ETHERNET

Clause 28 Auto-Negotiation
State Machine Base Page Exchange
Test Suite
v5.7

Technical Document

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MODIFICATION RECORD

- February 3, 2006 Version 5.7
  Matthew Hersh: Modified: Updated reference to IEEE std. 802.3 – 2005.
- November 3, 2004 Version 5.6
  Matthew Hersh: Modified: changed observable results and/or minor editorial changes to the following tests:
  Test #28.1.3 – Transmit Link Code Word (Base Page) Encoding
  Test #28.2.1 – Ability Match
  Test #28.2.2 – Acknowledge Match
  Test #28.2.3 – Consistency Match
  Test #28.2.4 – Complete Acknowledge
  Test #28.2.5 – Behavior with Incomplete FLPs
  Test #28.2.6 – Acceptance of Long FLPs
  Test #28.2.7 – Next Page and Remote Fault Bits
  Test #28.2.8 – Selector Field Combinations
  Test #28.2.9 – Technology Ability Field Bits
  Test #28.2.10 – Identification of Link Partner as Auto-Negotiation Able
  Test #28.2.11 – Range of NLP Timer
  Test #28.2.12 – Range of FLP Timer
  Test #28.2.13 – Range of Data Detect Timer
  Test #28.2.14 – Transmit Disable
  Test #28.4.4 – Link Integrity and RD Active
- October 14, 1996 Version 1.0 Initial Release

Previous versions of the test suite can be found at:
http://www.iol.unh.edu/testsuites/ethernet/archive.html

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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 observations 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 affect 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 Fast Link Pulses (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, 2005 Edition: subclause 28.3.2, Table 28-9, 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 are 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 5.7-22.3 ms.

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

a. 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, 2005 Edition: subclause 28.3.2, Table 28-1, Table 28-9, 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 55.5 µs to 69.5 µs.

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:

a. For data zeros, the spacing between clock pulses should be 125±14 µs.
b. 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 µs.

Possible Problems: None.

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

Purpose: To verify that the DUT transmits valid FLP data; including, an acceptable Selector Field combination, advertises the correct abilities in the Technology Ability Field, and transmits proper initial values for the Remote Fault, Acknowledge, and Next Page bits.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 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: November 3, 2004

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 the DUT supports Next Page exchange and zero if it does not, 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[12:5]), and of the Remote Fault bit, Acknowledge bit, and Next Page bit are acquired.

Observable Results:

a. The number of pulses in a burst should be 19-33 (inclusive).
b. The Selector Field combination should correspond to S[4:0]=00001 defined in Table 28A-1.
    - The Technology Ability Field should advertise the proper abilities indicated in Table 28B-1.
    - 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 Next Page exchange.

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Possible Problems: None.

Test #28.1.4: NLP Compliance

Purpose: To verify the DUT's link pulse waveforms meet specification.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 14.3.1.2.1, 28.1.4.1, 28.2.1.1, 28.4, Figure 14-12, *Transmitter waveform for link test pulse*

[2] IEEE Std 1802.3d-1993: subclauses 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, 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, *Start-of-TP_IDLE test load*), and an Unshielded twisted pair model (as defined in IEEE Std 802.3 Section 14.3.1.2) that 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 Std 802.3, 2000 Ed. Figure 14-12, *Transmitter waveform for link test pulse*, 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 Figure 14-11, *Start-of-TP_IDLE test load*.
4. Repeat procedure with loads connected through the twisted pair model (TPM).

Observable Results:

a. Under each test setup, the FLP's link pulses should fit within the NLP template defined in Figure 14-12, *Transmitter waveform for link test pulse*. 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, 2005 Edition: subclauses 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 DUT's receiver will see the Traffic Generator's signaling. 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 2-4 several times.

Observable Results:

a. 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 Test #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 Test #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 DUT will defer for the proper amount of time before attempting to verify the status of the link determined by the Auto-Negotiation process.

References:

[1] IEEE Std 802.3, 2005 Edition: Sections 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 5, 2001

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 DUT's receiver will see the Traffic Generator's signaling. 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: for devices with a 100BASE-TX PMA:

5. Repeat steps 1-3 above, changing the advertised abilities to include 100BASE-TX abilities.
6. Measure the amount of time the DUT was observed to source 100BASE-TX link signaling.

Part c – for devices with a 1000BASE-T PMA:

7. Repeat steps 1-3 above, changing the advertised abilities, by means of a Next Page exchange, to include 1000BASE-T abilities.
8. Measure the amount of time the DUT was observed to source 1000BASE-T link signaling.

Observable Results:

a. For devices with a 10BASE-T PMA, observation of the interval between FLP cessation and 10BASE-T link signaling cessation + transmit_link_burst_timer should be in the range of 750 to 1000 ms.
b. For devices with a 100BASE-TX PMA, observation of the interval between FLP cessation and 100BASE-TX link signaling cessation + transmit_link_burst_timer should be in the range of 750 to 1000 ms.
c. For devices with a 1000BASE-T PMA, observation of the interval between FLP cessation and 1000BASE-T link signaling cessation + transmit_link_burst_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, the DUT properly sets the Remote Fault bit in its Link Code Word and keeps the Remote Fault bit set until exiting the COMPLETE ACKNOWLEDGE state and restarting Auto-Negotiation.

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 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 5, 2001

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 and Auto-Negotiation is restarted.

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the DUT's receiver will see the Traffic Generator's signaling. 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: Acknowledge Match).
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:

a. In step 2, the DUT should have the Remote Fault bit set in all FLPs that are transmitted.
   - In step 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 step 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 DUT 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, 2005 Edition: subclause 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 DUT's receiver will see the Traffic Generator's signaling. 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 valid 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:

a. 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 DUT 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, 2005 Edition: subclauses 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: November 3, 2004

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 DUT's receiver will see the Traffic Generator's signaling. 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 steps 1 and 2 increasing the number (n) of FLPs until the Acknowledge bit is set by the DUT.
4. Send (n) FLPs to DUT all with the Acknowledge bit set to logic one, where (n) is the minimum number of FLPs determined in step 3 to put the DUT into 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 DUT 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. Using the Traffic Generator, send the DUT the following sequence: one FLP, followed by one NLP, followed by (n-2) FLPs; where all the FLPs in the series are identical.
10. Repeat step 9 varying the number of NLPs sent to the DUT while maintaining a total of (n) pulses.

Part d:

11. Send a series of FLPs designed to put the DUT in the ACKNOWLEDGE DETECT state.
12. 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. The DUT should not enter the ACKNOWLEDGE DETECT state and thus the Acknowledge bit should never be set.
d. 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 DUT enters the COMPLETE ACKNOWLEDGE state only after receiving three consecutive and consistent FLPs with the Acknowledge bit set.

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 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: November 3, 2004

Discussion: A station reaches the COMPLETE ACKNOWLEDGE 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 #28.2.1: Ability Match), 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 DUT's receiver will see the Traffic Generator's signaling. 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. (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 (2*m) FLPs that alternate between FLPs identical to the first group, and FLPs that are one bit different from the first group; however, all FLPs in this group have the Acknowledge bit set.
5. Repeat step 4 using all one bit different FLPs.

Part c:

6. Using the Traffic Generator send the DUT two series of FLPs. The first group consists of (n) valid FLPs. The second group is comprised of the following pattern: FLP with ACK, followed by one NLP, followed by FLPs with ACK until (m) is reached. All the FLPs in the second group are identical to the first group with the exception of the Acknowledge bit.
7. Repeat step 6 increasing the amount of NLPs sent, but never exceeding (m).

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.
c. 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. First, by observing that the DUT has transmitted 6-8 FLPs after receiving the test sequence, followed 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 DUT performs a consistency match test on received FLPs.

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 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: November 3, 2004

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 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 DUT's receiver will see the Traffic Generator's signaling. 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 that are one bit different from the first group, but all FLPs in this group have the Acknowledge bit set. (n) is the value found in test #28.2.1 to cause the DUT to enter the ACKNOWLEDGE DETECT state, and (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 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.

Part c:

7. Using the Traffic Generator send two groups of FLPs to the DUT. The first group consists of (n) valid FLPs. The second group consists of (m) FLPs and NLPs, where all the FLPs are one bit different but still have the Acknowledge bit set.

Observable Results:

a. The DUT should 'immediately' cease transmitting FLPs once the inconsistent FLPs are received.
b. The DUT should enter COMPLETE ACKNOWLEDGE after reception of 4, 5, 6, or 7 FLPs with the ACK bit set.
c. The DUT should cease transmitting FLPs once the inconsistent FLPs are received.

Possible Problems: None.

Test #28.2.4: Complete Acknowledge

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

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 28.2.1.2.4, 28.3.1, 28.3.4, 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: November 3, 2004

Discussion: A station reaches the COMPLETE ACKNOWLEDGE 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 #28.2.1: Ability Match), 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 with the Acknowledge bit set to one. 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 DUT's receiver will see the Traffic Generator's signaling. 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 (n) FLPs with the Acknowledge bit not set, followed by (m) FLPs 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:

a. 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 DUT's behavior upon receipt of incomplete FLP bursts.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 28.2.1.2, 28.3.1, Figure 28-7, *Base Page encoding*, 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: November 3, 2004

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 subclause 28.2.1.2 and Figure 28-7, *Base Page encoding*, suggest a Link Code Word is 16 bits, but this is not stated explicitly. Thus, if one interprets a Link Code Word to be 16 bits (or greater, refer to Test #28.2.6: Acceptance of Long FLPs), 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 DUT's receiver will see the Traffic Generator's signaling. 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 10 clock pulses and spaced so that the time to send (n) FLPs is larger than nlp_test_max_timer, to put the DUT into the ACKNOWELDGE DETECT state.
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 11 clock pulses to put the DUT into the ACKNOWLEDGE DETECT state.
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: 11000111000 with no clock pulse after the final logic one data pulse, and an 8 pulse FLP containing the following data: 000010 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 DUT properly accepts FLPs with more than 16 data positions by ignoring all but the first 16 data bits.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 28.2.2, 28.2.2.1, 28.3.3, 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: November 3, 2004

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 DUT's receiver will see the Traffic Generator's signaling. 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 logic one (1 extra clock pulse and 1 data pulses) attached to the end to put the DUT into the Acknowledge Detect state.
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:

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

Possible Problems: None.

Test #28.2.7: Next Page and Remote Fault Bits

Purpose: To verify that the DUT 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, 2005 Edition: subclauses 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: November 3, 2004

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 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 DUT's receiver will see the Traffic Generator's signaling. 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 (n) FLPs with the Acknowledge bit not set, and (m) FLPs with the Acknowledge bit set, all with the Next Page bit set to logic one to put it into the COMPLETE ACKNOWLEDGE state.
3. Verify that the DUT enters the COMPLETE ACKNOWLEDGE state.

Part b:

4. Repeat steps 1-3, with FLPs with the Remote Fault bit set to 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 DUT accepts FLPs with the Selector Field set to a reserved combination or any other defined combination.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 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: November 3, 2004

Discussion: There are Selector Field combinations 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 (01000). A third Selector Field combination has been defined as IEEE-802.5 Token Ring (11000).

Test Setup: Using Cat 5 cords, connect the DUT and the Traffic Generator to the Line Monitor such that the DUT's receiver will see the Traffic Generator's signaling. 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 (n) FLPs with the Acknowledge bit not set, and with Selector Field combinations of 00000b, 11000b(IEEE 802.5), 11111b, and 01000b(IEEE 802.9) (ordered bit S0 to S4) to put the DUT into the ACKNOWLEDGE DETECT state. Verify that the DUT enters the ACKNOWLEDGE DETECT state.

Part b: COMPLETE ACKNOWLEDGE with different Selector Field combinations

3. Use the Traffic Generator to send (n) FLPs with the Acknowledge bit not set, and (m) FLPs with the Acknowledge bit set, all with Selector Field combinations of 00000b, 11000b, 11111b, and 01000b (ordered bit S0 to S4) to put the DUT into the COMPLETE ACKNOWLEDGE state.

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 DUT accepts FLPs with different combinations of the Technology Ability Field bits set to logic one.

References:
[1] IEEE Std 802.3, 2005 Edition: subclauses 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: November 3, 2004

Discussion: The technology ability field contains eight bits that indicate supported technologies specific to the Selector Field value. Bits A0:A6 are encoded as 10BASE-T half duplex, 10BASE-T full duplex, 100BASE-TX half duplex, 100BASE-TX full duplex, 100BASE-T4, PAUSE, and Asymmetric PAUSE operation for full duplex links, respectively. The IEEE currently reserves the last bit of the Link Code Word's Technology Ability Field. A station is supposed to transmit this bit 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 affecting normal operation. 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:
Part a:
1. Establish a connection (not a link) to the DUT.
2. Use the Traffic Generator to send (n) FLPs with the Acknowledge bit not set and bit A0 set to logic one to put it into the ACKNOWLEDGE DETECT state.
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, A4, A5, and A6.

Part b:
5. Use the Traffic Generator to send (n) FLPs with the Acknowledge bit not set, and (m) FLPs with the Acknowledge bit set to put the DUT into the COMPLETE ACKNOWLEDGE state.
6. Verify that the DUT enters the COMPLETE ACKNOWLEDGE state.
7. Repeat step 5 but send FLPs encoded with all possible one bit differences.

Observable Results:

a. The DUT should enter the ACKNOWLEDGE DETECT state regardless of the received FLPs encoded with varying Technology Ability Field bits.
b. The DUT should enter the COMPLETE ACKNOWLEDGE state regardless of the received FLPs encoded with varying Technology Ability Field bits.

Possible Problems: None.

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

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

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 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: November 3, 2004

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 Figure 28-15 - *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 50 μs, wait 16 ms, then send enough valid FLP bursts to put the DUT into the ACKNOWLEDGE DETECT state. The proper number of FLP bursts should be (n) – 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 1-3 increasing the number of initial pulses until the DUT enters the ACKNOWLEDGE DETECT state.

Observable Results:

a. 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 DUT accepts FLP bursts with proper spacing, and refuses those with spacing outside of the acceptable range.

References:
[1] IEEE Std 802.3, 2005 Edition: subclauses 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: November 3, 2004

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 7 ms. The value for "nlp_test_max_timer" must be between 50 and 150 ms. 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 (n) FLPs with the Acknowledge bit not set spaced between 2 ms and 10 ms to put it into the ACKNOWLEDGE DETECT state.
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state.
4. Repeat steps 1-3 varying the spacing of the FLPs until the range at which the 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 1-3 varying the spacing of the FLPs starting between 30 ms and 200 ms, 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 5 ms and 7 ms.
b. The nlp_test_max_timer should lay between 50 ms and 150 ms.

Possible Problems: None.

Test #28.2.12: Range of FLP Test Timer

Purpose: To verify that the DUT 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, 2005 Edition: subclauses 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: November 3, 2004

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 DUT’s receiver will see the Traffic Generator’s signaling. 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 5 μs to identify the link partner as Auto-Negotiation able (refer to Test #28.2.10: Identification of Link Partner as Auto-Negotiation Able), wait 16 ms, then send (n) – 1 valid FLP bursts to put the DUT into the ACKNOWLEDGE DETECT state.
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state.
4. Repeat steps 1-3 varying the pulse spacing until the DUT enters ACKNOWLEDGE DETECT state.

Part b: flp_test_max_timer

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

Observable Results:

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

Possible Problems: None.

Test #28.2.13: Range of Data Detect Timer

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

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 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: November 3, 2004

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, *Receive State diagram*, 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 DUT's receiver will see the Traffic Generator's signaling. 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 (n) FLPs, alternating between FLPs with the first data pulse spaced 15 μs from the clock pulse and FLPs with nominal spacing, to put it into the ACKNOWLEDGE DETECT state.
3. Observe whether the DUT entered the ACKNOWLEDGE DETECT state.

4. Repeat steps 1-3, 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

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

Part c: ignoring pulses below data_detect_min_timer

6. Repeat steps 1-3, 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 15 μs and 47 μs.
b. The data_detect_max_timer should lay between 78 μs and 100 μs.
c. The DUT should ignore the first data pulse and decode the second data pulse as 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 DUT enters the ABILITY DETECT state upon completion of break_link_timer from the TRANSMIT DISABLE state.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 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: November 3, 2004

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 (n) FLPs designed to cause the DUT to enter the ACKNOWLEDGE DETECT state.
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:

a. 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.

Test #28.2.15: Priority Resolution Function

Purpose: To verify that the device under test properly configures the highest common denominator (HCD) technology for the transmitted technologies in a link code word.

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 28.2.3.3, Annex 28.B.2, 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: April 22, 2003

Discussion: Once a station has received its link partner's link code word and completed the exchange of FLP bursts, the technology at which communication is to be established must be resolved. Through the priority resolution function, the highest common denominator (HCD) technology should be found. This test is designed to verify that the device under test resolves the proper HCD for all possible technology and selector field combinations.

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:

Part a: Ethernet Selector Field Resolution

1. Establish a connection (not a link) to the DUT
2. Use the Traffic Generator to send a series of FLP bursts that advertise a set of abilities with an Ethernet selector field.
3. Verify that the DUT establishes a link when it can, and refuses a link otherwise
4. Verify that the DUT resolved the highest common technology by sending a packet to the DUT in that format and determining whether it was received
5. Verify that full duplex was resolved whenever possible
6. Repeat this procedure for all possible combinations of the first five bits of the technology ability field

Part b: Non- Ethernet Selector Field Resolution

7. Repeat steps 1-6 with Base Pages advertising selector fields other than 802.3

Observable Results:

a. In every case, the DUT should resolve a link at the highest priority possible based on the priority resolution function for the technologies advertised
b. INFORMATIVE: The DUT should enter the FLP LINK GOOD CHECK state and may disable all Ethernet PMAs.

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 DUT properly monitors the status of single_link_ready during Parallel Detection.

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 28.3.4, Figure 28-16, *Arbitration state diagram*, Figure 28-17, *NLP Receive Link Integrity Test 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: 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, *Arbitration state diagram*, 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 16 ms.
3. Determine the duration for which the DUT has ceased transmitting FLPs.

Observable Results:

a. The DUT should cease FLP transmission for approximately link_loss_timer + transmit_link_burst_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 1000 ms.

References:

[1] IEEE Std 802.3, 2005 Edition: subclause 28.3.4, 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 DUT 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:

a. 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 lies 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, *Link Integrity Test function state diagram*, 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) were 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 DUT implements lc_max within 2 to 10 link test pulses.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 14.2.3.1, 28.3.4, Figure 14-12, *Transmitter waveform for link test pulse*, Figure 28-16, *Arbitration state diagram*, Figure 28-17, *NLP Receive Link Integrity Test 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: When a device implementing a 10BASE-T PMA begins to receive link test pulses conformant to Figure 14-12, *Transmitter waveform for link test pulse*, it must indicate link_status[NLP]=READY after 'lc_max' number of pulses have been received. According to Figure 28-16, *Arbitration state diagram*, 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, *NLP Receive Link Integrity Test state diagram*, 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 16 ms.
3. Determine whether the DUT has ceased transmitting FLPs.
4. If the DUT did not cease FLP transmission, repeat steps 1-3 varying the number of pulses sent until the DUT ceases FLP transmission.

Observable Results:

a. 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 DUT accepts NLPs (link test pulses) with proper spacing, and refuses those with spacing outside of the acceptable range.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 14.2.1.7, 28.3.4, 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: January 17, 2002

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 1-3 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 1-3 varying the spacing of the link pulses from 25 ms 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 2 ms and 7 ms.
b. The link_test_max_timer should lay between 25 ms and 150 ms.
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 DUT implements link_loss_timer within 50 ms and 150 ms.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 14.2.1.7, 28.3, Figure 28-16, *Arbitration state diagram,* Figure 28-17, *NLP Receive Link Integrity Test 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: 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 150 ms after the last link pulse.
3. Determine whether the DUT has broken link.
4. Repeat steps 1-3 varying the gap until the DUT always keeps a good link.

Observable Results:

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

Possible Problems: None.

Test #28.4.4: Link Integrity and RD Active

Purpose: To verify that the DUT maintains 10BASE-T link upon reception of valid 10BASE-T frames.

References:

[1] IEEE Std 802.3, 2005 Edition: subclauses 14.2.3.1, 14.3.1.3.2, Figure 14-16, *Receive differential input voltage – narrow pulse*, Figure 14-17, *Receiver differential input voltage – wide pulse*, subclause 28.3, Figure 28-17, *NLP Receive Link Integrity Test 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: April 23, 2003

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 Figure 14-16, *Receive differential input voltage – narrow pulse*, or Figure14-17, *Receiver differential input voltage – wide pulse*, 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 16 ms followed by validly formed 10BASE-T frames spaced at 16 ms.
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 after less than ‘lc_max’ NLPs

4. Establish a connection (not a link) to the DUT.

5. Use a Traffic Generator to send the DUT less than 'lc_max' link pulses spaced at 16 ms followed by validly formed 10BASE-T frames spaced at 16 ms.
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 the frames after link_control[NLP]=ENABLE occurs.

Part c: Refusal of link based on RD=active

7. Establish a connection (not a link) to the DUT.
8. Use a Traffic Generator to send the DUT validly formed 10BASE-T frames spaced at 16 ms for a duration exceeding autoneg_wait_timer.
9. 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 d: Refusal of link maintenance upon reception of 100BASE-TX signaling

10. Establish a connection (not a link) to the DUT.
11. Use a Traffic Generator to send the DUT 'lc_max' link pulses spaced at 16 ms, then 100BASE-TX signaling for several seconds, followed by validly formed 10BASE-T frames spaced at 16 ms.
12. 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 never establish a link, and thus, never send out NLPs and never receive the frames.
d. 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. Following the loss of the 100BASE-TX link, the DUT should wait break_link_timer and then resume FLP transmission. Also, if possible, it should be verified that none of the frames sent after the 100BASE-TX Idle were received.

Possible Problems: None.