IEEE 100BASE-T1 PHY Control Test Suite

Version 1.0

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This suite of tests has been developed to help implementers identify problems that 100BASE-T1 devices may have with the PHY Control functions.

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Version Control of Document

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1.0	Stephen Johnson	• Document updated to reference IEEE 802.3bw 100BASE-T1 Standard. • Updated procedure for Test 4.1.1 – PMA Reset • Updated procedures and observable results for Test 4.1.2 – Value of Minwait_timer • Updated procedure for Test 4.1.4 – Value of stabilize timer • Updated discussion for Test 4.2.2 – PHY Control State Diagram – SLAVE SILENT State • Updated observable result for Test 4.2.5 – PHY Control State Diagram - SEND IDLE OR DATA State parts e & f	10/13/2016
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Contents

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2 INTRODUCTION

This particular suite of tests has been developed to help implementers evaluate the functionality of the PMA sublayer of their 100BASE-T1 products.

These tests are designed to determine if a product conforms to specifications defined in IEEE 802.3bw 100BASE-T1 standard. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other devices. However, combined with satisfactory operation in the OPEN Alliance interoperability test bed, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function properly in many 100BASE-T1 automotive environments.

The tests contained in this document are organized in such a manner as to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are organized into groups, primarily in order to reduce setup time in the lab environment, however the different groups typically also tend to focus on specific aspects of device functionality. A three-part numbering system is used to organize the tests, where the first number indicates the section of Clause 96 of the IEEE 802.3bw Standard on which the test suite is based. The second and third numbers indicate the test's group number and test number within that group, respectively. This format allows for the addition of future tests to the appropriate groups without requiring the renumbering of the subsequent tests.

The test definitions themselves are intended to provide a high-level description of the motivation, resources, procedures, and methodologies pertinent to each test. Specifically, each test description consists of the following sections:

Purpose

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

References

This section specifies source material *external* to the test suite, including specific subsections pertinent to the test definition, or any other references that might be helpful in understanding the test methodology and/or test results. External sources are always referenced by number when mentioned in the test description. Any other references not specified by number are stated with respect to the test suite document itself.

Resource Requirements

The requirements section specifies the test hardware and/or software needed to perform the test. This is generally expressed in terms of minimum requirements, however in some cases specific equipment manufacturer/model information may be provided.

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 initial configuration of the test environment. Small changes in the configuration should not be included here, and are generally covered in the test procedure section, below.

Test Procedure

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

Observable Results

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

Possible Problems

This section contains a description of known issues with the test procedure, which may affect test results in certain situations. It may also refer the reader to test suite appendices and/or whitepapers that may provide more detail regarding these issues.

3 Reference Table

Test Name	Test Number	IEEE 802.3bw References
Group 1: PHY Control and Timers		
PMA Reset	Test 4.1.1	• [1] IEEE Std. 802.3bw, subclause 96.4.1 – PMA Reset function
Value of minwait_timer	Test 4.1.2	• [1] IEEE Std. 802.3bw, subclause 96.4.7.2 – Timers • [2] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram • [3] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram
Value of maxwait_timer	Test 4.1.3	• [1] IEEE Std. 802.3bw, subclause 96.4.7.2 – Timers • [2] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram • [3] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram
Value of stabilize_timer	Test 4.1.4	• [1] IEEE Std. 802.3bw, subclause 96.4.7.2 – Timers • [2] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram
Group 2: PHY Control State Diagram		
PHY Control State Diagram	Test 4.2.1-4.2.5	• [1] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram
Group 3: Link Monitor State Diagram		
Link Monitor State Diagram	Test 4.3.1	• [1] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram

All tests are designed for the IEEE 802.3bw 100BASE-T1 Specification.

4 Device Under Test (DUT) Requirements

For the purposes of this test suite, the DUT is one port of a 100BASE-T1 capable device that includes a 100BASE-T1 PHY mounted on a PCB with an MDI connector and any necessary circuitry such as a low pass filter or common mode choke. All tests will be performed at the MDI connector of the DUT.

Please see the additional requirements listed in the following table:

Test Number and Name	**Required Capabilities**
Group 1: PHY Control and Timers	
Test 4.1.1 – PMA Reset	Access to PMA Reset Access to link_status[2] Ability to set master/slave configuration
Test 4.1.2 – Value of minwait_timer	Ability to set master/slave configuration
Test 4.1.3 – Value of maxwait_timer	Access to link_status[2] Ability to set master/slave configuration
Test 4.1.4 – Value of stabilize_timer	Access to link_status[2] Ability to set master/slave configuration
Group 2: PHY Control State Diagram	
Test 4.2.1 – PHY Control State Diagram - DISABLE TRANSMITTER State	Access to PMA Reset Ability to set master/slave configuration
Test 4.2.2 – PHY Control State Diagram - SLAVE SILENT State	Ability to set master/slave configuration
Test 4.2.3 – PHY Control State Diagram - TRAINING State	Ability to set master/slave configuration The ability to send and receive frames[1]
Test 4.2.4 – PHY Control State Diagram - SEND IDLE State	Ability to set master/slave configuration The ability to send and receive frames[1]
Test 4.2.5 – PHY Control State Diagram - SEND IDLE OR DATA State	Ability to set master/slave configuration The ability to send and receive frames[1] Access to the MII signals
Group 3: Link Monitor State Diagram	
Test 4.3.1 – Link Monitor State Diagram	Access to link_status[2] Ability to set master/slave configuration

[1] This can be accomplished through a loopback, responding to ICMP requests, or by forwarding traffic through two ports.

[2] Due to the nature of testing, the link_status signal must update as quickly as possible and have the ability to be probed by an oscilloscope or logic analyzer.

5 GROUP 1: PHY Control and Timers

Overview:

This section verifies the integrity of the 100BASE-T1 PHY Control functions and related timers.

5.1 Test 4.1.1 – PMA Reset

Purpose: To verify that the PMA properly initializes upon receipt of a reset request from the management entity.

References:

[1] IEEE Std. 802.3bw, subclause 96.4.1 – PMA Reset function

Resource Requirements:

- 100BASE-T1Transmit station (refer to appendix 96.A)
- 100BASE-T1Monitor station (refer to appendix 96.A)

Discussion:
Reference [1] states that the PMA is reset upon power on or the receipt of a reset request from management entity. The PMA Reset function causes the PHY Control State Diagram to transition to the DISABLE TRANSMITTER state. After exiting the DISABLE TRANSMITTER state while configured as master, the DUT should immediately transition from the SLAVE SILENT state to the TRAINING state and transmit Idle with tx_mode=SEND_I. After exiting the DISABLE TRANSMITTER state while configured as slave, the DUT should remain in the SLAVE SILENT state until it has set scr_status=OK.

The PMA Reset function also causes the Link Monitor State Diagram to transition to the LINK DOWN state. Here the DUT should set link_status=FAIL.

Test Setup: Connect the Device Under Test (DUT) to the Link Partner via the line tap or to the Test Station.

Procedure:

1. Configure the DUT as master.
2. Establish a valid link with the DUT.
3. Monitor the transmissions from the DUT and cause the management to request a PMA Reset while simultaneously ceasing transmissions from the test station.
4. Configure the DUT as slave and the test station as master and repeat steps 1-3.

Observable Results:

a. In step 3, the DUT should stop transmitting with tx_mode=SEND_N and start transmitting with tx_mode=SEND_I.
b. In step 3, the DUT should set link_status=FAIL.
c. In step 4, the DUT should stop transmitting.
d. In step 4, the DUT should set link_status=FAIL.

Possible Problems: If the ability to control the PMA Reset request is not available, this test cannot be performed. Parts b and d cannot be completed if access to link_status is not available. Some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested. If it is not possible to synchronize asserting PMA Reset and ceasing transmissions from the test station, care must be taken to ensure that the test station does not transmit a sequence that would cause the DUT to set scr_status=OK or loc_rcvr_status=OK.

5.2 Test 4.1.2 – Value of minwait_timer

Purpose: To verify that the device under test (DUT) properly implements a minwait_timer of 1.8 us +/- 0.18 us.

References:

[1] IEEE Std. 802.3bw, subclause 96.4.7.2 – Timers
[2] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram
[3] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

Reference [1] defines minwait_timer as 1.8 us +/- 0.18 us. This timer is used to ensure that the devices transmit the training pattern for enough time to ensure that the link partner can recover the signal and establish a link.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Case 1: minwait_timer in TRAINING

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
3. Start transmitting a valid training signal from the transmit station as soon as the DUT restarts the training process. If the DUT is a master then the Transmit station should begin transmissions with loc_rcvr_status = OK. If the DUT is a slave then the Transmit station should not set loc_rcvr_status = OK until after the DUT starts transmitting the Idle training pattern.
4. Monitor how long the DUT sends the Idle training pattern in the TRAINING state before transitioning to the SEND IDLE OR DATA state.
5. Repeat steps 2-4 10 times.
6. Repeat steps 2-5 with the DUT configured as slave.

Case 2: minwait_timer in SEND IDLE OR DATA

7. Configure the DUT as master.
8. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
9. Establish a valid link with the DUT, but stop transmitting from the test station as soon as the DUT enters the SEND IDLE OR DATA state.
10. Monitor how long the DUT transmits with tx_mode=SEND_N before restarting training.
11. Repeat steps 7-10 10 times.
12. Repeat steps 8-11 with the DUT configured as slave.

Case 3: minwait_timer between SEND IDLE to SEND IDLE OR DATA

13. Configure the DUT as master.

14. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
15. Establish a valid link with the DUT.
16. Instruct the Test station to transmit with tx_mode=SEND_I with loc_recvr_status = OK.
17. As soon as the DUT begins transmitting with tx_mode=SEND_N, instruct the test station to transmit with loc_recvr_status=NOT_OK for less than minwait_timer.
18. As soon as the DUT begins transmitting with tx_mode=SEND_I, instruct the test station to transmit with loc_recvr_status=OK.
19. Observe how long the DUT remains in the SEND_I state.
20. Repeat steps 14-19 10 times.
21. Repeat steps 14-20 with the DUT configured as slave.

Case 4: minwait_timer between SEND IDLE OR DATA to SEND IDLE

22. Configure DUT as master.
23. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
24. Establish a valid link with the DUT.
25. Instruct the test station to transmit with tx_mode=SEND_I with loc_recvr_status=NOT_OK.
26. As soon as the DUT begins transmitting with tx_mode=SEND_I, instruct the test station to transmit with loc_recvr_status=OK.
27. As soon as the DUT begins transmitting with tx_mode=SEND_N, instruct the test station to transmit with loc_recvr_status=NOT_OK.
28. Observe how long the DUT remains in the SEND_N state.
29. Repeat steps 23-28 10 times.
30. Repeat steps 23-29 with the DUT configured as slave.

Observable Results:

a. In step 4, the DUT should transmit the Idle training pattern for 1.8 us +/- 0.18 us for all 10 measurements.
b. In step 6, the DUT should transmit the Idle training pattern for 1.8 us +/- 0.18 us for all 10 measurements.
c. In step 10, the DUT should transmit with tx_mode=SEND_N for 1.8 us +/- 0.18 us for all 10 measurements.
d. In step 12, the DUT should transmit with tx_mode=SEND_N for 1.8 us +/- 0.18 us for all 10 measurements.
e. In step 19, the DUT should transmit with tx_mode=SEND_I for 1.8us +/- 0.18 us for all 10 measurements.
f. In step 21, the DUT should transmit with tx_mode=SEND_I for 1.8us +/- 0.18 us for all 10 measurements.
g. In step 28, the DUT should transmit with tx_mode=SEND_N for 1.8us +/- 0.18us for all 10 measurements.
h. In step 30, the DUT should transmit with tx_mode=SEND_N for 1.8us +/- 0.18us for all 10 measurements.

Possible Problems: Some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested. Case 1 cannot be tested if the DUT takes longer than minwait_timer to set loc_recvr_status. Case 2 cannot be tested if the DUT takes longer than minwait_timer to drop loc_recvr_status. Case 3 cannot be performed if it takes the DUT longer than minwait_timer to set rem_rcvr_status. Case 4 cannot be performed if it takes the DUT longer than minwait_timer to drop rem_rcvr_status.

5.3 Test 4.1.3 – Value of maxwait_timer

Purpose: To verify that the device under test (DUT) properly implements a maxwait_timer of 200 ms +/- 2 ms.

References:

[1] IEEE Std. 802.3bw, subclause 96.4.7.2 – Timers
[2] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram
[3] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

Reference [1] defines maxwait_timer as 200 ms +/- 2 ms. This timer is used to limit the amount of time the devices spend in the SLAVE SILENT and TRAINING states.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Case 1: Value of maxwait_timer

1. Configure the DUT as master.
2. Establish a link and ensure that link_status=OK.
3. Monitor the transmissions and link_status from the DUT.
4. Stop transmitting signaling to the DUT.
5. Determine when the DUT sets tx_mode≠SEND_N and mark this as TIME A.
6. Determine when the DUT sets link_status=FAIL and mark this as TIME B.
7. Measure max_wait_timer as the difference between TIME A and TIME B.
8. Repeat steps 2-7 with the DUT configured as slave.

Observable Results:

a. In step 7, the DUT should implement a max_wait_timer of 200 ms +/- 2 ms when configured as master.
b. In step 8, the DUT should implement a max_wait_timer of 200 ms +/- 2 ms when configured as slave.

Possible Problems: This test cannot be completed if access to link_status is not available. Also, some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

5.4 Test 4.1.4 – Value of stabilize_timer

Purpose: To verify that the device under test (DUT) properly implements a stabilize_timer of 1.8 us +/- 0.18 us.

References:

[1] IEEE Std. 802.3bw, subclause 96.4.7.2 – Timers
[2] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

Reference [1] defines stabilize_timer as 1.8 us +/- 0.18 us. This timer is used to ensure that the device is receiving a valid signal for the duration stabilize_timer before setting link_status=OK.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
3. Start transmitting a valid training signal from the transmit station as soon as the DUT restarts the training process.
4. After the DUT sets loc_rcvr_status = OK, continue to send the valid signal for 0.36 us, then stop transmitting.
5. Check the value of link_status.
6. Repeats steps 2-5, increasing the duration that the test station sends a valid signal in step 4 by 0.36 us until the DUT reports link_status = OK. This is the value for stabilize_timer.
7. Repeat steps 2-6 with the DUT configured as slave and the test station configured as MASTER.

Observable Results:

a. In step 6, the value of stabilize_timer should be 1.8 us +/- 0.18 us when configured as master.
b. In step 7, the value of stabilize_timer should be 1.8 us +/- 0.18 us when configured as slave.

Possible Problems: This test cannot be performed if real-time access to link_status is not available. Also, some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

6 GROUP 2: PHY Control State Diagram

Overview:

The tests defined in this section verify the PHY Control State Diagram for 100BASE-T1 capable PHYs.

6.1 Test 4.2.1 – PHY Control State Diagram - DISABLE TRANSMITTER State

Purpose: To verify that the device under test (DUT) properly disables the transmitter while in the DISABLE TRANSMITTER state.

References:

[1] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

Reference [1] states that the transmitters should be disabled when the PHY Control State Diagram transitions to the DISABLE TRANSMITTER state.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and cause the management to request a PMA Reset.
3. Observe if the DUT disables the transmitter upon entering the DISABLE TRANSMITTER state.
4. Configure the DUT as Slave and repeat steps 2 and 3.

Observable Results:

a. In step 3, the DUT should disable the transmitter upon entering the DISABLE TRANSMITTER state when configured as master.
b. In step 4, the DUT should disable the transmitter upon entering the DISABLE TRANSMITTER state when configured as slave.

Possible Problems: If the ability to control the PMA Reset request is not available, this test cannot be performed. Some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

6.2 Test 4.2.2 – PHY Control State Diagram - SLAVE SILENT State

Purpose: To verify that the device under test (DUT) properly does not transmit while in the SLAVE SILENT state and that the DUT properly transitions out of this state.

References:

[1] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

Reference [1] states that the DUT should be in tx_mode = send_z when it enters the SLAVE SILENT State. Devices configured as master transition out of this state immediately, but devices configured as slave stay in this state until scr_status = OK.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Part A: DUT is master

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT by sending invalid Ternary Codes after the DUT has established a link.
3. Observe that the DUT immediately transitions out of the SLAVE SILENT state without waiting for scr_status = OK.

Part B: DUT is slave

4. Configure the DUT as slave.
5. Monitor the transmissions from the DUT and restart the training process on the DUT by sending invalid Ternary Codes after the DUT has established a link.
6. Do not immediately send a valid Idle training pattern.
7. Send a valid Idle training pattern and observe that the DUT begins transmitting a valid Idle training pattern.

Observable Results:

a. In step 3, the DUT should transition out of the SLAVE SILENT state without waiting for loc_rcvr_status = OK.
b. In step 7, the DUT should not transition out of the SLAVE SILENT state until it receives a valid Idle training pattern.

Possible Problems: Some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

6.3 Test 4.2.3 – PHY Control State Diagram - TRAINING State

Purpose: To verify that the device under test (DUT) properly exits from the TRAINING state.

References:

[1] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

The Reference [1] states that the device will remain in the TRAINING state until it has loc_rcvr_status=OK and minwait_timer has finished. If the link partner does not have loc_rcvr_status=OK then the device will transition to the SEND IDLE state. If the link partner does have loc_rcvr_status=OK then the device will transition to the SEND IDLE OR DATA state. The link partner's value for rem_rcvr_status is determined based on the scrambler sequence transmitter by the link partner.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Case 1 - DUT remains in the TRAINING state

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
3. Do not transmit a valid Idle training pattern to the DUT, observe that the DUT continues to transmit a valid Idle pattern with tx_mode=SEND_I and the scrambler for loc_rcvr_status = NOT OK.
4. Configure the DUT as slave
5. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
6. Transmit a valid Idle training pattern to the DUT, then stop transmitting as soon as the DUT begins transmitting.
7. Observe that the DUT does not exit the training state and continues to transmit a valid Idle pattern with tx_mode=SEND_I and the scrambler for loc_rcvr_status = NOT OK.

Case 2 - DUT transitions to the SEND IDLE state

8. Configure the DUT as master.
9. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
10. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOTOK.
11. Observe that the DUT continues transmitting with tx_mode=SEND_I.
12. Configure the DUT as slave and repeat steps 9-11.

Case 3 - DUT transitions to the SEND IDLE OR DATA state

13. Configure the DUT as master.
14. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
15. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK.
16. Observe that the DUT begins transmitting with tx_mode=SEND_N and is capable of sending and receiving frames.
17. Configure the DUT as slave.
18. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
19. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
20. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK.
21. Observed that the DUT begins transmitting with tx_mode = SEND_N and is capable of sending a receiving frames.

Observable Results:

a. In step 6, the DUT should continue transmitting a valid Idle training pattern with tx_mode=SEND_I and loc_rcvr_status = NOT OK when configured as master.
b. In step 7, the DUT should continue transmitting a valid Idle training pattern with tx_mode=SEND_I and loc_rcvr_status = NOT OK when configured as slave.
c. In step 11, the DUT should continue transmitting a valid Idle training pattern with tx_mode=SEND_I and loc_rcvr_status = OK when configured as master.
d. In step 12, the DUT should continue transmitting a valid Idle training pattern with tx_mode=SEND_I and loc_rcvr_status = OK when configured as slave.
e. In step 16, the DUT should begin transmitting with tx_mode=SEND_N and be capable of transmitting and receiving frames when configured as master.
f. In step 17, the DUT should begin transmitting with tx_mode=SEND_N and be capable of transmitting and receiving frames when configured as slave.

Possible Problems: Some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested. In part f, it may not be possible to cause the DUT to set scr_status = OK without also setting loc_rcvr_status = OK at the same time. In this case, the DUT will transition to the SEND IDLE state and this test cannot be performed.

6.4 Test 4.2.4 – PHY Control State Diagram - SEND IDLE State

Purpose: To verify that the device under test (DUT) properly exits from the SEND IDLE state.

References:

[1] IEEE Std. 802.3bw, Figure 96-18 PHY Control state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)

Discussion:

Reference [1] states that the device will remain in the SEND IDLE state while it has loc_rcvr_status=OK and rem_rcvr_status = NOT_OK. The DUT will transition to the SEND IDLE OR DATA state once rem_rcvr_status=OK or to the SLAVE SILENT state if loc_rcvr_status=NOT_OK. The link partner's value for loc_rcvr_status is determined based on the scrambler sequence transmitter by the link partner.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Case 1 - DUT remains in the SEND IDLE state

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
3. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
4. Observe that the DUT continues transmitting a valid Idle training pattern.
5. Configure the DUT as slave and repeat steps 2-4.

Case 2 - DUT transitions to the SLAVE SILENT state

6. Configure the DUT as master.
7. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
8. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK for at least minwait_timer.
9. Stop transmitting to the DUT.
10. Observe that the DUT transitions to the SLAVE SILENT state.
11. Configure the DUT as slave and repeat steps 7-10.

Case 3 - DUT transitions to the SEND IDLE OR DATA state

12. Configure the DUT as master.
13. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
14. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK for at least minwait_timer, then transmit with loc_rcvr_status = OK.
15. Observe that the DUT begins transmitting with tx_mode=SEND_N and is capable of sending and receiving frames.
16. Configure the DUT as slave and repeat steps 13-15.

Observable Results:

a. The DUT should continue transmitting a valid Idle training pattern with loc_rcvr_status = OK in step 4.
b. The DUT should continue transmitting a valid Idle training pattern with loc_rcvr_status = OK in step 5.
c. The DUT should transition to the SLAVE SILENT state in step 10.
d. The DUT should transition to the SLAVE SILENT state in step 11.
e. In step 15, the DUT should begin transmitting with tx_mode=SEND_N and be capable of transmitting and receiving frames when configured as master.
f. In step 16, the DUT should begin transmitting with tx_mode=SEND_N and be capable of transmitting and receiving frames when configured as slave.

Possible Problems: Some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

6.5 Test 4.2.5 – PHY Control State Diagram - SEND IDLE OR DATA State

Purpose: To verify that the device under test (DUT) properly exits from the SEND IDLE OR DATA state.

References:

[1] IEEE Std. 802.3bw Figure 96-18 PHY Control state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)
- MII Test Station

Discussion:

Reference [1] states that the device will remain in the SEND IDLE OR DATA state until it has loc_rcvr_status=NOT_OK and tx_enable=FALSE. The DUT will transition to the SLAVE SILENT state if loc_rcvr_status=NOT_OK while tx_enable=FALSE. The DUT will transition to the SEND IDLE state if rem_rcvr_status=NOT_OK

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Case 1 - DUT remains in the SEND IDLE OR DATA state

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
3. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
4. Observe that the DUT establishes a valid link and is capable of transmitting and receiving frames.
5. Configure the DUT as slave.
6. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
7. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
8. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
9. Observed that the DUT begins transmitting with tx_mode = SEND_N and is capable of sending a receiving frames.

Case 2 - DUT transitions to the SLAVE SILENT state

10. Configure the DUT as master.
11. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
12. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
13. Stop transmitting to the DUT.
14. Observe that the DUT transitions to the SLAVE SILENT state, or transitions to the SEND IDLE state and then to the SLAVE SILENT STATE.

15. Configure the DUT as slave.
16. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
17. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
18. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
19. Stop transmitting to the DUT.
20. Observed that the DUT transitions to the SLAVE SILENT state, or transitions to the SEND IDLE state and then to the SLAVE SILENT state.
21.

Case 3 - DUT remains in the SEND IDLE OR DATA state while tx_enable=TRUE

22. Configure the DUT as master.
23. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
24. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
25. Force the DUT to set tx_enable=TRUE.
26. Stop transmitting to the DUT.
27. Observe that the DUT remains in the SEND IDLE OR DATA state for maxwait_timer if the DUT was observed to transition directly to the SLAVE SILENT state in step 14.
28. Configure the DUT as slave.
29. Monitor the transmissions from the DUT and restat the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
30. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
31. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
32. Force the DUT to set tx_enable=TRUE.
33. Stop transmitting to the DUT.
34. Observe that the DUT remains in the SEND IDLE OR DATA state for maxwait_timer if the DUT was observed to transition directly to the SLAVE SILENT state in step 20.

Case 4 - DUT transitions to the SEND IDLE state

35. Configure DUT as master.
36. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
37. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK until the DUT enters the SEND IDLE OR DATA state.
38. Send a valid idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
39. Observe that the DUT transitions to the SEND IDLE state.
40. Configure the DUT as slave.
41. Monitor the transmissions from the DUT and restat the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
42. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
43. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK for at least minwait_timer.
44. Send a valid idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
45. Observe that the DUT transitions to the SEND IDLE state.

Observable Results:

a. The DUT should establish a valid link and be capable of transmitting and receiving frames in step 4.
b. The DUT should establish a valid link and be capable of transmitting and receiving frames in step 9.
c. The DUT should transition to the SLAVE SILENT state, or transition to the SEND IDLE state and then to the SLAVE SILENT state in step 14.
d. The DUT should transition to the SLAVE SILENT state, or transition to the SEND IDLE state and then to the SLAVE SIDLENT state in step 20.
e. If the DUT was observed to transition directly to the SLAVE SILENT state in steps 14 and 20, the DUT should remain in the SEND IDLE OR DATA state in step 27.
f. If the DUT was observed to transition directly to the SLAVE SILENT state in steps 14 and 20, The DUT should remain in the SEND IDLE OR DATA state in step 34.
g. In step 39, the DUT should transition to the SEND IDLE state.
h. In step 45, the DUT should transition to the SEND IDLE state.

Possible Problems: Case 3 cannot be completed if access to the MII signals is not available. Case 3 can also not be completed in the case where the DUT transitions to the SEND IDLE state and then to the SLAVE SILENT state in steps 14 and 20. This is because loc_rcvr_status can take longer than minwait_timer to fall after transmissions to the DUT have ceased, and the transition tested in Case 3 will never occur. Also, some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

7 GROUP 3: Link Monitor State Diagram

Overview:

The tests defined in this section verify the Link Monitor State Diagram defined for 100BASE-T1 capable PHYs in section 96.4.5 of the IEEE 802.3bw 100BASE-T1 standard.

7.1 Test 4.3.1 – Link Monitor State Diagram

Purpose: To verify that the device under test (DUT) properly implements the Link Monitor State Diagram.

References:

[1] IEEE Std. 802.3bw, Figure 96-19 Link Monitor state diagram

Resource Requirements:

- 100BASE-T1 Transmit station (refer to appendix 96.A)
- 100BASE-T1 Monitor station (refer to appendix 96.A)
- Access to the link_status signal must be provided

Discussion:

The 100BASE-T1 specification provides the Link Monitor State Diagram. Devices must not set link_status=OK until the LINK UP state.

Test Setup: Connect the DUT to the 100BASE-T1 Transmit station and the 100BASE-T1 Monitor station.

Procedure:

Case 1 - DUT does not enter the LINK OK state

1. Configure the DUT as master.
2. Monitor the transmissions from the DUT and restart the training process on the DUT by sending invalid Ternary Codes after the DUT has established a link.
3. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK. Continue transmitting the valid Idle training pattern until the DUT sets it's loc_rcvr_status = OK, then stop transmitting before stabilize_timer expires.
4. Observe that the DUT does not set link_status = OK.
5. Configure the DUT as slave.
6. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
7. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.
8. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK. Continue transmitting the valid Idle training pattern until the DUT sets it's loc_rcvr_status = OK, then stop transmitting before stabilize_timer expires.
9. Observe that the DUT does not set link_status = OK.

Case 2 - DUT enters the LINK OK state

10. Configure the DUT as master.
11. Monitor the transmissions from the DUT and restart the training process on the DUT by sending invalid Ternary Codes after the DUT has established a link.
12. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = OK for at least stabilize_timer.
13. Observe that the DUT sets link_status = OK.
14. Configure the DUT as slave.
15. Monitor the transmissions from the DUT and restart the training process on the DUT, either through management or by sending invalid Ternary Codes after the DUT has established a link.
16. Send a valid Idle training pattern to the DUT with the scrambler for loc_rcvr_status = NOT OK.

17. As soon as the DUT sets scr_status = OK, begin transmitting a valid Idle training pattern with the scrambler for loc_rcvr_status = OK. Continue transmitting the valid Idle training pattern until the DUT sets it's loc_rcvr_status = OK, then continue transmitting for at least stabilize_timer.
18. Observe that the DUT sets link_status = OK.
19.

Case 3 - DUT exits the LINK OK state

20. Configure the DUT as master.
21. Monitor the transmissions from the DUT and link_status.
22. Establish a valid link with the DUT and observe that the DUT sets link_status=OK.
23. Stop transmitting to the DUT.
24. Observe that the DUT sets link_status = FAIL after maxwait_timer expires.
25. Configure the DUT as slave and repeat steps 20 - 24.

Observable Results:

a. The DUT should not set link_status = OK in step 4.
b. The DUT should not set link_status = OK in step 9.
c. The DUT should set link_status = OK in step 13.
d. The DUT should set link_status = OK in step 18.
e. The DUT should set link_status = OK then link_status = FAIL in step 24.
f. The DUT should set link_status = OK then link_status = FAIL in step 25.

Possible Problems: This test cannot be completed if access to the link_status signal is not available. Also, some devices may not allow configuration as master or slave, in which case only the supported configuration will be tested.

8 TEST SUITE APPENDICES

Overview:
The appendices contained in this section are intended to provide additional low-level technical details pertinent to specific tests defined in this test suite. Test suite appendices often cover topics that are beyond the scope of the standard, but are specific to the methodologies used for performing the measurements covered in this test suite. This may also include details regarding a specific interpretation of the standard (for the purposes of this test suite), in cases where a specification may appear unclear or otherwise open to multiple interpretations.

Scope:
Test suite appendices are considered informative, and pertain only to tests contained in this test suite.

8.1 Appendix 4.A – Test Stations

Purpose: To provide the requirements of the test stations used during 100BASE-T1 PHY Control testing.

Discussion:

Two test stations will be required to perform all tests that are specified in this document. The 100BASE-T1 Receive Test Station will examine the transmissions from the DUT, and the 100BASE-T1 Transmit Test Station will transmit the necessary test patterns to test the receiver of the DUT. It is possible to combine both stations into one setup.

The 100BASE-T1 Receive Test Station will consist of an oscilloscope and software to capture and decode the transmissions from the DUT. The DUT will connect to the test station through the Line Tap as specified in appendix 3.B. The software will download the capture from the oscilloscope and decode the ternary symbols, using knowledge of the 100BASE-T1 encoding, to create the MII data stream. The test setup is shown in Figure A - 1. Note that the MII test station is mandatory for some tests, while it can be replaced with higher layers or a loopback in some tests. Other solutions, such as an FPGA that can capture the ternary symbols, are possible however the test station must not modify or affect the transmissions from the DUT in any manner.

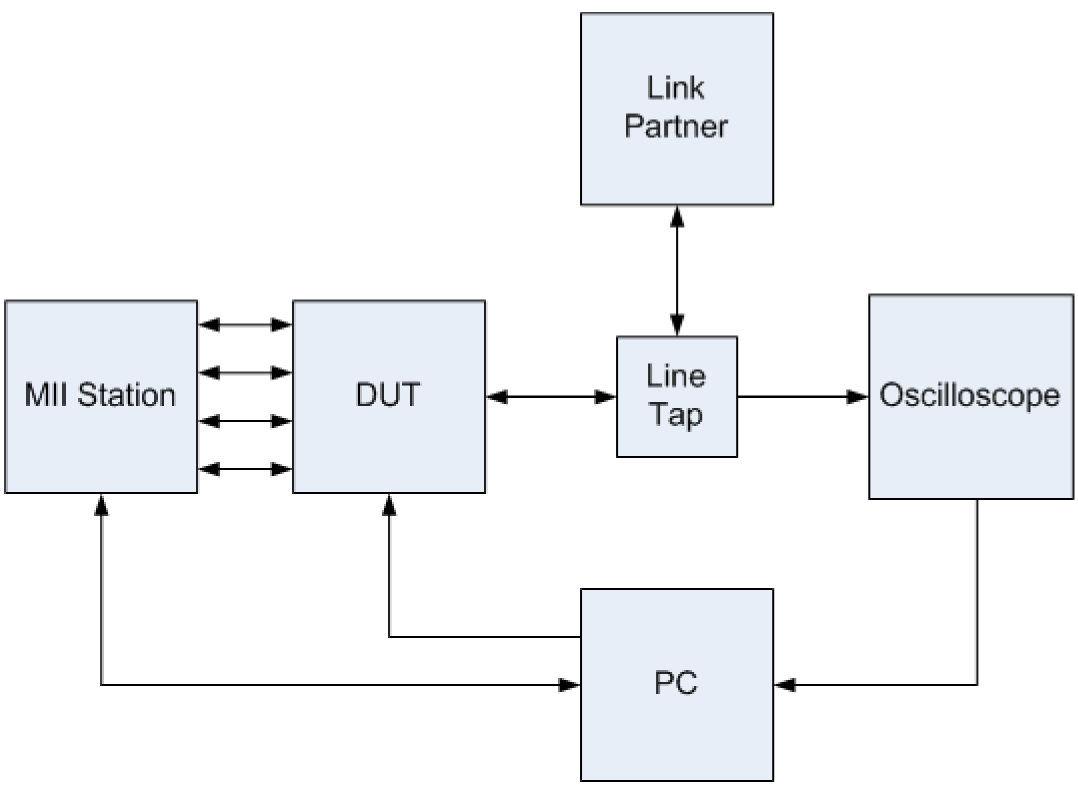

Figure A - 1: 100BASE-T1 Receive Station Setup

The 100BASE-T1 Transmit Test Station will consist of software and hardware that is capable of transmitting arbitrary ternary symbols to the DUT. The ability to send arbitrary sequences, such as invalid transitions of the PCS Transmit State Machine, is essential to fully test the receiver of the DUT. The test setup is shown in Figure A - 2. Note that the MII test station is mandatory for some tests, while it can be replaced with higher layers or a loopback in some tests.

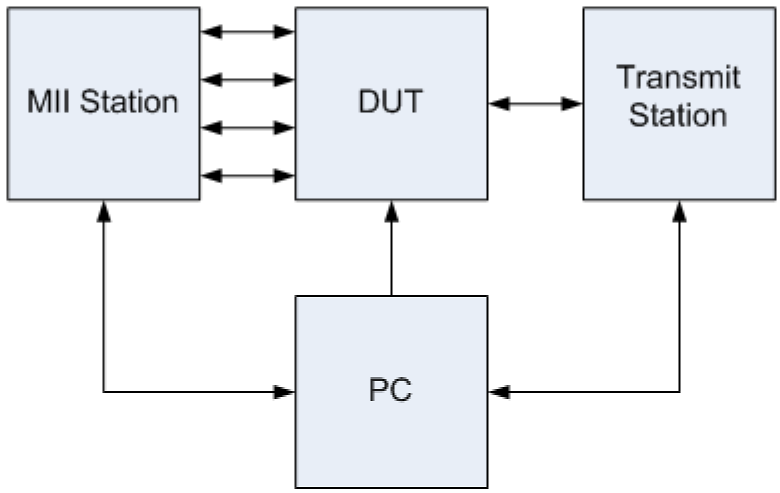

Figure A - 2: 100BASE-T1 Transmit Station Setup

8.2 Appendix 4.B – Line Tap

Purpose: To provide the requirements of a line tap that will be used, in conjunction with an oscilloscope, to capture the transmissions from the DUT.

Discussion: The line tap fixture used for collecting the necessary oscilloscope captures to perform this testing is not specified in this document. Since the line tap is part of the test channel between the Device Under Test (DUT) and Link Partner, the only performance requirement is that the channel (including the line tap) meets the link segment requirement of IEEE Std 802.3bw-2015. However, for more information regarding the UNH-IOL's implementation of the line tap used during 100BASE-T1 PHY Control testing, please contact the UNH-IOL.