University of New Hampshire InterOperability Laboratory
Ethernet Consortia

Superseded

As of February 3, 2006 the Ethernet InterOperability Test Suite version 2.2 has been superseded by the release of the InterOperability Test Suite version 2.3. This document along with earlier versions, are available on the Ethernet Consortia test suite archive page.

Please refer to the following site for both current and superseded test suites:

http://www.iol.unh.edu/testsuites/ethernet/

ETHERNET

Physical Layer Interoperability
Test Suite
Version 2.2

Technical Document

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Ethernet Consortium
InterOperability Laboratory
Research Computing Center
University of New Hampshire

121 Technology Drive, Suite 2
Durham, NH 03824
Phone: (603) 862-0166
Fax: (603) 862-4181
http://www.iol.unh.edu/consortiums/fe
http://www.iol.unh.edu/consortiums/ge
http://www.iol.unh.edu/consortiums/poe

MODIFICATION RECORD

May 10, 2005 – Minor Changes

Jon Beckwith — Changed copyright date and added passing statement to end of Test #1.1.4

October 11, 2004 – Minor Changes

Mike Henninger: — Added Copyright to footer

September 7, 2004 – Minor Changes

Mike Henninger: — Modified cover letter (added new logo and version number)

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Jeff Lapak: — Modified to include Power over Ethernet Interoperability testing (Clause 33).

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Jon Beckwith: — Updated references to 802.3, 2002, and fixed a small typo.

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Jeremy Kent: — 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.

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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 two 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 two 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, and the ability to detect and establish a link at the optimal speed between two devices that make up a link segment. A third area covers specific 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.

Cable Plants
The intent of interoperability testing is to insure 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 all of the possible cable plant scenarios in the real world, a "worst case cable plant" which is very close to the limit of the TIA/EIA cable standards is used. The cable plants are tuned to be between 1-5% above the margins specified in ANSI-TIA-EIA-568-B-2001 or other applicable specifications. A shorter patch cable is also included in testing to insure that short links between devices are also viable.

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. Tests are grouped in order to reduce setup time in the lab environment. 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 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. The items contained in this section are special test devices or other facilities, which may not be available on all devices.

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.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPLICATION TABLE

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

Table 1-1 Application of Tests to Given Physical Speeds

	10BASE-T	100BASE-TX	100BASE-FX	1000BASE-T	1000BASE-X
GROUP 1: POINT-TO-POINT INTEROPERABILITY					
Test #1.1.1: Link Speed Detection	√	√		√	
Test #1.1.2: Link Configuration					√
Test #1.1.3: Packet Error Ratio Estimation	√	√	√	√	√
Test #1.1.4: Endurance Stress Test	√	√	√	√	√
Test #1.1.5: Connect to a 1000BASE-X Manually Configured Port					√
Test #1.1.6: Connect to a Non-100/1000BASE-X Device			√		√
GROUP 2: CHANNEL TESTING					
Test #1.2.1: Channel Characteristics	√	√		√	

GROUP 1: POINT-TO-POINT INTEROPERABILITY

Scope: The following tests cover Physical layer interoperability specific to 10BASE-T, 100BASE-TX, 100BASE-FX, 1000BASE-T, and 1000BASE-X devices.

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

Test #1.1.1: Link Speed Detection

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

References:

[1] IEEE Std. 802.3, 2002 Edition Clause 28.2.3.3
[2] Annex 28B.3

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.

Last Modification: June 4, 2002

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. The large majority of Fast Ethernet and Gigabit Ethernet products use IEEE Std. 802.3, 2002 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. This test procedure addresses three conditions in which link speed detection should work. 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.

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.

Table 1-2 Minimum Media Specifications by Technology (UTP)

Technology	Media Type
10BASE-T	Category-3
100BASE-TX	Category-5
1000BASE-T	Category-5

Test Setup: Connect the DUT to another device via the appropriate media channel as outlined in Table 1-2, while supplying power over the channel (if possible).

Procedure:

Part A

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 (Refer to Table 1-2 and Table A-2) 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 test 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 or not.

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 (Refer to Table 1-2 and Table A-2) 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. 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 or not.

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

1. Power off the DUT and the link partner.
2. Power both devices back on at the same time and allow them to initialize.
3. Connect a compliant high attenuation media channel (Refer to Table 1-2 and Table A-2) between the devices.
4. Verify that a proper link is established as in Cases 1 and 2.

5. Remove and hold the cable for a few seconds, then reinsert. Repeat five 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.
6. Send the DUT a series of packets and observe whether the packets are accepted or not.

Part B

1. Establish a valid Highest Common Denominator (HCD) link between the DUT and link partner via a compliant high attenuation media channel (Refer to Table 1-2 and Table A-2). Verify that a valid HCD link is established.
2. Break the link and connect the DUT to a testing station configured to send link signaling at a speed other than the HCD.
3. Reconnect the DUT to the link partner. Verify that a valid HCD link is re-established.
4. Repeat steps 1-3 for all speeds supported by the link partner.

Observable Results:

a. The DUT and the link partner should establish an HCD link in all cases. Both 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 should establish an HCD link as described in part a.

Possible Problems: If management access is not provided, it may be difficult to determine if the DUT resolves a link at the proper speed.

Test #1.1.2: Link Configuration

Purpose: To verify that the DUT establishes a proper link with its link partner, and can re-establish that link after its cable connection is removed and reinserted.

References:

[1] IEEE Std. 802.3, 2002 Edition Clause 37.2.4.2

Resource Requirements:

- A reference set of stations that can be used as link partners.
- 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: July 5, 2002

Discussion: The Auto-Negotiation function specified in Clause 37 of IEEE 802.3 is designed to optimally configure a 1000BASE-SX/LX link based on the capabilities of both link partners. These capabilities are currently defined to include full and half duplex operation, and three PAUSE modes: symmetric, asymmetric toward, and asymmetric away. The Auto-Negotiation function may be disabled in a device. In such an event, both link partners must have the function disabled and their features must be manually configured. This test explores the Device Under Test's (DUT) auto-negotiation function when connected to various link-partners which have auto-negotiation enabled.

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.

Table 1-3 Minimum Media Specifications by Technology (Optical)

Technology	Media Type	Modal Bandwidth (MHz·km)[a]
1000BASE-SX	62.5 µm MMF 50 µm MMF	160 500
1000BASE-LX	62.5 µm MMF 50µm MMF 10 µm SMF	500 500 ---

Test Setup: Connect the DUT to another device via the appropriate media channel as outlined in Table 1-3

Procedure:

Case 1: The DUT receives no signal during link partner initialization.

1. Power off the DUT and the link partner.

2. Connect a compliant high attenuation media channel (Refer to Table 1-3 and Table A-3) 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 optimal link configuration was achieved.
6. Send the DUT a series of packets and observe whether the packets are accepted or not.

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 (Refer to Table 1-3 and Table A-3) 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 optimal link configuration was achieved.
6. Send the DUT a series of packets and observe whether the packets are accepted or not.

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

1. Power off the DUT and the link partner.
2. Power both devices back on and allow them to initialize.
3. Connect a compliant high attenuation media channel (Refer to Table 1-3 and Table A-3) between the devices.
4. Verify that a proper link is established as in Cases 1 and 2.
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 five times. Check local management information to verify that the optimal link configuration was achieved.

Observable Results:

a. The management entity of the DUT and its link partner must be examined for indications of proper duplex and pause mode resolution.

Possible Problems: If a management entity or LED indication of duplex and pause mode is not available, then no conclusion can be reached regarding the configured link mode of the device.

Test #1.1.3: Packet Error Ratio Estimation

Purpose: To determine if the DUT can exchange packets with a link partner such that the exchange of packets must produce a packet error ratio that is low enough to meet a desired bit error ratio.

References:

[1] ISO/IEC 9314-3:1990, Section 8
[2] ANSI/TIA/EIA-568-B-2001
[3] IEEE Std 802.3, 2002
  (a) 10BASE-T: - Clause 14
  (b) 100BASE-TX: - subclause 24.1.4.3, Clause 25
  (c) 100BASE-FX: - 24.1.4.3, Clause 25
  (d) 1000BASE-X: - subclauses 36.1.4.3, Clause 38
  (e) 1000BASE-T: - Clause 40
[4] IOL FEC 100BASE-TX PMD Test Suite Appendix 25D

Resource Requirements:

- A set of reference stations that can be used as link partners.
- Two test stations, one that can be used to source packets, and one that can be used to respond or echo the sourced packet. 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 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 A.

Last Modification: June 17, 2002

Discussion: This test is designed to verify the ability of a DUT to exchange packets with another station over the appropriate cable model. The exchange of packets must produce a packet error ratio that is low enough to meet a desired bit error ratio. The IOL uses a packet error ratio specification outlined in Appendix A Table A-1; this will insure the bit error ratio with 95% accuracy. The packets sourced by the testing station are then sent back to the DUT or an echo responder. 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 the bit error ratio 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 Table A-1. 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 64-bytes and of length 1518-bytes. The former, being the minimum specified frame size for a device implementing the CSMA/CD MAC sublayer, yields the least amount of time to process a single packet header and provides the smallest probability of multiple errors occurring in a single packet. The latter, specified as the maximum untagged frame size, provides the longest single packet transmission time and the highest probability of an error to be present.

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: The DUT is tested against a link partner. The link partner is the device at the other end of the channel being used for interoperability testing. There are four possible setups depending on the type of device being tested and the type of link partner. Both the DUT and the link partner may be either an end station or an internetworking device. For our purposes an internetworking device is any device that receives packets on one port and forwards them out another port. End stations are those devices that generate and respond to ICMP packets.

The following four figures show the respective setups for end stations and internetworking devices. In Figure 1-1 the DUT is an end station such as a Personal Computer (PC) Network Interface Card (NIC) and it is being tested against another device that is an end station, such as another PC NIC. In Figure 1-2 the DUT is still an end station but the link partner is an internetworking device. In this case the link partner connects a third station into the network, which either sources or sinks the packets. This device is called the echo source/responder or simply, the testing station. The channel between the link partner and the testing station must be compliant with the appropriate standard. Figure 1-3 covers the case of the DUT being an internetworking device as well as the link partner being an internetworking device. Figure 1-4 Midspan powered equipment covers the final case where the DUT is either a Midspan device or is a PD receiving power from a Midspan while passing traffic to a testing station.

For simplicity of presentation, 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 a network interface card, print server, or a router. The term DCE will be used to indicate a repeater, a buffered distributor, or an unmanaged switch.

Case 1: DTE to DTE

Connect the DUT to its link partner through the reference environment as shown in Figure 1-1.

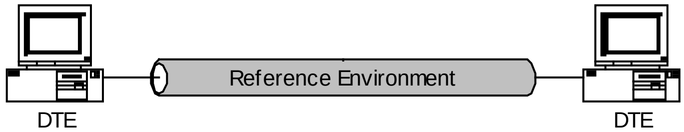

Figure 1-1 Both the DUT and link partner are DTEs

Case 2: DTE to DCE

Connect the DUT to its link partner through the reference environment as shown in Figure 1-2. The testing station will exchange packets with the DTE. The link between the testing station and the DTE must be error free.

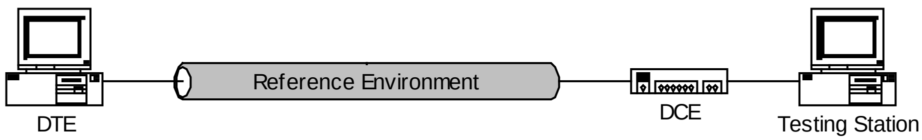

Figure 1-2 The DUT is a DTE and the link artner is a DCE, or vice versa

Case 3: DCE to DCE

Connect the DUT to its link partner through the reference environment as shown in Figure 1-3. The testing stations will exchange packets. The links between the testing stations and the DCEs must be error free.

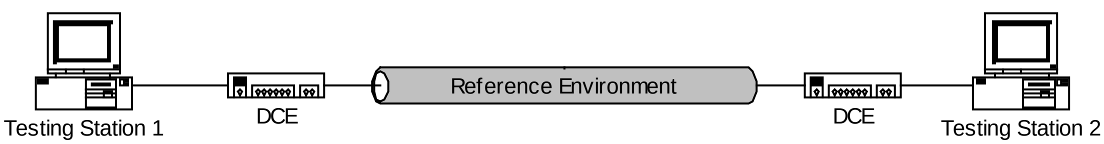

Figure 1-3 Both the DUT and link partner are DCEs

Case 4: DTE (Midspan Powered) to Testing Station

Connect the DUT to its link partner through the reference environment as shown in Figure 1-4. The testing station will exchange packets with the DTE. The link between the testing stations and the DTE must be error free.

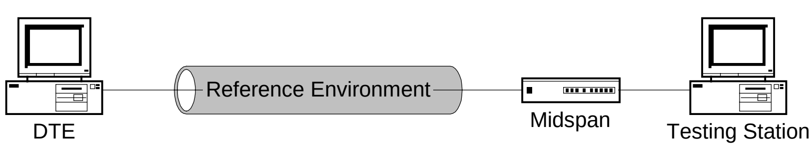

Figure 1-4 Midspan powered equipment

Test Setup: Connect the DUT to its link partner with an appropriate media channel as outlined in Appendix A.

Procedure:

1. Connect the high attenuation channel between the DUT and the link partner.
2. Reset 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. Using the echo source, transmit (n) 64-byte ICMP echo request packets to the IP address of the echo responder. Where (n) is the 64-byte value determined from Table A-1.
5. Using the echo source, transmit (m) 1518-byte ICMP echo request packets to the IP address of the echo responder. Where (m) is the 1518-byte value determined from Table A-1.
6. Repeat steps 2-4, replacing the current media channel with a low-attenuation channel.

Observable Results:

a. Using the counters on the echo source station, identify the number of ICMP echo reply packets received. The difference between the number of ICMP echo request packets sent and the number received is the number of lost packets. An ARP request and response may have occurred during the testing, adjust as needed. 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 is reliable it is often possible to isolate the failure to either the transmitter channel or the receiver channel. No more than seven 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 fourteen packets may be lost.

Possible Problems:

- Bit errors that occur outside the range of FCS coverage will not be detected.
- Some of the adapter cards will generate DMA underrun 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. These frames are often multicast frames but not always.

Test #1.1.4: Endurance Stress Test

Purpose: To verify that no obvious buffer management problems occur when directing a large volume of traffic at the DUT.

References:

[1] ISO/IEC 9314-3, 1990
  (a) 100BASE-FX: - Clause 8
[2] IEEE Std 802.3, 2002
  (a) 10BASE-T: - Clause 14
  (b) 100BASE-TX: - subclause 24.1.4.3, Clause 25
  (c) 100BASE-FX: - 24.1.4.3, Clause 25
  (d) 1000BASE-LX: - subclauses 36.1.4.3, Clause 38
  (e) 1000BASE-SX: - subclauses 36.1.4.3, Clause 38
  (f) 1000BASE-T: - Clause 40

Resource Requirements:

- Two test stations, one that can be used to source packets at minimum inter-packet gap (IPG), and one that can be used to respond or echo the sourced packet. 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: July 2, 2002

Discussion: This test is informative only and is designed to verify that the DUT has no obvious buffer management problems. In the first section of this test, the DUT is attached to a sourcing station (Refer to Table 1-4) that is capable of sending an appropriate number of 64-byte ICMP echo requests as outlined in Table 1-5 with a minimum IPG of 96BT. The DUT does not have to respond to all of the requests but the test should not cause any system failures.

The observable results in this testing process are one or more packet counters. 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 performance of the device but as information that may suggest the need for further analysis.**

Test Setup: A link is established between the DUT and the testing station. There are two possible setups depending on the type of device being tested. The DUT may be either an end station or an internetworking device. For our purposes an internetworking device is any device that receives packets on one port and forwards them out another port. End stations are those devices that respond to an ICMP echo request packet. When the DUT can play both the role of an end station and an internetworking device it is treated as an internetworking device.

The following two figures show the respective setups for end stations and internetworking devices. In Figure 1-5 Both the DUT and testing station are DTEs the DUT is an end station such as a PC NIC. It is connected to the testing station, which works as an end station, such as another

PC NIC. In Figure 1-6 the DUT is an internetworking device connected to two testing stations, one to source and the other to respond or echo the sourced packets. In Figure 1-7 Midspan powered equipment the DUT is a device receiving power from a mid-span device.

For simplicity of presentation, the DUT and its link partner will be categorized as either a DTE or a DCE. For the purposes of this explanation, the term DTE will be used to indicate a network interface card, a managed switch, a router, or the testing station. The term DCE will be used to indicate a repeater, a buffered distributor, or an unmanaged switch.

Table 1-4 Minimum Media Specifications by Technology

Technology	Media Type	Modal Bandwidth (MHz·km)[a]
10BASE-T	Category-3	---
100BASE-TX	Category-5	---
100BASE-FX	62.5 µm MMF	500
1000BASE-T	Category-5	---
1000BASE-SX	62.5 µm MMF 50 µm MMF	160 500
1000BASE-LX	62.5 µm MMF 50µm MMF 10 µm SMF	500 500 ---

Table 1-5 Packet Error Ratio Verification

Technology	BER	# of Packets
10BASE-T	10^{-8}	468,000
100BASE-TX	10^{-9}	4,680,000
100BASE-FX	$2.5x10^{-10}$	35,100,000
1000BASE-T	10^{-10}	46,800,000
1000BASE-X	10^{-12}	4,680,000,000

<u>Case 1: DTE to Testing Station</u>

Connect the DUT to the testing station as shown in Figure 1-5 Both the DUT and testing station are DTEs.

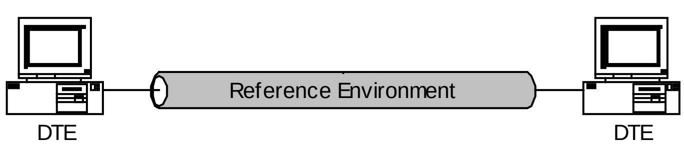

Figure 1-5 Both the DUT and testing station are DTEs

Case 2: DCE to Testing Stations

Connect the DUT to its link partner through the reference environment as shown in Figure 1-6. The testing station will exchange packets with the DTE. The link between the testing station and the DCE must be error free.

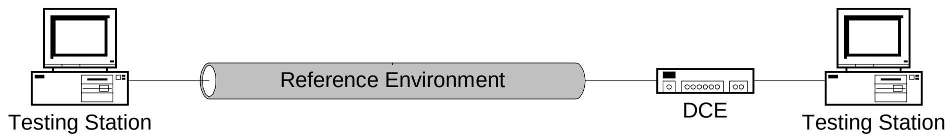

Figure 1-6 The DUT is a DCE and the testting stations are DTEs

Case 3: DTE (Midspan Powered) to Testing Station

Connect the DUT to its link partner through the reference environment as shown in Figure 1-7. The testing station will exchange packets with the DTE. The link between the testing stations and the DTE must be error free.

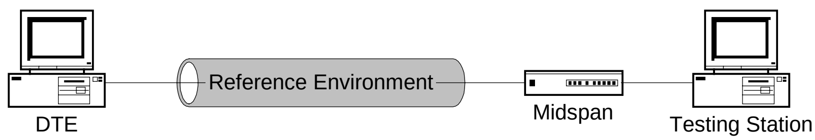

Figure 1-7 Midspan powered equipment

Procedure:

1. Connect the appropriate high attenuation channel between the DUT and the test station(s) determined from Appendix A.
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. Using the echo source, transmit (n) 64-byte ICMP echo request packets with an IPG of 96BT to the IP address of the echo responder, where (n) is the 64-byte value determined from Table 1-5.

Observable Results:

a. Using the counters on the echo source station, identify the number of ICMP echo reply packets received. The difference between the number of ICMP echo request packets sent and the number received is the number of lost packets. An ARP request and response may have occurred during the testing, adjust as needed. The DUT does not have to respond to all of the requests, but the test should not cause any system failures. *The DUT must respond to at least one frame to pass this test.*

Possible Problems: None

Test #1.1.5: Connect to a 1000BASE-X Manually Configured Port

Purpose: To determine if an Auto-Negotiating DUT establishes a link with a manually configured device.

References:

[1] IEEE Std. 802.3, 2002 Edition: Clause 37

Resource Requirements:

- A reference station that can be used as a link partner.
- 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 physical signaling channel with known compliant properties

Last Modification: June 21, 2002

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 providing and detecting the signaling technique or connection information being passed. The majority of Gigabit Ethernet products use IEEE Std. 802.3, 2002 Clause 37 compliant Auto-Negotiation. The rest use different proprietary schemes to detect the link partner's speed or do not detect link speed at all. This test procedure addresses a condition in which link should not occur between a manually configured device and a device with Clause 37 Auto-Negotiation enabled.

Test Setup: Connect the DUT to a manually configured port on another device via a compliant optical cable channel.

Procedure:

1. Via management, enable Auto-Negotiation and configure the DUT to advertise all supported technology duplex settings (full and half) in all supported speeds.
2. Connect the DUT to another device via a compliant high attenuation optical channel (Refer to Appendix A)
3. Set the port of the link partner to a manual configuration.
4. Verify that no link has been established by attempting to pass traffic between the DUT and the link partner.

Observable Results:

a. The DUT and testing station must be examined for indicators of proper link speed and type. This is typically an LED that indicates when 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. The DUT should not establish a link with a device that does not Auto-Negotiate.

Possible Problems: The DUT may not have LED's to indicate link status.

Test #1.1.6: Connect to a Non-100/1000BASE-X Device

Purpose: To determine if a DUT establishes a link with a device using a similar wavelength PHY.

References:

[1] ISO/IEC 9413-3,1990
   (a) 100BASE-FX: - section 9.1.1.1

[2] IEEE Std. 802.3, 2002
   (a) 1000BASE-X: - Clause 37

Resource Requirements:

- A reference station that can be used as a link partner.
- A reference station that can be used as a link partner from a similar but different network technology.
- 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 physical signaling channel with known compliant properties

Last Modification: June 21, 2002

Discussion: The ability to detect and establish a link at the optimal speed is dependent upon the two devices that make up the link segment providing and detecting the signaling technique or connection information being passed. The majority of Gigabit Ethernet products use IEEE Std. 802.3, 2002 Clause 37 Auto-Negotiation. 100BASE-X Fast Ethernet products use the detection scheme specified in the FDDI Physical Layer Medium Dependent (PMD) standard section 9.1.1.1 that specifies optical link up / link down values. The rest use different proprietary schemes to detect the link partner's speed or do not detect link speed at all. This test procedure, addresses a condition in which link should not occur. Gigabit Ethernet products that use compliant Auto-Negotiation and products that do not Auto-Negotiate such as manually configured 1000BASE-X devices and 100BASE-FX devices should not resolve a link with a device that is of a different network topology that uses signaling of a similar wavelength. For example, a 1000BASE-LX device and a 100BASE-FX device should not establish a link

Test Setup: Connect the DUT to a manually configured port on another device via a compliant optical fiber channel.

Procedure:

1. Establish a valid Highest Common Denominator (HCD) link between the DUT and a testing station via a compliant high attenuation optical channel (Refer to Appendix A Table A-3).
2. Break the link and connect the DUT to a similar wavelength device:
   For SX devices (λ = 850 nm):
   - Connect the DUT to an 850 nm 1.0625 Gb MMF Fiber Channel device.

   For FX and LX devices (λ = 1300 nm):

- Connect the DUT to a 1000BASE-LX device or a 100BASE-FX device, respectively.

3. Verify that a proper link is not established.
4. Reconnect the DUT to the testing station. Verify a valid HCD link is re-established.

Observable Results:

a. The DUT and testing station must be examined for indicators of proper link speed and type. This is typically an LED that indicates when 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. When Auto-Negotiation is disabled, the DUT should not resolve a link with a device that is of a different network topology that uses similar wavelength signaling.

Possible Problems: The DUT may not have LEDs to indicate link status.

GROUP 2: CHANNEL TESTING

Scope: The following tests cover performance of Category-5, Category-5e, and Category-6 cabling.

Overview: These tests are designed to measure frame loss and evaluate 100BASE-TX and 1000BASE-T performance over Category-5, Category-5e and Category-6 cabling.

Test #1.2.1: Channel Characteristics

Purpose: To verify that the characteristics of the DUT meet specification.

References:

[1] ANSI/TIA/EIA-568-B-2001

Resource Requirements:

- Two test stations, one that can be used to source packets, and one that can be used to respond or echo the sourced packet. These stations must be able to provide detailed counts of packets transmitted, received, as well as information on errors associated with link level operation.
- Cable Analyzer

Last Modification: June 21, 2002

Discussion: Cable that has been labeled as "Category 5e" or "Category 6" cable has certain characteristics. The cable along with the connectivity must have characteristics that allow a specified amount of attenuation, NEXT, Return Loss, and other criteria specified in the ANSI/TIA/EIA-568-B Standard**.** If the cable is improperly characterized, then the network that it is installed in may suffer, due to unsatisfactory cable conditions. This test is designed to verify that the Cable Under Tests (DUTs) characteristics are within specification.

Test Setup: Install the cable in a characteristic environment. This allows for a comparable environment to that which the cable will actually be used. Additionally, the cable should not be wound on a spool, thereby reducing adverse affects such as Alien Cross-talk. Punch down the cable in a configuration specified by the vendor.

Table 2-1 Packet Transmission by Technology

Technology	**Transmit Number of Packets (n)**
100BASE-TX	2,000,000
1000BASE-T	20,000,000

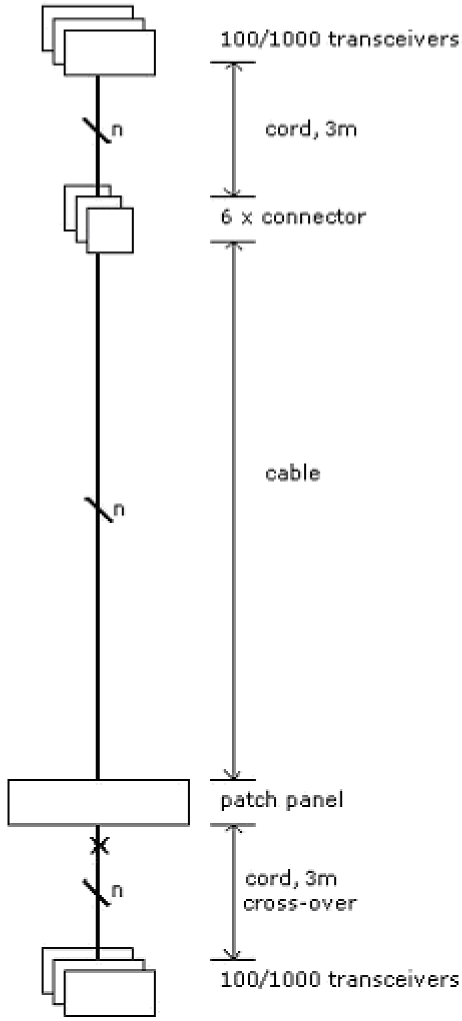

Figure 2-1 Channel Layout

Procedure:

1. After installing the cable and connectors, obtain the cable characteristics using a cable analyzer.
2. Using a traffic generator, send (n) 1518-byte packets on that data channel, where (n) is the value determined from Table 2-1.
3. Repeat steps 1-2 for several different PHY manufacturers.

Observable Results:

a. In the analysis of the cable, the results are determined on a pass/fail basis in accordance with the ANSI/TIA/EIA-568-B cable specifications for a given cable type. In the packet error ratio testing, the number of packets dropped is recorded along with the direction in which the failure occurred.

Possible Problems: None.

APPENDIX A: PACKET ERROR RATIO SPECIFICATIONS

Table A-1 Constrained Packet Error Ratio Verification

Technology	BER	# of Transmitted Packets[a]	
		64-byte	**1518-byte**
10BASE-T	$10E^{-8}$	468,000	19,700
100BASE-TX	$10E^{-8}$	468,000	19,700
100BASE-FX	$10E^{-9}$	4,680,000	197,000
1000BASE-T	$10E^{-9}$	4,680,000	197,000
1000BASE-X	$10E^{-9}$	4,680,000	197,000

[a]The number of transmitted packets outlined in Table A-1 will insure the listed bit error ratio with 95% accuracy. Due to time constraints of the testing period the IOL has chosen to limit the number of packets transmitted in a given test, and therefore, may not be verifying the true bit error ratio for a given technology. 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.

Category-5 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-5 compliant channel attenuated to simulate a worst-case environment equivalent of 60 degrees (Refer to Table A-2). The low attenuation testing is done over a Category-5 compliant channel specified in Table A-2. Each of these channels must be tested to ensure that they meet the expected characteristics as defined by their associated standards.

Table A-2 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	9.9	14.2	25.7	0.6	1.0	1.2
1000BASE-T	Category-5 UTP	9.9	14.2	25.7	0.6	1.0	1.2

[a]Insertion loss is the sum of channel attenuation and connector losses.

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 compliant optical channel and the signal is not attenuated. A summary of the optical channel definitions is provided in Table A-3.

Table A-3 Optical Channel Definitions

Label	**Fiber**	**λ (nm)**	**length (m)[a]**	**Insertion Loss (dB)[b]**	**Modal Bandwidth (MHz·km)[a]**
FX	62.5 μm MMF	1300	500	11.0	500
SX	62.5 μm MMF 50 μm MMF	850 850	220 550	2.38 3.56	160 500
LX	62.5 μm MMF 50μm MMF 10 μm SMF	1300 1300 1300	550 550 5000	2.35 2.35 4.57	500 500 N/A

[a]The requirements for length and modal bandwidth do not need to be met as long as the length-modal bandwidth product is maintained.
[b]Insertion loss is the sum of fiber attenuation and connector losses.