University of New Hampshire InterOperability Laboratory
Ethernet Consortium

Superseded

As of October 11th, 2001 the Ethernet Consortium Clause 28 Auto-Negotiation Management system Conformance Test Suite version 1.0 has been superseded by the release of the Clause 28 Auto-Negotiation Management system Conformance Test Suite version 2.0. This document along with earlier versions, are available on the Ethernet Consortium test suite archive page.

Please refer to the following site for both current and superseded test suites:

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

FAST ETHERNET
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Clause 28 Auto-Negotiation Management System Test Suite

Technical Document

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MODIFICATION RECORD

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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 evaluate the functioning of their Clause 28 Auto-Negotiation based products. Though the IOL's Fast Ethernet Consortium has long been performing a Clause 28 Auto-Negotiation test suite targeting the functionality of the auto-negotiation state machines specified in clause 28 of IEEE 802.3, that "state machine" test suite rarely focused on system level device issues. System level issues in this context refer to interoperability problems which occur between an auto-negotiating end-user device and its link partner even though the device's auto-negotiation state machines and associated registers may be functioning properly. These issues typically occur as a result of a problem with the device's management, whereby the underlying auto-negotiation mechanism may perform properly, but then the device's management acts or reacts inappropriately. While many end-user devices utilize the same underlying auto-negotiation mechanism (typically embedded in a PHY), most devices have very different management and user level control. The focus of the tests within this Auto-Negotiation Management System Test Suite is to examine the functionality of the auto-negotiation management entity of a device.

The tests do not determine if a product conforms to the IEEE 802.3 standard, nor are they purely interoperability tests. Rather, they provide one method to isolate problems within an auto-negotiating device. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other auto-negotiating 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 auto-negotiating environments.

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 observables that can be examined by the tester to verify that the DUT is operating properly. When multiple values are possible for an observable, 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.

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

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GROUP 1: ABILITY ADVERTISEMENT

Scope: The following tests cover auto-negotiation operation specific to capability advertisement.

Overview: These tests are designed to verify that the management entity properly controls the transmission and content of FLPs.

Test #1.1: Auto-Negotiation on/off

Purpose: To verify that when management enables or disables auto-negotiation, that the DUT responds to management by transmitting FLPs or the appropriate link signaling, respectively.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 22.2.4.1.4

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.

Last Modification: September 2, 1999

Discussion: In some implementations, management gives the user the ability to enable or disable auto-negotiation. If the user chooses to disable auto-negotiation, then the DUT should cease transmission of FLPs, if it is in the midst of the auto-negotiation process, wait a period of time, and then start to source appropriate link signaling. In addition, a device with auto-negotiation disabled should never transmit FLPs. Likewise, if the DUT has established a manual link, when auto-negotiation is enabled the DUT should cease transmission, wait a period of time (at least break link timer), and source FLPs. When a device has auto-negotiation enabled, it should always transmit FLPs when the link is broken, and should not transmit Idle until the correct stage of the auto-negotiation process. Note: Some devices may choose to periodically restart auto-negotiation, resulting in gaps in FLP transmission at least break_link_timer in length. It is recommended that the DUT's management not automatically switch between auto-negotiation and a manual/fixed-speed link as this may lead to sub-optimal links.

Test Setup: Using a Cat 5 cord, connect the DUT's transmitter to the Line Monitor. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Via management, enable auto-negotiation.
2. Observe transmissions from the DUT.
3. Repeat steps 2 and 3 but disable auto-negotiation.

Observable Results:

a. When auto-negotiation is enabled, the DUT should attempt to establish a link via the auto-negotiation process by sending FLPs, and should not transmit appropriate link signaling until the DUT enters FLP LINK GOOD.

b. When auto-negotiation is disabled, the DUT should cease current transmission and commence transmission of appropriate link signaling.

Possible Problems: If the DUT's management does not allow auto-negotiation to be turned off, then this test cannot be performed.

Test # 1.2: Base Page Technology Ability Field

Purpose: To verify that the management of the device under test (DUT) advertises valid technology ability field codes.

References:
[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.1.1, 28.2.1.2, 28.2.1.2.1, 28.2.1.2.2, 28.2.1.2.3, 28.2.1.2.4, 28.2.1.2.5, Annex 28A, 28B, 28B.1, 28B.2

Resource Requirements:
- Line Monitor:A system capable of detecting and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The monitor should allow the NLPs to pass through while minimally impacting the channel.

Last Modification: August 23, 1999

Discussion: This test is designed to verify that the DUT transmits Link Code Words whose technology ability field accurately reflects the capabilities of the device and the current management settings. The technology ability field reflects speed capabilities of the physical layer, duplex capabilities of the MAC layer, and flow control capabilities of the MAC control layer. A device must never advertise capabilities, which it does not possess. Through management, the user often has the ability to specify which capabilities are desired which may further restrict the abilities advertised. In this test, the technology ability field advertised by the device is verified to be within the capability set of the device, and reflects the desired mode set in management.

Test Setup: Using a Cat 5 cord, connect the DUT's transmitter to the Line Monitor. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:
1. The DUT is configured to send FLP bursts.
2. Monitor the transmitted bursts.
3. The data present in several bursts is observed.
4. If available via the DUT's management, modify the desired (advertised) ability. This may include turning on/off: 10Mbs HD, 10Mbs FD, 100TX HD, 100TX FD, PAUSE and ASYM_PAUSE. For each modifiable ability, repeat steps 1-4.

Observable Results:
- The technology ability field should advertise the proper abilities as indicated in table 28-10 for the device's capability and current management setting.
- The DUT should not advertise any abilities that it does not possess

Possible Problems: None.

Test # 1.3: 1000Base-T Abilities

Purpose: To verify that the management of a 1000Base-T device advertises valid capabilities.

References:

[1] IEEE Std 802.3ab, 1998: Sections, 40.5.1.2 Table 40-4, 28B, 28B.1, 28B.2

Resource Requirements:

- Line Monitor:A system capable of detecting and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The monitor should allow the NLPs to pass through while minimally impacting the channel.
- NLP Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs).

Last Modification: September 2, 1999

Discussion: This test is designed to verify that the 1000BASE-T DUT transmits capabilities which accurately reflects the capabilities of the device and the current management settings. A device must never advertise capabilities, which it does not possess. Through management, the user may have the ability to specify which capabilities are desired which further restricts the abilities advertised. In this test, the 1000BASE-T capabilities advertised by the device in the first unformatted next page (UP1) is verified to be within the capability set of the device, and reflects the desired mode set in management.

Test Setup: Using Cat 5 cords, connect the DUT and the NLP Generator to the Line Monitor such that the Traffic Generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Use the NLP Generator to complete the exchange of the first two pages (base page & 1000T Message page) sent by the DUT during auto-negotiation.
2. Monitor the third page, which should be the first unformatted page sent by the DUT (UP1).
3. The data present in UP1 is observed.
4. If available via the DUT's management, modify the desired (advertised) ability. This may include turning on/off: 1000Base-T HD, 1000Base-T FD, Manual Master, Manual Slave. For each modifiable ability, repeat steps 1-4.

Observable Results:

- UP1 should advertise the proper abilities as indicated in Table 40-4 for the device's capability and current management setting.
- The DUT should not advertise any abilities that it does not possess
- The 1000BASE-T port type bit (bit U2 in UP1, multiport/singleport) should be set appropriately for the DUT. Note: A multi-port device is considered to be any internetworking device with multiple ports, even if only one port supports 1000Base-T.

Possible Problems: None.

GROUP 2: PRIORITY RESOLUTION

Scope: The following tests cover auto-negotiation operation specific to priority resolution.

Overview: These tests are designed to verify that when a link is configured upon completion of auto-negotiation, it is resolved properly based on the received capabilities from the link partner and the advertised abilities from the device under test. Resolutions examined include:

-SPEED RESOLUTION

-DUPLEX RESOLUTION

-PAUSE MODE RESOLUTION

-1000BASE-T MASTER-SLAVE RESOLUTION

Test #2.1 Speed Resolution and Verification

Purpose: To verify that the DUT resolves a link to the highest speed possible.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.3, Annex 28B.3

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- NLP Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: September 8, 1999

Discussion: When a device has completed the auto-negotiation process, before a link can be established, the device must resolve the link in a certain way depending on the abilities of the two devices connected, and the priority of these abilities in order to establish an optimal link. With regards to speed, the order of priority (highest to lowest) is as follows: 1000Base-T FD, 1000Base-T HD, 100Base-T2 FD, 100Base-TX FD, 100Base-T2 HD , 100Base-T4, 100Base-TX HD, 10Base-T FD, and 10Base-T HD. Two devices should resolve a link to the highest common speed between the devices.

Test Setup: Using Cat 5 cords, connect the DUT and the NLP Generator to the Line Monitor such that the Traffic Generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. If necessary, configure the DUT to advertise all supported technology speeds.
2. Provide a series of FLPs to the DUT advertising a single speed, such that the DUT will enter the FLP LINK GOOD CHECK state. To advertise some technologies, a next page exchange may be required, this would require the DUT to support next page exchange and the Base Page sent to the DUT would have to be followed by the appropriate Message Page and Unformatted Pages required by the technology.
3. Observe transmissions from the DUT
4. Repeat steps 2&3 varying the abilities to be received by the DUT to the abilities: 10BASE-T (Full duplex and Half duplex), 100BASE-TX (FD&HD), 100BASE-T4, 100Base-T2(FD&HD), 1000BASE-T(FD&HD).
5. Repeat steps 2&3 but modify step 2 such that all abilities that the DUT supports are advertised.
6. Repeat steps 2&3, but advertise no speed.

Observable Results:

a) In step 4, the DUT should attempt to establish a link only when a supported technology is advertised, and should refuse a link when an unsupported technology is advertised.
b) In step 5, the DUT should attempt to establish a link at the highest common speed.
c) In step 6, the DUT should not establish a link with a device that does not advertise any abilities.

Possible Problems: If the DUT does not support next page exchange, then the DUT cannot be sent 100BASE-T2 and 1000BASE-T abilities.

Test #2.2 Duplex Resolution and Verification

Purpose: To verify that the DUT will resolve a link to the highest common duplex mode.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.3, Annex 28.B3

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) as well as valid link signaling and frames for 10/100/1000Base-T and recording received frames while connected to the receiver of the DUT.

Last Modification: September 2, 1999

Discussion: When a device has completed the auto-negotiation process, before a link can be established, the device must resolve the link in a certain way depending on the abilities of the two devices connected, and the priority of these abilities in order to establish an optimal link. A full duplex link takes priority over a half duplex link and devices configured for both duplexes should always establish a full duplex link.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the Traffic Generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Configure the DUT for all supported duplex settings (full and half) in all supported speeds.
2. Establish a link with the DUT by sending FLPs advertising full duplex only at one supported speed.
3. For Speeds >100Mbps:
   - Observe frames less than 512bytes in length transmitted from the DUT.

   For Speeds <=100Mbps:
   - When the DUT enters the FLP LINK GOOD CHECK state, the Traffic Generator should provide the appropriate link signaling to the DUT. Cause the DUT to transmit a frame and upon transmission, source a frame from the Traffic Generator. Observe the transmission from the DUT.
4. Repeat steps 1-3 but change the Traffic Generator to advertise half duplex only, full and half duplex, and no duplex
5. Repeat steps 1-5 for all different speeds that the DUT supports.

Observable Results:

a) The DUT should always resolve a full duplex link if both devices have the full duplex bit set.

b) The DUT should resolve a half duplex link whenever both devices only support half duplex.
c) The DUT should not establish a link if there is no common duplex mode.

Possible Problems: None

Test #2.3 Pause Mode Resolution

Purpose: To verify that the DUT resolves to the proper pause mode as seen in Table 28B-3.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28B.3, Table 28B-3

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) as well as valid link signaling and frames for 10/100/1000Base-T and recording received frames while connected to the receiver of the DUT.

Last Modification: July 28, 1999

Discussion: When a device has completed the auto-negotiation process, before a link can be established, the device must resolve the link in a certain way depending on the abilities of the two devices connected, and the priority of these abilities in order to establish an optimal link. When two devices advertise that they support flow control, they must resolve the link to what is specified in Table 28B-3, which is printed here for convenience.

Local Device		**Link Partner**		**Local Device Resolution**	**Link Partner Resolution**
PAUSE	ASM_DIR	PAUSE	ASM_DIR		
0	0	Don't Care	Don't Care	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
0	1	0	Don't Care	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
0	1	1	0	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
0	1	1	1	Enable PAUSE Transmit, Disable PAUSE Receive	Enable PAUSE Receive, Disable PAUSE Transmit
1	0	0	Don't Care	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
1	Don't Care	1	Don't Care	Enable PAUSE Transmit and Receive	Enable PAUSE Transmit and Receive
1	1	0	0	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive

1	1	0	1	Enable PAUSE Receive, Disable PAUSE Transmit	Enable PAUSE Transmit, Disable PAUSE Receive

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the Traffic Generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Complete auto-negotiation and establish a full duplex link at a compatible speed with the DUT with bits D10 and D11 of the Base Page Link Code word set to 11.
2. Cause the DUT to transmit frames and use the Traffic Generator to transmit PAUSE to the DUT.
3. Observe if the DUT reacts to the received PAUSE frames by pausing transmissions from the DUT.
4. Use the Traffic Generator to transmit traffic at or below minimum inter-frame spacing. If possible, direct the traffic to a lower speed output port, or to a congested output port (by transmitting 2 line-rate streams to 1 output port)
5. Observe if the DUT reacts to the high frame rate by transmitting PAUSE frames.
6. Repeat steps 1-4 by changing the values of D10 and D11 to 00, 01, and 10.
7. Complete auto-negotiation and establish a half-duplex link at a compatible speed with the DUT with bits D10 and D11 of the Base Page Link Code word set to 11.

Observable Results:

a) The DUT should resolve the link to the appropriate resolution listed in table 28B-3.
b) In step 7, the DUT should not respond to or transmit PAUSE frames if a half-duplex link has been established.

Possible Problems: There is no guaranteed method to cause a DUT to transmit a pause frame. It may be necessary to rely on the reported pause mode resolution from the DUT's management.

Test #2.4: 1000BASE-T Master-Slave Resolution

Purpose: To verify that the Master-Slave configuration for 1000Base-T links is resolved via Table 40-5

References:

[1] IEEE Std 802.3ab, 1999 Edition: Sections 40.5.2, Table 40-5

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- NLP Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: August 2, 1999

Discussion: Before a 1000Base-T link can be established between two devices, one device must resolve to being the Master, and the other device must resolve to being the Slave. During the next page exchange, one message page and two unformatted pages are transmitted. The two unformatted pages contain, among other abilities, information that is used to decide the master-slave resolution. Bit U2 of the first unformatted page shows whether the device is a single port or multiport device, and bits U1 and U0 of this page hold the manual configuration values for master-slave resolution. The second unformatted page contains a random master-slave seed in bits U10:U0. The two devices must resolve the link according to Table 40-5, which is printed here for convenience.

Local Device Type	Remote Device Type	Local Device Resolution	Remote Device Resolution
single port device	multiport device	SLAVE	MASTER
single port device	manual_MASTER	SLAVE	MASTER
manual_SLAVE	manual_MASTER	SLAVE	MASTER
manual_SLAVE	multiport device	SLAVE	MASTER
multiport device	manual_MASTER	SLAVE	MASTER
manual_SLAVE	single port device	SLAVE	MASTER
multiport device	single port device	MASTER	SLAVE
multiport device	manual_SLAVE	MASTER	SLAVE
manual_MASTER	manual_SLAVE	MASTER	SLAVE
manual_MASTER	single port device	MASTER	SLAVE
manual_MASTER	manual_SLAVE	MASTER	SLAVE
manual_MASTER	multiport device	MASTER	SLAVE

multiport device	multiport device	The device with the higher SEED value is configured as MASTER, otherwise SLAVE.	The device with the higher SEED value is configured as MASTER, otherwise SLAVE.
single port device	single port device	The device with the higher SEED value is configured as MASTER, otherwise SLAVE.	The device with the higher SEED value is configured as MASTER, otherwise SLAVE.
manual_SLAVE	manual_SLAVE	MASTER-SLAVE configuration fault	MASTER-SLAVE configuration fault
manual_MASTER	manual_MASTER	MASTER-SLAVE configuration fault	MASTER-SLAVE configuration fault

Test Setup: Using Cat 5 cords, connect the DUT and the NLP Generator to the Line Monitor such that the Traffic Generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Send a series of FLPs to proceed through the auto-negotiation process with the first unformatted page containing U2:U0 set to 100, and the second unformatted page having bits U10:U0 set to a random value.
2. Check whether the DUT has resolved the link to be Master or Slave by observing if 1000Base-T Idle signaling is transmitted.
3. Repeat steps 1-3 changing the contents of the next pages such that the different resolutions, shown in Table 40-5 are tested.

Observable Results:

- The DUT should resolve the link according to Table 40-5.

Possible Problems: Currently the Line Monitor is relied on to detect "activity" on pairs 1,2 & 3,6 indicating 100Base-T signaling sent by a Master device during startup training. It is possible that for some devices, the 1000Base-T transmitted signaling may not be seen as activity by the Line Monitor, in which case, an oscilloscope should be used to determine the presence of 1000Base-T signaling.

GROUP 3: Parallel Detection

Scope: The following tests cover auto-negotiation operation specific to parallel detection.

Overview: These tests are designed to verify that a capable device properly detects a fixed speed connection and connects at half duplex.

Test #3.1: Parallel Detection of 10Base-T Devices

Purpose: To verify that the device under test can detect that its link partner is a fixed speed 10Base-T device.

References:

[1] ANSI/IEEE Std 802.3, 1998 Edition: Sections 14.3.1.2.1, 28.2.2.2, 28.2.3.1, 28.4

Resource Requirements:

- Test Station: A system capable of generating and transmitting 10Base-T LTPs and frames, as well as recording 10Base-T frames and fragments.

Last Modification: September 7, 1999

Discussion: A station capable of auto-negotiation should be capable of detecting a 10Base-T device as its link partner solely on the receipt of 10Base-T normal link pulses (NLPs). When a 10Base-T device is detected, the station should either enable its 10Base-T PMA and establish a link if supported, or simply not allow a link to be established if not supported.

Test Setup: Using a Cat 5 cord, connect the DUT to the Test Station.

Procedure:

1. Use the Test Station to simulate the presence of a non-auto-negotiating 10Base-T device by sending the DUT 10Base-T LTPs.
2. If the DUT has a 10Base-T PMA:
   2a. Verify that it is enabled by determining whether a link is established. Send the DUT a packet and see if it is accepted.
   2b. Cause the DUT to transmit a packet. Upon transmission, transmit a colliding packet to the DUT.
   2c. If possible, via management, disable the advertisement of 10Base-T HD ability in the DUT's base page. Repeat step 2a.
3. If the DUT has no 10Base-T PMA:
   3a. Verify that no link is established.

Observable Results:

a) If the DUT supports a 10Base-T PMA, a link should be established. If not, a link should be refused.
b) If the DUT supports a 10Base-T PMA, step 2b should cause the DUT to transmit a 10Base-T collision fragment, indicating that the DUT has properly parallel detected a half duplex connection.
c) INFORMATIVE: If the DUT supports a 10Base-T PMA, and the DUT's management allows 10Base-T HD advertisement to be disabled, then the DUT's management may also prevent the parallel detection of 10Base-T.

Possible Problems: None.

Test #3.2: Parallel Detection of 100Base-TX Devices

Purpose: To verify that the device under test can properly parallel detect a fixed speed 100Base-TX link partner.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.1

Resource Requirements:

- Test Station: A system capable of generating and transmitting 100Base-TX Idle and frames, as well as recording 100Base-TX frames and fragments.

Last Modification: September 7, 1999

Discussion: A station capable of auto-negotiation should also implement the parallel detection function. This provides for the detection of a 100Base-TX fixed speed device before the detection of FLPs. In this case, a station should either enable its 100Base-TX PMA if supported and establish a link, or otherwise not allow a link to be established. This test is designed to verify that the device under test properly handles the presence of a fixed speed 100Base-TX device as a link partner.

Test Setup: Using a Cat 5 cord, connect the DUT to the Test Station.

Procedure:

1. Use the Test Station to simulate the presence of a non-auto-negotiating 100Base-TX device by sending the DUT 100Base-TX Idle.
2. If the DUT has a 100Base-TX PMA:
   2d. Verify that it is enabled by determining whether a link is established. Send the DUT a packet and see if it is accepted.
   2e. Cause the DUT to transmit a packet. Upon transmission, transmit a colliding packet to the DUT.
   2f. If possible, via management, disable the advertisement of 100Base-TX HD ability in the DUT's base page. Repeat step 2a.
3. If the DUT has no 100Base-TX PMA:
   3a. Verify that no link is established.

Observable Results:

a) If the DUT supports a 100Base-TX PMA, a link should be established. If not, a link should be refused.
b) If the DUT supports a 100Base-TX PMA, step 2b should cause the DUT to transmit a 100Base-TX collision fragment, indicating that the DUT has properly parallel detected a half duplex connection.

c) INFORMATIVE: If the DUT supports a 100Base-TX PMA, and the DUT's management allows 100Base-TX HD advertisement to be disabled, then the DUT's management may also prevent the parallel detection of 100Base-TX.

Possible Problems: None.

Test #3.3: Parallel Detection of 100Base-T4 Devices

Purpose: To verify that the device under test can properly parallel detect a fixed speed 100Base-T4 link partner.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.1

Resource Requirements:

- Test Station: A system capable of generating and transmitting 100Base-T4 Idle and frames, as well as recording 100Base-T4 frames and fragments.

Last Modification: September 7, 1999

Discussion: A station capable of auto-negotiation should also implement the parallel detection function. This provides for the detection of a 100Base-T4 fixed speed device before the detection of FLPs. In this case, a station should either enable its 100Base-T4 PMA if supported and establish a link, or otherwise not allow a link to be established. This test is designed to verify that the device under test properly handles the presence of a fixed speed 100Base-T4 device as a link partner.

Test Setup: Using a Cat 5 cord, connect the DUT to the Test Station.

Procedure:

1. Use the Test Station to simulate the presence of a non-auto-negotiating 100Base-T4 device by sending the DUT 100Base-T4 Idle.
2. If the DUT has a 100Base-T4 PMA:
   2g. Verify that it is enabled by determining whether a link is established. Send the DUT a packet and see if it is accepted.
   2h. If possible, via management, disable the advertisement of 100Base-T4 ability in the DUT's base page. Repeat step 2a.
3. If the DUT has no 100Base-T4 PMA:
   3b. Verify that no link is established.

Observable Results:

a) If the DUT supports a 100Base-T4 PMA, a link should be established. If not, a link should be refused.
b) INFORMATIVE: If the DUT supports a 100Base-T4 PMA, and the DUT's management allows 100Base-T4 advertisement to be disabled, then the DUT's management may also prevent the parallel detection of 100Base-T4.

Possible Problems: None.

GROUP 4: GENERIC MANAGEMENT LEVEL NEXT PAGE FUNCTIONALITY

Scope: The following tests cover generic auto-negotiation operation specific to the exchange of next pages.

Overview: These tests are designed to verify the device's management properly controls the next page exchange, regardless of the actual meaning of the next pages exchanged.

Test #4.1 Next Page Bit

Purpose: To verify that the device under test makes proper use of the next page bit throughout the next page exchange process.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.2.1.2.5, 28.2.3.4, 28.2.3.4.1, 28.2.3.4.2, 28.2.3.4.11

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: September 7, 1999

Discussion: During the exchange of next pages, the NP bit plays a simple role. It is to have the value 1 if a station has further next pages to transmit, and 0 if it is transmitting its last page of information. Once both a device and its link partner have transmitted all of their next pages, the next page process should end and a link should be established. If a device's partner finishes transmitting message or unformatted pages before the device and is sending out null pages, then the device should go directly from its last message or unformatted page to a link. If both devices transmit their last message or unformatted page at the same time, they should both go straight to a link and no null pages should be sent. This test is designed to verify that the device under test properly sets the NP bit throughout the next page process, and does not transmit any null pages if its link partner either finishes transmitting its message and unformatted pages before it or at the same time that it does.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the traffic generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

Part A: Send More Next Pages than DUT has to transmit

1. Use the Traffic Generator to send the DUT validly formed Base and Next Pages with NP=1 and proper toggle bit values. Continue sending new Next Pages until the DUT sets NP=0 in its outgoing Pages.
2. Send one additional Next Page with NP=1, followed by a final Next Page with NP=0.
3. Monitor the next pages transmitted by the DUT. Count the number ('n') of Next Pages (not FLPs) sent by the DUT.

Part B: Send same number of Next Pages as DUT has to transmit

4. Repeat step 1 above, but send 'n' Next Pages to the DUT (where 'n' is the value found in part a, the number of pages the DUT transmits), setting NP=0 in the final Next Page sent to the DUT.
5. Monitor the next pages transmitted by the DUT.

Part C: Send Fewer Next Pages than DUT has to transmit

6. Use the Traffic Generator to send the DUT validly formed Base and 'n' Next Pages. All Next Pages sent by the Traffic Generator should be Null Message pages with NP=0.
7. Monitor the next pages transmitted by the DUT.

Observable Results:

a. The DUT should keep the NP bit set in all but the last three Next Pages sent by the DUT.
b. The DUT should keep the NP bit set in all but the last Next Page sent by the DUT.
c. The DUT should keep the NP bit set in all but the last Next Page sent by the DUT.

Possible Problems: If the DUT does not desire a Next Page exchange, then this test cannot be performed.

Test #4.2: Null Message Page Generation

Purpose: To verify that the device under test transmits proper Null Message pages if it completes sending Message and Unformatted Pages before its link partner.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.3.4, 28.2.3.4.1, 28.2.3.4.7, 28.2.3.4.8, 28.2.3.4.11, Annex 28C, 28C.2

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: September 7, 1999

Discussion: Once a device has finished sending Message and Unformatted next pages, it is required to send Null Message pages until its link partner is done as well. A null page is defined as a Message Page that contains the null message code 0 0 0 0 0 0 0 0 0 0 1 (bits M[10:0]). This test is designed to verify that once the device under test completes its transmission of Message and Unformatted Pages, it sends out valid Null Message pages until its link partner is done as well. Alternatively, a device may solely transmit next pages containing Null Message codes. This would allow a device with no next page data to transmit to still receive next page information from it's link partner.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the traffic generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

Part A: Send More Next Pages than DUT has to transmit

1. Use the Traffic Generator to send the DUT validly formed Base and Next Pages with NP=1 and proper toggle bit values. Continue sending new Next Pages until the DUT sets NP=0 in its outgoing Pages.
2. Send one additional Next Page with NP=1, followed by a final Next Page with NP=0.
3. Monitor the next pages transmitted by the DUT. Count the number ('n') of Next Pages (not FLPs) sent by the DUT.

Part B: Send same number of Next Pages as DUT has to transmit

4. Repeat step 1 above, but send 'n' Next Pages to the DUT (where 'n' is the value found in part a, the number of pages the DUT transmits), setting NP=0 in the final Next Page sent to the DUT.
5. Monitor the next pages transmitted by the DUT.

Observable Results:

a. The DUT's last two next pages should contain validly formed Null Message Pages.

b. When both devices exchange the same number of Next Pages, there is no need to transmit Null Message Pages. However, if a device did do this, it would be considered acceptable (though wasteful) as long as the page sent by the DUT before the Null Message Page still had NP=1.

Test #4.3: Reception of Next Pages

Purpose: To verify that the device under test behaves acceptably upon receipt of message and unformatted pages, for both existing message codes as well as reserved.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.2.3.4, 28.2.3.4.1, 28.2.3.4.4, 28.2.3.4.7, 28.2.3.4.8, 28.2.3.4.9, 28.2.3.4.10, 28.2.3.4.11, Annex 28C

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: September 7, 1999

Discussion: A device supporting next page exchange should be capable of receiving a wide variety of next pages from its link partner. It should properly accept all sequences of message pages and unformatted pages that are attainable from the defined message code fields in Annex 28C. However, it should also be capable of receiving message and unformatted page combinations not yet defined by simply ignoring them. If defined and undefined combinations are mixed, the device should be able to recognize all of the message codes that are defined and ignore those that are not. Presently, there is no way of confirming whether a device ignores or accepts a next page, unless it prematurely restarts autonegotaition or reports an error on the reception of an undefined page.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the traffic generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Use the Traffic Generator to send the DUT validly formed Base and Next Pages with NP=1 and proper toggle bit values. The last page sent should have NP=0. Send the device the following sequence of next pages:
   a. An unformatted page followed by Message Code 2 followed by one Unformatted Page,
   b. Message Code 3 followed by two Unformatted Pages.
   c. Message Code 4 followed by one Unformatted Page. (Repeat 5 times, where the value encoded in the Unformatted page is incremented from 0 to 4. For these sequences, in the Base Page, the RF bit should be set)
   d. A message page containing an undefined encoding (#13) for the message code field followed by 3 unformatted pages followed by Message Code 5 followed by four Unformatted Pages
   e. Message Code 6 followed by four Unformatted pages.

f. Message Code 8 followed by two Unformatted Pages followed by Message Code 7 followed by two Unformated pages.

In all cases, if the link partner has not finished transmission of message and unformatted pages, transmit the appropriate number of null pages

2. Monitor the next pages transmitted by the DUT
3. Verify that the DUT concludes its next page exchange

Observable Results:

- The DUT should accept all defined combinations by properly concluding the exchange of next pages (NP=0 in last non-Null Message Page) and attempt to establish a highest common denominator link.
- The DUT should ignore the unformatted pages not preceded by Message Pages as well as undefined Message Codes.

Possible Problems: If the device does not desire a Next Page exchange then this test cannot be performed. Presently, there is no way of confirming whether a device ignores or accepts a next page, unless it prematurely restarts auto-negotiation or management reports an error.

GROUP 5: 1000BASE-T NEXT PAGE FUNCTIONALITY

Scope: The following tests cover auto-negotiation operation for specific to the exchange of next pages for 1000Base-T capable devices.

Overview: These tests are designed to verify the proper transmission and reception of 1000Base-T message and unformatted pages.

Test #5.1: 1000Base-T Message and Unformatted Page Transmission Order

Purpose: To verify that the 1000Base-T device under test transmits a properly formatted 1000Base-T Message Page immediately following the base page, followed immediately by two Unformatted Pages.

References:

[1] IEEE Std 802.3, 1998: 28.2.3.4.4, 28.2.3.4.7
[2] IEEE Std 802.3ab, 1999: 40.5.1.2, Annex 28C- 28C.10.

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: August 30, 1999

Discussion: 1000Base-T devices desiring to advertise 1000Base-T capabilities are required to send a 1000Base-T Message Page immediately following completion of the base page exchange (refer to 40.5.1.2). The Message Code Field in the message page should contain the value "8" and the message page bit (D13) should be set to logic one. This Message Page must be followed by 2 unformatted pages, though the content of the Unformatted Code Field is not investigated in this test, the message page bit (D13) should be set to logic zero in these pages.

This test verifies the transmission order of the pages sent from the DUT, the value of the message page bit in the transmitted pages, and the value of the Message Code Field in the Message Page.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the traffic generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Use the Traffic Generator to send enough FLPs to put the DUT through the Complete Acknowledge state, followed by enough null pages (with proper toggle bit values) to allow the DUT to transmit all of its next pages
2. Monitor the next pages transmitted by the DUT.

Observable Results:

- The DUT should transmit its Base Page, followed immediately by a Message Page, followed by two Unformatted Pages.
- The Message Code Field should be "8" in the Message Page sent before the Unformatted Pages.

- The MP bit (D13 the 14th of the 16 bits) should be set to 1 in the first next page and 0 in the second and third pages.

Possible Problems: None

Test #5.2 Content and Format of 1000Base-T UP1 and UP2

Purpose: To verify that the DUT transmits two properly encoded unformatted message pages after the 1000Base-T message page.

References:

[1] IEEE Std 802.3ab, 1999 Edition: Sections 40.5.1.2, Table 40-4

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: August 2, 1999

Discussion: Before two 1000Base-T devices can establish a link, a next page exchange must be accomplished, consisting of one message page and two unformatted pages. The content of these unformatted pages is defined in Table 40-4, which is partially printed here for convenience.

Bit	Bit Definition	Register Location
Page 1 (Unformatted Next Page)		
U10:U5	Reserved transmit as 0	GMII register 9.8 (MASTER/SLAVE Control Register)
U4	1000Base-T half duplex (1 = half duplex and 0 = no half duplex)	
U3	1000Base-T full duplex (1 = full duplex and 0 = no full duplex)	GMII register 9.9 (MASTER/SLAVE Control Register)
U2	1000Base-T port type bit (1 = multiport device and 0 = single port device)	GMII register 9.10 (MASTER/SLAVE Control Register)
U1	1000Base-T MASTER-SLAVE Manual Configuration value (1 = MASTER and 0 = SLAVE). This bit is ignored if 9.12 = 0.	GMII register 9.11 (MASTER/SLAVE Control Register)
U0	1000Base-T MASTER-SLAVE Manual Configuration Enable (1 = Manual Configuration Enable). This bit is intended to be used for manual selection in a particular MASTER-SLAVE mode and is to be used in conjunction with bit 9.11	GMII register 9.12 (MASTER/SLAVE Control Register)
Page 2 (Unformatted Next Page)		

U10	1000Base-T MASTER-SLAVE Seed Bit 10 (SB10) (MSB)	MASTER-SLAVE Seed Value (10:0)
U9	1000Base-T MASTER-SLAVE Seed Bit 9 (SB9)	
U8	1000Base-T MASTER-SLAVE Seed Bit 8 (SB8)	
U7	1000Base-T MASTER-SLAVE Seed Bit 7 (SB7)	
U6	1000Base-T MASTER-SLAVE Seed Bit 6 (SB6)	
U5	1000Base-T MASTER-SLAVE Seed Bit 5 (SB5)	
U4	1000Base-T MASTER-SLAVE Seed Bit 4 (SB4)	
U3	1000Base-T MASTER-SLAVE Seed Bit 3 (SB3)	
U2	1000Base-T MASTER-SLAVE Seed Bit 2 (SB2)	
U1	1000Base-T MASTER-SLAVE Seed Bit 1 (SB1)	
U0	1000Base-T MASTER-SLAVE Seed Bit 0 (SB0)	

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the traffic generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Provide a series of FLPs to the DUT such that it will proceed through the auto-negotiation process and transmit both 1000Base-T unformatted next pages.
3. Observe transmissions from the DUT
4. Repeat steps 1-3 several times

Observable Results:

a) The first Unformatted Page (UP1) should contain the proper encoding based on Table 40-4
b) The second Unformatted Page (UP2) should contain a random integer value based on Table 40-4. The DUT should change the value transmitted here each time the auto-negotiation process is completed.

Test #5.3: 1000Base-T Message Page Reception

Purpose: To verify that the device under test transmits properly formatted message and unformatted pages.

References:

[1] IEEE Std 802.3ab, 1999 Edition: Subclause 40.5.1.2, Table 40.4, Annex 28C.

Resource Requirements:

- Line Monitor: A system capable of detecting, time-stamping, and recording normal link pulses (NLPs) on both the receive and transmit channels of the DUT. The channel signaling should pass through the line monitor with minimal distortion.
- Traffic Generator: A system capable of generating and transmitting normal link pulses (NLPs) and fast link pulses (FLPs) while connected to the receiver of the DUT.

Last Modification: September 7, 1999

Discussion: When attempting to establish a 1000Base-T link using auto-negotiation, the transmitted Base Page must be followed immediately (refer to 40.5.1.2) by a 1000Base-T Message Page (Message Code #8), followed by two Unformatted Pages following the assignments of Table 40.4. Any deviation from this sequence of pages should result in a failure to resolve a 1000Base-T link (though non-1000Base-T abilities advertised, such as in the Base Page, may still be resolved). The one exception to this would be a tolerant device that can receive a 1000Base-T Message Page at any point in a next page exchange so long as two valid 1000Base-T Unformatted Pages follow it immediately, note however that this capability is not a standards based requirement.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the traffic generator's signaling will be seen by the DUT's receiver. Terminate the DUT's transmit channel with a 100Ω line termination.

Procedure:

1. Use the Traffic Generator to send enough FLPs with NP=1 to put the DUT through the Complete Acknowledge state, followed by one of the sequences below. NP=0 in the last page transmitted to the DUT. Repeat for all listed sequences.
   a. A Message Page with Message Code= 8, followed by two Unformatted Pages whose content conform to valid 1000Base-T UP1 and UP2 pages.
   b. An Unformatted Page, with Unformatted Code= 8, followed by two Unformatted Pages whose content conform to valid 1000Base-T UP1 and UP2 pages.
   c. A Message Page with Message Code= 7, followed by two Unformatted Pages whose content conform to valid 1000Base-T UP1 and UP2 pages.
   d. A Message Page with Message Code= 9, followed by two Unformatted Pages whose content conform to valid 1000Base-T UP1 and UP2 pages.
   e. A Message Page with Message Code= 8, followed by one Unformatted Pages whose content conforms to a valid 1000Base-T UP1 page.

f. A Message Page with Message Code=8, followed by a Message Page whose code field conforms to a valid 1000Base-T UP1 page, followed by a Unformatted page conforming to UP2.
g. A Message Page with Message Code=8 followed by two Message Pages whose content conforms to valid 1000Base-T UP1 and UP2 pages.
h. A Message Page with Message Code= 20, followed by two Unformatted Pages whose Unformatted Codes are all zero, followed by a Message page with Message Code= 8, followed by two Unformatted Pages whose content conform to valid 1000Base-T UP1 (with Manual_SLAVE indicated) and UP2 pages

In all cases, if the link partner has not finished transmission of message and unformatted pages, transmit the appropriate number of null pages

2. For all cases, monitor the next pages transmitted by the DUT

Observable Results:

a) A 1000Base-T link attempt should occur after sequence (a).
b) No 1000Base-T link attempt should occur after sequences (b) through (g).
c) INFORMATIVE: Case (h): A 1000Base-T link may be attempted upon receipt of a valid sequence of 1000Base-T Next Page sequence even though the 1000Base-T Message Page was not received immediately after the Base Page transmission.

Possible Problems: None.