1000BASE-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 1000BASE-T1 devices may have with the PHY Control functions.

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1 Copyright Notice and Disclaimer

2 Introduction

2.1 Overview

This particular suite of tests has been developed to help implementers evaluate the functionality of the PMA sublayer of their 1000BASE-T1 device, specifically the PHY Control function.

These tests are designed to determine if a product conforms to specifications defined in IEEE802.3 Clause 97. 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 when tested in accordance with the OPEN Alliance 1000BASE-T1 Interoperability Test Suite, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function properly in many 1000BASE-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 the IEEE 802.3 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.

2.2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEEE 802.3-2022

2.3 Terms and definitions

DUT	Device Under Test
PHYC	PHY Control

3 Organization of Tests

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

3.1 Elementary Test Structure

Specifically, each test description consists of the following fields as shown in Table 3.1. A brief description of each field is provided.

Table 3.1 – Elementary Test Structure

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.
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.
Potential Issues	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.

3.2 DUT Requirements

For the purposes of this test suite, the DUT is one port of a 1000BASE-T1 capable device that includes a 1000BASE-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 table 3.3:

Table 3.3 – DUT Requirements

Test Number and Name	Required Capabilities
Group 1: PHY Control and Timers	
Test PHYC.97.1.1 – PMA Reset	Configuration as MASTER/SLAVE, access to PMA Reset and link_status (LED or register)
Test PHYC.97.1.2 – Value of break_link_timer	Configuration as MASTER/SLAVE
Test PHYC.97.1.3 – Value of send_s_timer	Configuration as MASTER/SLAVE
Test PHYC.97.1.4 – Value of sigdet_wait_timer	Configuration as MASTER/SLAVE
Test PHYC.97.1.5 – Value of link_fail_inhibit_timer	Configuration as MASTER/SLAVE
Test PHYC.97.1.6 – Value of minwait_timer	Configuration as MASTER/SLAVE, a method of transmitting and/or receiving frames
Test PHYC.97.1.7 – Value of maxwait_timer	Configuration as MASTER/SLAVE, a method of transmitting and/or receiving frames
Group 2: PHY Control State Diagram	
Test PHYC.97.2.1 – DISABLE_TRANSMITTER State	Configuration as MASTER/SLAVE
Test PHYC.97.2.3 – SILENT State	Configuration as MASTER/SLAVE
Test PHYC.97.2.4 – TRAINING State	Configuration as MASTER/SLAVE
Test PHYC.97.2.5 – COUNTDOWN State	Configuration as MASTER/SLAVE
Test PHYC.97.2.6 – SEND IDLE1 State	Configuration as MASTER/SLAVE
Test PHYC.97.2.7 – SEND IDLE2 State	Configuration as MASTER/SLAVE, a method of transmitting and/or receiving frames
Test PHYC.97.2.8 – SEND DATA State	Configuration as MASTER/SLAVE, a method of transmitting and/or receiving frames
Group 3: Link Synchronization State Diagram	
Test PHYC.97.3.1 – Link Sync – TRANSMIT DISABLE State	Configuration as MASTER/SLAVE
Test PHYC.97.3.2 – Link Sync – TX_SEND_S State	Configuration as MASTER/SLAVE
Test PHYC.97.3.3 – Link Sync – SIGDET_WAIT State	Configuration as MASTER/SLAVE
Test PHYC.97.3.4 – Link Sync – SILENT WAIT State	Configuration as MASTER/SLAVE
Test PHYC.97.3.6 – Link Sync – LINK_GOOD_CHECK State	Configuration as MASTER/SLAVE
Test PHYC.97.3.7 – Link Sync – LINK_GOOD State	Configuration as MASTER/SLAVE, a method of transmitting and/or receiving frames
Group 4: Link Monitor State Diagram	
Test PHYC.97.4.1 – Link Monitor State Diagram	Configuration as MASTER/SLAVE, a method of transmitting and/or receiving frames,

4 Test Cases

The following test cases shall be performed on all 1000BASE-T1 PHYs.

4.1 GROUP 1: PHY Control and Timers

This section verifies the integrity of the 1000BASE-T1 PHY Control functions and related timers.

4.1.1 Test PHYC.97.1.1 – PMA Reset

Purpose	To verify that the PMA properly initializes upon receipt of a reset request from the management entity.
References	[1] IEEE 802.3 - 2022 Subclause 97.4.2.1 – PMA Reset Function [2] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [3] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [4] IEEE 802.3 - 2022 Figure 92 – 27 Link Monitor state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A) (R)GMII Test Station (refer to Appendix A) Management access to *link_status* and/or led indication of *link_status*
Discussion	Reference [1] states that the PMA is reset when power for the device containing the PMA has not yet reached the operating state, or upon the receipt of a reset request from management entity. The PMA Reset function causes the PHY Control state diagram [2] to transition to the DISABLE_TRANSMITTER state. After exiting the DISABLE_TRANSMITTER state while configured as MASTER, the DUT should immediately transition from the SILENT state to the TRAINING state and transmit with tx_mode = SEND_T and PMA_state = 00. After exiting the DISABLE_TRANSMITTER state while configured as SLAVE, the DUT should remain in the SILENT state until loc_SNR_margin = OK, en_slave_tx = 1, and minwait_timer = done. The PMA Reset function also causes the Link Monitor State Diagram [4] to transition to the LINK_DOWN state. Here the DUT should set link_status = FAIL. While not explicitly stated in clause 97, it is also presumed that the PHY Link Synchronization state diagram should transition to TRANSMIT_DISABLE following a PMA Reset, per the language of reference [1].
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.

Test Procedure Part A	**Part A:** *DUT as MASTER properly reacts to a PMA Reset.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame and observe if sent/received. [To confirm *link_status* = OK for the DUT]. a. If the frame is not observed, abort this test part and restart, waiting an increased amount of time before sending the frame. Repeat until the frame is received. 4. Cause the management of the DUT to request a PMA Reset. 5. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part A	a. In step 3, frame transmission and/or reception should be observed, confirming that link_status = OK. (Observed by tx/rx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded in/out a secondary DUT port) b. In step 5, the DUT should stop transmitting with *tx_mode* = SEND_N and start transmitting with *sync_tx_mode* = SEND_Z.
Test Procedure Part B	**Part B:** *DUT as SLAVE properly reacts to a PMA Reset.* 6. Configure the DUT as SLAVE with Auto-negotiation disabled. 7. Establish a link with the DUT. 8. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame and observe if sent/received. [To confirm *link_status* = OK for the DUT]. a. If the frame is not observed, abort this test part and restart, waiting an increased amount of time before sending the frame. Repeat until the frame is received. 9. Cause the management of the DUT to request a PMA Reset. 10. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part B	c. In step 8, frame transmission and/or reception should be observed, confirming that link_status = OK. (Observed by tx/rx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded in/out a secondary DUT port) d. In step 10, the DUT should stop transmitting with *tx_mode* = SEND_N and start transmitting with *sync_tx_mode* = SEND_Z.
Potential Issues	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.

4.1.2 Test PHYC.97.1.2 – Value of break_link_timer

Purpose	To verify that the DUT properly implements a break_link_timer of 300 – 305 µs.
References	[1] IEEE 802.3 - 2022 Subclause 98.5.2 – State diagram timers [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Break_link_timer is defined as 300 – 305 µs. This timer is used to assure the link partner has entered a Link Fail state. In Part A, a MASTER device is expected to SEND_Z for *break_link_timer* then commence SEND_S transmissions without further delay. In Part B, a SLAVE device is expected to SEND_Z for *break_link_timer* then look for the receipt of a SEND_S signal from the 1000BASE-T1 Test Station acting as the MASTER, wait for that SEND_S signal to complete, then send a SEND_S signal to the Master. When considering the minimum period permitted by the SLAVE to send SEND_Z, the minimum break_link_timer of 300 µs should be considered the lower-bound, in at least some observations, it is conceivable that a given SLAVE's implementation may be able to detect *send_s_sigdet* = true immediately upon *break_link_timer_done* and transition to SILENT_WAIT just as the SEND_S from the Test Station is ending, causing a near-immediate transition of *send_s_sigdet* to false. Hence, an observation of the SLAVE sending SEND_Z for only 300 µs is not proof of a violation of the break_link_timer value. When considering the maximum period permitted by the SLAVE to send SEND_Z, the maximum *break_link_timer* of 305 µs should be considered as the starting point, but additional delays are warranted. Consider *ts_sigdet_wait_timer* as the 1000BASE-T1 Test Station's *sigdet_wait_timer* (as observed), and *ts_send_s_timer* as the duration of the SEND_S signal from the Test Station (as observed), then the observed maximum time allowed before the DUT enters SIGDET_WAIT would be 305 µs plus the additional (*N-1*)*(*ts_sigdet_wait_timer* + *N**(*ts_send_s_timer)* + 1 µs (1 µs is per definition of *send_s_sigdet*) before commencing transmission of SEND_S from the SLAVE DUT. 'N' in this case refers to how many SEND_S transmissions are sent by the test station before the DUT emits its own SEND_S transmission. No limit is enforced in this test plan on the number of SEND_S received before the DUT must transmit its SEND_S pattern; however the expectation is no more than 2 such SEND_S signals should be received before the DUT (as SLAVE) responds. Using maximum values for compliant devices, *ts_sigdet_wait_timer* would be 4.1 µs, and *ts_send_s_timer* would be 1.04 µs, thus, in that maximum compliant value case, the maximum value allowed if the DUT responded after two SEND_S transmission from the test station would be 305 µs + 4.1 µs + 2*1.04 µs + 1 µs (312.18 µs) of allowed SEND_Z from the SLAVE DUT before a failure would be issued. Note: Actual observed start of SEND_S to end of SEND_S transmissions from the test station should be used when evaluating the SLAVE DUT behavior.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.

Test Procedure Part A	**Part A:** *Value of break_link_timer for a MASTER* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link and ensure that *link_status* = OK. a. This can be done via frame transmission/reception or via monitoring management indications for *link_status*. 3. Cease transmissions to the DUT and observe transmissions. [causing *link_status* = FAIL and a transition to TRANSMIT_DISABLE.] 4. Measure the time from when the DUT begins transmitting with *sync_tx_mode* = SEND_Z to when it transitions to *sync_tx_mode* = SEND_S.
Observable Results for Part A	a. In step 4, the DUT should implement a *break_link_timer* of 300 – 305 µs, observed by measuring the time that SEND_Z is first observed to when SEND_S is first observed. Any value outside of the expected timer range will be considered a FAIL.
Test Procedure Part B	**Part B:** *Value of break_link_timer for a SLAVE* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. 6. Establish a link and ensure that *link_status* = OK. a. This can be done via frame transmission/reception or via monitoring management indications for *link_status*. 7. Cease transmissions to the DUT and observe transmissions. [causing *link_status* = FAIL and a transition to TRANSMIT_DISABLE.] 8. Emulate a valid MASTER port by issuing a SEND_S after an emulated period of SEND_Z that is below minimum break_link_timer in duration and otherwise emulating [2]. 9. Measure the time from when the DUT begins transmitting with *sync_tx_mode* = SEND_Z to when it transitions to *sync_tx_mode* = SEND_S.
Observable Results for Part B	b. In step 9, any observed value below300 µs will be considered a FAIL (see discussion above). c. In step 9, any observed value above 305 µs + (N-1)*(*ts_sigdet_wait_timer) + N*(ts_send_s_timer)* + 1 µs will be considered a FAIL (see discussion above). d. Informatively report the observed period from SEND_Z to the start of the DUT's first SEND_S transmission.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

133 ### 4.1.3 Test PHYC.97.1.3 – Value of send_s_timer

Purpose	To verify that the DUT properly implements a send_s_timer of 1.00 µs ± 0.04 µs.
References	[1] IEEE 802.3 - 2022 Subclause 97.4.2.6.2 – State diagram timers [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Send_s_timer is defined as 1.00 µs ± 0.04 µs. This timer is used to control the duration that SEND_S is transmitted.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *Value of send_s_timer as MASTER* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Issue a PMA Reset to the DUT; or, break and re-establish a link to the DUT; or, cease all transmissions to the DUT. 3. Observe transmissions from the DUT. 4. Measure the time from when the DUT begins transmitting with *sync_tx_mode* = SEND_S to when it transitions to *sync_tx_mode* = SEND_Z.
Observable Results for Part A	a. In step 4, the DUT should implement a send_s_timer of 1.00 µs ± 0.04 µs.
Test Procedure Part B	**Part B:** *Value of send_s_timer as SLAVE* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. 6. Issue a PMA Reset to the DUT; or, break and re-establish a link to the DUT; or, cease all transmissions to the DUT. 7. Emulate a valid MASTER by waiting *break_link_timer* before transmitting with *sync_tx_mode* = SEND_S to the DUT for *send_s_timer* and then stop transmitting for *sigdet_wait_timer* and repeat this step until the DUT emits a SEND_S. 8. Measure the time from when the DUT begins transmitting with *sync_tx_mode* = SEND_S to when it transitions to *sync_tx_mode* = SEND_Z.
Observable Results for Part B	b. In step 8, the DUT should implement a *send_s_timer* of 1.00 µs ± 0.04 µs.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

134 4.1.4 Test PHYC.97.1.4 – Value of sigdet_wait_timer

Purpose	To verify that the DUT properly implements a *sigdet_wait_timer* of 4.0 µs ± 0.1 µs.
References	[1] IEEE 802.3-2018 Subclause 97.4.2.6.2 – State diagram timers [2] IEEE 802.3-2018 Figure 97–25 PHY Link Synchronization state diagram [3] IEEE 802.3-2018 Figure 97–26 PHY Control state diagram [4] IEEE 802.3-2018 Subclause 97.1.5 – Conventions of this clause
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	*Sigdet_wait_timer* is defined as 4.0 µs ± 0.1 µs. This timer is used to control the wait time after transmitting or detecting the end of SEND_S. The PHY Link Synchronization state diagram makes use of the *sigdet_wait_timer* in two states, the SIGDET_WAIT state and the PAUSE state. The first part of this test will examine the MASTER's timer value in the SIGDET_WAIT state, where the test station will emulate a SLAVE that does not SEND_S, forcing the MASTER to timeout (*sigdet_wait_timer_done*) and return to the TX_SEND_S state. The remaining parts of this test will examine the DUT's transition from PAUSE by observing the interval from SEND_S to SEND_T, which for a MASTER is principally governed by the *sigdet_wait*_timer, but for a SLAVE, the interval is the combined value of *sigdet_wait_timer*, *minwait_timer* and any time required by the slave beyond *minwait_timer* before entering the TRAINING state. Note: While [4] and associated conventions expect state machines to be evaluated instantaneously, including transitions, practical implementations may experience some delay. This test proposes a performance bound of 2 TX_AGGREGATE signals of delay, which is 200 bit times, or 0.2 µs of delay.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *Value of sigdet_wait_timer in SIGDET_WAIT* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Issue a PMA Reset to the DUT; or, break and re-establish a link to the DUT; or, cease all transmissions to the DUT. 3. Measure the time the DUT transmits *sync_tx_mode* = SEND_Z, starting from when the DUT stops transmitting *sync_tx_mode* = SEND_S to when the DUT transitions to *sync_tx_mode* = SEND_S in the TX_SEND_S state.
Observable Results for Part A	a. In step 3, the DUT should implement a *sigdet_wait_timer* of 4.0 µs ± 0.1 µs, observed by measuring a period of SEND_Z between two periods of SEND_S transmission from the DUT. The period of SEND_Z transmission should be 4.0 µs ± 0.1 µs and should directly correspond to the duration of the sigdet_wait_timer. An observed interval outside of this range will be considered a FAIL.

Test Procedure Part B	**Part B:** *Value of sigdet_wait_timer in PAUSE for a MASTER port* 4. Configure the DUT as MASTER with Auto-negotiation disabled. 5. Issue a PMA Reset to the DUT; or, break and re-establish a link to the DUT; or, cease all transmissions to the DUT. 6. Wait for the DUT to transmit SEND_S and then stop its SEND_S transmission. 7. Emulate a valid SLAVE port by transmitting with *sync_tx_mode* = SEND_S to the DUT for *send_s_timer*. 8. Measure the duration of SEND_Z from the DUT, from when the 1000BASE-T1 Test Station stops transmitting *sync_tx_mode* = SEND_S to when *tx_mode* = SEND_T is observed.
Observable Results for Part B	b. In step 8, the DUT should implement a *sigdet_wait_timer* of 4.0 µs ± 0.1 µs, observed by measuring a period of SEND_Z between SEND_S as sent by the 1000BASE-T1 Test Station to SEND_T transmissions sent by the DUT of at least 928.9 µs (0 µs + 3.9 µs + 925 µs (minimum time for *send_s_sidget* = FALSE + minimum *sigdet_wait_timer* + minimum *minwait_timer*)), any observation less than this will be considered a FAIL. c. In step 8, SEND_Z transmissions may be longer than 1030.1 µs (1.0 µs + 4.1 µs + 1025 µs (maximum time for *send_s_sidget* = FALSE + maximum *sigdet_wait_timer* + maximum *minwait_timer*)), as the *sync_link_control* must be set to ENABLE and the DUT must transition from DISABLE_TRANSMITTER to the TRAINING state. For the purposes of this test part, any observed SEND_Z transmission greater than 1030.3 µs will be considered a FAIL. Refer to the Discussion in this test for further commentary (1030.3 µs = 1.0 µs + 4.1 µs + 1025 µs + 0.2 µs (maximum time for *send_s_sidget* = FALSE + maximum *sigdet_wait_timer* + maximum *minwait_timer* + maximum allowed DUT error)).

Test Procedure Part C	**Part C:** *Value of sigdet_wait_timer in PAUSE for a SLAVE port* 9. Configure the DUT as SLAVE with Auto-negotiation disabled. 10. Issue a PMA Reset to the DUT; or, break and re-establish a link to the DUT; or, cease all transmissions to the DUT. 11. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE and then transmitting to the DUT with *tx_mode* = SEND_T and eventually *en_slave_tx* = 1 per [3]. 12. Measure the time from when the DUT stops transmitting with *sync_tx_mode* = SEND_S to when the DUT begins to transmit with *tx_mode* = SEND_T.
Observable Results for Part C	d. In step 12, the DUT should implement a *sigdet_wait_timer* of 4.0 µs ± 0.1 µs, observed by measuring a period of SEND_Z between SEND_S to SEND_T transmissions of at least 928.9 µs (3.9 µs + 925 µs (minimum *sigdet_wait_timer* + minimum *minwait_timer*)). Any observed interval less than this value will be considered a FAIL. e. In step 12, SEND_Z transmissions may be longer than 1029.1 µs (4.1 µs + 1025 µs), as the sync_link_control must be set to ENABLE and the DUT must transition to the SILENT state and then the TRAINING state after (at least) minwait_timer (975 µs ± 50 µs). For the purposes of this test part, no upper bound will be enforced in this test as the DUT's SLAVE port may wait longer than minwait_timer before entering the TRAINING state. The value observed will be reported informatively.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

4.1.5 Test PHYC.97.1.5 – Value of link_fail_inhibit_timer

Purpose	To verify that the DUT properly implements a link_fail_inhibit_timer of 97 – 98 ms with Auto-Negotiation disabled.
References	[1] IEEE 802.3 - 2022 Subclause 98.5.2 – State diagram timers [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Link_fail_inhibit_timer is defined as 97 – 98 ms. This timer is used as the qualifying time for either link_status = FAIL or link_status = OK indication.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station. Note, link_fail_inhibit_timer and maxwait_timer are the same duration. When Auto-Negotiation is not in use (as is the case presumed in this test plan), these timers are only distinguishable based on whether the DUT establishes link or not. This test simply follows the PHY Link Synchronization state machine to cause *sync_link_control* = ENABLE but never completes a link.
Test Procedure Part A	**Part A:** *DUT as MASTER implements valid link_fail_inhibit_timer* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Issue a PMA Reset to the DUT or break and re-establish a link to the DUT. 3. Emulate a valid SLAVE per [2] and complete link synchronization with the DUT. a. Send from the 1000BASE-T1 Test Station valid link signaling such that *sync_link_control* = ENABLE but do send signaling such that *link_status* = FAIL (*tx_mode* never reaches SEND N) for the DUT (send valid SEND_T from the Transmit station, but never set *loc_rcvr_status* = OK from the 1000BASE-T1 Test Station such that the TRAINING state is never exited) 4. Measure the time from when the test station finishes transmitting with *sync_tx_mode* = SEND_S in the TX_SEND_S state to when the MASTER DUT ceases transmissions with tx_mode = SEND_T following expiration of *link_fail_inhibit_timer*. Note this time as *S-to-Tend-time.* 5. Subtract the DUT's mean *sigdet_wait_timer* (see 4.1.4), from this *S-to-Tend-time* measurement. This will be the reported value of *link_fail_inhibit_timer*.
Observable Results Part A	a. In step 4, the maximum lower bound of the value measured would be 97 ms + 3.9 µs, or 97.0039 ms, any value less than this will also be considered a FAIL. b. In step 5, the DUT should implement a *link_fail_inhibit_timer* of 97 – 98 ms. Any value of *link_fail_inhibit_timer* less than 97 ms or more than 98 ms will be reported as a failure. c. Report the observed *S-to-Tend-time,* as well as the mean observed values for *sigdet_wait_timer* (see 4.1.4), and the resulting calculation for the observed *link_fail_inhibit_timer.*

Test Procedure Part B	**Part B:** *DUT as SLAVE implements valid link_fail_inhibit_timer* 6. Configure the DUT as SLAVE with Auto-negotiation disabled. 7. Issue a PMA Reset to the DUT or break and re-establish a link to the DUT. 8. Emulate a valid MASTER per [2] and complete link synchronization with the DUT. a. Send from the 1000BASE-T1 Test Station valid link signaling such that *sync_link_control* = ENABLE and send signaling such that *link_status* = FAIL (*tx_mode* never reaches SEND N) but that the SLAVE DUT does set *tx_mode* = SEND_T (send valid SEND_T from the 1000BASE-T1 Test Station, but never set *loc_rcvr_status* = OK from the 1000BASE-T1 Test Station such that the TRAINING state is never exited.) 9. Measure the time from when the DUT finishes transmitting with *sync_tx_mode* = SEND_S in the TX_SEND_S state to when the SLAVE DUT ceases transmissions with tx_mode = SEND_T following expiration of *link_fail_inhibit_timer*. Note this time as *S-to-Tend-time.*
Observable Results Part B	d. In step 9, the maximum lower bound of the value measured would be 97 ms + 3.9 µs, or 97.0039 ms, any value less than this will also be considered a FAIL. e. In step 10, the DUT should implement a *link_fail_inhibit_timer* of 97 – 98 ms. Any value of *link_fail_inhibit_timer* less than 97 ms or more than 98 ms will be reported as a failure. f. Report the observed *S-to-Tend-time,* as well as the mean observed values for *sigdet_wait_timer* (see 4.1.4), and the resulting calculation for the observed *link_fail_inhibit_timer.*
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

136 4.1.6 Test PHYC.97.1.6 – Value of minwait_timer

Purpose	To verify that the DUT properly implements a minwait_timer of 975 µs ± 50 µs.
References	[1] IEEE 802.3 - 2022 Subclause 97.4.4.2 – Timers [2] IEEE 802.3 - 2022 Figure 97-26 PHY Control state diagram [3] IEEE 802.3 - 2022 Figure 97–25 PHY Link Synchronization state diagram [4] IEEE 802.3 - 2022 Figure 97-27 Link Monitor state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	The *minwait_timer* is defined as 975 µs ± 50 µs. This timer is used to control the minimum amount of time the DUT remains in the SILENT, TRAINING, SEND IDLE2, and SEND DATA states for the PHY Control state diagram, and the LINK DOWN state for the Link Monitor state diagram.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *minwait_timer in SILENT for a MASTER* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE 3. Emulate a valid SLAVE per [3] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 4. Continue to emulate a valid SLAVE per [3] by sending SEND_I from the 1000BASE-T1 Test Station, but never send *loc_phy_ready* = OK such that the DUT does not receive *rem_phy_ready* = OK. Cease transmission of *tx_mode* = SEND_I at any time (within ~90ms) after the 1000BASE-T1 Test Station has started SEND_I transmission. a. The DUT should never enter SEND_DATA as *rem_phy_ready* is not OK. 5. Measure from when the 1000BASE-T1 Test Station last sends *sync_tx_mode* = SEND_S to when the DUT begins transmitting with *tx_mode* = SEND_T. 6. As the DUT is receiving no further signaling from the 1000BASE-T1 Test Station, the DUT should detect *loc_rcvr_status* = NOT_OK and return to SILENT, measure from the time when the DUT transitions from *tx_mode* = SEND_I (or SEND_T) to transmitting with *tx_mode* = SEND_Z to when the DUT resumes transmitting with *tx_mode* = SEND_T.

Observable Results for Part A	a. In step 5, the DUT should remain in the SILENT state for 975 µs ± 50 µs, in this step, this is observed by measuring the time from when the 1000BASE-T1 Test Station stopped transmission of *sync_tx_mode* = SEND_S to the DUT's transmission of *tx_mode* = SEND_T, which will include, at least, *sigdet_wait_timer* and any additional time required to transition states by the implementation. Thus only the minimum bound of 928.9 µs can be enforced in this step (928.9 µs = 3.9 µs + 925 µs + 0 µs (minimum *sigdet_wait_timer* + minimum minwait_timer + minimum time for *send_s_sigdet* = false)), where any observed interval less than this is considered a FAIL. b. In step 6, the DUT should remain in the SILENT state for 975 µs ± 50 µs, in this step, this is observed by measuring the time starting from SEND_I (or SEND_T) to SEND_Z transition and ending at the SEND_Z to SEND_T transition in the DUT signaling, which should be within the defined range, and if not, then this is considered a FAIL. Note, if the DUT is, for any reason, still in TRAINING (PMA_state = 00) when the 1000BASE-T1 Test Station ceases transmission, then this observation cannot be made (the DUT must be in the COUNTDOWN, SEND_IDLE1, or SEND_IDLE2 states when it detects *loc_rcvr_status* = NOT_OK), if the DUT is still in TRAINING, then *link_fail_inhibit_timer* must expire before transitioning back through Link Synchronization, which is not the purpose of this step's observation. Repeat the test attempt.
Test Procedure Part B	**Part B:** *minwait_timer in SILENT for a SLAVE* 7. Configure the DUT as SLAVE with Auto-negotiation disabled. 8. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE 9. Emulate a valid MASTER per [3] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values (eg: set en_slave_Tx = 1 and encoding *loc _rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 10. Continue to emulate a valid MASTER per [3] by sending SEND_I from the 1000BASE-T1 Test Station, but never send *loc_phy_ready* = OK such that the DUT does not receive *rem_phy_ready* = OK. Cease transmission of *tx_mode* = SEND_I at any time (within ~90 ms) after the 1000BASE-T1 Test Station has started SEND_I transmission. a. The DUT should never enter SEND_DATA as *rem_phy_ready* is not OK. 11. Measure the time from when the DUT last transmitted *sync_tx_mode* = SEND_S to when the DUT begins transmitting with *tx_mode* = SEND_T. 12. As the DUT is receiving no further signaling from the test station, the DUT should detect *loc_rcvr_status* = NOT_OK and return to SILENT, measure from when the DUT transitions from *tx_mode* = SEND_I (or SEND_T) to transmitting with *tx_mode* = SEND_Z to when it resumes transmitting with *tx_mode* = SEND_T.

Observable Results for Part B	c. In step 11, the DUT should remain in the SILENT state for 975 µs ± 50 µs, in this step, this is observed by measuring the time from SEND_S to SEND_T, which will include, at least, *sigdet_wait_timer* and any additional time required to transition states by the implementation. Thus only the minimum bound of 928.9 µs can be enforced in this step (928.9 µs = 3.9 µs + 925 µs + 0 µs (minimum *sigdet_wait_timer* + minimum minwait_timer + minimum time for *send_s_sigdet* = false)), where any observed interval less than this is considered a FAIL. d. In step 12, the DUT should remain in the SILENT state for 975 µs ± 50 µs, in this step, this is observed by measuring the time from the time SEND_Z starts after SEND_I or SEND_T transmission from the DUT to when *tx_mode* = SEND_T resumes. As the DUT is configured as a SLAVE, the value for loc_SNR_margin cannot be observed and may extend the duration the DUT remains in SILENT, thus only a lower bound can be enforced, thus any value less than 925 µs is considered a FAIL.
Test Procedure Part C	**Part C:** *minwait_timer in TRAINING for MASTER* 13. Configure the DUT as MASTER with Auto-negotiation disabled. 14. Emulate a valid SLAVE per [2] and cause the DUT to set *sync_link_control* = ENABLE. 15. Emulate a valid SLAVE per [3] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 16. Measure the time from when the DUT transmits *tx_mode* = SEND_T with *PMA_state* = 00 and monitor the value of *loc_rcvr_status* as sent by the DUT in its InfoField (effectively *rem_rcvr_status* from the 1000BASE-T1 Test Station's perspective).
Observable Results for Part C	e. In step 16, the DUT should transmit with *tx_mode* = SEND_T and *PMA_state* = 00 for at least 925 µs (minimum *minwait_timer*), any observed value less than this will be considered a FAIL. f. In step 16, if the DUT is observed to send SEND_T with PMA_state = 00 and the DUT's loc_rcvr_status = OK for more than 1025 µs (an entire maximum minwait_timer period), then this will also be considered a FAIL as the DUT will have had ample time while receiving rem_rcvr_status = OK from the 1000BASE-T1 Test Station to proceed to the COUNTDOWN state. Note: The maximum minwait_timer period is an arbitrary choice to allow some implementation delay before entering the COUNTDOWN state and setting *PMA_state* = 01. . g. The time from when the 1000BASE-T1 Test Station starts to transmit tx_mode = SEND_T to loc_rcvr_status = OK will be reported.

Test Procedure Part D	**Part D:** *minwait_timer in TRAINING SLAVE* 17. Configure the DUT as SLAVE with Auto-negotiation disabled. 18. Emulate a valid MASTER per [2] and cause the DUT to set *sync_link_control* = ENABLE. 19. Emulate a valid MASTER per [3] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 20. Measure the time from when the DUT transmits *tx_mode* = SEND_T with *PMA_state* = 00 and monitor the value of *loc_rcvr_status* as sent by the DUT in its InfoField (effectively *rem_rcvr_status* from the 1000BASE-T1 Test Station 's perspective).
Observable Results for Part D	h. In step 20, the DUT should transmit with *tx_mode* = SEND_T and *PMA_state* = 00 for at least 925 µs (minimum *minwait_timer*), any observed value less than this will be considered a FAIL. i. If the DUT is observed to send SEND_T with PMA_state = 00 for more than 1025 µs with the DUT's loc_rcvr_status = OK at least 10 µs prior to this time, then this will also be considered a FAIL. Note: 10 µs is an arbitrary choice to allow some implementation delay between before entering the COUNTDOWN state and setting *PMA_state* = 01. If the DUT's loc_rcvr_status is set to OK after this time, no FAIL will be issued for this test. j. The time from when the 1000BASE-T1 Test Station starts to transmit tx_mode = SEND_T to loc_rcvr_status = OK will be reported.
Test Procedure Part E	**Part E:** *minwait_timer in SEND IDLE2 for a MASTER* 21. Configure the DUT as MASTER with Auto-negotiation disabled. 22. Emulate a valid SLAVE per [2] and [3] and cause the DUT to set *link_status* = OK. 23. Attempt to send a frames at line rate from the DUT to the 1000BASE-T1 Transmit Station. a. This can be done via any GMII-like interface, or another port of the DUT. 24. Monitor transmissions from SEND_T to SEND_N from the DUT. 25. Measure the time from when the DUT begins transmitting with *tx_mode* = SEND_I until the DUT indicates *loc_phy_ready* = OK is indicated. 26. Measure the time from when the DUT begins transmitting with *tx_mode* = SEND_I until the DUT sends the first frame to the Transmit station.

Observable Results for Part E	k. In step 25, report the observed time from start of SEND_I to *loc_phy_ready* = OK. l. In step 26, the DUT can commence frame transmission as soon as tx_mode = SEND_N which occurs at least 1 minwait_timer after the start of PAM3 signaling. The observed time from start of SEND_I transmission to the first frame from the DUT must be at least 925 µs. If the value is less than the result is considered a FAIL. m. In step 26, the observed time from start of SEND I transmission to the first frame from the DUT is reported.
Test Procedure Part F	**Part F:** *minwait_timer in SEND IDLE2 for a SLAVE* 27. Configure the DUT as SLAVE with Auto-negotiation disabled. 28. Emulate a valid MASTER per [2] and cause the DUT to set *link_status* = OK 29. Attempt to send a frames at line rate from the DUT to the 1000BASE-T1 Test Station. a. This can be done via any GMII-like interface, or another port of the DUT. 30. Monitor transmissions from SEND_T to SEND_N from the DUT. 31. Measure the time from when the DUT begins transmitting with *tx_mode* = SEND_I until the DUT indicates *loc_phy_ready* = OK is indicated. 32. Measure the time from when the DUT begins transmitting with *tx_mode* = SEND_I until the DUT sends the first frame to the 1000BASE-T1 Test Station.
Observable Results for Part F	n. In step 31, report the observed time from start of SEND_I to *loc_phy_ready* = OK. o. In step 32, the DUT can commence frame transmission as soon as tx_mode = SEND_N which occurs at least 1 minwait_timer after the start of PAM3 signaling. The observed time from start of SEND_I transmission to the first frame from the DUT must be at least 925 µs. If the value is less than the result is considered a FAIL. p. In step 32, the observed time from start of SEND I transmission to the first frame from the DUT is reported.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested. Test parts (c) and (d) presume the 1000BASE-T1 Test Station is able to set its loc_rcvr_status before the DUT.

137 4.1.7 Test PHYC.97.1.7 – Value of maxwait_timer

Purpose	To verify that the DUT properly implements a maxwait_timer of 97.5 ms +/- 0.5 ms with Auto-Negotiation disabled.
References	[1] IEEE 802.3 - 2022 Subclause 98.5.2 – State diagram timers [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A) (R)GMII Test Station (refer to Appendix A)
Discussion	*Link_fail_inhibit_timer* is defined as 97 – 98 ms. This timer is used as the qualifying time for either *link_status* = FAIL or *link_status* = OK indication. Note, *link_fail_inhibit_timer* and *maxwait_timer* are the same duration. When Auto-Negotiation is not in use (as is the case presumed in this test plan), these timers are only distinguishable based on whether the DUT establishes link or not. To avoid interference in this measurement by functions such as the *PMA_watchdog_status*, this test will establish a link, and then rely on *hi_rfer* = TRUE to set *pcs_status* to NOT_OK resulting in *loc_phy_ready* being set to NOT_OK which should cause a transition to LINK_DOWN after *maxwait_timer_done*. This test presumes the *loc_phy_ready* variable will be NOT_OK long before *maxwait_timer_done* occurs. This test relies on frame transmission and/or reception to infer *link_status* = OK on the DUT, without relying on management querying.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station, the 1000BASE-T1 Monitor station and, if a suitable interface is exposed, the (R)GMII Test Station.

Test Procedure Part A	**Part A:** *DUT as MASTER implements valid maxwait_timer*
	1. Configure the DUT as MASTER with Auto-negotiation disabled.
	2. Issue a PMA Reset to the DUT or break and re-establish a link to the DUT.
	3. Emulate a valid SLAVE per [2] and [3] and establish a link with the DUT.
	    a. Send from the 1000BASE-T1 Test Station valid link signaling such that *link_status* = OK is indicated by the DUT
	4. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame. [To confirm *link_status* = OK for the DUT].
	5. Begin sending a sequence of invalid Reed-Solomon frames such that the DUT keeps hi_rfer = TRUE.
	    a. Send a repeating pattern of 16 consecutive invalid PHY frames followed by 72 valid PHY frames {violating the RFRX_CNT_LIMIT but avoids setting block_lock=FALSE}
	6. Measure the time from when the test station finishes transmitting with tx_mode = SEND_S in the TX_SEND_S state to when the DUT ceases tx_mode = SEND_N and starts SEND_Z transmission. Note this time as *S-to-NZ-maxwaitMaster.*
	7. Subtract the DUT's mean *sigdet_wait_timer* (see 4.1.4), from this *S-to-NZ-maxwaitMaster* measurement. This will be the reported value of *maxwait_timer(master)*.

Observable Results Part A	a. In step 4, frame transmission and/or reception should be observed, confirming that link_status = OK. b. In step 6, the maximum lower bound of the value measured would be the minimum *maxwait_timer*, and *sigdet_timer*. This is 97 ms + 3.9 µs, or 97.0039 ms. Any observed value for *S-to-NZ-maxwaitMaster* less than this will be considered a FAIL. c. In step 7, the DUT should implement a *maxwait_timer(master)* of 97 – 98 ms. Any value of *maxwait_timer(master)* less than 97 ms or more than 98 ms will be reported as a failure. d. Report the observed *S-to-NZ-maxwaitMaster,* as well as the mean observed value for *sigdet_wait_timer* (see 4.1.4), and the resulting calculation for the observed *maxwait_timer(master).*

Test Procedure Part B	**Part B:** *DUT as SLAVE implements valid maxwait_timer*
	8. Configure the DUT as SLAVE with Auto-negotiation disabled.
	9. Issue a PMA Reset to the DUT or break and re-establish a link to the DUT.
	10. Emulate a valid MASTER per [2] and [3] and establish a link with the DUT.
	    a. Send from the 1000BASE-T1 Test Station valid link signaling such that *link_status* = OK is indicated by the DUT
	11. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame. [To confirm *link_status* = OK for the DUT].
	12. Begin sending a sequence of invalid Reed-Solomon frames such that the DUT keeps hi_rfer = TRUE.
	    a. Send a repeating pattern of 16 consecutive invalid PHY frames followed by 72 valid PHY frames {violating the RFRX_CNT_LIMIT but avoids setting block_lock=FALSE}
	13. Measure the time from when the DUT finishes transmitting with tx_mode = SEND_S in the TX_SEND_S state to when the DUT ceases tx_mode = SEND_N and starts SEND_Z transmission. Note this time as *S-to-NZ-maxwaitSlave.*
	14. Subtract the DUT's mean *sigdet_wait_timer* (see 4.1.4), from this *S-to-NZ-maxwait* measurement. This will be the reported value of *maxwait_timer(slave)*.

Observable Results Part B	e. In step 11, frame transmission and/or reception should be observed, confirming that link_status = OK. f. In step 13, the maximum lower bound of the value measured would be the minimum maxwait_timer, and sigdet_timer. This is 97 ms + 3.9 µs, or 97.0039 ms. Any observed value of *S-to-NZ-maxwaitSlave* less than this will be considered a FAIL. g. In step 14, the DUT should implement a *maxwait_timer(slave)* of 97 – 98 ms. Any value of *maxwait_timer(slave)* less than 97 ms or more than 98 ms will be reported as a failure. h. Report the observed *S-to-NZ-maxwaitSlave,* as well as the mean observed value for *sigdet_wait_timer* (see 4.1.4), and the resulting calculation for the observed *maxwait_timer(slave).*
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

4.2 GROUP 2: PHY Control State Diagram

The tests defined in this section verify the PHY Control State Diagram for 1000BASE-T1 capable PHYs.

4.2.1 Test PHYC.97.2.1 – DISABLE_TRANSMITTER State

Purpose	To verify that the DUT properly behaves in, and exits from, the DISABLE_TRANSMITTER state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	When a device enters the DISABLE_TRANSMITTER state in the PHY Control state diagram, it should remain there until sync_link_control = ENABLE. Despite its name, the DUT will continue to transmit, either with Auto-Negotiation disabled and sync_tx_mode = SEND_S when configured as MASTER due to continued operation of the PHY Link Synchronization state diagram, or with DME page transmission if Auto-Negotiation is enabled. When configured as SLAVE, the DUT will remain silent in the SIGDET_WAIT state until it receives sync_tx_mode = SEND_S codegroups from its link partner.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly behaves in DISABLE_TRANSMITTER state.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT; or, issue a PMA Reset on the DUT. 4. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part A	a. In step 4, the DUT should disable its transmitter, observed by noting a SEND_N to SEND_Z transition, indicating entry to TRANSMIT_DISABLE. b. SEND_Z, once started, should last at least 300 µs (*break_link_timer* is validated in Test PHYC.97.1.2 – Value of break_link_timer), after which, SEND_S should be observed.
Test Procedure Part B	**Part B:** *DUT as SLAVE properly behaves in DISABLE_TRANSMITTER state.* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. 6. Establish a link with the DUT. 7. Cease transmissions to the DUT; or, issue a PMA Reset on the DUT. 8. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part B	c. In step 8, the DUT should disable its transmitter, observed by noting a SEND_N to SEND_Z transition if link was established, indicating entry to TRANSMIT_DISABLE. SEND_Z, once started, should last for the entire remaining observation window (as the SLAVE DUT does not receive any SEND_S).
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

4.2.2 Test PHYC.97.2.2 – Placeholder {TEST REMOVED}

Note	This test did address the INIT_MAXWAIT_TIMER state requirements, which are effectively tested in Test PHYC.97.1.7 – Value of maxwait_timer Test PHYC.97.1.7 – Value of maxwait_timer and thus are not tested again. This note is left to preserve test numbering.

142 4.2.3 Test PHYC.97.2.3 – SILENT State

Purpose	To verify that the DUT properly behaves in, and exits from, the SILENT state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Clause 97 of the IEEE 802.3 specification states that the device will remain in the SILENT state until minwait_timer has finished when configured as MASTER. When configured as SLAVE, the device will remain in the SILENT state until *loc_SNR_margin* = OK, *en_slave_tx* = 1, and minwait_timer has finished. This test allows for 5% error in observed timer values before considering the expected state machine transition behavior to be reported as a FAIL.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly behaves in SILENT state.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 3. Monitor transmissions from the DUT for at least 1100 µs.
Observable Results for Part A	a. In step 3, the MASTER DUT should be observed to transmit with *sync_tx_mode* = SEND_S, followed by *tx_mode* = SEND_Z, followed by *tx_mode* = SEND_T. b. In step 3, the observed SEND_Z transmission should be at least 874.8 µs (95% of 4.1 µs (maximum *sigdet_wait_timer*) and 925 µs (minimum *minwait_timer*), Refer to test 4.1.6 for strict measurement of *minwait_timer*). c. In step 3, the observed SEND_Z transmission should not exceed 1084.9 µs (105% of 8.2 µs (2x maximum *sigdet_wait_timer*) and 1025 µs (maximum *minwait_timer*), Refer to test 4.1.6 for strict measurement of *minwait_timer*). d. In step 3, if *tx_mode* = SEND_T is not observed, the test result will be FAIL.

Test Procedure Part B	**Part B:** *DUT as SLAVE behavior in SILENT state when unable to exit.*
	4. Configure the DUT as SLAVE with Auto-negotiation disabled.
	5. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE.
	    a. From the 1000BASE-T1 Test Station, set *tx_mode* = SEND_Z.
	6. Monitor transmissions from the DUT for at least 100 ms.
	    a. From the 1000BASE-T1 Test Station, set tx_mode = SEND_S after *link_fail_inhibit_timer* expires (97-98 ms).

Observable Results for Part B	e. In step 6, the SLAVE DUT should be observed to transmit with *sync_tx_mode* = SEND_S, followed by *tx_mode* = SEND_Z for link_fail_inhibit_timer ± 1 ms (96 - 99 ms) followed by *sync_tx_mode* = SEND_S.

Test Procedure Part C	**Part C:** *DUT as SLAVE properly transitions from SILENT state to TRAINING state.* 7. Configure the DUT as SLAVE with Auto-negotiation disabled. 8. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE and then transmitting to the DUT with *tx_mode* = SEND_T and *en_slave_tx* = 1 per [1]. 9. Monitor transmissions from the DUT for at least 100 ms.
Observable Results for Part C	f. In step 9, the SLAVE DUT should be observed to transmit with *sync_tx_mode* = SEND_S, followed by *tx_mode* = SEND_Z, followed by *tx_mode* = SEND_T. g. Report the DUT's duration of SEND_Z transmission between its last SEND_S to the beginning of SEND_T.
Test Procedure Part D	**Part D:** *DUT as SLAVE properly remains in SILENT state if en_slave_tx not set.* 10. Configure the DUT as SLAVE with Auto-negotiation disabled. 11. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE and then transmitting to the DUT with *tx_mode* = SEND_T per [1], but keep *en_slave_tx* = 0. 12. Monitor transmissions from the DUT for at least 100 ms.
Observable Results for Part D	h. In step 12, the SLAVE DUT should be observed to transmit with *sync_tx_mode* = SEND_S, followed by *tx_mode* = SEND_Z. Any observation of SEND_T will be considered a failure. i. Report the DUT's duration of SEND_Z transmission between its last SEND_S to the beginning of SEND_S.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

143 4.2.4 Test PHYC.97.2.4 – TRAINING State

Purpose	To verify that the DUT properly behaves in, and exits from, the TRAINING state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 - 2022 97.3.4 – PMA training side-stream scrambler polynomials [4] IEEE 802.3 - 2022 97.4.2.4.10 – Start-up Sequence
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Clause 97 of the IEEE 802.3 specification states that the device will remain in the TRAINING state until it has *loc_rcvr_status* = OK, *rem_rcvr_status* = OK, *infofield_complete*, and *minwait_timer* has finished. Note: The requirements for setting *infofield_complete* are relaxed in this test. A device will be considered to exhibit passing behavior so long as, at least, 256 PHY Frames are sent with infofields indicating *PMA_state* = 00. i. Some devices may send, at least, 256 PHY Frames with *PMA_state* = 00 and *loc_rcvr_status* = NOT_OK, followed by, at least, 256 PHY Frames with *PMA_state* = 00 and *loc_rcvr_status* = OK. ii. Some devices may send, at least, 256 PHY Frames with *PMA_state* = 00 and *loc_rcvr_status* = NOT_OK before allowing transition to the COUNTDOWN state (observed by *PMA_state* = 01 in the infoField transmitted by the DUT). Either behavior is considered acceptable. Observable results (b) and (e) informatively report the time (or number of PHY Frames) from when the DUT starts to send SEND_T to when it transitions a PHY Frame encoding PMA_state = 01, as well as how long the DUT emits PHY Frames encoding PMA_state = 00 and loc_rcvr_status = OK.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly transitions from TRAINING to COUNTDOWN.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 3. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values, and send *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 4. Monitor transmissions from the DUT for at least 100 ms.

Observable Results for Part A	a. In step 4, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01. b. Informatively report the time from when the 1000BASE-T1 Test Station began sending SEND_T to when the DUT was first observed to send an InfoField encoding *PMA_state* = 01. Additionally, report how long the DUT emitted infoFields with PMA_state = 00 and loc_rcvr_status = OK. c. In step 4, the MASTER DUT should be observed to transmit utilizing the proper training side-stream scrambler: $g_M(x) = 1 + x^{13} + x^{33}$ per [3].
Test Procedure Part B	**Part B:** *DUT as SLAVE properly transitions from TRAINING to COUNTDOWN.* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. Configure the DUT with EEE (Energy-Efficient Ethernet) enabled, if supported by the DUT. 6. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 7. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *en_slave_tx* = 1 and *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. a. The 1000BASE-T1 Test Station, emulating a valid MASTER, will first encode infoFields with *en_slave_tx* = 0 and *loc_rcvr_status* = NOT_OK, 8. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part B	d. In step 8, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01. e. Informatively report the time from when the DUT began sending SEND_T to when the DUT was first observed to send an InfoField encoding PMA_state = 01. Additionally, report how long the DUT emitted infoFields with PMA_state = 00 and loc_rcvr_status = OK. f. In step 8, the SLAVE DUT should be observed to transmit utilizing the proper training side-stream scrambler: $g_M(x) = 1 + x^{20} + x^{33}$ per [3]. g. In step 8, if the DUT supports EEE, the SLAVE DUT should be observed to align its transmit 81B-RS frame to within +0/-1 partial PHY frames of the MASTER as seen at the SLAVE MDI [4]. Calibrate the 1000BASE-T1 Monitor Station propagation delays to/from the Monitor Station and the DUT, as the partial PHY Frame boundaries observed from the 1000BASE-T1 Test Station at the Monitor Station and the response received from the DUT at the Monitor station are impacted by propagation delays of the cable. Note, 1 partial PHY Frame is 240 ns. h. In step 8, if the DUT supports EEE, the SLAVE DUT should be observed to transmit all PHY Frames with the infoField's PFC24 value matching that of the MASTER's PFC24 value for each aligned (see item (g) above) PHY Frame. i. In step 8 the SLAVE DUT should remain in the SILENT state until at least one PHY frame is received with an infoField encoding *en_slave_tx* = 1.

Test Procedure Part C	**Part C:** *DUT as MASTER behavior in TRAINING state when unable to exit.* 9. Configure the DUT as MASTER with Auto-negotiation disabled. 10. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 11. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = **NOT_OK** such that the DUT receives *rem_rcvr_status* = NOT_OK. 12. Monitor transmissions from the DUT for at least 100 ms.
Observable Results for Part C	j. In step 12, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00. The DUT should transmit with *tx_mode* = SEND_T until *link_fail_inhibit_timer* expires, any period less than this timer (within 2 ms) is considered a failure. k. In step 12, any observation of an InfoField encoding *PMA_state* = 01 is considered a FAIL.
Test Procedure Part D	**Part D:** *DUT as SLAVE behavior in TRAINING state when unable to exit.* 13. Configure the DUT as SLAVE with Auto-negotiation disabled. 14. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 15. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = **NOT_OK** such that the DUT receives *rem_rcvr_status* = NOT_OK. 16. Monitor transmissions from the DUT for at least 100 ms.
Observable Results for Part D	l. In step 16, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding PMA_state = 00. The DUT should transmit with *tx_mode* = SEND_T until *link_fail_inhibit_timer* expires, any period less than this timer (within 2 ms) is considered a failure m. In step 16, any observation of an InfoField encoding *PMA_state* = 01 is considered a FAIL.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

144 ### 4.2.5 Test PHYC.97.2.5 – COUNTDOWN State

Purpose	To verify that the DUT properly behaves in, and exits from, the COUNTDOWN state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 – 2018 Subclause 97.4.2.4.6
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Clause 97 of the IEEE802.3 specification states that the device will remain in the COUNTDOWN state until it has loc_countdown_done (see [3]) and InfoField_complete; at which point, it will transition to the SEND IDLE1 state and begin to send Idle. The DUT will transition to the SLAVE SILENT state if loc_rcvr_status = NOT_OK while in the COUNTDOWN state.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly transitions from COUNTDOWN to SEND_IDLE1.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 3. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values, encoding *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 4. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part A	a. In step 4, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. b. In step 4, the DUT's transmissions should transition from PAM2 (SEND_T) to PAM3 (SEND_I) encoding should occur on a PHY frame boundary (per [3])
Test Procedure Part B	**Part B:** *DUT as SLAVE properly transitions from COUNTDOWN to SEND_IDLE1.* 5. Configure the DUT as *SLAVE* with Auto-negotiation disabled. 6. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 7. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK such that the DUT receives *rem_rcvr_status* = OK. 8. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part B	c. In step 8, the *SLAVE* DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. d. In step 8, the DUT's transmissions should transition from PAM2 (SEND_T) to PAM3 (SEND_I) encoding should occur on a PHY frame boundary (per [3])

Test Procedure Part C	**Part C:** *DUT as MASTER properly transitions from COUNTDOWN to SILENT.* 9. Configure the DUT as MASTER with Auto-negotiation disabled. 10. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 11. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = **NOT_OK** such that the DUT receives *rem_rcvr_status* = NOT_OK. 12. Monitor received loc_rcvr_status until it is OK, then from the 1000BASE-T1 Test Station send PHY frames with *loc_rcvr_status* = **OK** such that the DUT receives *rem_rcvr_status* = OK. Then perform any action to cause the DUT's *loc_rcvr_status* = NOT OK. a. Example actions include ceasing all PAM2 transmissions. 13. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part C	e. The MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_Z (SILENT state). Note: the observation of an InfoField encoding PMA_state = 01 may not occur if a partial InfoField encoding the 01 value is in progress of being transmitted from the DUT when the state transitions to SILENT. f. Report the time from when the 1000BASE-T1 Test Station acted in step 12 to set the DUT's *loc_rcvr_status* = NOT_OK to when the DUT was observed to transition to *tx_mode* = SEND_Z. If this time is less than 925 µs, this is ideal (see Potential Issues section below); however, for the purposes of this test part, if this time is over 2 ms a FAIL will be issued.

Test Procedure Part D	**Part D:** *DUT as SLAVE properly transitions from COUNTDOWN to SILENT.* 14. Configure the DUT as SLAVE with Auto-negotiation disabled. 15. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 16. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values, and send *loc_rcvr_status* = **NOT_OK** such that the DUT receives *rem_rcvr_status* = NOT_OK. 17. Monitor received loc_rcvr_status until it is OK, then from the 1000BASE-T1 Test Station send PHY frames with *loc_rcvr_status* = **OK** such that the DUT receives *rem_rcvr_status* = OK. Then perform any action to cause *loc_rcvr_status* = NOT OK. a. Example actions include sending invalid Ternary codes, or ceasing all PAM3 transmissions. 18. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part D	g. The SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_Z (SILENT state). Note: the observation of an InfoField encoding PMA_state = 01 may not occur if a partial InfoField encoding the 01 value is in progress of being transmitted from the DUT when the state transitions to SILENT. h. Report the time from when the 1000BASE-T1 Test Station acted in step 17 to set the DUT's *loc_rcvr_status* = NOT_OK to when the DUT was observed to transition to *tx_mode* = SEND_Z. If this time is less than 925 µs this is ideal (see Potential Issues section below); however, for the purposes of this test part, if this time is over 2 ms a FAIL will be issued.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested. The DUT variable *rem_rcvr_status* may not be set after just one PHY frame in steps 12 and 17. Sending additional PHY frames may be necessary to stimulate the DUT to enter the COUNTDOWN state. If the number of additional PHY frames approach 256, it is possible the DUT may enter SEND_IDLE1 before the 1000BASE-T1 Test Station attempts to cause the DUT's *loc_rcvr_status* to be set to NOT_OK. The DUT variable *loc_rcvr_status* may not be set to NOT_OK while in the COUNTDOWN state, either due to 1000BASE-T1 Test Station limitations, or due to the implementation-specific nature of how loc_rcvr_status is set and updated, it is possible the DUT would advance to SEND_IDLE1 or SEND_IDLE2 before transitioning to SILENT. If the transition to the SILENT state occurs after 2ms, this will be considered a FAIL. Note, there is no standard defined behavior for how quickly loss of signal should result in *loc_rcvr_status* being set to NOT_OK, outside of this test requirement. Interoperability issues may result if a MASTER link partner ceases SEND_T, returns to SILENT and transmits SEND_Z for 925 µs (minwait_timer) then resumes SEND_T transmission all before the SLAVE link partner detects loc_rcvr_status as NOT_OK due to the MASTER ceasing transmission.

145 4.2.6 Test PHYC.97.2.6 – SEND IDLE1 State

Purpose	To verify that the DUT properly behaves in, and exits from, the SEND IDLE1 state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 – 2018 Subclause 97.4.2.4.6
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	Clause 97 of the IEEE802.3 specification states that the device will remain in the SEND IDLE1 state until it has rem_countdown_done; at which point, it will transition to the SEND IDLE2 state. The DUT will transition to the SILENT state if loc_rcvr_status = NOT_OK while in the SEND IDLE1 state. Note: This test only examines the transition to the SILENT state from the SEND_IDLE1 state, as the following test verifies the nominal path from COUNTDOWN to SEND_IDLE1 to SEND_IDLE2.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly transitions from SEND_IDLE1 to SILENT.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 3. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = **OK** such that the DUT receives *rem_rcvr_status* = OK. 4. Monitor received signaling until PAM3 (Idle) is received, then from the 1000BASE-T1 Test Station perform any action to cause the DUT's *loc_rcvr_status* = NOT OK. a. Example actions include sending invalid Ternary codes or ceasing all PAM3 transmissions. 5. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part A	a. In step 4, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. b. Report the time from when the 1000BASE-T1 Test Station acted in step 4 to set the DUT's *loc_rcvr_status* = NOT_OK to when the DUT was observed to transition to *tx_mode* = SEND_Z. If this time is less than 925 µs this is ideal (see Potential Issues section below); however, for the purposes of this test part, if this time is over 2 ms a FAIL will be issued. c. The DUT should be observed to transition from SEND_I to SEND_Z, following a proper transition from SEND_IDLE1 (or SEND_IDLE2) to SILENT.

Test Procedure Part B	**Part B:** *DUT as SLAVE properly transitions from SEND_IDLE1 to SILENT.* 6. Configure the DUT as SLAVE with Auto-negotiation disabled. 7. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 8. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = **OK** such that the DUT receives rem_rcvr_status = OK. 9. Monitor received signaling until PAM3 (Idle) is received, then from the 1000BASE-T1 Test Station perform any action to cause the DUT's *loc_rcvr_status* = NOT OK. a. Example actions include sending invalid Ternary codes or ceasing all PAM3 transmissions. 10. Monitor transmissions from the DUT for at least 2200 µs.
Observable Results for Part B	d. In step 9, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. e. Report the time from when the 1000BASE-T1 Test Station acted in step 9 to set the DUT's *loc_rcvr_status* = NOT_OK to when the DUT was observed to transition to *tx_mode* = SEND_Z. If this time is less than 925 µs this is ideal (see Potential Issues section below); however, for the purposes of this test part, if this time is over 2 ms a FAIL will be issued. f. The DUT should be observed to transition from SEND_I to SEND_Z, following a proper transition from SEND_IDLE1 (or SEND_IDLE2) to SILENT.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested. The DUT variable *loc_rcvr_status* may not be set to NOT_OK while in the SEND_IDLE1 state, either due to 1000BASE-T1 Test Station limitations, or due to the implementation-specific nature of how loc_rcvr_status is set and updated, it is possible the DUT would advance to SEND_IDLE2 before transitioning to SILENT. If the transition to the SILENT state occurs after 2ms, this will be considered a FAIL. Note, there is no standard defined behavior for how quickly loss of signal should result in *loc_rcvr_status* being set to NOT_OK, outside of this test requirement. Interoperability issues may result if a MASTER link partner ceases SEND_T, returns to SILENT and transmits SEND_Z for 925 µs (minwait_timer) then resumes SEND_T transmission all before the SLAVE link partner detects loc_rcvr_status as NOT_OK due to the MASTER ceasing transmission.

146 ### 4.2.7 Test PHYC.97.2.7 – SEND IDLE2 State

Purpose	To verify that the DUT properly behaves in, and exits from, the SEND IDLE2 state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A) (R)GMII Test Station (refer to Appendix A)
Discussion	Clause 97 of the IEEE802.3 specification states that the device will remain in the SEND IDLE2 state until it has loc_phy_ready = OK, rem_phy_ready = OK, and minwait_timer = done; at which point, it will transition to the SEND DATA state. The DUT will transition to the SLAVE SILENT state if loc_rcvr_status = NOT_OK while in the SEND IDLE2 state.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station, the 1000BASE-T1 Monitor station and, if a suitable interface is exposed, the (R)GMII Test Station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly transitions from SEND_IDLE1 to SEND_IDLE2 to SEND_DATA.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 3. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = OK (by encoding PCS control codes as 010) such that the DUT receives *rem_phy_ready* = OK. a. The 1000BASE-T1 Test Station may initially encode *loc_rcvr_status* = NOT_OK before transitioning to OK, and likewise for *loc_phy_ready*, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs. 4. Monitor transmissions from the DUT for at least 3300 µs. 5. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame. [To confirm *tx_mode = SEND_N* for the DUT].
Observable Results for Part A	a. In step 4, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. b. In step 4, the DUT's transmissions should include an entire PHY Frame containing only control codes 000 or 010 (encoding Normal Inter-Frame with *loc_phy_ready* either OK or NOT_OK) c. In step 4, the DUT's control code encoding for IDLE should change from 000 (Normal Inter-Frame with *loc_phy_ready* = NOT_OK) to 010 (Normal Inter-Frame with *loc_phy_ready* = OK) d. In step 5, frame transmission and/or reception should be observed, confirming that tx_mode = SEND_N. (Observed by rx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded out a secondary DUT port)

Test Procedure Part B	**Part B:** *DUT as SLAVE properly transitions from SEND_IDLE1 to SEND_IDLE2 to SEND_DATA. {Note: this part is effectively identical to the MASTER case}* 6. Configure the DUT as SLAVE with Auto-negotiation disabled. 7. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 8. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = OK (by encoding PCS control codes as 010) such that the DUT receives *rem_phy_ready* = OK. a. The 1000BASE-T1 Test Station may initially send *rem_rcvr_status* = NOT_OK before transitioning to OK, and likewise for *rem_phy_ready*, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs. 9. Monitor transmissions from the DUT for at least 3300 µs. 10. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame. [To confirm *tx_mode = SEND_N* for the DUT].
Observable Results for Part B	e. In step 9, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. f. In step 9, the DUT's transmissions should include an entire PHY Frame containing only control codes 000 or 010 (encoding Normal Inter-Frame with *loc_phy_ready* either OK or NOT_OK). g. In step 9, the DUT's control code encoding for IDLE should change from 000 (Normal Inter-Frame with *loc_phy_ready* = NOT_OK) to 010 (Normal Inter-Frame with *loc_phy_ready* = OK). h. In step 10, frame transmission and/or reception should be observed, confirming that tx_mode = SEND_N. (Observed by rx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded out a secondary DUT port)

Test Procedure Part C	**Part C:** *DUT as MASTER does not transition from SEND_IDLE2 to SEND_DATA.* 11. Configure the DUT as MASTER with Auto-negotiation disabled. If supported, configure a line-side loopback above the PCS. 12. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 13. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = NOT_OK (by encoding PCS control codes as 000) such that the DUT receives *rem_phy_ready* = NOT_OK. a. The 1000BASE-T1 Test Station may initially send *loc_rcvr_status* = NOT_OK before transitioning to OK, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs. 14. Monitor transmissions from the DUT for at least 3300 µs. 15. Either; a. From the 1000BASE-T1 Test Station, send a frame to the DUT. [The frame may be accepted as PCS frame reception is independent of the DUT's tx_mode]; or, b. From the (R)GMII Test Station, send frames at line rate to the DUT's TX (R)GMII path, 16. From the 1000BASE-T1 Test Station cause loc_rcvr_status = NOT_OK on the DUT, either by ceasing transmissions, sending invalid Ternary codes or any other method. 17. Monitor transmissions from the DUT for at least 1100 µs.
Observable Results for Part C	i. In step 14, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. j. In step 14, the DUT's transmissions should include an entire PHY Frame containing only control codes 000 or 010 (encoding Normal Inter-Frame with *loc_phy_ready* either OK or NOT_OK). k. In step 14, the DUT's control code encoding for IDLE should change from 000 (Normal Inter-Frame with *loc_phy_ready* = NOT_OK) to 010 (Normal Inter-Frame with *loc_phy_ready* = OK). l. In step 15, report if the frame sent by the 1000BASE-T1 Test Station is received. (Observed by: rx frame counter incrementing; frame observed on an GMII equivalent interface; or, frame forwarding out a secondary DUT port) m. In step 15, if the line-side loopback is configured, if the DUT transmits the received frame from the 1000BASE-T1 Test Station , then record a failure, as the DUT's tx_mode is not SEND_N. n. In step 17, the DUT should be observed to transition to *tx_mode* = SEND_Z with little delay following the 1000BASE-T1 Test Station sending conditions to cause *loc_rcvr_status* = NOT_OK (eg: via stopping transmissions). o. In step 17, report the time from when the 1000BASE-T1 Test Station begins to send conditions to cause *loc_rcvr_status* = NOT_OK on the DUT, to when the DUT stops transmissions (SEND_Z). This time should be less than 925 µs, as no *minwait_timer* is involved in this transition to SILENT.

Test Procedure Part D	**Part D:** *DUT as SLAVE does not transition from SEND_IDLE2 to SEND_DATA.* *{Note: this part is effectively identical to the MASTER case}*
	18. Configure the DUT as SLAVE with Auto-negotiation disabled. If supported, configure a line-side loopback above the PCS.
	19. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE.
	20. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = NOT_OK (by encoding PCS control codes as 000) such that the DUT receives *rem_phy_ready* = NOT_OK.
	  a. The 1000BASE-T1 Test Station may initially send *loc_rcvr_status* = NOT_OK before transitioning to OK, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs.
	21. Monitor transmissions from the DUT for at least 3300 µs.
	22. Either:
	  a. From the 1000BASE-T1 Test Station, send a frame to the DUT. [The frame may be accepted as PCS frame reception is independent of the DUT's tx_mode]; or,
	  b. From the (R)GMII Test Station, send frames at line rate to the DUT's TX (R)GMII path.
	23. From the 1000BASE-T1 Test Station cause *loc_rcvr_status* = NOT_OK on the DUT, either by ceasing transmissions, sending invalid Ternary codes or any other method.
	24. Monitor transmissions from the DUT for at least 1100 µs.

Observable Results for Part D	p. In step 21, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. q. In step 21, the DUT's transmissions should include an entire PHY Frame containing only control codes 000 or 010 (encoding Normal Inter-Frame with *loc_phy_ready* either OK or NOT_OK). r. In step 21, the DUT's control code encoding for IDLE should change from 000 (Normal Inter-Frame with *loc_phy_ready* = NOT_OK) to 010 (Normal Inter-Frame with *loc_phy_ready* = OK). s. In step 22, report if the frame sent by the 1000BASE-T1 Test Station is received. (Observed by: rx frame counter incrementing; frame observed on an GMII equivalent interface; or, frame forwarding out a secondary DUT port) t. In step 22, if the line-side loopback is configured, if the DUT transmits the received frame from the 1000BASE-T1 Test Station , then record a failure, as the DUT's tx_mode is not SEND_N. u. In step 24, the DUT should be observed to transition to *tx_mode* = SEND_Z with little delay following the 1000BASE-T1 Test Station sending conditions to cause *loc_rcvr_status* = NOT_OK (eg: via stopping transmissions). v. In step 24, report the time from when the 1000BASE-T1 Test Station begins to send conditions to cause *loc_rcvr_status* = NOT_OK on the DUT, to when

	the DUT stops transmissions (SEND_Z). This time should be less than 925 µs, as no *minwait_timer* is involved in this transition to SILENT.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

147 4.2.8 Test PHYC.97.2.8 – SEND DATA State

Purpose	To verify that the DUT properly behaves in, and exits from, the SEND DATA state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A) (R)GMII Test Station (refer to Appendix A)
Discussion	Clause 97 of the IEEE802.3 specification states that the device will remain in the SEND IDLE2 state until it has loc_phy_ready = OK, rem_phy_ready = OK, and minwait_timer = done; at which point, it will transition to the SEND DATA state. The DUT will transition to the SLAVE SILENT state if loc_rcvr_status = NOT_OK while in the SEND IDLE2 state.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station, the 1000BASE-T1 Monitor station and, if a suitable interface is exposed, the (R)GMII Test Station.
Test Procedure Part A	**Part A:** *DUT as MASTER transitions enters SEND_DATA when rem_phy_ready.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 3. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = **NOT_OK** (by encoding PCS control codes as 000) such that the DUT receives *rem_phy_ready* = NOT_OK. a. The 1000BASE-T1 Test Station may initially send *loc_rcvr_status* = NOT_OK before transitioning to OK, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs. 4. Wait 3.3 ms while monitoring transmissions from the DUT. 5. From the 1000BASE-T1 Test Station, send a frame to the DUT. [The frame may be accepted as PCS frame reception is independent of the DUT's tx_mode]. 6. Modify the transmissions from the 1000BASE-T1 Test Station to encode *loc_phy_ready* = OK. [DUT should be in SEND_IDLE2 state, as step 4 provides a 3.3 ms wait] 7. Wait 1025 µs. [maximum *minwait_timer* – In this time, DUT is expected to set tx_mode = SEND_N, wait for *minwait_timer_done* and then set *link_status* = OK] 8. Cause the DUT to issue a frame. [To confirm *tx_mode = SEND_N* for the DUT]. This may be achieved by: directly stimulating the DUT via the TX GMII path; sending a frame in another port of the DUT to be forwarded by this port; or, sending from the 1000BASE-T1 Test Station a frame to the DUT with a line-side loopback (above the PCS) enabled. 9. Monitor transmissions from the DUT for at least 1100 µs.

Observable Results for Part A	a. In step 4, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. b. In step 5, report if the frame sent by the 1000BASE-T1 Test Station is accepted. (Observed by: rx frame counter incrementing; frame observed on an GMII equivalent interface; or, frame forwarding out a secondary DUT port) c. In step 8, frame transmission should be observed, confirming that tx_mode = SEND_N. (Observed by tx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded in/out a secondary DUT port)
Test Procedure Part B	**Part B:** *DUT as SLAVE transitions enters SEND_DATA when rem_phy_ready.* 10. Configure the DUT as SLAVE with Auto-negotiation disabled. 11. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE. 12. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = **NOT_OK** (by encoding PCS control codes as 000) such that the DUT receives *rem_phy_ready* = NOT_OK. a. The 1000BASE-T1 Test Station may initially send *loc_rcvr_status* = NOT_OK before transitioning to OK, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs. 13. Wait 3.3 ms while monitoring transmissions from the DUT. 14. From the 1000BASE-T1 Test Station, send a frame to the DUT. [The frame may be accepted as PCS frame reception is independent of the DUT's tx_mode]. 15. Modify the transmissions from the 1000BASE-T1 Test Station to encode *loc_phy_ready* = OK. [DUT should be in SEND_IDLE2 state, as step 12 provides a 3.3 ms wait] 16. Wait 1025 µs. [maximum *minwait_timer* – In this time, DUT is expected to set tx_mode = SEND_N, wait for *minwait_timer_done* and then set *link_status* = OK] 17. Cause the DUT to issue a frame. [To confirm *tx_mode = SEND_N* for the DUT]. This may be achieved by: directly stimulating the DUT via the TX GMII path; sending a frame in another port of the DUT to be forwarded by this port; or, sending from the 1000BASE-T1 Test Station a frame to the DUT with a line-side loopback (above the PCS) enabled. 18. Monitor transmissions from the DUT for at least 1100 µs.

Observable Results for Part B	d. In step 12, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. e. In step 14, report if the frame sent by the 1000BASE-T1 Test Station is accepted. (Observed by: rx frame counter incrementing; frame observed on an GMII equivalent interface; or, frame forwarding out a secondary DUT port) f. In step 17, frame transmission should be observed, confirming that tx_mode = SEND_N. (Observed by tx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded in/out a secondary DUT port)
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

4.3 GROUP 3: PHY Link Synchronization State Diagram

The tests defined in this section verify the PHY Link Synchronization State Diagram defined for 1000BASE-T1 capable PHYs. Note, the PAUSE state requirements are effectively tested in Test PHYC.97.1.4 – Value of sigdet_wait_timer and thus are not tested in this section.

4.3.1 Test PHYC.97.3.1 – Link Sync – TRANSMIT DISABLE State

Purpose	To verify that the DUT properly behaves in, and exits from, the TRANSMIT DISABLE state.
References	[1] IEEE 802.3 – 2018 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 – 2018 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	When a device enters the TRANSMIT DISABLE state in the Link Synchronization state diagram, it ceases transmissions, starts break_link_timer and then should remain there until break_link_timer_done is true. If force_config = MASTER when break_link_timer_done is true, the DUT should transition to the TX_SEND_S state. If force_config = SLAVE when break_link_timer_done is true, the DUT should transition to the SIGDET_WAIT state.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly exits TRANSMIT_DISABLE* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT. 4. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part A	a. In step 4, the DUT should disable its transmitter, observed by noting a SEND_N to SEND_Z transition, indicating entry to TRANSMIT_DISABLE. SEND_Z, once started, should last at least 300 µs (*break_link_timer* is validated in Test PHYC.97.1.2 – Value of break_link_timer), after which, SEND_S should be observed.
Test Procedure Part B	**Part B:** *DUT as SLAVE properly exits TRANSMIT_DISABLE* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. 6. Establish a link with the DUT. 7. Cease transmissions to the DUT. 8. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part B	b. In step 8, the DUT should disable its transmitter, observed by noting a SEND_N to SEND_Z transition, indicating entry to TRANSMIT_DISABLE. SEND_Z, once started, should last for the entire remaining observation window (as the SLAVE DUT does not receive any SEND_S).
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

4.3.2 Test PHYC.97.3.2 – Link Sync – TX_SEND_S State

Purpose	To verify that the DUT properly behaves in, and exits from, the TX_SEND_S state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	When a device enters the TX_SEND_S state in the Link Synchronization state diagram, it starts send_s_timer and begins transmitting with sync_tx_mode = SEND_S. When the DUT is MASTER, and send_s_timer_done is true, the DUT should transition to the SIGDET_WAIT state. When the DUT is SLAVE and send_s_timer_done is true, the DUT should transition to the PAUSE state.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER sends SEND_S and properly exits TX_SEND_S* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT. 4. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part A	a. In step 4, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. SEND_S, once started, should last approximately 1 µs (*send_s_timer* is validated in test 0), after which, SEND_Z should be observed, indicating entry into the SIGDET_WAIT state.
Test Procedure Part B	**Part B:** *DUT as SLAVE sends SEND_S and properly exits TX_SEND_S* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. 6. Establish a link with the DUT. 7. Cease transmissions to the DUT. 8. Wait 300 µs. 9. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_S for 1 µs. 10. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_Z for 4 µs. a. Monitor transmissions from the DUT for sync_tx_mode = SEND_S. 11. Repeat the previous two steps until the DUT is observed to SEND_S, or until SEND_S has been sent a total of 10 times. a. The 1000BASE-T1 Test Station may, or may not, detect the receipt of SEND_S in real-time. This step allows for the MASTER SEND_S loop to continue sufficiently for the SLAVE DUT to detect send_s_sigdet = TRUE. The limit of 10 is arbitrary and may be increased if necessary.
Observable Results for Part A	b. In an iteration of step 10, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. SEND_S, once started, should last approximately 1 µs (*send_s_timer* is validated in test 0), after which, SEND_Z should be observed, indicating re-entry into the SIGDET_WAIT state.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

156 4.3.3 Test PHYC.97.3.3 – Link Sync – SIGDET_WAIT State

Purpose	To verify that the DUT properly behaves in, and exits from, the SIGDET_WAIT state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	When a device enters the SIGDET_WAIT state in the Link Synchronization state diagram, it starts sigdet_wait_timer and begins transmitting with sync_tx_mode = SEND_Z. If the DUT is MASTER and sigdet_wait_timer expires, the DUT should transition to the TX_SEND_S state. Otherwise, when send_s_sigdet = true, the DUT should transition to the SILENT WAIT state, which is verified in the next test.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER sends SEND_S multiple times if no send_s_sigdet* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT. 4. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part A	a. In step 4, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. SEND_S, once started, should last approximately 1 µs (*send_s_timer* is validated in test 0), after which, SEND_Z should be observed for 4 µs (*sigdet_wait_timer* is validated in test 4.1.4), indicating entry into the SIGDET_WAIT state. b. In step 4, once SEND_S from the DUT is observed, the DUT should be observed to send a pattern of SEND_S for approximately 1 µs followed by SEND_Z for approximately 4 µs for the remainder of the observation window.
Test Procedure Part B	**Part B:** *DUT as SLAVE sends SEND_Z if no send_s_sigdet* 5. Configure the DUT as SLAVE with Auto-negotiation disabled. 6. Establish a link with the DUT. 7. Cease transmissions to the DUT. 8. Monitor transmissions from the DUT for at least 400 µs.
Observable Results for Part B	c. In step 8, the DUT should disable its transmitter, observed by noting a SEND_N to SEND_Z transition, indicating entry to TRANSMIT_DISABLE and later SIGDET_WAIT. SEND_Z, once started, should last for the entire remaining observation window (as the SLAVE DUT does not receive any SEND_S).
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

157 4.3.4 Test PHYC.97.3.4 – Link Sync – SILENT WAIT State

Purpose	To verify that the DUT properly behaves in, and exits from, the SILENT_WAIT state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 – 2018 Subclause 97.4.2.6.1
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	When a device enters the SILENT_WAIT state in the Link Synchronization state diagram, it continues transmitting with sync_tx_mode = SEND_Z. If the DUT is MASTER and send_s_sigdet = false, the DUT should transition to the PAUSE state. If the DUT is SLAVE and send_s_sigdet = false, the DUT should transition to the TX_SEND_S state. For a SLAVE, this test also verifies that the SLAVE's SEND_S does not overlap with that of the MASTER port's, and the requirements of [3] for send_s_sigdet are met, where the variable definition sets a performance requirement that it must be set to false within 1 µs.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER properly transitions after send_s_sigdet* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT. 4. Wait 310 µs (or more) for the DUT to transmit SEND_S a. Note if the DUT has set sync_tx_mode = SEND_S. Increase this delay if this has not been observed. 5. When the DUT ceases transmission of SEND_S, from the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_S for 1 µs. 6. Monitor transmissions from the DUT for at least 1100 µs.
Observable Results for Part A	a. In step 4, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. b. After step 5, the DUT should not be observed to SEND_S again. c. In step 6, once SEND_S from the DUT is observed, the 1000BASE-T1 Test Station 's SEND_S transmission should cause the DUT to enter SILENT_WAIT, observed by the cessation of SEND_S from the DUT, and SEND_Z followed by SEND_T. SEND_Z transmission should occur for at least 900 µs (more precise values for *sigdet_wait_timer* and *minwait_timer* are validated in tests 4.1.4 and 4.1.6, respectively)

Test Procedure Part B	**Part B:** *DUT as SLAVE properly transitions after send_s_sigdet = TRUE* 7. Configure the DUT as SLAVE with Auto-negotiation disabled. 8. Establish a link with the DUT. 9. Cease transmissions to the DUT. 10. Wait 300 µs. 11. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_S for 1 µs. 12. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_Z for 4 µs. a. Monitor transmissions from the DUT for sync_tx_mode = SEND_S. 13. Repeat the previous two steps until the DUT is observed to SEND_S, or until SEND_S has been sent a total of 10 times. a. The 1000BASE-T1 Test Station may, or may not, detect the receipt of SEND_S in real-time. This step allows for the MASTER SEND_S loop to continue sufficiently for the SLAVE DUT to detect send_s_sigdet = TRUE. The limit of 10 is arbitrary and may be increased if necessary. 14. Monitor transmissions from the DUT for at least 100 µs.
Observable Results for Part B	d. In an iteration of step 12, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. After which the DUT should not be observed to SEND_S again. e. The SEND_S transmission from the DUT should not occur at the same time as the SEND_S transmission from the emulated MASTER port of the 1000BASE-T1 Test Station. f. The SEND_S transmission from the DUT should commence no later than 1 µs after the transmission of SEND_S from the emulated MASTER port. {refer to the definition of send_s_sigdet in refence [3]}
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

158 4.3.5 Test PHYC.97.3.5 – Placeholder {TEST REMOVED}

Note	This test did address the PAUSE state requirements, which are effectively tested in Test PHYC.97.1.4 – Value of sigdet_wait_timer and thus are not tested again. This note is left to preserve test numbering.

159 ### 4.3.6 Test PHYC.97.3.6 – Link Sync – LINK_GOOD_CHECK State

Purpose	To verify that the DUT properly behaves in, and exits from, the LINK_GOOD_CHECK state.
References	[1] IEEE 802.3bp - 2018 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A)
Discussion	When a device enters the LINK_GOOD_CHECK state in the Link Synchronization state diagram, it sets sync_link_control = ENABLE and starts link_fail_inhibit_timer. If link_fail_inhibit_timer_done is true before *link_status* = OK, the DUT should return to the TRANSMIT_DISABLE state. If *link_status* = OK while the DUT is in the LINK_GOOD_CHECK state, the DUT should transition to the LINK_GOOD state. This test focuses only on the expiration of link_fail_inhibit_timer and the resulting transition to TRANSMIT_DISABLE.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station and the 1000BASE-T1 Monitor station.
Test Procedure Part A	**Part A:** *DUT as MASTER attempts to train after send_s_sigdet* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT. 4. Wait 310 µs (or more) for the DUT to transmit SEND_S a. Note if the DUT has set sync_tx_mode = SEND_S. Increase this delay if this has not been observed. 5. When the DUT ceases transmission of SEND_S, from the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_S for 1 µs. 6. From the 1000BASE-T1 Test Station , do **not** send signaling that would result in *link_status* = OK. 7. Monitor transmissions from the DUT for at least 100 ms.
Observable Results for Part A	a. In step 4, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. b. In step 7, once SEND_S from the DUT is observed, the 1000BASE-T1 Test Station ’s SEND_S transmission should cause the DUT to enter SILENT_WAIT, observed by the cessation of SEND_S from the DUT, and SEND_Z followed by SEND_T. SEND_Z transmission should occur for at least 900 µs (more precise values for *sigdet_wait_timer* and *minwait_timer* are validated in tests 4.1.4 and 4.1.6, respectively) c. In step 7, after approximately 97 ms, the DUT should resume transmission of SEND_S signaling.

Test Procedure Part B	**Part B:** *DUT as SLAVE attempts to train after send_s_sigdet* 8. Configure the DUT as SLAVE with Auto-negotiation disabled. 9. Establish a link with the DUT. 10. Cease transmissions to the DUT. 11. Wait 300 µs. 12. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_S for 1 µs. 13. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_Z for 4 µs. a. Monitor transmissions from the DUT for sync_tx_mode = SEND_S. 14. Repeat the previous two steps until the DUT is observed to SEND_S. 15. After the DUT ceases SEND_S transmission, wait sigdet_wait_timer and minwait_timer before setting tx_mode = SEND_T from the 1000BASE-T1 Test Station. a. Send valid signaling and info_fields such that the DUT should enter the training state. b. By any method, do **not** send signaling that would result in *link_status* = OK. 16. Monitor transmissions from the DUT for at least 100 ms.
Observable Results for Part B	d. In an iteration of step 12, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. e. In step 16, the DUT should be observed to transition from SEND_Z to SEND_T significantly before 97 ms of the observation window has elapsed. f. In step 16, the DUT should transition from SEND_T to SEND_Z, indicating a transition to TRANSMIT_DISABLE as a result of the expiration of the link_fail_inhibit_timer. Depending on the method employed in step 15(b), the DUT may also be observed to transition from SEND_T to SEND_I and then to SEND Z, which is permissible.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

160 4.3.7 Test PHYC.97.3.7 – Link Sync – LINK_GOOD State

Purpose	To verify that the DUT properly behaves in the LINK_GOOD state.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [2] IEEE 802.3 - 2022 Figure 92 – 27 Link Monitor state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A) (R)GMII Test Station (refer to Appendix A)
Discussion	When a device sets *link_status* = OK, it should transition from the LINK_GOOD_CHECK state to the LINK_GOOD state. When it sets *link_status* = FAIL, it should transition to the TRANSMIT_DISABLE state.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station, the 1000BASE-T1 Monitor station and, if a suitable interface is exposed, the (R)GMII Test Station.
Test Procedure Part A	**Part A:** *DUT as MASTER is observed to enter LINK_GOOD.* 1. Configure the DUT as MASTER with Auto-negotiation disabled. 2. Establish a link with the DUT. 3. Cease transmissions to the DUT. 4. Wait 310 µs (or more) for the DUT to transmit SEND_S a. Note if the DUT has set sync_tx_mode = SEND_S. Increase this delay if this has not been observed. 5. When the DUT ceases transmission of SEND_S, from the 1000BASE-T1 Test Station , transmit with sync_tx_mode = SEND_S for 1 µs. 6. From the 1000BASE-T1 Test Station, **do** send signaling that would result in *link_status* = OK for the remainder of this test. 7. Monitor transmissions from the DUT for at least 100 ms. 8. From the 1000BASE-T1 Test Station , send a frame to the DUT, or cause the DUT to issue a frame.
Observable Results for Part A	a. In step 4, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. b. In step 7, once SEND_S from the DUT is observed, the 1000BASE-T1 Test Station 's SEND_S transmission should cause the DUT to enter SILENT_WAIT, observed by the cessation of SEND_S from the DUT, and SEND_Z followed by SEND_T. SEND_Z transmission should occur for at least 900 µs (more precise values for *sigdet_wait_timer* and *minwait_timer* are validated in tests 4.1.4 and 4.1.6, respectively) c. In step 7, after SEND_T is observed, the DUT should be observed to enter SEND I and then SEND N. d. In step 8, frame transmission and/or reception should be observed, indicating that *link_status* is likely OK.

Test Procedure Part B	**Part B:** *DUT as SLAVE is observed to enter LINK_GOOD* 9. Configure the DUT as SLAVE with Auto-negotiation disabled. 10. Establish a link with the DUT. 11. Cease transmissions to the DUT. 12. Wait 300 µs. 13. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_S for 1 µs. 14. From the 1000BASE-T1 Test Station, transmit with sync_tx_mode = SEND_Z for 4 µs. a. Monitor transmissions from the DUT for sync_tx_mode = SEND_S. 15. Repeat the previous two steps until the DUT is observed to SEND_S. 16. After the DUT ceases SEND_S transmission, wait sigdet_wait_timer and minwait_timer before setting tx_mode = SEND_T from the 1000BASE-T1 Test Station. a. Send valid signaling and info_fields such that the DUT should enter the training state. b. From the 1000BASE-T1 Test Station, **do** send signaling that would result in *link_status* = OK for the remainder of this test. 17. Monitor transmissions from the DUT for at least 100 ms. 18. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame.
Observable Results for Part B	e. In an iteration of step 12, the DUT should enter TX_SEND_S, observed by noting a SEND_Z to SEND_S transition. f. In step 17, the DUT should be observed to transition from SEND_Z to SEND_T significantly before 97 ms of the observation window has elapsed. g. In step 17, after SEND_T is observed, the DUT should be observed to enter SEND I and then SEND N. h. In step 18, frame transmission and/or reception should be observed, indicating that *link_status* is likely OK.
Potential Issues	Some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

161 4.4 GROUP 4: Link Monitor State Diagram

162 The tests defined in this section verify the Link Monitor State Diagram defined for 1000BASE-T1 PHYs.

163 4.4.1 Test PHYC.97.4.1 – Link Monitor State Diagram

Purpose	To verify that the DUT properly implements the Link Monitor State Diagram.
References	[1] IEEE 802.3 - 2022 Figure 97 – 26 PHY Control state diagram [2] IEEE 802.3 - 2022 Figure 97 – 25 PHY Link Synchronization state diagram [3] IEEE 802.3 - 2022 Figure 92 – 27 Link Monitor state diagram
Resource Requirements	1000BASE-T1 Test Station (refer to Appendix A) 1000BASE-T1 Monitor Station (refer to Appendix A) (R)GMII Test Station (refer to Appendix A)
Discussion	The Link Monitor state diagram states that a device must not set *link_status* = OK until it is transmitting with *tx_mode* = SEND_N and minwait_timer has expired. It also states that a device must set *link_status* = NOT OK when either PMA_watchdog_status = NOT OK, *PMA_refresh_status* = FAIL, or maxwait_timer_done & loc_phy_ready = NOT OK. Note that a compliant 1000BASE-T1 device can receive frames, independent of *link_status*, at any time that the device has *block_lock* and does not have *hi_rfer* detected. Similarly, such a device can transmit a frame as soon as *tx_data_mode* is true, which occurs when *tx_mode* = SEND_N, which should occur approximately one *minwait_timer* before *link_status* is set to OK. Thus, frame monitoring is a strong indicator of *link_status*, but not a guarantee. As there is no fast, real-time, guaranteed access to *link_status*, this test does not directly monitor *link_status*. Refer to earlier tests, eg: Test PHYC.97.1.1 – PMA Reset which confirms a *link_status* indication under nominal conditions.
Test Setup	Connect the DUT to the 1000BASE-T1 Test Station, the 1000BASE-T1 Monitor station and, if a suitable interface is exposed, the (R)GMII Test Station.

Test Procedure Part A	**Part A:** *DUT as MASTER PMA_watchdog_status causes transition to LINK_DOWN without maxwait_timer.*
	1. Configure the DUT as MASTER with Auto-negotiation disabled.
	2. Emulate a valid SLAVE per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE.
	    a. Note the time the DUT sends SEND_S as '*startMaxwaiTimer+sigdet'.*
	3. Emulate a valid SLAVE per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = **OK** (by encoding PCS control codes as 000) such that the DUT receives *rem_phy_ready* = OK.
	    a. The 1000BASE-T1 Test Station may initially send *loc_rcvr_status* = NOT_OK and/or *loc_phy_ready* = NOT_OK before transitioning to OK, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs.
	4. Wait at least 4.4 ms while monitoring transmissions from the DUT.
	    a. Adjust the wait time such that the DUT should have established *link_status* = OK as soon as possible after the wait (as observed by noting *loc_phy_ready* = OK from the DUT followed by a *minwait_timer* period
	5. From the 1000BASE-T1 Test Station, send a frame to the DUT, or cause the DUT to issue a frame. [To infer *link_status* = OK for the DUT, see discussion].
	6. Monitor transmissions from the DUT for at least 1100 µs.
	7. Cease transmissions to the DUT.
	    a. Note the time of transmission cessation starts as '*testEndTime*'.
	8. Continue to observe transmissions from the DUT for at least 1100 µs, but no more than 100 ms.
	    a. Note the time the DUT sets *tx_mode* = SEND_Z as '*sendZObserved*'.

Observable Results for Part A	a. In step 4, the MASTER DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. b. In step 6, frame transmission and/or reception should be observed, inferring *link_status* = OK. (Observed by tx/rx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded in/out a secondary DUT port) c. In step 8, the DUT should be observed to set tx_mode = SEND_Z well before maxwait_timer_done occurs. This result is only valid if '*startMaxwaitTimer+sigdet'* subtracted from '*testEndTime'*, referred to here as *'testLinkUpTime'* is substantially less than *maxwait_timer*. For this test purpose, *'testLinkUpTime'* should be less than 95 ms. If the DUT does not transition tx_mode to SEND_Z until after 98.004 ms (as measure by '*sendZObserved'* minus '*startMaxwaitTimer+sigdet'*), then this test is considered to FAIL.

Test Procedure Part B	**Part B:** *DUT as SLAVE PMA_watchdog_status causes transition to LINK_DOWN without maxwait_timer. {Note: this part is effectively identical to the MASTER case}*
	9. Configure the DUT as SLAVE with Auto-negotiation disabled.
	10. Emulate a valid MASTER per [2] by sending SEND_S to cause the DUT to set *sync_link_control* = ENABLE.
	    a. Note the time the DUT sends SEND_S as ‘*startMaxwaiTimer+sigdet’.*
	11. Emulate a valid MASTER per [1] by sending SEND_T to cause the DUT to set *loc_rcvr_status* = OK, send valid InfoField values encoding *loc_rcvr_status* = OK, and send *loc_phy_ready* = **OK** (by encoding PCS control codes as 000) such that the DUT receives *rem_phy_ready* = OK.
	    a. The 1000BASE-T1 Test Station may initially send *loc_rcvr_status* = NOT_OK and/or *loc_phy_ready* = NOT_OK before transitioning to OK, provided the 1000BASE-T1 Test Station sends NOT_OK for no more than 925 µs.
	12. Wait at least 4.4 ms while monitoring transmissions from the DUT.
	    a. Adjust the wait time such that the DUT should have established *link_status* = OK as soon as possible after the wait (as observed by noting *loc_phy_ready* = OK from the DUT followed by a *minwait_timer* period
	13. From the 1000BASE-T1 Test Station , send a frame to the DUT, or cause the DUT to issue a frame. [To infer *link_status* = OK for the DUT, see Discussion].
	14. Monitor transmissions from the DUT for at least 1100 µs.
	15. Cease transmissions to the DUT.
	    a. Note the time of transmission cessation starts as ‘*testEndTime*’.
	16. Continue to observe transmissions from the DUT for at least 1100 µs, but no more than 100 ms.
	    a. Note the time the DUT sets *tx_mode* = SEND_Z as ‘*sendZObserved*’.

Observable Results for Part B	d. In step 12, the SLAVE DUT should be observed to transmit with *tx_mode* = SEND_T with an InfoField encoding *PMA_state* = 00, then transition to the COUNTDOWN state, observed by an InfoField encoding *PMA_state* = 01, and then transition to *tx_mode* = SEND_I. e. In step 14, frame transmission and/or reception should be observed, inferring *link_status* = OK. (Observed by tx/rx frame counter incrementing if available, or frame observed on an GMII equivalent interface, or frame forwarded in/out a secondary DUT port) f. In step 16, the DUT should be observed to set tx_mode = SEND_Z well before maxwait_timer_done occurs. This result is only valid if ‘*startMaxwaiTimer+sigdet’* subtracted from ‘*testEndTime*’, referred to here as *‘testLinkUpTime’* is substantially less than *maxwait_timer*. For this test purpose, *‘testLinkUpTime’* should be less than 95 ms. If the DUT does not transition tx_mode to SEND_Z until after 98.004 ms (as measure by ‘*sendZObserved’* minus ‘*startMaxwaiTimer+sigdet*’), then this test is considered to FAIL.
Potential Issues	Also, some devices may not allow configuration as MASTER or SLAVE, in which case only the supported configuration will be tested.

5 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.

5.1 Appendix A – Test Stations

Purpose: To provide the requirements of the test stations used during 1000BASE-T1 PHY Control testing.

Discussion:

Two to Three test stations will be required to perform all tests that are specified in this document, depending on DUT capabilities.

The **1000BASE-T1 Test Station** emulates a compliant 1000BASE-T1 PHY, with testability features to perform controlled negative test cases (eg: cease transmission, keep loc_rcvr_status indications as NOT_OK, etc) as required by the tests in this test plan. The 1000BASE-T1 Test Station also has external triggering capability to align events observed by the 1000BASE-T1 Test Station with those observed by the 1000BASE-T1 Monitor Station.

The **1000BASE-T1 Monitor Station** would typically consist of an oscilloscope and software to capture and decode the transmissions from the DUT. The DUT will connect through the Line Tap as specified in appendix 5.2 B. The software will download the capture from the oscilloscope and decode the symbols, using knowledge of the 1000BASE-T1 encoding. Calibration of the 1000BASE-T1 Monitor Station may be required to ensure propagation delays to/from the Monitor Station and the DUT are accounted for, as signals observed from the 1000BASE-T1 Test Station at the Monitor Station and the response received from the DUT at the Monitor station may be impacted by propagation delays of the cable.

The **(R)GMII Test Station** is required for some tests, if the DUT exposes a supported interface (typically RGMII, following the Samtec connector and pinout employed by the 1000BASE-T1 Interoperability Test Plan). While some tests can be performed with either loopback enabled, or the (R)GMII Test Station, use of the (R)GMII Test Station is generally preferred unless indicated otherwise in the specific test.

Figures A - 1 and A - 2 below show the typical test setups with a DUT with an exposed (R)GMII interface in Figure A – 1, or configured with a line-side loopback, as shown in Figure A – 2.

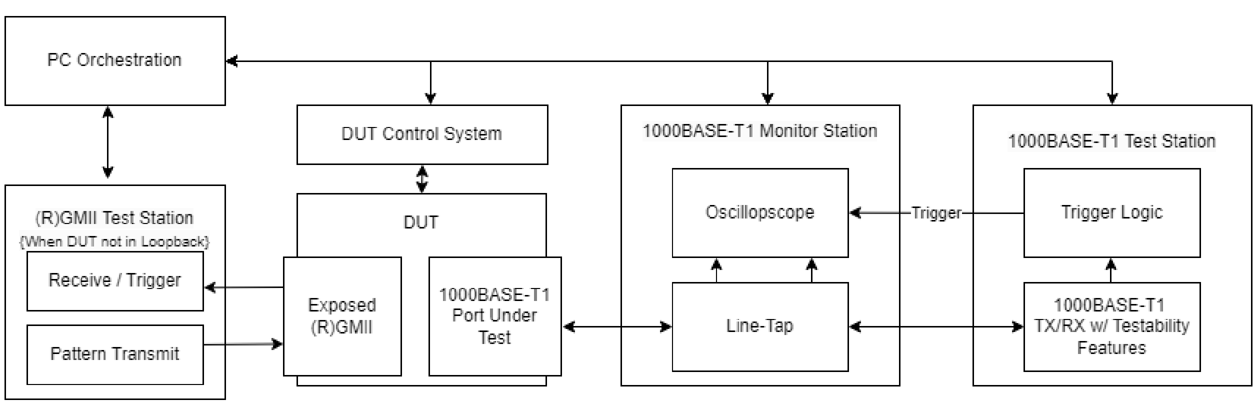

Figure A - 1: 1000BASE-T1 Test Setup with RGMII Test Station

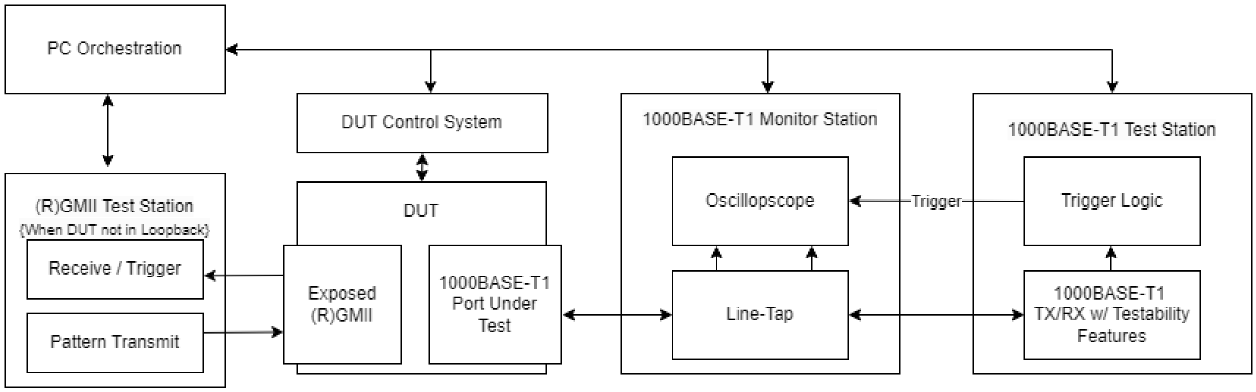

Figure A - 2: 1000BASE-T1 Test Setup with Loopback

Figure A – 3 shows the potential to test a multi-port DUT that has no exposed RGMII interface. Any equivalent setup is acceptable (eg: two 1000BASE-T1 Test Stations, substituted for the compliant 1000BASE-T PHY and (R)GMII Test Station). The test plan does not explicitly refer to this test setup but multi-port DUTs (with 2 or more ports operating at 1000 Mbps) can be tested by such as setup where the test plan’s (R)GMII Test Station is driving traffic into (or monitoring traffic from) the 1000Mbps port not under test.

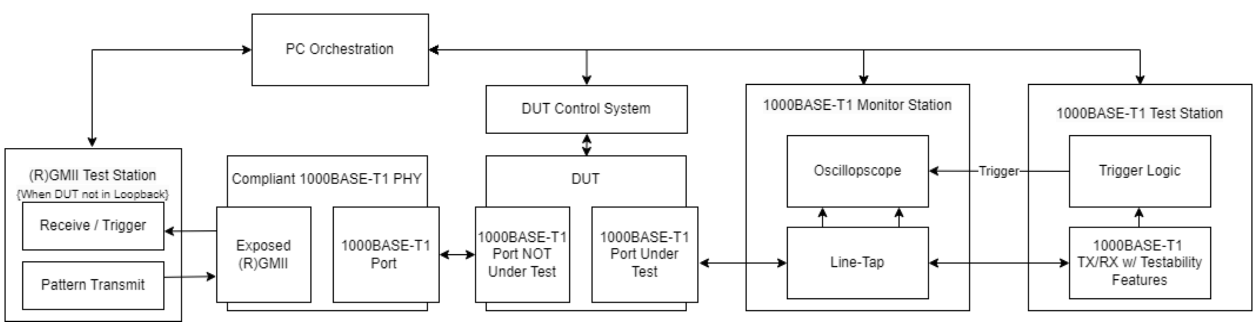

Figure A - 3: 1000BASE-T1 Test Setup with multi-port 1000BASE-T1 (eg: no exposed RGMII)

5.2 Appendix 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:

Any directional line- tap capable of providing a low insertional loss impedance matched channel connection with at least 500MHz bandwidth has been shown to be functional for short reach (~2 meter) connections between the Test Station and DUT. Additional bandwidth is recommended. A minimum of 8GSps sampling with a 10bit oscilloscope is recommended. Care should be taken to ensure cabled connections to the oscilloscope are on equal-length cables and that the directional taps do not provide substantial asymmetry in monitored paths.

Delays from the Line-Tap to the DUT should be considered in those tests that may be impacted by such propagation delays, notably Test PHYC.97.1.3 – Value of send_s_timer and Test PHYC.97.2.4 – TRAINING State.