT and LP can successfully pass traffic at link up value.
4. Observe the power level of the signal.

Observable Results:

- a. The DUT should establish a link with the LP with a power level less than or equal to -31.0 dBm. This should also be at least 1.5 dBm above the deassertion level (Link Down).
- b. The traffic passed in step 3 should not exceed a BER of 0.01.

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Possible Problems: None.

Test #1.1.5: 100BASE-FX Link Down – Receiver

Purpose: To determine if link is deasserted at appropriate power levels and BER.

References:

- [1] ISO-IEC_9413-3
- [2] IEEE 802.3 2012 Clause 26

Resource Requirements:

- A set of stations to be used as link partners, at least one must be capable of sourcing frames, and one must be capable of monitoring and recording erroneous frames.
- Link monitoring facilities that are able to determine the signaling being used on the link.
- Local management indicators on the DUT and reference set that indicate the state of the link as perceived by the different stations.
- A channel with known characteristics within allowable margins.

Last Modification: February 6, 2014

Discussion: Section 9.1.1.1 defines that Signal_Detect will be deasserted for any power level which gives a 1% BER on the receiver output, or -45dBm, whichever is the greater power level. Again, the -45dBm power level is based on reception of halt symbols, rather than idle symbols. However, at this time, there is no anticipated significant difference for the required power levels for either halt symbols or idle symbols, due to the NRZI encoding of the symbol streams, both patterns should result in similar average power levels. Additionally, referring to the FDDI Physical Layer Medium Dependent (PMD) standard section 8.1 *Active Output Interface*, specifies the maximum transmitted average power (-14dBm) and the minimum transmitted average power (-20dBm) between which a conformant device shall operate. Section 8.2 *Active Input Interface*, specifies the maximum received average power (-14dBm) and the minimum received average power (-31dBm) over which a conformant device shall operate.

This test is an interoperability test. Therefore, failure against any one device does not necessarily indicate nonconformance. Rather, it indicates that the two devices are unable to work "properly" together and that further work should be done to isolate the cause of the failure.

Test Setup: Connect the DUT to another device via the appropriate media channel.

Procedure:

1. Deattenuate the signal of the RX channel of the DUT until link is asserted.
2. Attenuate the signal of the RX channel of the DUT until link is deasserted.
3. Observe the power level of the signal.

Observable Results:

- a. The DUT should deassert link with the LP before the BER at the given power level reaches 0.01, or before the power level drops to -45.0dBm, whichever occurs first.

Possible Problems: None.

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GROUP 2: Operational Tests

Scope: The following tests cover BER and the ability to remain functional when receiving packets at line rate for an extended period of time.

Overview: These tests are designed to identify problems that IEEE 802.3 compatible devices may have in exchanging packets with each other.

Test #1.2.1: Packet Error Ratio Estimation

Purpose: To determine if the DUT can exchange packets with a Link Partner such that the exchange of packets produces a packet error ratio that is low enough to meet a desired bit error ratio.

References:

- [1] APPENDIX B: PACKET ERROR RATIO SPECIFICATIONS
- [2] UNH-IOL FEC 100BASE-TX PMD Test Suite Appendix 25D

Resource Requirements:

- A set of reference stations that can be used as Link Partners.
- Test Stations, if necessary, to transmit packets between the DUT and the Link Partner. These stations must be able to provide detailed counts of packets transmitted, received, as well as information on errors associated with link level operation.
- Local management indicators on the DUT and Link Partners that provide information on link level errors such as CRC errors, and frame counts. (Optional)
- Cable channels with well known compliant properties applicable to the appropriate technology referenced in APPENDIX C: TEST CHANNELS.

Last Modification: February 12, 2013

Discussion: This test is designed to verify the ability of a DUT to exchange packets with another station over the appropriate cable model. To ensure that the desired bit error ratio is met with 95% confidence, the IOL uses a packet error ratio specification outlined in reference [2]. The desired bit error ratios and the required number of packets are detailed in APPENDIX B: PACKET ERROR RATIO SPECIFICATIONS. If more than 14 packets are lost during the exchange, the bit error ratio criterion has not been met and the test fails. In addition to packets lost, local management information may make it possible to isolate the packet loss to either the transmit side or the receive side of the test channel relative to the DUT. If more than seven packets are lost in either side of the channel, then the DUT has failed to meet the desired bit error ratio with 95% confidence and the DUT has failed the test.

The observable results in this testing process are one or more packet counters. A single packet contains many bits; therefore the measurement technique does not actually measure the bit error ratio. The pass/fail criterion assumes that no more than one bit is in error in a lost packet. Thus, a device may, in theory, pass a test with a bit error ratio in excess of those specified in APPENDIX B: PACKET ERROR RATIO SPECIFICATIONS. However, given that any one bit in error will corrupt the packet, multiple errors within a packet do not, in practice, make a difference in the number of packets that must be retransmitted on real links. Thus, a short-term clock deviation that causes a bit error ratio of 5 bits in a stream of 10^8 bits will, under most conditions, cause as many packet errors as a device with a bit error ratio of 1 in 10^8 .

For the purposes of this test the exchange of packets is performed using packets of length 1518-bytes unless specified otherwise in APPENDIX B: PACKET ERROR RATIO SPECIFICATIONS. 1518-byte frames provide the longest single packet required to be accepted

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by all devices giving the maximum transmission time and therefore the highest probability of an error to be present during a packet transmission.

The underlying issues, which cause bit errors in the transmission of packets in this testing process, have the tendency to vary due to the statistical nature of such events. In past testing, the IOL has observed a significant variation in the number of packets in error for a given set up. **The results obtained from this testing process should therefore not be seen as a true measure of the bit error ratio, but as information that may suggest the need for further analysis.**

Test Setup: Refer to APPENDIX A: INTEROPERABILITY TEST SETUPS for possible test setups.

Procedure:

Ideally all applicable parts are completed against multiple Link Partners.

1. Connect the DUT to the Link Partner and Tests Station(s), using a high attenuation channel (as described in APPENDIX C: TEST CHANNELS) if applicable.
2. Reset or observe all counters that will be used to measure or monitor the exchange of packets between the DUT and the Link Partner. Configure software as needed.
3. Via Auto-Negotiation or manual configuration, place the DUT and its Link Partner into compatible modes of operation.
4. Cause both the Link Partner and DUT to transmit (m) 1518-byte frames, where (m) is the 1518-byte value determined from APPENDIX B: PACKET ERROR RATIO SPECIFICATIONS and observe the pertinent counters.
5. If applicable, repeat steps 2-4, replacing the current media channel with a low attenuation channel.

Observable Results:

- a. Using the counters, identify the number of packets received. The difference between the number of packets sent and the number received is the number of lost packets. This value should be examined with other information gathered during the testing process to ensure that the failure is due to bit errors and not resource errors on the DUT or testing stations. In the ideal case all lost packets are identified on one of the testing stations or the DUT as either an FCS error, or some other type of receiver error. If the local information gathered from the DUT or link partner is reliable, it is often possible to isolate the failure to either the transmitter channel or the receiver channel. No more than 7 packets may be lost on either side of the channel (transmit or receive). If it is not possible to determine which side of the channel the packets were lost on, no more than 14 packets may be lost.

Possible Problems:

- Bit errors that occur outside the range of FCS coverage may not be detected.
- Some devices may encounter under-run conditions causing the testing station or DUT to generate truncated packets.
- A number of devices may transmit packets during the testing process that are not associated with the testing.

Test #1.2.2: Endurance Stress Test

Purpose: To verify that no system errors occur when traffic is received at line rate for long periods of time.

References:

- [1] IEEE Std 802.3-2012

Resource Requirements:

- Test Station(s) that can be used to source and monitor packets at minimum inter-packet gap (IPG). These stations must be able to provide detailed counts of packets transmitted and received, as well as information on errors associated with link level operation.

Last Modification: February 28, 2013

Discussion: This test is designed to verify that the DUT can continue operating while receiving line rate traffic. In the first section of this test, the DUT is attached to a sourcing station that is capable of sending traffic at the minimum IPG of 96BT for a sustained period of time. The DUT does not have to respond to all of the requests but the test should not cause any system failures.

Test Setup: Connect the DUT to the Test Station(s) through a compliant high attenuation channel as outlined in APPENDIX C: TEST CHANNELS. Two Test Stations will be used if the DUT is a DCE. One Test station will be used if the DUT is a DTE. If the DUT is a pluggable module or an active direct attached cable, connect the DUT to a known good Host using the setups defined in APPENDIX A: INTEROPERABILITY TEST SETUPS. This test is not applicable for passive direct attached cables.

Procedure:

1. For Direct Attached Cable or Pluggable Modules, connect the Cable/Module to the Host and a known good channel to the Test Station(s). In all other cases, connect the high attenuation channel if applicable between the DUT and the Test Station(s).
2. Reset all counters that will be used to measure or monitor the exchange of packets between the DUT and the testing station. Configure software as needed.
3. Cause the Test Station(s) to transmit 64-byte frames to the DUT for 10 minutes.
4. Transmit 1 additional 64-byte frame and ensure that the DUT is capable of frame reception and transmission.
5. Repeat steps 2-4 using 1518-byte frames.

Observable Results:

- a. Using the counters on the Test Stations(s), identify the number of packets received. The difference between the number of packets sent and the number received is the number of lost packets. The DUT does not have to respond to all of the packets, but the test should not cause any system failures. The DUT must respond to at least one frame to pass this test.

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Possible Problems: None

GROUP 3: EEE-Related Tests

Scope: The following tests cover interoperability and power consumption for the optional Energy Efficient Ethernet capability defined in IEEE 802.3 and present in 100BASE-TX, 1000BASE-T, 10GBASE-T, 1000BASE-KX, XAUI, 10GBASE-KX4, and 10GBASE-KR devices.

Overview: These tests are designed to identify problems that the Energy Efficient Ethernet portion of IEEE 802.3 compliant devices may have in operating in Low-Power Idle (LPI) mode

Test #1.3.1: Low-Power Idle Mode Interoperability

Purpose: To determine if the DUT interoperates with a Link Partner while transitioning between LPI and normal operational modes.

References:

- [1] IEEE Std 802.3-2012
 - (a) Energy Efficient Ethernet – Clause 78
 - (b) 100BASE-TX – subclause 24.1.4.3, Clause 25
 - (c) 1000BASE-T – Clause 40
 - (d) XAUI – Clause 47
 - (e) 10GBASE-T – Clause 55
 - (f) 1000BASE-KX – Clause 70
 - (g) 10GBASE-KX4 – Clause 71
 - (h) 10GBASE-KR – Clause 72

Resource Requirements:

- A set of reference stations that can be used as Link Partners.
- Test Stations, if necessary, to transmit packets between the DUT and the Link Partner. These stations must be able to provide detailed counts of packets transmitted and received, as well as information on errors associated with link level operation.
- A means of verifying that the devices have entered into LPI mode operation.
- Cable channels with well known compliant properties applicable to the appropriate technology referenced in Appendix A.

Last Modification: February 26, 2013

Discussion: Reference [1] defines a LPI mode of operation for IEEE 802.3 Ethernet devices. During LPI mode, periods of quiet and refresh signaling are transmitted to allow the receive circuitry to remain active on the link.

Test Setup: Refer to APPENDIX A: INTEROPERABILITY TEST SETUPS for possible test setups.

Procedure:

1. Connect a high attenuation channel between the DUT and the Link Partner, as outlined in APPENDIX C: TEST CHANNELS.
2. Place the DUT and its Link Partner into compatible EEE modes of operation.
3. Cause the DUT and its Link Partner to exchange a series of packets and observe the response.
4. Through any means, disable all traffic to and from the DUT while maintaining the link.
5. Verify that the DUT's and link partner are sending quiet and refresh signaling, indicating that the devices have entered LPI mode.
6. While the DUT is operating in LPI mode, cause the DUT and Link Partner to exchange 1/5th the number of packets determined in test Test #1.2.1: Packet Error Ratio Estimation and observe the response.

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7. Repeat steps 5 and 6 until the total number of packets determined in Test #1.2.1: Packet Error Ratio Estimation is transmitted.

Observable Results:

- a. The DUT should accept the frames.

Possible Problems:

- It may not be possible to complete this test if all traffic cannot be disabled from the DUT or Link Partner.

APPENDIX A: INTEROPERABILITY TEST SETUPS

Purpose: To provide detailed information about the test setups utilized during the interoperability tests.

References:

Last Modification: February 26, 2013

Discussion: The test setups will vary based on the interoperability testing being performed, the DUT, and the Link Partner. In Point to Point Interoperability the DUT and its Link Partner will be categorized as either Data Terminal Equipment (DTE) or Data Connecting Equipment (DCE). For the purposes of this explanation, the term DTE will be used to indicate an end station that generates and responds to ICMP requests such as a network interface card, print server, router. The term DCE will be used to indicate a multiport forwarder such as a repeater, a buffered distributor, or a switch. In PoE Interoperability the DUT and its Link Partner will be categorized as either Power Sourcing Equipment (PSE), a Powered Device (PD), or a Midspan. In Direct Attached Cable or Pluggable Module Interoperability the DUT and its Link Partner will be categorized as either a Host or Cable/Module. The Host can be either a DTE or a DCE.

Point to Point and non-midspan PoE Interoperability Test Setups

In Point to Point Interoperability, the Link Partner is the device at the other end of the channel being used for interoperability testing. The test channel is connected between the DUT and the Link Partner. Both the DUT and the Link Partner may be either a DTE or a DCE. There are three possible setups depending on the type of DUT and the type of Link Partner.

In non-midspan PoE Interoperability, there is the additional requirement that one device will be a PD and one device will be a PSE. See **PoE Midspan Test Setups** for test setups when a midspan is used as a DUT or Link Partner.

If both devices are DTEs, then the devices are connected together through the Test Channel as illustrated in Figure 1. One of the devices must be capable of controllably sourcing and monitoring received packets and the other device must be capable of responding to packets. If one device is a DCE and the other device is a DTE, then one port of the DCE is connected to the DTE through the test channel and another port is connected to a Test Station as illustrated in Figure 2. The Test Station must be capable of sourcing packets and either the test station or the DCE must be capable of monitoring received packets. If both devices are DCEs, then the devices are connected to each other through the Test Channel and a second port of each device is connected to Test Stations as illustrated in Figure 3. The Test Stations must be capable of sourcing packets and either the test station or the DCE on each side of the Test Channel must be capable of monitoring received packets.

In all cases, the Test Channel refers to the appropriate media channel as defined in APPENDIX C: TEST CHANNELS.

Case 1: DTE to DTE

Connect the DUT to its Link Partner through the Test Channel as shown in Figure 1.

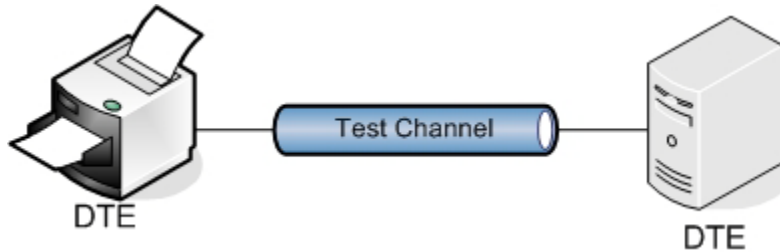


Figure 1 Both the DUT and Link Partner are DTEs

Case 2: DTE to DCE

Connect the DUT to its Link Partner through the Test Channel as shown in Figure 2. The Test Station will exchange packets with the DTE. The link between the Test Station and the DCE must be error free.

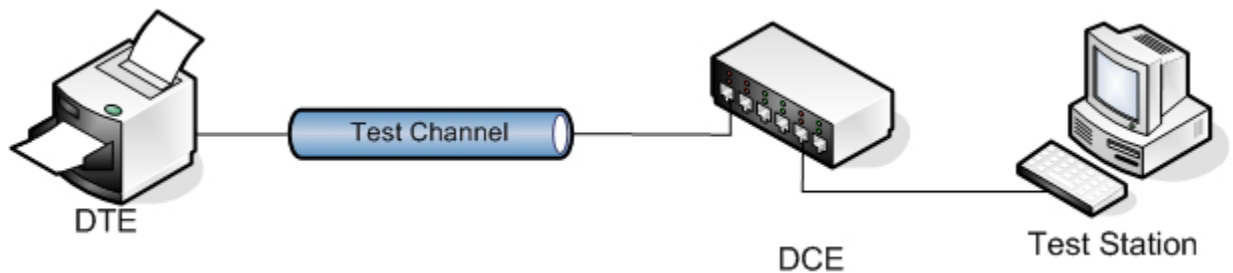


Figure 2 The DUT is a DTE and the Link Partner is a DCE, or vice versa

Case 3: DCE to DCE

Connect the DUT to its Link Partner through the Test Channel as shown in Figure 3. The Test Stations will exchange packets with each other. The links between the Test Stations and the DCEs must be error free.

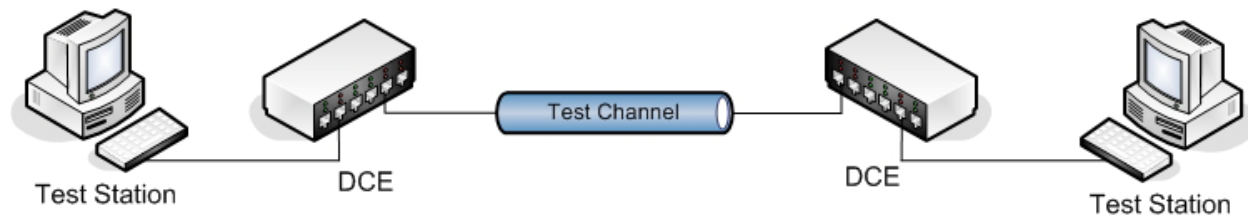


Figure 3 Both the DUT and Link Partner are DCEs

PoE Midspan Test Setups:

Midspan devices connect inline between a non-PoE device and a PD to provide power to the PD. The PD can be either a DTE or a DCE. The non-PoE device can be a Test Station, a DTE, or a DCE.

Figure 4 illustrates the case when the PD is a DTE and is connected to a Test Station through the Test Channel and the midspan. The Test Station must be capable of sourcing packets and monitoring received packets. Figure 5 illustrates the case when the PD is a DTE and is connected to another DTE through the Test Channel and the midspan. At least one of the devices must be capable of controllably sourcing and monitoring received packets and the other device must be capable of responding to packets. Figure 6 illustrates the case when the PD is a DTE and is connected to a DCE through the Test Channel and the midspan. A second port of the DCE is connected to a Test Station capable of sourcing packets and either the Test Station or the DCE must be capable of monitoring received packets. Figure 7 illustrates the case when the PD is a DCE and is connected to a Test Station through the Test Channel and the midspan. A second port of the DCE is connected to a Test Station. The Test Stations must be capable of sourcing packets and either the Test Station or the DCE must be capable of monitoring received packets. Figure 8 illustrates the case when the PD is a DCE and is connected to a DTE through the Test Channel and the midspan. A second port of the DCE is connected to a Test Station capable of sourcing packets and either the Test Station or the DCE must be capable of monitoring received packets. Figure 9 illustrates the case when the PD is a DCE and is connected to another DCE through the Test Channel and the midspan. A second port of both DCEs is connected to two Test Stations capable of sourcing packets and monitoring must be performed on either the Test Station or the DCE at each end.

In all cases, the Test Channel refers to the appropriate media channel as defined in APPENDIX C: TEST CHANNELS and is connected between the PD and the midspan.

Case 1: DTE (Midspan Powered) to Testing Station

Connect the PD to the Test Station through the Test Channel and the midspan as shown in Figure 4. The testing station will exchange packets with the DTE.

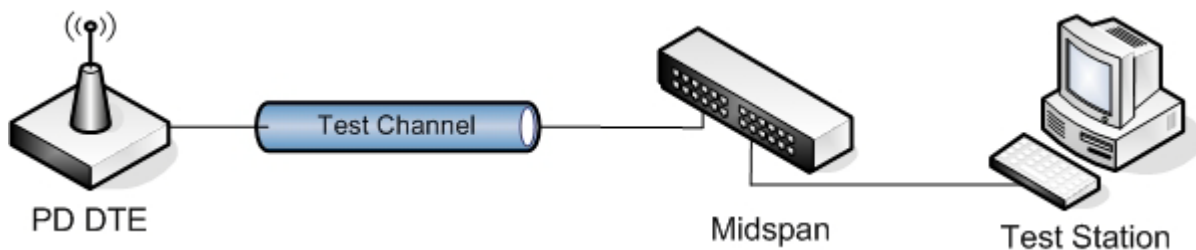


Figure 4 PD DTE connected to a Test Station

Case 2: DTE (Midspan Powered) to DTE

Connect the PD DUT to the non-PoE DTE through the Test Channel and the midspan as shown in Figure 5.

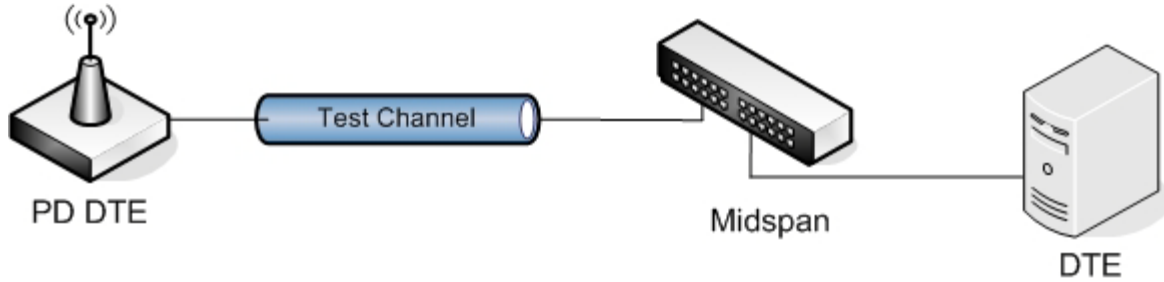


Figure 5 PD DTE to a non-PoE DTE

Case 3: DTE (Midspan Powered) to DCE

Connect the PD to the DCE through the Test Channel and the midspan as shown in Figure 6. The Test Station will exchange packets with the DTE. The link between the Test Station and the DCE must be error free.

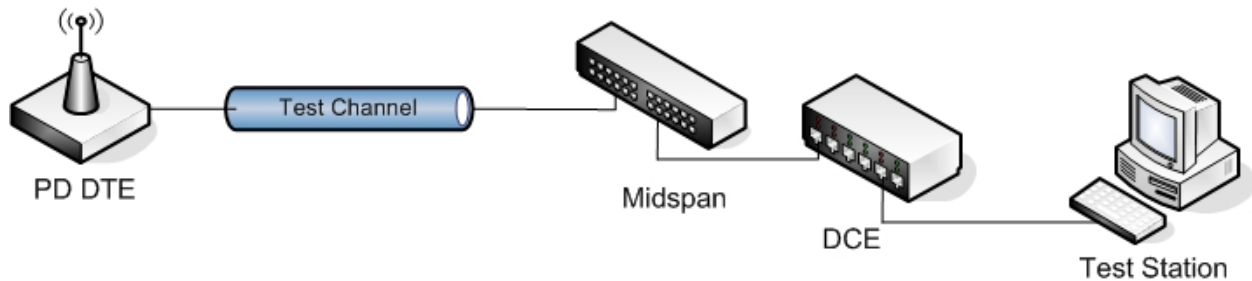


Figure 6 PD DTE to a DCE

Case 4: DCE (Midspan Powered) to Testing Station

Connect the PD to the Test Station through the Test Channel and the midspan as shown in Figure 7. Connect a second port of the PD to a second Test Station. The Test Stations will exchange packets with each other. The link between the Test Station and the PD must be error free.

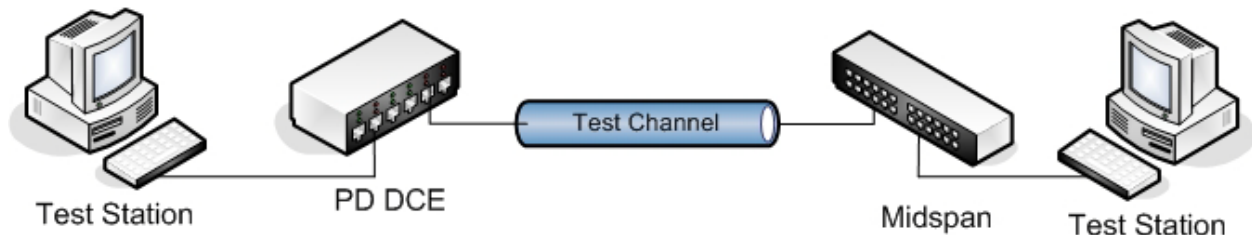


Figure 7 PD DCE to a Test Station

Case 5: DCE (Midspan Powered) to DTE

Connect the DCE to the DTE through the Test Channel and the midspan as shown in Figure 8. Connect a second port of the PD to a Test Station. The Test Station will exchange packets with the DTE. The link between the Test Station and the PD must be error free.

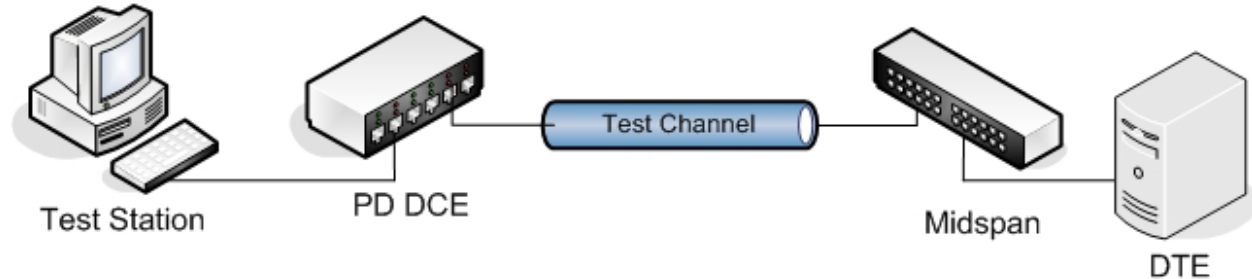


Figure 8 PD DCE to DTE

Case 6: DCE (Midspan Powered) to DCE

Connect the PD DCE to the non-PoE DCE through the Test Channel and the midspan as shown in Figure 9. Connect a second port of the DCEs to Test Stations. The Test Stations will exchange packets with each other. The link between the Test Stations and the DCEs must be error free.

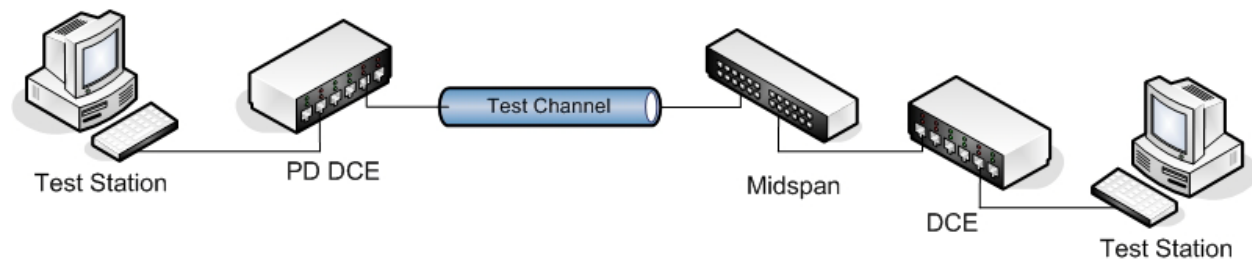


Figure 9 PD DCE to non-PoE DCE

Direct Attached Cable and Pluggable Module Interoperability Test Setups:

In Direct Attached Cable and Pluggable Module Interoperability Test Setups, the DUT is either a Host or a Cable/Module. If the DUT is a Host then the Link Partner is a Cable/Module. If the DUT is a Cable/Module then the Link Partner is a Host. The Host may be either a DTE or a DCE. There are four possible setups depending on the type of Host and if a Cable or Module is used.

If a Cable is used, the Host will connect directly to a Test Station via the Cable. If a Module is used, the Host will connect to a Test Station via the applicable Test Channel as defined in APPENDIX C: TEST CHANNELS. If the Host is a DCE, a second Test Station will be connected to another port on the Host.

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The following four figures show the respective setups. In Figure 10 the Host is a DTE and a Cable is connected directly to the Test Station. In Figure 11 the Host is a DTE and is connected to the Test Station via the Test Channel. In Figure 12 the Host is a DCE and a Cable is connected directly to the Test Station. A second Test Station is connected to another port on the Host. In Figure 13 the Host is a DCE and is connected to the Test Station via the Test Channel. A second Test Station is connected to another port on the Host

Case 1: DTE Host and Cable

Connect the Host to the Test Station through the Cable as shown in Figure 10. The Test Station will exchange packets with the DTE.

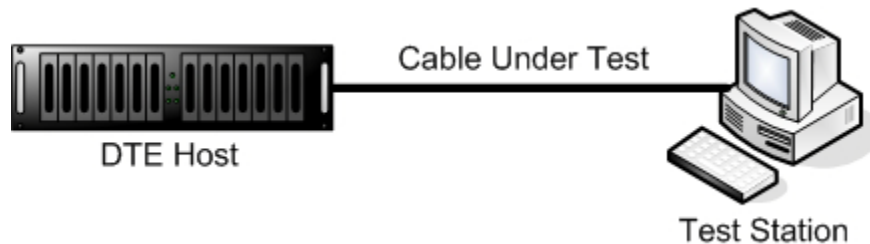


Figure 10 DTE Host and Cable

Case 2: DTE Host and Module

Connect the Host and module to the Test Station through the Test Channel as shown in Figure 11. The Test Station will exchange packets with the DTE.

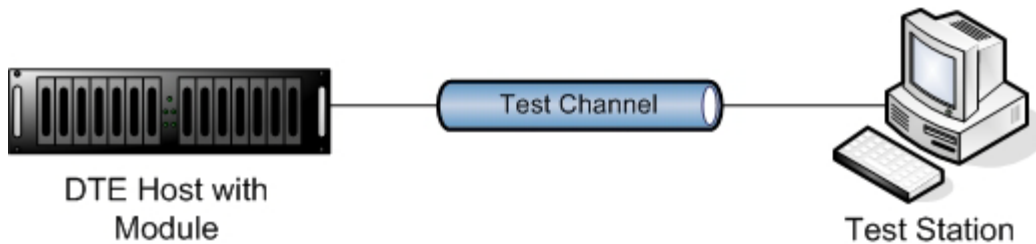


Figure 11 DTE Host and Module

Case 3: DCE Host and Cable

Connect the Host to the Test Station through the Cable as shown in Figure 12. Connect a Test Station to a second port of the Host. The Test Stations will exchange packets with each other.

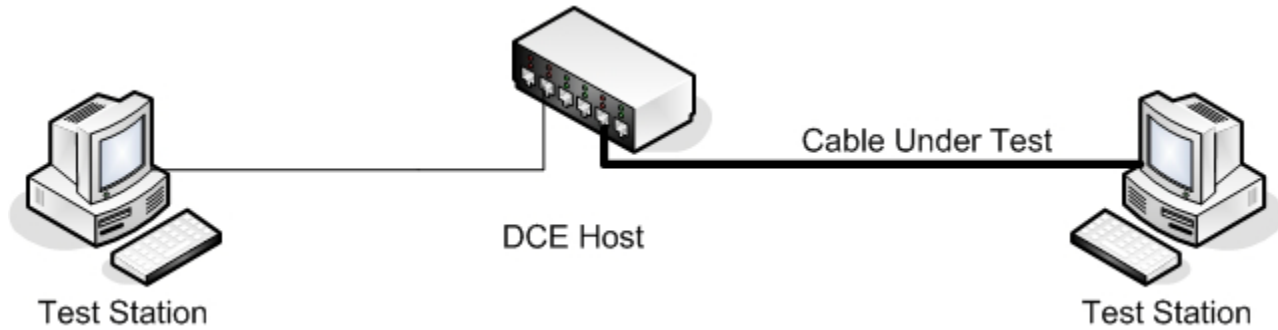


Figure 12 DCE Host and Cable

Case 4: DCE Host and Module

Connect the Host and module to the Test Station through the Test Channel as shown in Figure 13. Connect a Test Station to a second port of the Host. The Test Stations will exchange packets with each other.

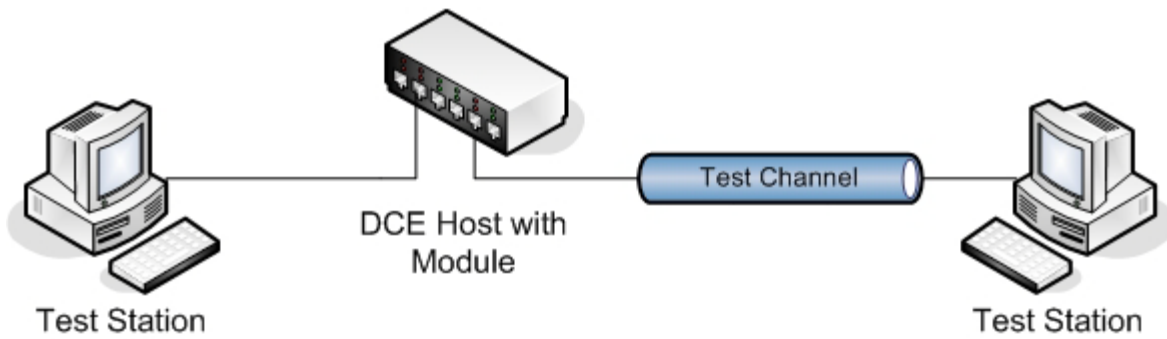


Figure 13 DCE Host and Module

APPENDIX B: PACKET ERROR RATIO SPECIFICATIONS

Last Modification: June 11, 2014

Discussion: The number of frames sent in each test is determined by using the statistical method outlined in Appendix 25.D of the UNH-IOL TP-PMD Test Suite. This reference defines the number of frames required to be sent to verify a desired Bit Error Ratio with 95% confidence at the physical layer. As the BER specifications vary with the technology, the number of packets transmitted needs to be scaled for the technology being tested.

Table B1: Packet Error Ratio Specifications

Technology	Ref.	BER	Frame Error Ratio	Bits to send	1518-byte Packets	Other Packet sizes
10BASE-T / Te	14.1.3.1	1E-8		3E8	24,704 ¹	
100BASE-TX		1E-8		3E8	19,763 ²	
100BASE-FX	ANSI 8	1E-12		3E12	197,628,459 ³	
1000BASE-T	40.6.1.3.1	1E-10	10E-7 (125-byte frames)	3E10	2,470,356 ⁴	30,000,000 (125-byte) ⁴
1000BASE-X	36.1.2	1E-12		3E12	197,628,459 ⁵	
10GBASE-X	54.6.4.1, 47.3.4.1	1E-12		3E12	197,628,459 ⁶	198,938,993 (1508-byte) ⁶
10GBASE-T	55.5.4.1	1E-12	9.6E-9 (800-byte frames)	2E12		312,500,000 (800-byte) ⁷
10GBASE-R	44.1.2	1E-12		3E12	247,035,573 ⁸	
40GBASE-R	80.1.2	1E-12		1.2E13	988,142,293 ⁹	
100GBASE-R4	80.1.2	1E-12		1.2E13	988,142,293 ⁹	
100GBASE-R10	80.1.2	1E-12		3E13	2,470,355,732 ¹⁰	

Note: Only the frame data that is checked by the CRC (and the CRC itself) are used in the calculation to determine the number of frames to transmit. Bit errors in Idle, Preamble, SFD, or other control characters could also affect packet loss in compliant devices.

Calculation Notes:

- 1) There is no overhead in 10BASE-T or 10BASE-Te, so to verify a BER of 1E-8 with 95% confidence we need to send $3 \times 1E8$ bits, or 24,704 1518-byte packets.
- 2) 100BASE-TX uses 4B/5B encoding, so to verify a BER of 1E-8 with 95% confidence we need to send $(4/5) \times 3 \times 1E8$ bits, or 19,763 1518-byte packets.
- 3) 100BASE-FX uses 4B/5B, so to verify a BER of 1E-12 with 95% confidence we need to send $(4/5) \times 3 \times 1E12$ bits, or 197,628,459 1518-byte packets.
- 4) 1000BASE-T does not use block encoding, so to verify BER of 1E-10 with 95% confidence we need to send $3 \times 1E10$ bits, or 2,470,356 1518-byte packets. 1000BASE-T also specifies a frame error ratio of 1E-7 with 125 byte frames, so to verify this with 95% confidence we need to send $3 \times 1E7$ 125-byte packets, or 30,000,000 125-byte packets.
- 5) 1000BASE-X uses 8B/10B encoding, so to verify a BER of 1E-12 with 95% confidence we need to send $(8/10) \times 3 \times 1E12$ bits, or 197,628,459 1518-byte packets.

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- 6) 10GBASE-X uses 8B/10B encoding, so to verify a BER of 1E-12 with 95% confidence we need to send $(8/10) * 3 * 1E12$ bits, or 197,628,459 1518-byte packets. 10GBASE-X also defines a specific 1508-byte CJPAT packet to be used for BER testing, so to verify a BER of 1E-12 with 95% confidence we need to send 198,938,993 1508-byte packets.
- 7) 10GBASE-T uses 64B/65B and LDPC FEC. While 10GBASE-T specifies a BER of 1E-12 it also specifies a frame error ratio of 9.6E-9 with 800-byte frames at line rate or with an IPG of at least 799 bytes. The specified frame error ratio only requires 2 trillion bits unlike the specified BER which requires 3 trillion bits. This is due to the LDPC blocks that are used for Forward Error Correction. Each LDPC block contains 400-bytes of data. Since the 800-byte frames also include a Start Character and Preamble, each frame will encompass 3 LDPC blocks. At line rate the blocks will be shared among multiple frames, but at an IPG of 800-bytes the blocks are completely independent. The advantage to the larger IPG is that there is no double-counting of valid or invalid blocks. So we need to send $3 * 1 / 9.6E-9$ 800-byte frames, which is 312,500,000 800-byte frames at line rate or at an IPG greater than 799 bytes (which is approximately 50% utilization).
- 8) 10GBASE-R uses 64B/66B, so to verify a BER of 1E-12 with 95% confidence we need to send $3 * 1E12$ bits, or 247,035,573 1518-byte packets.
- 9) The objectives for 40 Gigabit and 100 Gigabit Ethernet specify a BER of 1E-12 at the MAC. Subclause 85.8.4.3 defines a BER of 1E-12 or better for 40GBASE-CR4 and 100GBASE-CR10 PMDs at the receiver. Since the requirement at the PHY is more strict, assuming each individual lane must meet the requirement, this test suite will verify the BER using the physical layer requirement. To verify a BER of 1E-12 at the MAC with 95% confidence on 4 lanes we need to send $4 * 3 * 1E12$ bits, or 988,142,293 1518-byte packets.
- 10) The objectives for 40 Gigabit and 100 Gigabit Ethernet specify a BER of 1E-12 at the MAC. Subclause 85.8.4.3 defines a BER of 1E-12 or better for 40GBASE-CR4 and 100GBASE-CR10 PMDs at the receiver. Since the requirement at the PHY is more strict, assuming each individual lane must meet the requirement, this test suite will verify the BER using the physical layer requirement. To verify a BER of 1E-12 with 95% confidence on 10 lanes we need to send $10 * 3 * 1E12$ bits, or 2,470,355,732 1518-byte packets.

APPENDIX C: TEST CHANNELS

References:

- [1] ANSI-TIA-EIA-568-B-2001
- [2] TSB-155-D4.0-5-1-2006
- [3] IEE802.3-2012
- [4] ISO/IEC 11801

Last Modification: May 20, 2014

Category 5 and 5e Cable Test Environment

Since equalizers often tend to be optimized for particular cable conditions the test procedure uses both high attenuation and a low attenuation environment. The high attenuation testing is done over a compliant channel attenuated to simulate a worst-case environment equivalent of 60 degrees (Refer to Table A-0-1). The low attenuation testing is done over a Category-5 compliant channel specified in Table A-0-1. Each of these channels must be tested to ensure that they meet the expected characteristics as defined by their associated standards.

Table A-0-1 UTP Channel Definitions

Technology	Media Type	Insertion Loss – Low (+/- 1 dB) ^a			Insertion Loss – High (+/- 1 dB) ^a		
		16 MHz	32 MHz	100 MHz	16 MHz	32 MHz	100 MHz
100BASE-TX	Category-5 UTP	0.6	1.0	1.2	9.9	14.2	25.7
1000BASE-T	Category-5e UTP	0.6	1.0	1.2	9.9	14.2	25.7

^aInsertion loss is the sum of channel attenuation and connector losses.

10GBASE-T Cable Test Environment

Since equalizers often tend to be optimized for particular cable conditions the test procedure uses both high attenuation and a low attenuation environment. The high attenuation testing is done over a Category-6/6A compliant channel attenuated to simulate a worst-case environment equivalent of 60 degrees (Refer to Table A-0-3). The low attenuation testing is done over a Category-6 compliant channel specified in Table A-0-3. Each of these channels must be tested to ensure that they meet the expected characteristics as defined by their associated standards.

Table A-0-2 UTP/ScTP Channel Definitions

Media Type	Insertion Loss Equation	Frequencies
Class E / Category 6	$IL_{channel}(f) \leq 1.924\sqrt{f} + 0.0173f + \frac{0.204}{\sqrt{f}} + 0.0003f^{1.5}$	1 MHz – 250 MHz
Class E / Category 6: unscreened	$IL_{channel}(f) \leq 1.924\sqrt{f} + 0.0173f + \frac{0.204}{\sqrt{f}} + 0.0003f^{1.5}$	1 MHz – 250 MHz
Class E / Category 6: screened	$IL_{channel}(f) \leq 1.924\sqrt{f} + 0.0173f + \frac{0.204}{\sqrt{f}} + 0.0003f^{1.5}$	1 MHz – 250 MHz

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Class EA/ Augmented Category 6	$IL_{channel}(f) \leq 1.05 \left(1.82\sqrt{f} + 0.0169 \cdot f + \frac{0.25}{\sqrt{f}} \right) + 4 \cdot 0.02\sqrt{f}$	250 MHz – 500 MHz
Class F / Category 7		

^aInsertion loss is the sum of channel attenuation and connector losses.

Alien crosstalk details and equations can be found in section 55.7.3 of IEEE 802.3-2012.

There are two ways to energize environment noise. One involves directly coupling onto the wires via some sort of resistive network, whether using resistors explicitly or baluns and power splitters, as shown in figure 55-32 of IEEE 802.3-2012. The other approach is to use magnetic coupling, which does not involve any direct connections on the physical wires. In order to imitate a “real-world” cable installation as closely as possible, the crosstalk injection for interoperability testing is done by magnetic coupling. The measured coupled noise should meet the receiver Alien crosstalk noise rejection, found in Clause 55.5.4.4, which states that the noise should have a 3 dB bandwidth from at least 10 MHz to 400 MHz and a power spectral density such that at the MDI port of the device under test the power spectral density of the injected noise is –141.9 dBm/Hz.

A worst-case alien crosstalk environment is achieved through a 6-around-1 configuration as discussed in Annex 55B of IEEE 802.3-2012. A 100m 6-around-1 channel with tie-wrap separation of 12” provides both a worst case UTP test channel from an Insertion Loss standpoint as well as Alien Crosstalk interference. A 15m 6-around-1 channel provides a worst-case Return Loss environment as well as Alien Crosstalk interference.

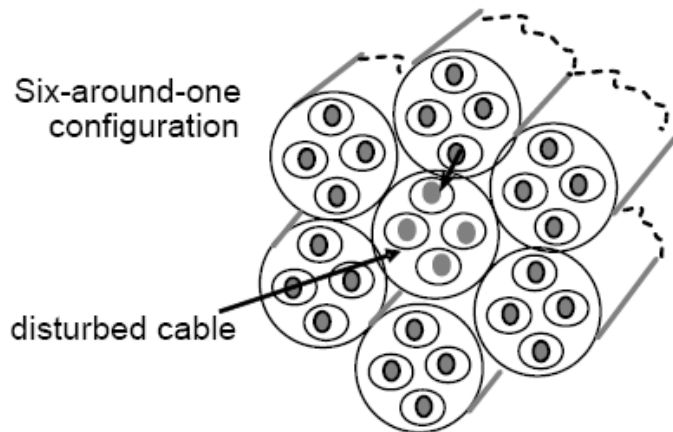


Figure 55B–2—Six-around-one cable configuration

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Optical Test Environment

For optical devices, the high attenuation testing is performed over a compliant optical channel where the signal is attenuated using an optical fiber attenuator to the minimum TX Link Up value for the DUT. The low attenuation testing is done over a short compliant optical channel and the signal is not additionally attenuated. A summary of the optical channel definitions is provided in Table A-0-2.

Table A-0-3 Optical Channel Definitions

Label	Fiber	λ (nm)	length (m) ^a	Insertion Loss (dB) ^b	Modal Bandwidth (MHz·km) ^a
FX	62.5 μ m MMF	1325	Refer to note c	Refer to note c	N/A
SX	62.5 μ m MMF	850	220	2.38	160
	50 μ m MMF	850	550	3.56	500
LX	62.5 μ m MMF	1300	550	2.35	500
	50 μ m MMF	1300	550	2.35	500
	10 μ m SMF	1300	5,000	4.57	N/A
SR	62.5 μ m MMF	850	26	1.6	160
		850	33	1.6	200
SR	50 μ m MMF	850	66	1.7	400
		850	82	1.8	500
		850	300	2.6	2000
LR	10 μ m SMF	1310	10,000	6.2	N/A
ER	10 μ m SMF	1550	30,000	10.9	N/A
			40,000	10.9	
SR4/SR10	50 μ m MMF	850	100	1.9	2000
	125 μ m MMF		150	1.5	4700
LR4	10 μ m SMF	1271 1291 1311 1331	10,000	6.7	N/A

^aThe requirements for length and modal bandwidth do not need to be met as long as the length-modal bandwidth product is maintained.

^bInsertion loss is the sum of fiber attenuation and connector losses.

^cFor 100BASE-FX, the FDDI-PMD Section 8 states that the BER shall not exceed 1×10^{-12} when the Active Input Interface power level is 2dB or more than the minimum level. Through the use of an air-gap attenuator and the value obtained from test #1.1.4, the min+2dBm level can be achieved, and is used in packet error rate testing for the Receive Channel of the DUT. For the Transmit Channel of the DUT an air-gap attenuator (or similar) is used to attenuate the power level to -31dBm.

Backplane Ethernet Test Environment

The test points specified in Clauses 70, 71, and 72 of the 802.3 Standard do not include any connector. Thus, an agreed upon form factor must be established prior to interoperability testing. Since the setup is likely to include a wide range of implementations (evaluation boards to finished DUTs), the interface used for interoperability testing is an SMA connector. This allows for characterization of the DUT without a requirement to perform de-embedding, and also allows for measurement of the backplane test channel and any line cards. Both the silicon and backplane manufacturers must agree on this test point.

The two Link Partners are interconnected via a Backplane Ethernet test channel using SMA connectors in one of the 3 configurations shown in figures 1-3 below.

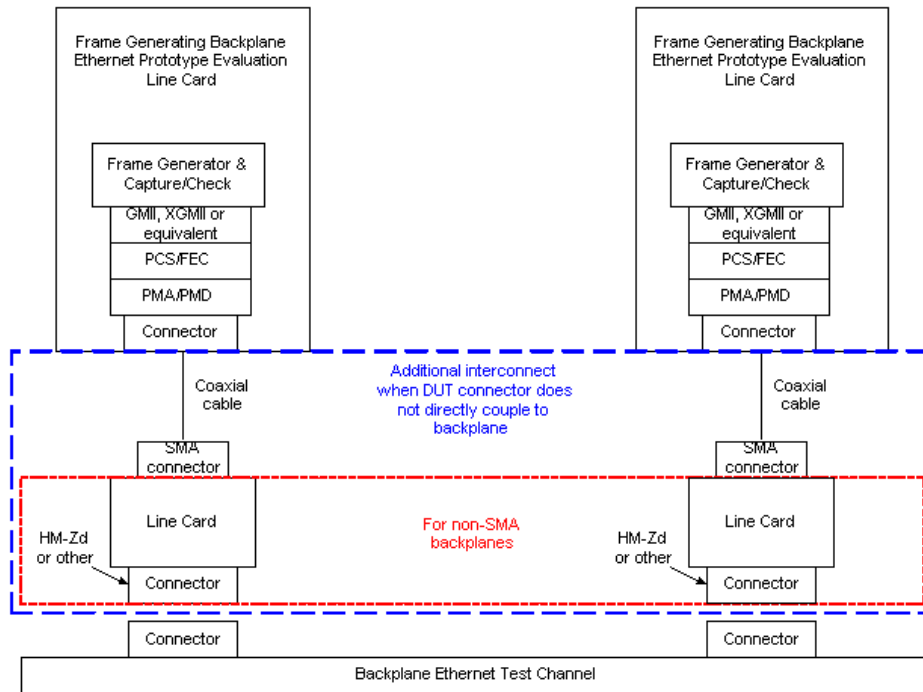


Figure 14: Frame Generating board connected to frame generating board

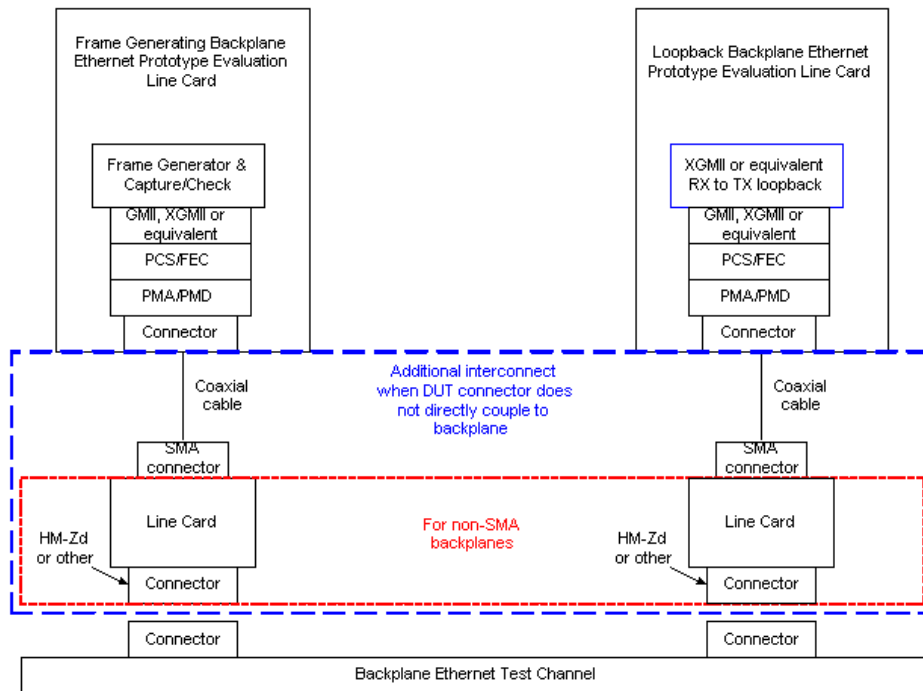


Figure 15: Frame generating board connected to loopback board (XGMII loopback)

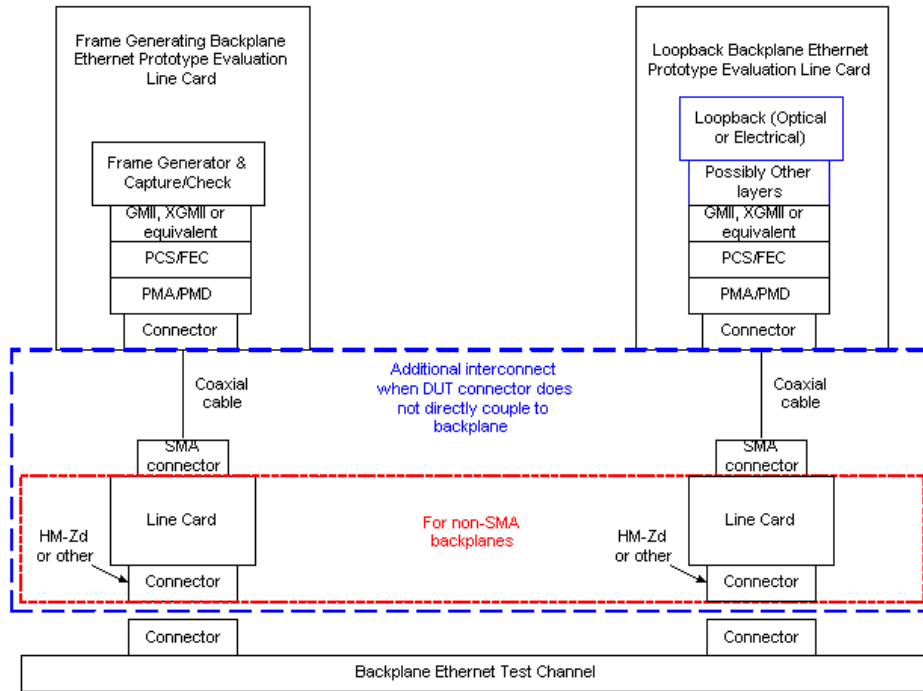


Figure 16: Frame generating board connected to loopback board (external loopback)