University of New Hampshire InterOperability Laboratory
Ethernet Consortium

Superseded

As of July 2nd, 2001 the Ethernet Consortium Clause # 28 Auto Negotiation State Machine Base Page Exchange Conformance Test Suite version 4.0.3 has been superseded by the release of the Auto Negotiation State Machine Base Page Exchange Conformance Test Suite version 5.0. 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Please refer to the following site for both current and superseded test suites: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
&
GIGABIT ETHERNET

Clause 28 Auto-Negotiation
State Machine Test Suite

Technical Document

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MODIFICATION RECORD

- June 28, 2000 Version 4.0.3
  Jeremy Kent: Removed Next Page exchange tests.
- June 1, 2000 Version 4.0.2
  Lisa T. Beats: Removed all management register tests.
- January 13, 2000 Version 4.0.1
  Ben Schultz: Minor editorial changes to the Initial Release.
- November 4, 1999 Version 4.0.0 Initial Release:
  Bob Noseworthy: Improved procedures, additional Management tests, and minor editorial changes from draft release.
- September 10, 1999 Version 4 draft release
- May 5, 1999 Version 3.1 Released
  Modifications since last revision:
  Updated to IEEE Std 802.3 1998 Edition and changed test numbering to conform with system used in other test suites. New: Test 28.2.2

Test Group 1: FLP Burst Transmission
- Test #28.1.1 - Separation of FLP Bursts
- Test #28.1.2 - Internal Separation of FLP Bursts
- Test #28.1.3 - Transmitted Link Code Word (Base Page) Encoding
- Test #28.1.4 - NLP Compliance

Test Group 2: FLP Burst Reception
- Test #28.2.1 - Acknowledge Bit
- Test #28.2.2 - Transmit Disable State
- Test #28.2.3 - Behavior with Incomplete FLPs
- Test #28.2.4 - Acceptance of Long FLPs
- Test #28.2.5 - Next Page and Remote Fault Bits
- Test #28.2.6 - Selector Field Reserved Combinations
- Test #28.2.7 - Technology Ability Field Reserved Bits
- Test #28.2.8 - Range of NLP Timer
- Test #28.2.9 - Identification of Link Partner as Auto-Negotiation Able
- Test #28.2.10 - Range of FLP Pulse Timer
- Test #28.2.11 - Range of Data Detect Timer
- Test #28.2.12 - Consistency Match
- Test #28.2.13 - Range of Break Link Timer
- Test #28.2.14 - Range of Link Fail Inhibit Timer
- Test #28.2.15 - Complete Acknowledge

Test Group 3: Establishing a Link
- Test #28.3.1 - Range of Link Loss Timer
- Test #28.3.2 - Link Count Max
- Test #28.3.3 - Single Link Ready
- Test #28.3.4 - Range of Link Test Timers
- Test #28.3.5 - Range of Auto-Negotiation Wait Timer
- Test #28.3.6 - Link Integrity and RD Active
- Test #28.3.7 - Parallel Detection of 10Base-T Devices
- Test #28.3.8 - Parallel Detection of 100Base-TX Devices
- Test #28.3.9 - Parallel Detection of 100Base-T4 Devices
- Test #28.3.10 - Priority Resolution Function
- Test #28.3.11 - Failed Link for HCD

Test Group 4: Next Page Functionality
- Test #28.4.1 - Transmitted Next Pages
- Test #28.4.2 - Next Page Consistency Matchs
- Test #28.4.3 - Null Message Page
- Test #28.4.4 - Next Page Bit
- Test #28.4.5 - Toggle Bit
- Test #28.4.6 - Message and Unformatted Pages
- Test #28.4.7 - Reception of Next Pages
- Test #28.4.8 - Transmit Disable
- Test #28.4.9 - Priority Resolution Following Next Page Exchange

- September 17, 1997 Version 3.01 Released

  Modifications since last revision:

  Most improvements apply to testing Figure 28-17.

  Note test #7.28 was downgraded to informative due to the loose definition of the size of "Link Code Word"

  New: Tests #21.28, #22.28, #23.28, #25.28, #39.28

  Modified: Tests #3.28, #7.28, #24.28

  Test Group 1: FLP Burst Transmission
  - Test #1.28 - Separation of FLP Bursts
  - Test #2.28 - Internal Separation of FLP Bursts
  - Test #3.28 - Burst Content
  - Test #4.28 - NLP Compliance
  - Test #5.28 - Transmitted Link Code Word (Base Page) Encoding

  Test Group 2: FLP Burst Reception
  - Test #6.28 - Acknowledge Bit
  - Test #7.28 - Refusal of Incomplete FLPs
  - Test #8.28 - Acceptance of Long FLPs
  - Test #9.28 - Next Page and Remote Fault Bits
  - Test #10.28 - Selector Field Reserved Combinations
  - Test #11.28 - Technology Ability Field Reserved Bits
  - Test #12.28 - Range of NLP Timer
  - Test #13.28 - Identification of Link Partner as Auto-Negotiation Able
  - Test #14.28 - Range of FLP Pulse Timer
  - Test #15.28 - Range of Data Detect Timer
  - Test #16.28 - Consistency Match
  - Test #17.28 - Range of Break Link Timer
  - Test #18.28 - Range of Link Fail Inhibit Timer
  - Test #19.28 - Complete Acknowledge

  Test Group 3: Establishing a Link
  - Test #20.28 - Complete Acknowledge
  - Test #21.28 - Link Count Max
  - Test #22.28 - Single Link Ready
  - Test #23.28 - Range of Link Test Timers
  - Test #24.28 - Range of Auto-Negotiation Wait Timer
  - Test #25.28 - Link Integrity and RD Active
  - Test #26.28 - Parallel Detection of 10Base-T Devices
  - Test #27.28 - Parallel Detection of 100Base-TX Devices
  - Test #28.28 - Parallel Detection of 100Base-T4 Devices
  - Test #29.28 - Priority Resolution Function
  - Test #30.28 - Failed Link for HCD

  Test Group 4: Next Page Functionality
  - Test #31.28 - Transmitted Next Pages
  - Test #32.28 - Next Page Consistency Match
  - Test #33.28 - Null Message Page
  - Test #34.28 - Next Page Bit
  - Test #35.28 - Toggle Bit
  - Test #36.28 - Message and Unformatted Pages
  - Test #37.28 - Reception of Next Pages
  - Test #38.28 - Transmit Disable
  - Test #39.28 - Priority Resolution Following Next Page Exchange

- April 16, 1997 Version 2.0 Released

  Modifications since last revision:

  Defined tests for Next Page testing

  New: Tests #26.28, #27.28, #28.28, #29.28, #30.28. #31.28, #32.28, #33.28

Modified: Tests #9.28

Test Group 1: FLP Burst Transmission
- Test #1.28 - Separation of FLP Bursts
- Test #2.28 - Internal Separation of FLP Bursts
- Test #3.28 - Number of Pulses in a Burst
- Test #4.28 - NLP Compliance
- Test #5.28 - Transmitted Link Code Word (Base Page) Encoding

Test Group 2: FLP Burst Reception
- Test #6.28 - Acknowledge Bit
- Test #7.28 - Refusal of Incomplete FLPs
- Test #8.28 - Acceptance of Long FLPs
- Test #9.28 - Next Page and Remote Fault Bits
- Test #10.28 - Selector Field Reserved Combinations
- Test #11.28 - Technology Ability Field Reserved Bits
- Test #12.28 - Range of NLP Timer
- Test #13.28 - Identification of Link Partner as Auto-Negotiation Able
- Test #14.28 - Range of FLP Pulse Timer
- Test #15.28 - Range of Data Detect Timer
- Test #16.28 - Consistency Match
- Test #17.28 - Range of Break Link Timer
- Test #18.28 - Range of Link Fail Inhibit Timer
- Test #19.28 - Range of Auto-Negotiation Wait Timer

Test Group 3: Establishing a Link
- Test #20.28 - Complete Acknowledge
- Test #21.28 - Parallel Detection of 10Base-T Devices
- Test #22.28 - Parallel Detection of 100Base-TX Devices
- Test #23.28 - Parallel Detection of 100Base-T4 Devices
- Test #24.28 - Priority Resolution Function
- Test #25.28 - Failed Link for HCD

Test Group 4: Next Page Functionality
- Test #26.28 - Transmitted Next Pages
- Test #27.28 - Next Page Consistency Matchs
- Test #28.28 - Null Message Page
- Test #29.28 - Next Page Bit
- Test #30.28 - Toggle Bit
- Test #31.28 - Message and Unformatted Pages
- Test #32.28 - Reception of Next Pages
- Test #33.28 - Transmit Disable

- January 7, 1997 Version 1.1 Released

Modifications since last revision:

Concatenated group 2 from Version 1.0 into test #5.28
Massive renumbering of tests and groups.
New: Tests #16.28, #17.28, #18.28, #19.28
Modified: Tests #5.28

Test Group 1: FLP Burst Transmission
- Test #1.28 - Separation of FLP Bursts
- Test #2.28 - Internal Separation of FLP Bursts
- Test #3.28 - Number of Pulses in a Burst
- Test #4.28 - NLP Compliance
- Test #5.28 - Transmitted Link Code Word (Base Page) Encoding

Test Group 2: FLP Burst Reception
- Test #6.28 - Acknowledge Bit
- Test #7.28 - Refusal of Incomplete FLPs
- Test #8.28 - Acceptance of Long FLPs
- Test #9.28 - Next Page Bit
- Test #10.28 - Selector Field Reserved Combinations
- Test #11.28 - Technology Ability Field Reserved Bits
- Test #12.28 - Range of NLP Timer
- Test #13.28 - Identification of Link Partner as Auto-Negotiation Able
- Test #14.28 - Range of FLP Pulse Timer
- Test #15.28 - Range of Data Detect Timer

Test #16.28 - Consistency Match
Test #17.28 - Range of Break Link Timer
Test #18.28 - Range of Link Fail Inhibit Timer
Test #19.28 - Range of Auto-Negotiation Wait Timer
Test Group 3: Establishing a Link
Test #20.28 - Complete Acknowledge
Test #21.28 - Parallel Detection of 10Base-T Devices
Test #22.28 - Parallel Detection of 100Base-TX Devices
Test #23.28 - Parallel Detection of 100Base-T4 Devices
Test #24.28 - Priority Resolution Function
Test #25.28 - Failed Link for HCD

- October 14, 1996 Version 1.0 Released

Initial Release
Test Group 1: Transmitted FLP Burst Composition
Test #1.28 - Separation of FLP Bursts
Test #2.28 - Internal Separation of FLP Bursts
Test #3.28 - Number of Pulses in a Burst
Test #4.28 - NLP Compliance
Test Group 2: Transmitted Link Code Word (Base Page) Encoding
Test #5.28 - Transmitted Selector Field Combination
Test #6.28 - Transmitted Technology Ability Field
Test #7.28 - Remote Fault, Acknowledge, and Next Page Bits
Test Group 3: FLP Burst Reception
Test #8.28 - Acknowledge Bit
Test #9.28 - Refusal of Incomplete FLPs
Test #10.28 - Acceptance of Long FLPs
Test #11.28 - Range of NLP Timer
Test #12.28 - Range of FLP Pulse Timer
Test #13.28 - Identification of Link Partner as Auto-Negotiation Able
Test #14.28 - Range of Data Detect Timer
Test #15.28 - Next Page Bit
Test #16.28 - Technology Ability Field Reserved Bits
Test #17.28 - Selector Field Reserved Combinations
Test Group 4: Establishing a Link
Test #18.28 - Complete Acknowledge
Test #19.28 - Parallel Detection of 10Base-T Devices
Test #20.28 - Parallel Detection of 100Base-TX Devices
Test #21.28 - Parallel Detection of 100Base-T4 Devices
Test #22.28 - Priority Resolution Function
Test #23.28 - Failed Link for HCD

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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. 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.

TABLE OF CONTENTS

GROUP 1: BASE PAGE TRANSMISSION

Scope: The following tests cover Auto-Negotiation operation specific to the transmission of Base Pages.

Overview: These tests are designed to verify that the device under tests transmits acceptable normal link pulses (NLPs), which are properly spaced, forming FLPs with acceptable content making up the Base Page transmitted by the device.

Test #28.1.1: Transmit Link Burst Timer

Purpose: To verify proper separation of consecutive fast link pulse (FLP) bursts.

References:

[1] IEEE Std 802.3, 1998 Edition: Subclause 28.3.2, Table 28-8, Figure 28-14 Transmit state diagram.

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: July 28, 1999

Discussion: A station capable of Auto-Negotiation must transmit fast link pulse (FLP) bursts. Not only is the content and composition of these bursts important, but also the timing of the bursts. This test is designed to verify that the timing of the device under test's consecutive FLP bursts fall within the specified range of 5.7-22.3ms.

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 separation of each burst is measured from the last NLP sent in an FLP to the first NLP sent in the next FLP.

Observable Results:

The separation of FLP bursts from the last NLP in an FLP to the first NLP in the next FLP must be within the range of be 14 ± 8.3 ms.

Possible Problems: None.

Test #28.1.2: Interval Timer

Purpose: To verify that the device under test (DUT) transmits FLPs with valid pulse separation.

References:

[1] IEEE Std 802.3, 1998 Edition: Subclause 28.3.2, Table 28-8, Figure 28-14 Transmit state diagram.

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: July 8, 1999

Discussion: To ensure that the content of an FLP burst is interpreted accurately, the individual pulses that make up the burst must be analyzed. This test is designed to verify that the device under test sends FLP bursts whose clock and data pulses are spaced properly. This spacing is governed by the Interval Timer, which is defined to be within the range of 55.5us to 69.5us.

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 spacing between data/clock NLPs within an FLP is measured.

Observable Results:

- For data zeros, the spacing between clock pulses should be 125±14 us
- For data ones, the spacing from the clock to the data pulse, and from the data pulse to the clock pulse, should be 62.5±7 us.

Possible Problems: None.

Test #28.1.3: Transmit Link Code Word (Base Page) Encoding

Purpose: To verify that the device under test (DUT) transmits valid base page data.

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: July 27, 1999

Discussion: This test is designed to verify that the device under test transmits Link Code Words with acceptable content. There are defined selector field combinations that a station is permitted to transmit in its Link Code Word. The technology ability field of the Link Code Word advertises a station's abilities. The final three bits in the Link Code Word (Remote Fault bit, Acknowledge bit, Next Page bit) should all have a proper initial setting. The default value for the RF bit on a non-faulting link is zero. The Ack bit should be initially zero. The NP bit should be one if it supports Next Page exchange and zero if it doesn't or does not wish to implement a NP exchange. In this test, it is confirmed that the device under test transmits a Link Code Word with the selector field combination corresponding to IEEE 802.3, advertises the data service abilities that it supports in its technology ability field, and has the RF, Ack, and NP bits set correctly.

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 number of pulses and the data present in several bursts is observed
4. The contents of the selector field (first five data bits), technology ability field (D[5:12]), and of the Remote Fault bit, Acknowledge bit, and Next Page bit are acquired

Observable Results:

- The number of pulses in a burst should be 19-33 (inclusive)
- The selector field combination should correspond to S[4:0]=00001 as defined in table 28-9
- The technology ability field should advertise the proper abilities as indicated in table 28-10
- The DUT should not advertise any abilities that it does not possess
- The initial value of the Remote Fault bit should be zero
- The initial value of the Acknowledge bit should be zero
- The value of the Next Page bit should be one if it supports Next Page exchange and zero if it doesn't or does not wish to implement a NP exchange

Possible Problems: None.

Test #28.1.4: NLP Compliance

Purpose: To verify the device under test's link pulse waveforms meet specification.

References:

[1] IEEE Std 802.3, 1998 Edition Sections 14.3.1.2.1, Figure 14-12, 28.1.4.1, 28.2.1.1, 28.4
[2] IEEE Std 1802.3d-1993 Sections 6.3.4.8, 6.3.4.9

Resource Requirements:

- Oscilloscope: A digitizing signal analyzer which meets or exceeds the specifications for an oscilloscope as defined in IEEE Std 1802.3d-1993 Section 6.3.4.8
- Differential Voltage Probes: Meets or exceeds specifications defined in IEEE Std 1802.3d-1993 Section 6.3.4.9
- TP Test Card: A testing card with an RJ-45 interface with cable termination of Test Load 1, or Test Load 2 (as defined in IEEE 802.3 Section 14.3.1.2.1 and Figure 14-11) and an Unshielded twisted pair model (as defined in IEEE Std 802.3 Section 14.3.1.2) which can be inserted inline.

Last Modification: July 27, 1999

Discussion: All link pulses need to conform to the transmitter waveform specifications for Link Test Pulses defined in IEEE 802.3 Figure 14-12, including those contained in an FLP burst. This test is designed to verify that the device under test produces link pulses within specification.

Test Setup: Using Category 5 UTP cable, connect the DUT to the TP Test Card. Connect the Oscilloscope to the TP Test Card using Differential Voltage Probes.

Procedure:

1. The DUT is configured to send FLP bursts
2. Monitor the transmitted bursts
3. Observe the link pulse waveforms across each test load defined in fig. 14-11
4. Repeat procedure with loads connected through the twisted pair model (TPM).

Observable Results:

- Under each test setup, the FLP's link pulses should fit within the NLP template defined in Figure 14-12.
- After the differential output voltage drops below -50 mV, it shall remain below +50 mV.

Possible Problems: None.

Test #28.1.5: Break Link Timer

Purpose: To verify that the DUT ceases transmission within the acceptable range.

References:
[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.2, 28.3

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) while connected to the receiver of the DUT.

Last Modification: August 27, 1999

Discussion: Once a device has entered the TRANSMIT DISABLE state, it must wait a specified amount of time before it restarts the Auto-Negotiation process. This time is defined by the device's "break_link_timer," and is required to be between 1200 and 1500 ms. This test is designed to verify that the device under test restarts the Auto-Negotiation process after entering the TRANSMIT DISABLE state within this range.

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. Use the Traffic Generator to put the DUT in the ACKNOWLEDGE DETECT state. Send a series of 20 identical, validly formed FLP bursts without the ACK bit set. Once reception of the FLP bursts cease, the DUT should enter the TRANSMIT DISABLE state.
3. Verify that the DUT restarts Auto-Negotiation.
4. Measure the amount of time between when the DUT ceased FLP transmission (upon entry of the TRANSMIT DISABLE state) and when the first FLP of the re-negotiation process was transmitted. This time will be the value of break_link_timer plus any additional gap due to partial completion of an FLP's transmit_link_burst_timer.
5. Repeat steps 2 thru 4 several times.

Observable Results:

- Assuming a fixed value for the implemented break_link_timer, the minimum of the observed gaps is the DUT's break_link_timer, which should be in the range of 1200 to 1500 ms

Possible Problems: If the DUT fails to enter the ACKNOWLEDGE DETECT state, the number of FLPs sent may need to be increased (see 28.2.1 Ability Match) or the encoding of the FLPs may need to be altered. If the DUT does not restart Auto-Negotiation due to a flp_receive_idle=true while in ACKNOWLEDGE DETECT, then a consistency match error could be sent to the DUT to try to cause an Auto-Negotiation restart (see 28.2.3 Consistency Match). Else, resetting the DUT's phy and/or restarting Auto-Negotiation via management should also produce a break_link_timer gap, measurable via the techniques outlined above.

Test #28.1.6: Link Fail Inhibit Timer

Purpose: To verify that the device under test will wait a specified amount of time between when it parallel detects a link partner and when it establishes that link.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.2, 28.3

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) while connected to the receiver of the DUT.

Last Modification: July 27, 1999

Discussion: Once a device has entered the FLP LINK GOOD CHECK state, it must receive a link_status=OK message from its link partner within a specified amount of time. If this message is not received, it will enter the TRANSMIT DISABLE state and wait for the duration of its break_link_timer before starting a re-negotiation. This time is defined by the device's "link_fail_inhibit_timer," and is required to be between 750 and 1000 ms. This test is designed to verify that the device under test enters the TRANSMIT DISABLE state from the FLP LINK GOOD CHECK state when a link_status=OK message is not received from its link partner in the acceptable range of time.

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 – for devices with a 10Base-T PMA:

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to put the device into the FLP LINK GOOD CHECK state and resolve a 10Base-T link by sending enough FLPs that advertise only 10Base-T abilities.
3. Verify that the DUT restarts Auto-Negotiation.
4. Measure the amount of time NLPs are sent from the DUT and verify it is link_fail_inhibit_timer.

Part B:

5. Repeat steps 1-3 above, changing the advertised abilities to include 100Base-TX abilities.
6. Measure the amount of time between when the station transmitted it's final FLP after entering the COMPLETE ACKNOWLEDGE state and when the first FLP of the renogotiation process was transmitted. This will be the value of break_link_timer + link_fail_inhibit_timer plus any additional gap due to partial completion of an FLP's transmit_link_burst_timer.

7. Subtract the value of break_link_timer (see results of test #28.1.5) from the minimum observed value to acquire the value of link_fail_inhibit_timer

Observable Results:

- All observations of the DUT's link_fail_inhibit_timer should be in the range of 750 to 1000 ms

Possible Problems: None.

Test #28.1.7: Remote Fault Bit

Purpose: To verify that if the DUT implements the Remote Fault function, that the DUT properly sets the remote fault bit in its Link Code Word and keeps the remote fault bit set until the COMPLETE ACKNOWLEDGE state has been reached.

References:
[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.3.5

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.
- 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 29, 1999

Discussion: A device that elects to support the Remote Fault function must not reset the RF encoding until the device transitions to the COMPLETE ACKNOWLEDGE state during base page exchange, thus ensuring that the link partner receives the fault indication. This test observes the device's transmitted RF bits when signaling a remote fault, in order to determine if the device continues sending the RF code until the COMPLETE ACKNOWLEDGE state is entered.

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. If the DUT supports the indication of a remote fault, then cause the DUT to indicate a remote fault by any means, else this test cannot be performed.
2. Verify that the DUT is sending a Link Code Word with the Remote Fault bit set.
3. Send the DUT a series of FLPs such that the DUT should obtain an ability match (see test 28.2.2)
4. Observe transmissions from the DUT
5. Repeat steps 3-4 but send the DUT enough FLPs to obtain both an ability match and an acknowledge match.
6. Observe transmissions from the DUT

Observable Results:
- In part 2, the DUT should have the Remote Fault bit set in all FLPs that are transmitted
- In part 4, the DUT should have the Remote Fault bit set when it sends FLPs with the ACK bit set, and when the DUT restarts Auto-Negotiation, the Remote Fault bit should still be set.
- In part 6, when the DUT restarts Auto-Negotiation, the Remote Fault bit should not be set

Possible Problems: None.

Test #28.1.8: Failed Link for HCD

Purpose: To verify that the device under test starts a re-negotiation upon the reception of a link_status=FAIL from the resolved highest common denominator (HCD) technology.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.3.2

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) 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: January 13, 2000

Discussion: Once the highest common denominator (HCD) technology has been determined through the parallel detection function, if a station receives a link_status=FAIL message from that priority, it should cause a re-negotiation. This test is designed to verify that the device under test does start a re-negotiation upon the receipt of a link_status=FAIL message from the HCD technology.

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 a series of FLP bursts that advertise a set of abilities compatible with the DUT.
2. Verify the DUT resolves the HCD and establishes a link
3. Break the link to the Traffic Generator, leaving the Line Monitor attached to the DUT, thus causing the DUT to see a link_status=FAIL for the HCD link.
4. Verify that the DUT starts a re-negotiation

Observable Results:

- Upon reception of the link_status=FAIL message, the DUT should disable all transmission for approximately break_link_timer and restart Auto-Negotiation.

Possible Problems: None.

GROUP 2: BASE PAGE RECEPTION

Scope: The following tests cover Auto-Negotiation operation specific to the reception of Base Pages.

Overview: These tests are designed to verify that the device under tests reacts properly to the receipt of both valid and invalid fast link pulse (FLP) bursts.

Test #28.2.1: Ability Match

Purpose: To verify that the device under test enters the ACKNOWLEDGE DETECT state upon reception of complete, consecutive and consistent FLP bursts, ignoring the value of the Acknowledge bit.

References:
[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.1.4.2, 28.2.1.2.4

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: January 13, 2000

Discussion: Once an auto-negotiating device identifies its link partner as Auto-Negotiation able, it will enter the ACKNOWLEDGE DETECT state only after it receives at least 3 complete, consecutive and consistent Link Code Words from its link partner, ignoring the Acknowledge bit. Once the ACKNOWLEDGE DETECT state is entered, the station should send out FLP bursts containing its Link Code Word with the Acknowledge bit (the fifteenth data pulse) set to logic one. This test is designed to verify that the device under test will set the Acknowledge bit after the reception of 3 or more complete, consecutive and consistent Link Code Words.

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:
1. Use the Traffic Generator to send 1 FLP to the DUT.
2. Monitor the FLPs sent back by the DUT and determine whether the Acknowledge bit is set
3. If it was not set, repeat the procedure with an increasing number (n) of FLPs until the Acknowledge bit is set.
4. Send (n) FLPs to DUT all with the Acknowledge bit set to a logic one. Where (n) is the minimum number of FLPs determined in step 3 to put the DUT in the ACKNOWLEDGE DETECT state.
5. Repeat step 4 using FLPs that have Acknowledge bits that alternate between 1 and 0.

Part B:
6. Use the Traffic Generator to send (n) FLPs, alternating between an initial FLP and a valid FLP containing different advertised abilities, such that the number of FLPs would be enough to put the station into the ACKNOWLEDGE DETECT state
7. Monitor the FLPs sent back by the DUT and determine whether the Acknowledge bit is set

8. Repeat steps 6-7 by sending all combinations of FLPs that are one bit different than the initial FLP

Part C:

9. Send a series of FLPs designed to put the DUT in the ACKNOWLEDGE DETECT State.
10. Monitor the FLPs sent from the DUT after returning to the ABILITY DETECT state and determine whether the Acknowledge bit is set

Observable Results:

a) The Acknowledge bit should be set after the reception of at least 4 complete and matching FLPs, regardless of the value of the Acknowledge bit. Record the number of FLPs required to put the DUT into the ACKNOWLEDGE DETECT state for use in later tests
b) The DUT should not enter the ACKNOWLEDGE DETECT state and thus the Acknowledge bit should never be set.
c) Upon returning to the ABILITY DETECT state, the DUT should reset to its default base page and send FLPs without the Acknowledge Bit set

Possible Problems: None.

Test #28.2.2: Acknowledge Match

Purpose: To verify that the device under test enters the COMPLETE ACKNOWLEDGE state only after receiving 3 consecutive and consistent FLPs with the Acknowledge bit set.

References:
[1] IEEE Std 802.3, 1998 Edition: Section 28.2.1.2.4

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: September 29, 1999

Discussion: Well into the Auto-Negotiation process is the COMPLETE ACKNOWLEDGE state. A station reaches this state after first entering the ACKNOWLEDGE DETECT state (which is done when at least 3 complete, consecutive and consistent FLP bursts are received, ignoring the Acknowledge bit, - see Test #28.4.1), and then receiving 3 complete, consecutive and consistent FLPs with the Acknowledge bit set. This test is designed to verify that the device under test requires the reception of 3 consecutive and consistent FLPs with the Acknowledge bit set before doing entering the COMPLETE ACKNOWLEDGE state.

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:
1. Use the Traffic Generator to send a series of (n) FLPs with the Acknowledge bit not set followed by (m) FLPs with the Acknowledge bit set to logic one but otherwise identical to the initial FLPs. Where (n) is the value found in test #28.2.1 to cause the DUT to enter the ACKNOWLEDGE DETECT state. (m) is initially set to one.
2. Observe transmissions from the DUT.
3. Repeat steps 1-2 increasing (m), until the DUT is observed to enter into the COMPLETE ACKNOWLEDGE state.

Part B:

4. Use the Traffic Generator to send two groups of FLPs. The first group consists of (n) FLPs with the Acknowledge bit not set. The second group consists of (2m) FLPs which alternate between FLPs which are identical to the first group, and FLPs which are one bit different from the first group, but all FLPs in this group have the Acknowledge bit set.
5. Repeat step 4 using all one bit different FLPs.

Observable Results:

a) The DUT should enter the COMPLETE ACKNOWLEDGE state after receiving three FLPs with the Acknowledge bit set to logic one.
b) The DUT should never enter the COMPLETE ACKNOWLEDGE state, and should send out FLPs with the Acknowledge bit set until nlp_test_max_timer expires. Following the FLPs should be a gap of 'break_link_timer' until FLP transmission resumes.

Note: Observing if the DUT has previously entered the COMPLETE ACKNOWLEDGE state can be most easily accomplished by any of three methods. By observing the transmission of a Next Page, if a Next Page exchange is required. By observing the transmission of the highest common denominator link signaling, if a link is to be established. Or timing the cessation of FLP transmission to the resumption of FLP transmission if a link is to be established, but no link signaling is provided to the DUT. In this last case, the gap should be link_fail_inhibit_timer + break_link_timer.

Possible Problems: None.

Test #28.2.3: Consistency Match

Purpose: To verify that the device under test performs a consistency match test on received FLPs.

References:
[1] IEEE Std 802.3, 1998 Edition: Section 28.3.1

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 29, 1999

Discussion: Upon entering the ACKNOWLEDGE DETECT state of the Auto-Negotiation process, a device must receive 3 consecutive and consistent FLPs from its link partner before it can proceed. However, these FLPs must not only be consistent amongst themselves, but also with the FLPs that the device received to put it into the ACKNOWLEDGE DETECT state. To ensure this, a station must perform a consistency match test. If a consistency mismatch occurs, the device should enter the TRANSMIT DISABLE state and cease sending FLPs. This test is designed to verify that the device under test checks to be sure that the FLPs received in the ACKNOWLEDGE DETECT state are consistent (ignoring the Acknowledge bit) with the FLPs that it received to get it there.

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:
1. Use the Traffic Generator to send two groups of FLPs. The first group consists of (n) FLPs with the Acknowledge bit not set. The second group consists of (m) FLPs are one bit different from the first group, but all FLPs in this group have the Acknowledge bit set. Where (n) is the value found in test #28.2.1 to cause the DUT to enter the ACKNOWLEDGE DETECT state. And where (m) is the value found in test #28.2.2.
2. Monitor the transmit line coming from the DUT
3. Repeat steps 1-2 toggling all bits of the FLPs, except the ACK bit.

Part B: Minimum number of FLPs to complete Auto-Negotiation
4. Use the Traffic Generator to send (n) FLPs all with the Acknowledge bit set. Where (n) is the value found in test #28.2.1 to cause the DUT to enter the ACKNOWLEDGE DETECT state.
5. Monitor the transmit line coming from the DUT.

6. Repeat steps 4-5 increasing the number of FLPs sent until the DUT is observed to enter the COMPLETE ACKNOWLEDGE state.

Observable Results:

a) The DUT should cease transmitting FLPs once the inconsistent FLPs are received
b) The DUT should enter COMPLETE ACKNOWLEDGE after reception of 4 or 5 FLPs with the ACK bit set.

Possible Problems: None

Test #28.2.4: Complete Acknowledge

Purpose: To verify that the device under test sends out a valid number of Link Code Words after the COMPLETE ACKNOWLEDGE state has been entered.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.1.2.4, 28.3.1, 28.3.4 Figure 28-16

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 23, 1999

Discussion: Well into the Auto-Negotiation process is the COMPLETE ACKNOWLEDGE state. A station reaches this state after first entering the ACKNOWLEDGE DETECT state (which is done when at least 3 complete, consecutive and consistent FLP bursts are received, ignoring the Acknowledge bit- see Test #6.28), and then receiving 3 complete, consecutive and consistent FLPs with the Acknowledge bit set. Once the COMPLETE ACKNOWLEDGE state has been entered, a station should send out 6 to 8 (inclusive) more FLPs containing its Link Code Word and with the Acknowledge bit set to 1. This test is designed to verify that the device under test sends out 6 to 8 (inclusive) FLPs after entering the COMPLETE ACKNOWLEDGE state.

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. Use the Traffic Generator to send a series of FLPs- first some with the Acknowledge bit not set (enough to put the DUT into the Acknowledge Detect state- refer to results of test #28.2.1) followed by 3 with the Acknowledge bit set to logic one, to put the DUT into the COMPLETE ACKNOWLEDGE state
3. Monitor the transmit line coming from the DUT and count the number of FLPs sent by the DUT after the COMPLETE ACKNOWLEDGE state has been entered

Observable Results:

- After COMPLETE ACKNOWLEDGE state has been entered, the DUT should send out 6 to 8 (inclusive) FLPs containing its Link Code Word. Following the FLPs should be a gap of link_fail_inhibit_timer + break_link_timer until FLP transmission resumes.

Possible Problems: None

Test #28.2.5: Behavior with Incomplete FLPs

Purpose: To observe the device under test's behavior upon receipt of incomplete FLP bursts.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.3.1 & Figures 28-7, 28-15 Receive state diagram

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: January 13, 2000

Discussion: This test identifies how a given implementation chooses to handle FLPs with less than 16 data positions. While Figure 28-15 'Receive state diagram', will accept incomplete FLPs without error, a difficulty in interpretation lies with the definition of 'ability_match' in 28.3.1. Here it is stated that the Acknowledge bit will be set upon reception of three matching consecutive Link Code Words. While section 28.2.1.2 and Figure 28-7 'Base page encoding' suggest a Link Code Word is 16 bits, this is not stated explicitly. Thus, if one interprets a Link Code Word to be 16 bits (or greater, refer to #28.2.6), then any FLP containing less than 16 data positions would be ignored as such a short FLP would not be used in the ability_match function. Alternatively, if a Link Code Word is interpreted to mean any length bit-vector, then any short/incomplete FLP must be used in an ability_match. This would allow for the possibility of ability_match being set to true upon receipt of three matching consecutive, but short, FLPs. While such a scenario would undoubtedly present problems, the likelihood seems small. A benefit gained through such an approach may be increased robustness as incomplete FLPs resulting from error conditions and/or line noise will not be ignored by the auto-negotiating device, as is the case in the first case.

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:

1. Establish a connection (not a link) to the DUT.
2. Use a Traffic Generator to send the DUT enough incomplete FLPs, consisting of only 9 clock pulses and spaced so that the time to send all four FLPs is larger than nlp_test_max_timer, to put the DUT into the ACKNOWELDGE DETECT state. (see test #28.2.1)
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state.

Part B: (informative)

4. Establish a connection (not a link) to the DUT
5. Use a Traffic Generator to send the DUT enough incomplete FLPs consisting of only 10 data bits to put the DUT into the ACKNOWLEDGE DETECT state (see test #28.2.1)
6. Observe whether the DUT entered the ACKNOWLEDGE DETECT state
7. Repeat steps 4-6, incrementing the number of data bits until the DUT is observed to enter the ACKNOWLEDGE DETECT state.

Part C:

8. Establish a connection (not a link) to the DUT
9. Use a Traffic Generator to send the DUT a series of the following 2 FLPs alternating at 16 ms apart: a 17 pulse FLP containing the following data: 1 1 0 0 0 1 1 1 1 1 with no clock pulse after the final 1 an 8 pulse FLP containing the following data: 0 0 0 0 1 0 with a final clock pulse
10. Observe whether the DUT entered the Acknowledge Detect state

Observable Results:

a) The DUT should not enter the ACKNOWLEDGE DETECT state.
b) As mentioned in the discussion above, a DUT may or may not enter the ACKNOWLEDGE DETECT state when the number of data bits is less than 16, corresponding to 17 clock pulses. The number of clock pulses at which the DUT enters the ACKNOWLEDGE DETECT state is the rx_bit_cnt_check value. This value needs to lie between 10 and 17.
c) The DUT should not enter the ACKNOWLEDGE DETECT state.

Possible Problems: None

Test #28.2.6: Acceptance of Long FLPs

Purpose: To verify that the device under test properly accepts FLPs that have more than 16 data positions by ignoring all but the first 16 data bits.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.2, 28.2.2.1, 28.3.3 (Rx_bit_cnt), Figure 28-15 Receive state diagram

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: January 13, 2000

Discussion: An FLP burst normally consists of 17 to 33 pulses, with normally 16 data bits. However, if a device receives an FLP with more than 16 data positions, it should still accept the burst. The first 16 data bits should be kept and any additional should be ignored. This test is designed to determine whether the Device Under Test properly accepts FLPs with more than 16 data bits.

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:

1. Use a Traffic Generator to send enough valid FLPs with 1 extra data position corresponding to a '1' (1 extra clock pulse and 1 data pulses) attached to the end to put the DUT into the Acknowledge Detect state (see #28.2.1).
2. Observe whether the DUT enters the ACKNOWLEDGE DETECT state.

Part B:

3. Repeat steps 1 and 2 above, sending 5 additional data bits corresponding to 10001.

Observable Results:

- The DUT should enter the ACKNOWLEDGE DETECT state in both cases

Possible Problems: None

Test #28.2.7: Next Page and Remote Fault Bits

Purpose: To verify that the device under test can handle the reception of an FLP from a Next Page capable device as well as the reception of a flagged remote fault bit.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.2.1.2.3, 28.2.1.2.5, 28.2.3.4, 28.2.3.5

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.
- 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: July 27, 1999

Discussion: When a station is connected to a Next Page able device, it will receive FLP bursts with set Next Page bits (the final bit of the Link Code Words set to logic one). Regardless of whether the receiving station is Next Page able or not, it should still accept the Link Code Word as valid. When connected to any station, it is possible for a device to receive a logic one in the Remote Fault (RF) bit position (bit D13) of the Link Code Word. If a device supports the remote fault function, the only defined behavior is to set the remote fault bit in the MII status register. Other than that, there is no specification as to what action a device should take upon reception of a remote fault. This test is designed to verify that the device under test is capable of receiving a flagged Next Page and/or remote fault bit.

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:

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to send enough FLPs with the Next Page bit set to a logic one to put it into the COMPLETE ACKNOWLEDGE state (see tests #28.2.1 Ability Match and #28.2.2 Acknowledge Match)
3. Verify that the DUT enters the COMPLETE ACKNOWLEDGE state

Part B:

4. Repeat with FLPs with the remote fault bit set to a logic one

Observable Results:

a) The DUT should enter the COMPLETE ACKNOWLEDGE state

b) The DUT should enter the COMPLETE ACKNOWLEDGE state. If the DUT supports the remote fault function, then the DUT should set the remote fault bit in its MII status register, and any other behavior is unpredictable

Possible Problems: None

Test #28.2.8: Selector Field Combinations

Purpose: To verify that the device under test accepts FLPs with the selector field set to a reserved combination or to the defined Isochronous Ethernet combination.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.2.1.2.1, 28.3.1, Annex 28A, 28B, 28B.1

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: January 13, 2000

Discussion: There are combinations for the selector field that are reserved by the IEEE. A station is never supposed to transmit these combinations, but there are no specifications as to the combinations that can be received. Therefore, as long as complete and consistent Link Code Words are received, a station should accept them as valid regardless of the selector field combination. This test is designed to verify that the device under test will accept a Link Code Word with the selector field set to a reserved combination. A second Selector Field combination has been defined as Isochronous Ethernet (0,1,0,0,0).

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: ACKNOWLEDGE DETECT with different selector field combinations

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to send enough FLPs with the selector field combination of 0,0,1,1,1 (ordered bit S0 to S4) to put it into the ACKNOWLEDGE DETECT state (see test #28.2.1)
3. Verify that the DUT enters the ACKNOWLEDGE DETECT state
4. Repeat steps 2 and 3 changing the selector field combination to 0,1,0,0,0

Part B: COMPLETE ACKNOWLEDGE with different selector field combinations

5. Use the Traffic Generator to send enough FLPs with the selector field combination of 0,0,1,1,1 (ordered bit S0 to S4) with the ACK bit set to put it into the COMPLETE ACKNOWLEDGE state (see test #28.2.1)
6. Repeat step 5 changing the selector field combination to 0,1,0,0,0

Observable Results:

a) The DUT should enter the ACKNOWLEDGE DETECT state.
b) The DUT should enter the COMPLETE ACKNOWLEDGE state.

Possible Problems: None

Test #28.2.9: Technology Ability Field Bits

Purpose: To verify that the device under test accepts FLPs with different combinations of the technology ability field bits set to logic one.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.2.1.2.2, 28.2.3.3, Annex 28B.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: January 13, 2000

Discussion: The technology ability field contains eight bits that indicate supported technologies specific to the selector field value. Bits A0:A4 are encoded as 10Base-T, 10Base-T full duplex, 100Base-Tx, 100Base-Tx full fuplex, 100Base-T4, and Pause operation for full duplex links, respectively. The last three bits of the technology ability field of a Link Code Word are reserved by the IEEE. A station is supposed to transmit these bits as logic zero. Regardless of what abilities a device advertises, it is supposed to be able to receive any of the technology ability field bits set to a one without a problem. This test is designed to verify that the device under test will accept a Link Code Word with various combinations of the technology ability field set to logic one.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to send enough FLPs with bit A0 set to logic one to put it into the ACKNOWLEDGE DETECT state (see test #28.2.1)
3. Verify that the DUT enters the ACKNOWLEDGE DETECT state
4. Repeat steps 1-3 but send FLPs encoded with bit combinations set to logic one including A1, A2, A3, and A4.

Observable Results:

- The DUT should enter the ACKNOWLEDGE DETECT state regardless of the received value of the technology ability field bits.

Possible Problems: None

Test #28.2.10: Identification of Link Partner as Auto-Negotiation Able

Purpose: To verify that the device under test is able to recognize its link partner as capable of Auto-Negotiation within specification.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.2.2.1, Figure 28-15, Receive state diagram.

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: January 13, 2000

Discussion: When establishing a link, a station is required to recognize its link partner as Auto-Negotiation able within a certain range of pulses in an FLP burst. This test is designed to verify that the device under test adheres to this range. As determined from the Receive state diagram, flp_cnt is determined to be 1 less than the number of pulses required to recognize its link partner as Auto-Negotiation able.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT pulses (beginning with one pulse) spaced at 50µs, wait 16ms, then send enough valid FLP bursts to put the DUT into the ACKNOWLEDGE DETECT state. The proper number of FLP bursts should be one less than the value determined in test #28.2.1, as that value includes the FLP required to identify a device as Auto-Negotiation able.
3. Determine whether the DUT has entered the ACKNOWLEDGE DETECT state
4. If the DUT did not enter the ACKNOWLEDGE DETECT state, repeat steps 1 through 3 increasing the number of initial pulses until the DUT enters the ACKNOWLEDGE DETECT state

Observable Results:

- The DUT should recognize the Link Partner as Auto-Negotiation able within 7 to 18 (inclusive) pulses. Flp_cnt is one less than this determined number.

Possible Problems: None

Test #28.2.11: Range of NLP Timer

Purpose: To verify that the device under test accepts FLP bursts with proper spacing, and refuses those with spacing outside of the acceptable range.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.2.1, 28.3.2

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: January 13, 2000

Discussion: As well as characteristic requirements, FLP bursts have requirements for the delay between consecutive bursts. In order to be accepted, as valid, received FLP bursts must have a delay between them between “nlp_test_min_timer” and “nlp_test_max_timer.” The value for “nlp_test_min_timer” must be between 5 and 7ms. The value for “nlp_test_max_timer” must be between 50 and 150ms. This test is to verify that the device under test accepts FLP bursts with spacing within these ranges, and refuses FLP bursts with spacing outside of these ranges. Note, “nlp_test_min_timer” is measured from the beginning of an FLP to the beginning of the next FLP, whereas “nlp_test_max_timer” is measured from the end of an FLP to the beginning of the next FLP.

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. Using a Cat 5 cord, connect the DUT’s receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

Part A: nlp_test_min_timer

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT enough FLP bursts spaced between 2ms and 10ms to put it into the ACKNOWLEDGE DETECT state (see test #28.2.1)
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state
4. Repeat steps 1 through 3 varying the spacing of the FLPs until the DUT range at which DUT enters the ACKNOWLEDGE DETECT state and does not enter the ACKNOWLEDGE DETECT state is found.

Part B: nlp_test_max_timer

5. Repeat steps 1 through 3 varying the spacing of the FLPs starting between 30ms and 200ms, until the range at which DUT enters the ACKNOWLEDGE DETECT state and does not enter the ACKNOWLEDGE DETECT state is found.

Observable Results:

a) The nlp_test_min_timer should lay between 5ms and 7ms
b) The nlp_test_max_timer should lay between 50ms and 150ms

Possible Problems: None

Test #28.2.12: Range of FLP Test Timer

Purpose: To verify that the device under test determines that its link partner is Auto-Negotiation able upon receiving pulses spaced within flp_test_min_timer and flp_test_max_timer, and does not recognize a device as Auto-Negotiation able upon receiving pulses spaced outside the acceptable range.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.2.1, 28.3.2, Figure 28-15 Receive state diagram

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: July 27, 1999

Discussion: As well as characteristic requirements, FLP bursts have requirements for the delay between consecutive pulses within the burst. In order to be accepted, as valid, received pulses must have a delay between them between "flp_test_min_timer" and "flp_test_max_timer." The value for "flp_test_min_timer" must be between 5 and 25 μs. The value for "flp_test_max_timer" must be between 165 and 185 μs. This test is to verify that the device under test accepts FLP bursts with pulses spaced within these ranges, and refuses FLPs with pulses spaced outside of these ranges.

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: flp_test_min_timer

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT enough pulses spaced at 5μs to identify the link partner as Auto-Negotiation able (refer to #28.2.10), wait 16ms, then send enough valid FLP bursts to put the DUT into the ACKNOWLEDGE DETECT state. The proper number of FLP bursts should be one less than the value determined in #28.2.1 as that value includes the FLP required to identify a device as Auto-Negotiation able.
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state
4. Repeat steps 1 through 3 varying the pulse spacing until the DUT enters ACKNOWLEDGE DETECT state

Part B: flp_test_max_timer

5. Repeat steps 1 through 3 varying the pulse spacing, starting at 185μs until the DUT enters the ACKNOWLEDGE DETECT state

Observable Results:

a) The flp_test_min_timer should lay between 5μs and 25μs
b) The flp_test_max_timer should lay between 165μs and 185μs

Possible Problems: None

Test #28.2.13: Range of Data Detect Timer

Purpose: To verify that the device under test accepts data pulses with proper spacing and refuses data pulses with spacing outside the acceptable range.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.2.1, 28.3.2, Figure 28-15 Receive state diagram

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: January 13, 2000

Discussion: As well as characteristic requirements, FLP bursts have requirements for the delay between clock and data pulses within the burst. In order to be accepted as valid, received data pulses must have a delay between them and the previous clock pulse between “data_detect_min_timer” and “data_detect_max_timer.” The value for “data_detect_min_timer” must be between 15 and 47 μs. The value for “data_detect_max_timer” must be between 78 and 100 μs. This test is designed to verify that the device under test accepts FLP bursts with data pulses spaced within these ranges, and ignores FLPs with data pulses spaced outside of these ranges. As defined in Figure 28-15, if an FLP containing the data pattern 1,0 is sent with the data 1 transmitted a time exceeding 100 μs following the clock pulse, then the data_detect_max_timer should be violated. In a conformant device, this should result in the interpretation of the data pattern as 0,1. Thus, by alternating the transmission of this test FLP with FLPs containing typical spacing, a conformant device should not enter the ACKNOWLEDGE DETECT state. This technique is used to test the validity of data_detect_max_timer.

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: data_detect_min_timer

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to send the DUT enough FLPs, alternating between FLPs with the first data pulse spaced 15μs from the clock pulse and FLPs with perfect spacing, to put it into the ACKNOWLEDGE DETECT state (see test #28.2.1)
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state

Repeat steps 1 through 3, varying the gap from the clock pulse to the data pulse until the DUT enters the ACKNOWLEDGE DETECT state

Part B: data_detect_max_timer

4. Repeat steps 1 through 3, varying the gap from the clock pulse to the data pulse, starting at 100µs, until the DUT enters the ACKNOWLEDGE DETECT state

Part C: ignoring pulses below data_detect_min_timer

5. Repeat steps 1 through 3, changing the FLP to contain two “data” pulses, one before the implemented data_detect_min_timer is finished, and another after the data_detect_min_timer is finished. (the time between the clock and the first data pulse should be the same as the time between the two data pulses).

Observable Results:

a) The data_detect_min_timer should lay between 15µs and 47µs
b) The data_detect_max_timer should lay between 78µs and 100µs
c) The DUT should ignore the first data pulse and decode the second data pulse as a logic one causing the DUT to enter the ACKNOWLEDGE DETECT State

Possible Problems: None

Test #28.2.14: Transmit Disable State

Purpose: To verify that the device under test enters the ABILITY DETECT state upon completion of break_link_timer from the TRANSMIT DISABLE state

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 28.2.1.2, 28.1.4.2, 28.2.1.2.4

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: July 28, 1999

Discussion: Once an auto-negotiating device enters the TRANSMIT DISABLE state, it should stop transmission for break_link_timer before it re-enters the ABILITY DETECT state. However, there is no specification as to whether the DUT's receiver has to be turned off in the TRANSMIT DISABLE state. If a sequence of FLPs designed to cause an auto-negotiating station to enter the ACKNOWLEDGE DETECT state is sent to the DUT during Transmit Disable, acknowledge detect can be set to true. However, once break_link_timer is finished, the DUT will enter the ABILITY DETECT state where acknowledge detect is reset to false. Thus, the DUT will need to get another ability match once it enters the ABILITY DETECT state.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to send a series of 4 FLPs designed to cause the DUT to enter the ACKNOWLEDGE DETECT state (determined in test #28.2.1)
3. Once the DUT halts its FLP transmission, send the same sequence of FLPs at periodic intervals less than break_link_timer
4. Monitor the DUT's FLP transmission during this process

Observable Results:

- The DUT should resume FLP transmission after break_link_timer is finished, regardless of the received FLPs during the time where the DUT was in the TRANSMIT DISABLE state

Possible Problems: None

GROUP 3: PARALLEL DETECTION

Scope: The following tests cover Auto-Negotiation operation specific to the Parallel Detection mechanism.

Overview: These tests are designed to verify that an auto-negotiating device can properly detect a legacy (non-auto-negotiating) fixed speed device.

Test #28.3.1: Single Link Ready

Purpose: To verify that the device under test properly monitors the status of single_link_ready during parallel detection.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.3, Figures 28-16 & 28-17

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: July 28, 1999

Discussion: When a device implementing a 10Base-T PMA begins to receive link test pulses it must indicate link_status[NLP]=READY after 'lc_max' number of pulses have been received. According to Figure 28-16, once link_status[NLP]=READY is indicated, the device should cease transmitting FLPs and start autoneg_wait_timer. Single_link_ready is then used to indicate if exactly one PMA is currently ready. If no link is ready or if more than a single link is simultaneously ready then single_link_ready=false, mr_parallel_detection_fault=true, and FLP transmission should resume "immediately". This test is designed to verify that the process described above functions appropriately.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT 'lc_max' pulses spaced at 16ms.
3. Determine the duration for which the DUT has ceased transmitting FLPs

Observable Results:

- The DUT should cease FLP transmission for approximately link_loss_timer

Possible Problems: None

Test #28.3.2: Range of Auto-Negotiation Wait Timer

Purpose: To verify that the implemented value of autoneg_wait_timer is within the specified range of 500 to 1000ms.

References:

[1] IEEE Std 802.3, 1998 Edition: Section 28.3.2, Figure 28-16 Arbitration state diagram

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: July 28, 1999

Discussion: In order for an Auto-Negotiation able device to properly parallel detect a link partner, it must receive a valid single_link_ready=true signal from its link partner for a period of time before it negotiates to that link. This time is defined by the device's "autoneg_wait_timer," and is specified to be between 500 and 1000 ms. This test is designed to verify that the device under test does not parallel detect to a link before waiting a time within this range. This timer cannot be measured precisely from the RJ-45 interface; however, it can be bounded. The upper bound can be established by causing a single link to be ready and observing the gap between cessation of FLPs and commencement of the link pulses/stream. This delay includes any inter-FLP gap that the device may be in the midst of when detection of single_link_ready occurs. Additionally, any delay from the proper link being enabled to actual signaling appearing on the line will add to the value of the observed gap. The lower bound may be established for devices implementing a 10Base-T PMA by first determining the implemented values of lc_max and link_loss_timer. With these values known, the DUT can be sent a burst of link test pulses corresponding to lc_max plus the duration of autoneg_wait_timer found for the upper bound. The number of pulses in the burst may then be decreased until the DUT is observed to source FLPs following reception of the pulses, instead of NLPs (10Base-T link). This transition identifies the range of the lower bound. This range should be autoneg_wait_timer minus the time required to detect single_link_ready=false.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the station valid NLPs continuously with valid spacing
3. Monitor the DUT's transmit line
4. Verify that the DUT establishes a 10Base-T link

5. Measure the time between when the DUT ceased transmission of FLPs and when the DUT began transmitting NLPs. The minimum of these observations is the upper bound of autoneg_wait_timer
6. Break link, and calculate the number of NLPs to send to satisfy: X*NLP_gap = 'upper bound of autoneg_wait_timer'.
7. Send X + lc_max NLPs at a gap of 'NLP_gap' to the DUT.
8. Repeat step 7, decreasing X until the DUT sources FLPs following cessation of the NLPs from the Traffic Generator. (the gap should be approximately link_loss_timer)

Observable Results:

- The DUT's autoneg_wait_timer should be in the range of 500 to 1000 ms

Possible Problems:

- If only the upper or lower bound lays outside the conformance window, then the autoneg_wait_timer cannot be found conformant or non-conformant.

GROUP 4: 10BASE-T RELATED TESTS

Scope: The following tests cover 10BASE-T operation specific to the NLP Receive Link Integrity Test state diagram.

Overview: These tests are designed to verify the operation of the NLP Receive Link Integrity Test state diagram for 10BASE-T devices. This state machine was introduced in clause 28 replacing the previously defined Link Integrity Test Function state Diagram of Figure 14-6 in clause 14 of IEEE 802.3. The primary motivation for this change was to prevent an Auto-Negotiation capable 10BASE-T device from detecting a link when non-10BASE-T frames (such as 100BASE-TX idle) was received.

NOTE: THESE TESTS CANNOT BE PERFORMED IF THE DUT DOES NOT SUPPORT A 10BASE-T PMA.

Test #28.4.1: Link Count Max

Purpose: To verify that the device under test implements lc_max within 2 to 10 link test pulses.

References:

[1] IEEE Std 802., 1998 Edition: Sections 14.2.3.1 Figure 14-12, 28.3 Figures 28-16 & 28-17

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: July 28, 1999

Discussion: When a device implementing a 10Base-T PMA begins to receive link test pulses conformant to Figure 14-12, it must indicate link_status[NLP]=READY after 'lc_max' number of pulses have been received. According to Figure 28-16, once link_status[NLP]=READY is indicated, the device should cease transmitting FLPs. To prevent a device from indicating link off a received FLP, the state machine depicted in Figure 28-17 resets if a pulse is received before the link_test_min_timer has expired. This test is designed to verify that the implemented value of lc_max is between 2 and 10 pulses (inclusive).

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT 2 pulses spaced at 16ms.
3. Determine whether the DUT has ceased transmitting FLPs
4. If the DUT did not cease FLP transmission, repeat steps 1 through 3 varying the number of pulses sent until the DUT ceases FLP transmission.

Observable Results:

- The DUT should cease FLP transmission for approximately link_loss_timer after receiving between 2 to 10 link test pulses

Possible Problems: None

Test #28.4.2: Range of Link Test Timers

Purpose: To verify that the device under test accepts NLPs (link test pulses) with proper spacing, and refuses those with spacing outside of the acceptable range.

References:

[1] ANSI/IEEE Std 802.3, 1998 Edition: Sections 14.2.1.7, 28.3, Figure 28-17, Arbitration state diagram

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: January 13, 2000

Discussion: The acceptable gap between NLPs (10Base-T link test pulses) is defined to be between "link_test_min_timer" and "link_test_max_timer". The value for "link_test_min_timer" must be between 2 and 7 ms. The value for "link_test_max_timer" must be between 25 and 150 ms. This test is designed to verify that a device implementing a 10Base-T PMA will establish a 10Base-T link upon receipt of NLPs with valid spacing, and refuses link with spacing outside of these ranges.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

Part A: link_test_min_timer

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT lc_max link pulses spaced at 7ms apart to cause it to enter the LINK STATUS CHECK state
3. Determine whether the DUT entered the LINK STATUS CHECK state by monitoring the DUT for any delay in FLP transmission
4. Repeat steps 1 through 3 varying the spacing of the link pulses until the DUT fails to enter the Parallel Detect State

Part B: link_test_max_timer

5. Repeat steps 1 through 3 varying the spacing of the link pulses from 25ms and higher

Part C:

6. Repeat steps 1-3 sending link pulses continuously and spaced closer together than the determined link_test_min_timer

Observable Results:

a) The link_test_min_timer should lay between 2ms and 7ms
b) The link_test_max_timer should lay between 25ms and 150ms
c) The device should never enter the LINK STATUS CHECK state

Possible Problems: None

Test #28.4.3: Range of Link Loss Timer

Purpose: To verify that the device under test implements link_loss_timer within 50ms and 150ms.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 14.2.1.7, 28.3, Figures 28-16 & 28-17

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: July 28, 1999

Discussion: Once a 10Base-T link has been detected, the link should not fail unless frames or link test pulses are not received for a period of time governed by the link_loss_timer.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT a sufficient number of link pulses to cause the device to enter the FLP LINK GOOD state. Once the link is up, halt for 150ms after the last link pulse
3. Determine whether the DUT has broken link
4. Repeat steps 1 through 3 varying the gap until the DUT always keeps a good link.

Observable Results:

- The DUT should keep link with a gap within 50ms and 150ms

Possible Problems: None

Test #28.4.4: Link Integrity and RD Active

Purpose: To verify that the device under test maintains 10Base-T link upon reception of valid 10Base-T frames.

References:

[1] IEEE Std 802.3, 1998 Edition: Sections 14.2.3.1, 14.3.1.3.2 Figures 14-16, 14-17, 28.3, Figure 28-17

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: July 28, 1999

Discussion: Auto-Negotiating devices implementing a 10Base-T PMA must support Figure 28-17 "NLP Receive Link Integrity Test state diagram", unlike legacy 10Base-T implementation which follow Figure 14-6 "Link Integrity Test Function state diagram". The significant difference between these figures is that link may not be established based on the reception of 10Base-T frames (indicated as RD=active). However, once a 10Base-T link is ready, reception of either link test pulses or 10Base-T frames may maintain the link. However, as indicated in section 14.3.1.3.2, reception of signaling not meeting the requirements of Figures, 14-16, or 14-17 should not be accepted as RD=active. This includes 100Base-TX signaling.

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. Using a Cat 5 cord, connect the DUT's receiver to the Traffic Generator using a 100Ω line termination.

Procedure:

Part A: Link maintenance via RD=active

1. Establish a connection (not a link) to the DUT
2. Use a Traffic Generator to send the DUT 'lc_max' link pulses spaced at 16ms followed by validly formed 10Base-T frames spaced at 16ms
3. Determine whether the DUT entered into a good link by determining if it is sending NLPs. Also, if the means exists, determine if the DUT received the frames after link_control[NLP]=ENABLE occurs.

Part B: Refusal of link based on RD=active

4. Establish a connection (not a link) to the DUT
5. Use a Traffic Generator to send the DUT validly formed 10Base-T frames spaced at 16ms for a duration exceeding autoneg_wait_timer
6. Determine whether the DUT entered into a good link by determining if it is sending NLPs. Also, if the means exists, determine if the DUT received any of the frames

Part C: Refusal of link maintenance upon reception of 100Base-TX signaling

7. Establish a connection (not a link) to the DUT
8. Use a Traffic Generator to send the DUT 'lc_max' link pulses spaced at 16ms, then 100Base-TX signaling for several seconds, followed by validly formed 10Base-T frames spaced at 16ms
9. Determine whether the DUT remains in a 10Base-T link by monitoring if it is sending out NLPs throughout the process. Also, if the means exists, determine if the DUT received any of the frames

Observable Results:

a) Once the device enters the FLP LINK GOOD state, the DUT should be sending out NLPs and receiving the frames
b) The DUT should never establish a link, and thus, never send out NLPs and never receive the frames
c) The DUT should exit break its 10Base-T link and parallel detect to 100Base-TX upon reception of the 100Base-TX idle. Once it is switched back to the 10Base-T frames, the 100Base-TX link should be broken and no link should be formed by the detection of the frames. Also, none of the frames sent after the 100Base-TX idle should be received

Possible Problems: None