

Road vehicles — In-vehicle Ethernet

Part 6: Electrical 100-Mbit/s physical entity
requirements and conformance test plan

National foreword

This British Standard is the UK implementation of ISO 21111-6:2021.

The UK participation in its preparation was entrusted to Technical Committee AUE/16, Data Communication (Road Vehicles).

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Road vehicles — In-vehicle Ethernet —
Part 6:
Electrical 100-Mbit/s physical entity
requirements and conformance test
plan

Véhicules routiers — Ethernet embarqué —

*Partie 6: Exigences et plan de tests de conformité de l'entité physique
à 100-Mbit/s électrique*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

A list of all parts in the ISO 21111 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 21111 series includes in-vehicle Ethernet requirements and test plans that are disseminated in other International Standards and complements them with additional test methods and requirements. The resulting requirement and test plans are structured in different documents following the Open Systems Interconnection (OSI) reference model and grouping the documents that depend on the physical media and bit rate used.

In general, the Ethernet requirements are specified in ISO/IEC/IEEE 8802-3. The ISO 21111 series provides supplemental specifications (e.g. wake-up, I/O functionality), which are required for in-vehicle Ethernet applications. In road vehicles, Ethernet networks are used for different purposes requiring different bit-rates. Currently, the ISO 21111 series specifies the 1-Gbit/s optical and 100-Mbit/s electrical physical layer.

The ISO 21111 series contains requirement specifications and test methods related to the in-vehicle Ethernet. This includes requirement specifications for physical layer entity (e.g. connectors, physical layer implementations) providers, device (e.g. electronic control units, gateway units) suppliers, and system (e.g. network systems) designers. Additionally, there are test methods specified for conformance testing and for interoperability testing.

Safety (electrical safety, protection, fire, etc.) and electromagnetic compatibility (EMC) requirements are out of the scope of the ISO 21111 series.

The structure of the specifications given in the ISO 21111 series complies with the Open Systems Interconnection (OSI) reference model is specified in ISO/IEC 7498-1^[1] and ISO/IEC 10731^[3].

ISO 21111-1 defines the terms which are used in this series of standards and provides an overview of the standards for in-vehicle Ethernet including the complementary relations to ISO/IEC/IEEE 8802-3 and the amendments, the document structure, type of physical entities, in-vehicle Ethernet specific functionalities, and so on.

ISO 21111-2 specifies the interface between reconciliation sublayer and physical entity including reduced gigabit media independent interface (RGMI), and the common physical entity wake-up and synchronised link sleep functionalities, independent from physical media and bit rate.

ISO 21111-3 specifies supplemental requirements to a physical layer capable of transmitting 1-Gbit/s over plastic optical fibre compliant with ISO/IEC/IEEE 8802-3, with specific application to communications inside road vehicles, and a test plan for physical entity conformance testing.

ISO 21111-4^[3] specifies the optical components requirements and test methods for 1-Gbit/s optical in-vehicle Ethernet.

ISO 21111-5 specifies, for 1-Gbit/s optical in-vehicle Ethernet, requirements on the physical layer at system level, requirements on the interoperability test set-ups, the interoperability test plan that checks the requirements for the physical layer at system level, requirements on the device-level physical layer conformance test set-ups, and device-level physical layer conformance test plan that checks a set of requirements for the OSI physical layer that are relevant for device vendors.

This document specifies advanced features of an ISO/IEC/IEEE 8802-3 in-vehicle Ethernet physical layer (often also called transceiver), e.g. for diagnostic purposes for in-vehicle Ethernet physical layers. It specifies advanced physical layer features, wake-up and sleep features, physical layer test suite, physical layer control requirements and conformance test plan, physical sublayers test suite, and physical sublayers requirements and conformance test plan.

ISO 21111-7 specifies the implementation for ISO/IEC/IEEE 8802-3, which defines the interface implementation for automotive applications together with requirements on components used to realize this Bus Interface Network (BIN). ISO 21111-7 also defines further testing and system requirements for systems implemented according to the system specification. In addition, ISO 21111-7 defines the channels for tests of transceivers with a test wiring harness that simulates various electrical communication channels.

ISO 21111-8 specifies the transmission media, the channel performance, and the tests for an ISO/IEC/IEEE 8802-3 in-vehicle Ethernet.

ISO 21111-9 specifies the data link layer requirements and conformance test plan. It specifies the requirements and test plan for devices and systems with bridge functionality.

ISO 21111-10 specifies the application to session layer requirements and conformance test plan. It specifies the requirements and conformance test plan for devices and systems that include functionality related with OSI layers from 7 to 5.

ISO 21111-11 specifies the transport to network layer requirements and conformance test plan. It specifies the requirements and conformance test plan for devices and systems that include functionality related with OSI layers from 4 and 3.

Figure 1 shows the parts of the ISO 21111 series and the document structure.

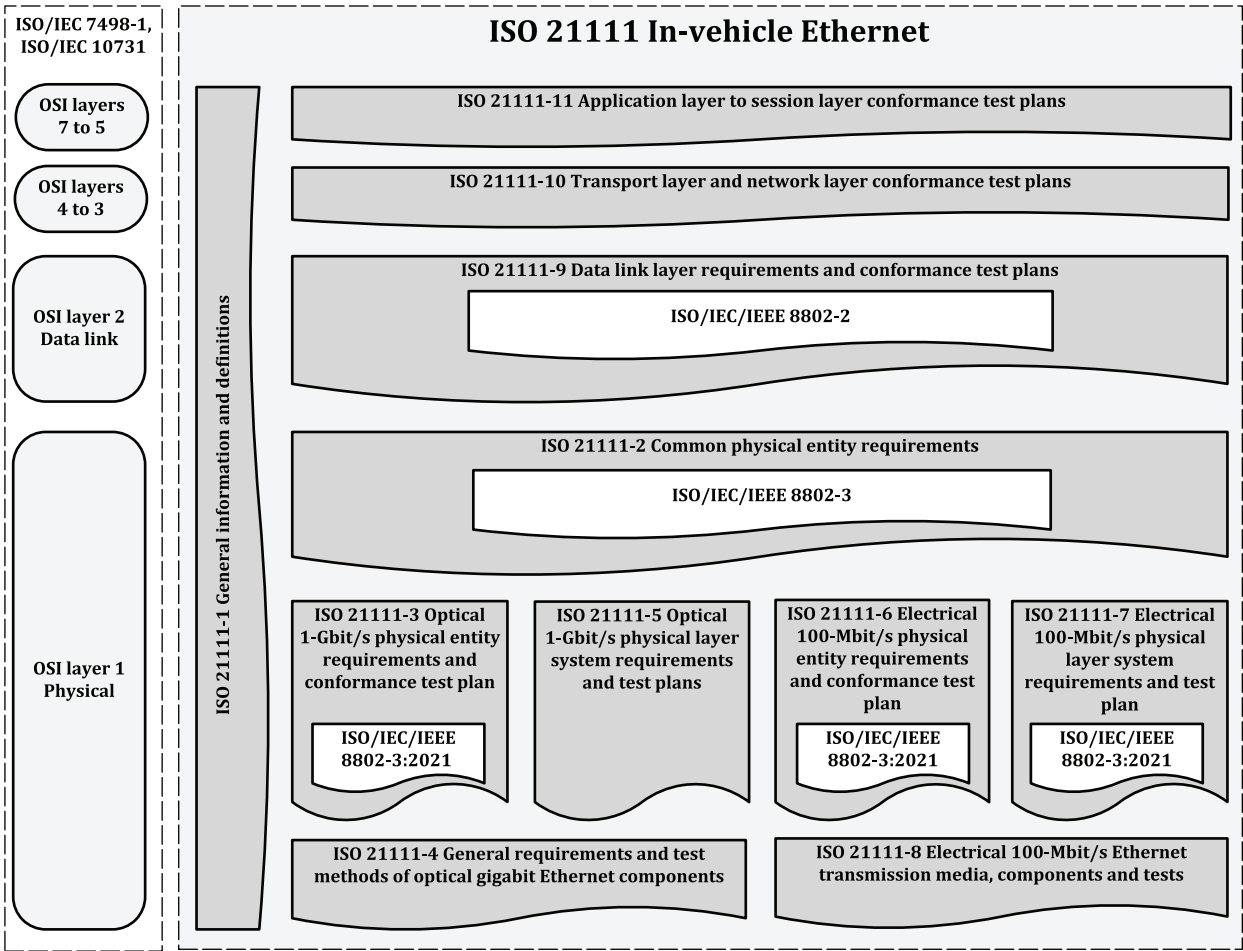


Figure 1 — In-vehicle Ethernet document reference according to OSI model

Road vehicles — In-vehicle Ethernet —

Part 6:

Electrical 100-Mbit/s physical entity requirements and conformance test plan

1 Scope

This document specifies advanced features of an ISO/IEC/IEEE 8802-3 automotive Ethernet PHY (often also called transceiver), e.g. for diagnostic purposes for automotive Ethernet PHYs.

This document specifies:

- advanced PHY features;
- wake-up and sleep features;
- PHY test suite;
- PHY control IUT requirements and conformance test plan;
- PCS test suite;
- PCS IUT requirements and conformance test plan;
- PMA test suite; and
- PMA IUT requirements and conformance test plan.

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.

ISO/IEC 9646-1, *Information technology — Open Systems Interconnection — Conformance testing methodology and framework — Part 1: General concepts*

ISO 21111-1, *Road vehicles — In-vehicle Ethernet — Part 1: General information and definitions*

ISO 21111-2, *Road vehicles — In-vehicle Ethernet — Part 2: Common physical entity requirements*

ISO/IEC/IEEE 8802-3:2021, *Telecommunications and exchange between information technology systems — Requirements for local and metropolitan area networks — Part 3: Standard for Ethernet*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21111-1, ISO/IEC 9646-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1
automotive cable

balanced 100-Ω one pair cable having characteristics defined in ISO/IEC/IEEE 8802-3:2021, 96.7 physical layer specifications and management parameters for 100-Mbit/s operation over a single balanced twisted pair cable

3.2
short automotive cable

cable complying with *automotive cable* (3.1) used for test purposes and limited in length to reduce the amount of loss between the IUT transmitter and test and measurement equipment

3.3
PHY frame

normal data transmission consisting of SEND_N code groups defined in ISO/IEC/IEEE 8802-3:2021, 96.3.3.3.7 and which begins with a valid start-of-stream delimiter (SSD) and ends with a valid end-of-stream delimiter (ESD)

3.4
monitor

test system used to capture and decode the transmissions from the IUT

Note 1 to entry: See B.2.

4 Symbols and abbreviated terms

4.1 Symbols

–	empty table cell or feature undefined
L_{CL}	longitudinal conversion loss ($\frac{S_{dc11}}{S_{dc22}}$)
L_{CTL}	longitudinal conversion transmission loss
P_{SD}	power spectral density
T_{CL}	transverse conversion loss
T_{CTL}	transverse conversion transmission loss
x_2	binary wild card value representation

4.2 Abbreviated terms

ADC	analogue to digital converter
AFEXTDC	alien far end cross conversion loss common to differential
ANEXTDC	alien near end cross conversion loss common to differential
AWGN	additive white Gaussian noise
BER	bit error rate
BI_DA	bi-directional data signal pair A
COM	communication ready (status bit)
COR	polarity correct

CTC	conformance test case
CTP	conformance test plan
Cvt	convention
DCQ	dynamic channel quality
DD	defect distance
DET	polarity detection
DSP	digital signal processing
ECU	electronic control unit
GMII	gigabit media independent interface
HDD	harness defect detection
ICMP	Internet Control Message Protocol
IOL	interoperability laboratory
IUT	implementation under test
LCL	longitudinal conversion loss
LCTL	longitudinal conversion transmission loss
LFL	link failures and losses
LP	link partner
LPF	low-pass filter
LQ	link quality
LRT	local receiver time
LTT	link-training time
LU	link-up time
M	mandatory
MAC	media access control
MDC	management data clock
MDI	medium dependent interface
MII	media independent interface
MSE	mean square error
MSE_WC	mean square error_worst-case
O	optional
OS	OPEN/SHORT detection

PAM3	pulse amplitude modulation (3 level)
PCB	printed circuit board
PCS	physical coding sub-layer
PEC	pulse error correction
PHY	physical layer
pMSE	peak MSE
PLL	phase locked loop
POL	polarity (detection and correction)
PSAACRF	power sum attenuations to alien crosstalk ratio far end
PSANEXT	power sum alien near end crosstalk loss
PSD	power spectral density
RBW	resolution bandwidth
RGMII	reduced gigabit media independent interface
RRT	remote receiver time
SA	RF spectral analyser
SNR	signal to noise ratio
SQI	signal quality index
TDR	time domain reflectometer
TIE	time interval error
UI	unit interval
VBW	video bandwidth
VNA	RF network analyser

5 Conventions

This document is based on OSI service conventions as specified in ISO/IEC 10731^[2].

6 Wake-up and sleep features

6.1 Extension of physical coding sub-layer

This subclause describes the modification of the physical coding sub-layer of ISO/IEC/IEEE 8802-3:2021.

REQ	1.1 Wake-up and sleep features – Extension of physical coding sub-layer
Figure 2 specifies the state diagram of the power state machine, which implements the two-way hand-shake protocol.	

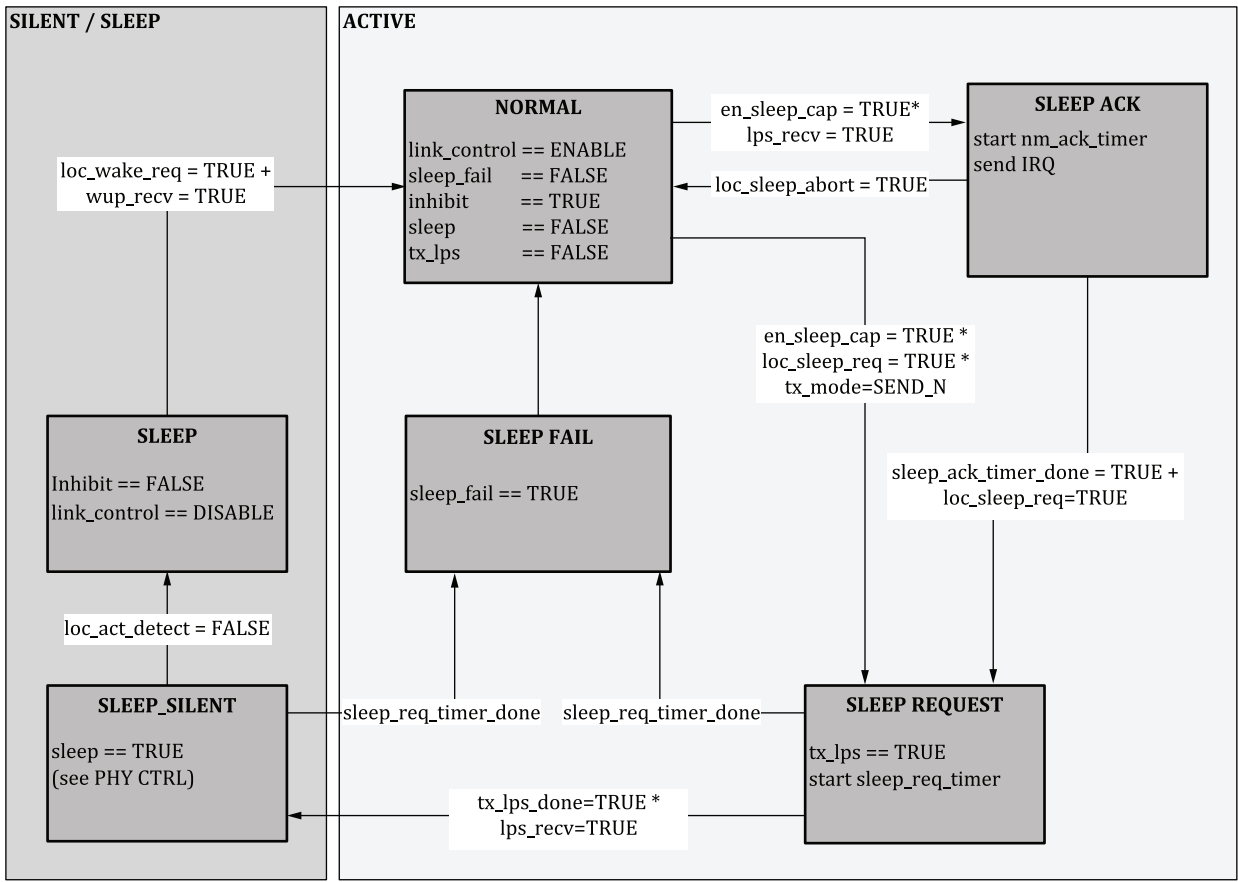


Figure 2 — Power sequencing ISO/IEC/IEEE 8802-3:2021

In case the link is up (`tx_mode = SEND_N`) and `Sleep.request` is asserted, the PHY enters the `Sleep.Request` state and sends LPS commands. The link partner receiving those LPS commands enters `SLEEP_ACK` state and starts `sleep_ack_timer`. If `loc_sleep_abort` is asserted, the sleep is aborted because of an incoming data message. If sleep reject is not done, the link partner enters `SLEEP_REQUEST` state and sends LPS commands. If the PHY detects that it sends and receives LPS commands, it transits to `SLEEP_SILENT` state and eventually to `SLEEP`. On the other hand, if the handshaking is not done before the `sleep_req_timer` timeout, the PHY enters `SLEEP_FAIL` and transits back to `SEND_IDLE` OR `DATA` state.

The signalling of a `Wakeup.request` depends on the state of the link. If the link is up (`tx_mode = SEND_N`) the PHY transmits a WUR command over the active link during `IDLE` times. If the link is down (`tx_mode = SEND_Z`) the PHY transmits a WUP pulse. If the link is not yet established (`!loc_rcvr_status`), for instance because the link is still in training (`tx_mode = SEND_I`), the link is first established, then a WUR command is sent.

REQ	1.2 Wake-up and sleep features - Selective wake-up forwarding mechanism
Multi-PHY devices (e.g. switches) shall implement a selective wake-up forwarding mechanism. If a multi-PHY device detects a <code>Wakeup.request</code> (either WUR or WUP) on one port, it shall be possible to forward the request to other PHYs of the device and to any other Single-PHY or Multi-PHY device.	

REQ	1.3 Wake-up and sleep features - Selective wake-up forwarding mechanism Single PHY device
-----	--

Single-PHY devices shall implement a selective wake-up forwarding mechanism. If a Single-PHY device detects a Wakeup.request (either WUR or WUP), it shall be possible to forward the request to other Single-PHY or Multi-PHY devices.

REQ	1.4 Wake-up and sleep features – wake-up over a passive link (WUP) and active link (WUR)
------------	---

It shall be possible to forward a wake-up over a passive link (WUP) as well as a wake-up over an active link (WUR) immediately to another port (or PHY).

The Wakeup.indicate should be generated upon wake-up events. In case the link is down, this service primitive is generated upon the reception of WUP pulses (wup_rcv) or if a local wake-up request (loc_wake_req) or a WUR is received (wur_rcv). The implementation of the energy detection process is left to the PHY vendor.

REQ	1.5 Wake-up and sleep features – Energy detection
------------	--

The energy detection process shall not take longer than 2 ms.

REQ	1.6 Wake-up and sleep features – IDLE pattern on the link triggers the energy detection
------------	--

It shall be ensured that any transmitted IDLE pattern on the link triggers the energy detection (wup_rcv = TRUE).

REQ	1.7 Wake-up and sleep features – PHY detects a wake-up request
------------	---

If the PHY detects a wake-up request, while the sleep process has already been started, going into sleep shall be terminated and the wake-up shall be processed if possible.

REQ	1.8 Wake-up and sleep features – Entering the SLEEP state
------------	--

If the PHY detects a wake-up request while the transit into SLEEP state is irreversible, this wake-up request shall be stored and executed immediately upon entering the SLEEP state.

No wakeup request should be lost.

6.2 Service primitives and interfaces

Figure 3 shows the ISO/IEC/IEEE 8802-3:2021 service primitives.

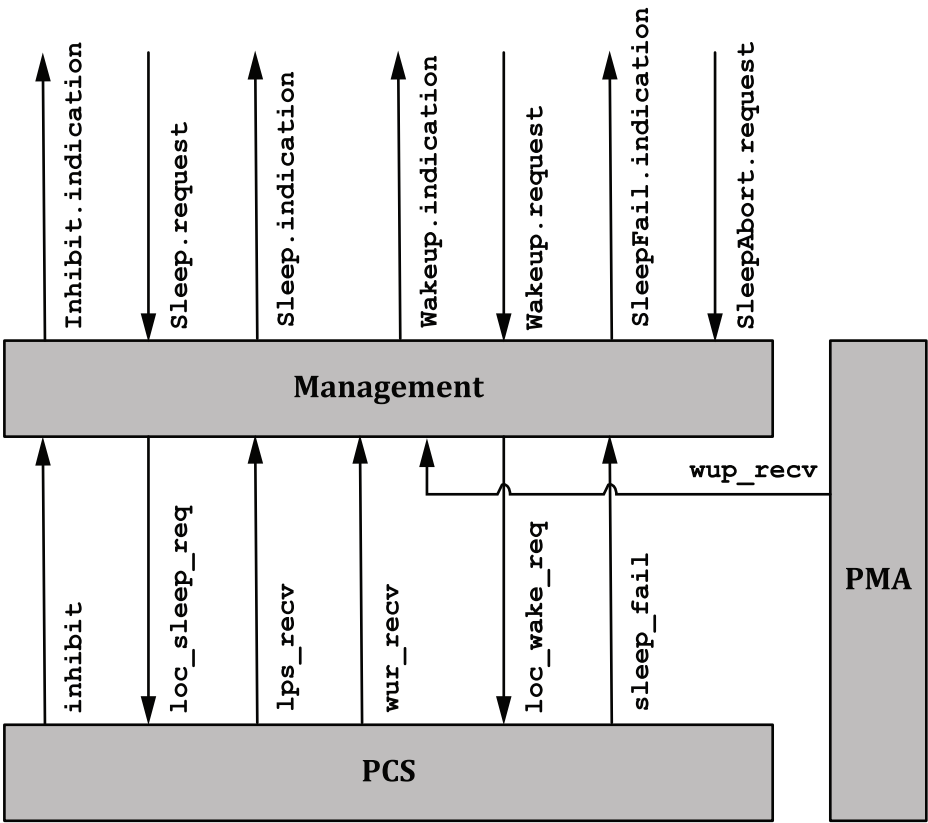


Figure 3 — ISO/IEC/IEEE 8802-3:2021 service primitives

REQ	1.9 Wake-up and sleep features – Mapping between this document and ISO 21111-2 service primitives
Table 1 specifies the mapping between this document and ISO 21111-2 service primitives which shall be followed.	

Table 1 — Mapping between this document and ISO 21111-2 service primitives

ISO 21111-6 (this document) service primitives	ISO 21111-2 service primitives
SleepConfig.request	PHY_ConfigSleepReject.request
Inhibit.indication	PHY_SleepStatus.indication
Sleep.request	PHY_LinkSleep.request
Sleep.indication	PHY_LinkSleepRequestEvent.indication
Wakeup.indication	PHY_WakeUp.indication
Wakeup.request	PHY_WakeUp.request
SleepFail.indication	PHY_LinkSleep.indication
SleepAbort.request	PHY_LinkSleepRequestAbort.request

6.3 Power sequencing states

The following requirements specify power sequencing states.

REQ	1.10 Wake-up and sleep features – Power sequencing states
The power sequencing states NORMAL, SLEEP_ACK, SLEEP_REQ, SLEEP_SILENT, SLEEP_FAIL and SLEEP shall be implemented as specified in Figure 2.	

REQ	1.11 Wake-up and sleep features – NORMAL state
The <code>NORMAL</code> state shall be the substate of <code>SEND_IDLE_OR_DATA</code> with normal data transmission. On entering <code>NORMAL</code> state, <code>lps_rcv</code> and <code>loc_sleep_abort</code> shall be deasserted.	

REQ	1.12 Wake-up and sleep features – SLEEP_ACK state
The <code>SLEEP_ACK</code> state is also a substate of <code>SEND_IDLE_OR_DATA</code> which allows a higher layer implicit acknowledgement during the time <code>sleep_ack_timer</code> . During <code>SLEEP_ACK</code> the sleep handshake can be aborted (<code>loc_sleep_abort = TRUE</code>) and the PHY transitions to <code>NORMAL</code> . The link partner senses the aborted sleep handshake (<code>loc_sleep_abort = TRUE</code>) and the PHY of the IUT transitions to <code>NORMAL</code> . When this happens the link partner sets <code>sleep_req_timer_done</code> and eventually transitions to <code>SLEEP_FAIL</code> .	

REQ	1.13 Wake-up and sleep features –SLEEP_REQ state
The <code>SLEEP_REQ</code> state is entered when the PHY is requested to enter <code>SLEEP</code> state over the <code>LinkSleep.request</code> primitive or after an implicit acknowledgement (<code>sleep_ack_timer_done</code>). In this state it is expected that the peer PHY also sends an LPS to acknowledge the flow. If the PHY has sent its own LPS command and also received LPS, then <code>SLEEP_SILENT</code> is entered. Otherwise the PHY enters <code>SLEEP_FAIL</code> after <code>sleep_req_timer</code> expires.	

REQ	1.14 Wake-up and sleep features – SLEEP_SILENT state
In <code>SLEEP_SILENT</code> the PHYs transmitter remains silent (<code>tx_mode=SEND_Z</code>) but the energy detection circuitry remains disabled to prevent spurious <code>wup_rcv</code> glitches. This acts as a safeguard to prevent a mutual wake-up through LPS commands. <code>SLEEP</code> state is entered if both PHYs are silent (<code>loc_act_detect = FALSE</code>).	

REQ	1.15 Wake-up and sleep features – SLEEP_FAIL state
The <code>SLEEP_FAIL</code> state is entered if either one or both PHYs cannot finish handshaking before the <code>sleep_req_timer</code> timeout. The sleep flow is terminated and the PHYs go back to <code>SEND_IDLE_OR_DATA</code> state.	

REQ	1.16 Wake-up and sleep features – SLEEP state
In <code>SLEEP</code> the transmitter shall be powered down and waits for a wake-up pulse or software wake-up.	

6.4 Command definitions

6.4.1 General

This document specifies three commands, which are used to request a power down and signal a wake-up over an active as well as a passive link.

6.4.2 Low power sleep (LPS)

LPS is encoded in the scrambler stream as specified in [6.5](#).

REQ	1.17 Wake-up and sleep features – Cmd – LPS
------------	--

The LPS command shall be sent for a minimum of 64 bit.
--

The detection of an LPS command is left to the implementer. Aborting an LPS command may lead to sending less than 64 bit.

6.4.3 Wake-up request (WUR)

The WUR is encoded in the scrambler stream as specified in 6.4.

REQ	1.18 Wake-up and sleep features – Cmd – WUR
------------	--

The WUR command shall be sent for a minimum of 64 bit.
--

The detection of a WUR command is left to the implementer. Aborting a WUR command may lead to sending less than 64 bit. In addition, the maximum number of hops of a wake-up network is 4.

6.4.4 Wake-up pulse (WUP)

WUP are link-training codes transmitted on the network by a node in $tx_mode = SEND_I$ or switch PHY to distribute the wake-up request over a link, which is down. The activity on the twisted-pair lines is detected by the partner PHY as a remote wake-up.

REQ	1.19 Wake-up and sleep features – Cmd – WUP
------------	--

The wake-up pulse shall have a minimum duration of 1 ms $\pm$ 0,3 ms.

REQ 1.18 allows reliable detection.

The energy detection of a WUP command is implementation-specific.

6.5 Generation of scrambling bits $s_{dn}[2:0]$

Commands are transmitted in the **IDLE** state of the PCS state machine. Therefore, the side stream scrambler is modified. The generation of $s_{dn}[1:0]$ of ISO/IEC/IEEE 8802-3:2021 is modified. The bit $s_{dn}[2]$ remains identical to ISO/IEC/IEEE 8802-3:2021.

The bit $s_{dn}[1]$ is used to scramble the data bit $tx_data_n[1]$ during data mode and to encode LPS otherwise. It is defined below.

IF ($tx_enable_{n-3} = 1$)

$$s_{dn}[1] = (s_{cn}[1] \wedge tx_data_n[1])$$

ELSE IF (($tx_lps = TRUE$) & ($loc_wake_req = FALSE$) & ($tx_mode = SEND_N$))

$$s_{dn}[1] = s_{cn}[1] \wedge 1$$

ELSE

$$s_{dn}[1] = s_{cn}[1]$$

The bit $s_{dn}[0]$ is used to scramble the data bit $tx_data_n[0]$ during data mode and to encode WUR otherwise. It is defined below.

IF ($tx_enable_{n-3} = 1$)

$$s_{dn}[0] = (s_{cn}[0] \wedge tx_data_n[0])$$

ELSE IF (($tx_lps = TRUE$) & ($loc_wake_req = TRUE$) & ($tx_mode = SEND_N$))

$$Sd_n[0] = Sc_n[0] \wedge 1$$

ELSE

$$Sd_n[0] = Sc_n[0]$$

6.6 PCS PHY control state diagram

Each variable shall have its own REQ statement with a reference to [Figure 4](#).

REQ	1.20 Wake-up and sleep features – PCS PHY control state diagram
The PCS PHY control state machine, which implements parts of the power sequencing state machine, shall be implemented as specified in Figure 4 .	

REQ	1.21 Wake-up and sleep features – PCS PHY control state diagram – Local activity detection signal
The variable <code>loc_act_detect</code> shall be set to <code>FALSE</code> if consecutive symbols of zeros were received; otherwise shall be set to <code>TRUE</code> . The value of <code>loc_act_detect</code> shall be set to <code>TRUE</code> (<code>FALSE</code>) within 1 μ s (see Figure 4).	

REQ	1.22 Wake-up and sleep features – PCS PHY control state diagram – Low power sleep received
The variable <code>lps_recv</code> shall be set if the LPS command is entirely received (see Figure 4).	

REQ	1.23 Wake-up and sleep features – PCS PHY control state diagram – Wake-up request received
The variable <code>wur_recv</code> shall be set if the WUR command is entirely received (see Figure 4).	

REQ	1.24 Wake-up and sleep features – PCS PHY control state diagram – Wake-up pulse received
The variable <code>wup_recv</code> shall be set if the WUP pulses are sensed (see Figure 4).	

REQ	1.25 Wake-up and sleep features – PCS PHY control state diagram – Low power sleep transmitted
The variable <code>tx_lps</code> shall be set if the LPS bits are transmitted by the scrambler (see Figure 4).	

REQ	1.26 Wake-up and sleep features – PCS PHY control state diagram – Low power sleep transmitted done
The variable <code>tx_lps_done</code> shall be set if the LPS command is entirely sent (at least 64-bit) (see Figure 4).	

REQ	1.27 Wake-up and sleep features – PCS PHY control state diagram – Local sleep request
The variable <code>loc_sleep_req</code> shall be set if a sleep is requested by the local PHY (see Figure 4).	

REQ	1.28 Wake-up and sleep features – PCS PHY control state diagram – Local wake-up requested
The variable <code>loc_wake_req</code> shall be set if a wake-up is requested by the local PHY (see Figure 4).	
REQ	1.29 Wake-up and sleep features – PCS PHY control state diagram – Local sleep abort
The variable <code>loc_sleep_abort</code> shall be set if a remote sleep request is to be rejected while still in <code>SLEEP_ACK</code> state (see Figure 4).	
REQ	1.30 Wake-up and sleep features – PCS PHY control state diagram – Sleep fail
The variable <code>sleep_fail</code> shall be set if a sleep handshake is aborted by the link partner (see Figure 4).	
REQ	1.31 Wake-up and sleep features – PCS PHY control state diagram – Inhibit
The variable <code>inhibit</code> shall be set if the (external) power supply shutdown is inhibited (see Figure 4).	
REQ	1.32 Wake-up and sleep features – PCS PHY control state diagram – Sleep
The variable <code>sleep</code> shall be set by the power state machine to notify PHY CTRL to disable transmission (see Figure 4).	
REQ	1.33 Wake-up and sleep features – PCS PHY control state diagram – Enable sleep capability
The variable <code>en_sleep_cap</code> shall be set to <code>TRUE</code> when the IUT sleep capability is enabled and set to <code>FALSE</code> when the IUT sleep capability is not enabled (see Figure 4).	
REQ	1.34 Wake-up and sleep features – PCS PHY control state diagram – Wake-up timer
The IUT shall use the timer <code>wup_timer</code> to wait for reliable detection of a WUP pulse. The timer shall expire $1\text{ ms} \pm 0,3\text{ ms}$ after being started (see Figure 4).	
REQ	1.35 Wake-up and sleep features – PCS PHY control state diagram – Sleep acknowledge timer
The timer <code>sleep_ack_timer</code> shall be used in <code>SLEEP_ACK</code> state to check whether NM decides to reject sleep flow on an incoming data message or not. The timer shall expire $8\text{ ms} \pm 0,8\text{ ms}$ after being started (see Figure 4).	
REQ	1.36 Wake-up and sleep features – PCS PHY control state diagram – Sleep request timer
The timer <code>sleep_req_timer</code> shall be set-up in <code>SLEEP_REQ</code> to check if the handshaking is done by both PHYs. If the PHY does not enter <code>SLEEP</code> state before timeout, it enters <code>SLEEP_FAIL</code> state and back to <code>NORMAL</code> . The timer shall expire $16\text{ ms} \pm 1,6\text{ ms}$ after being started (see Figure 4).	

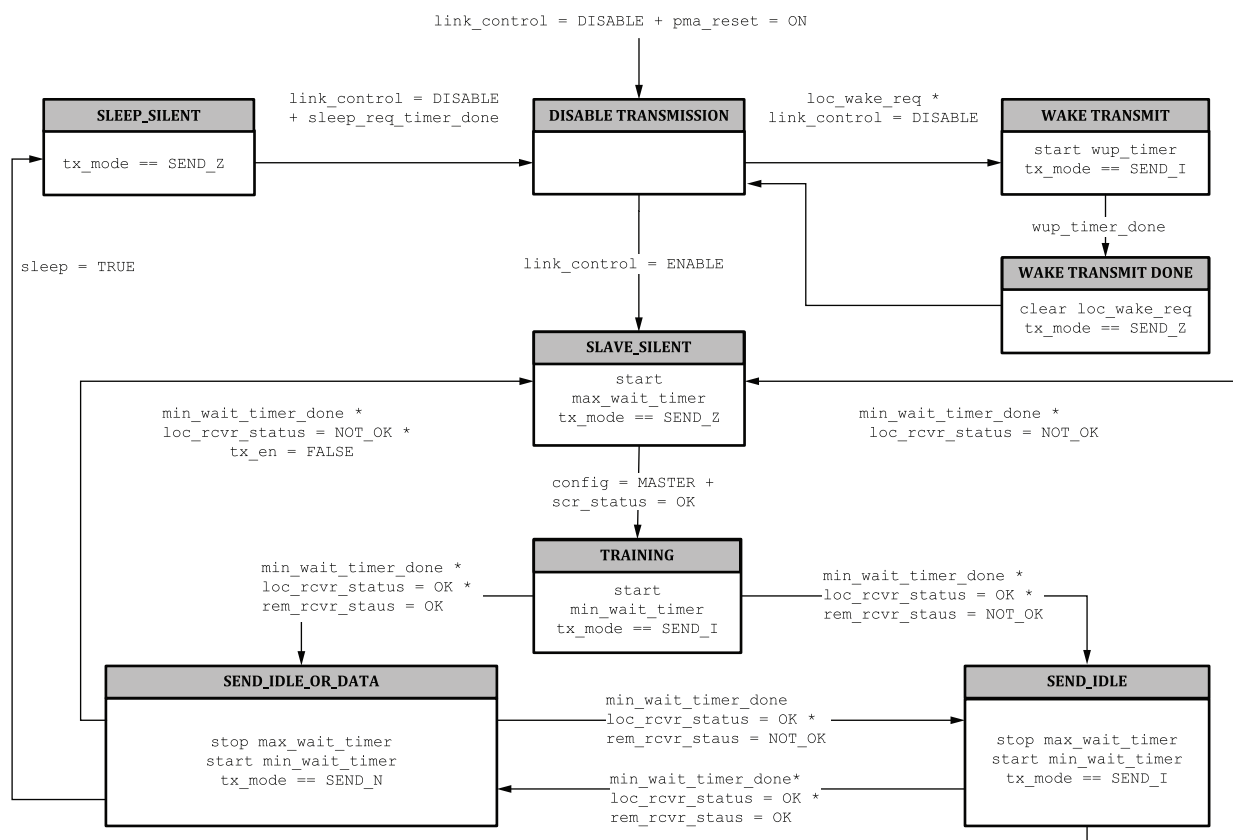


Figure 4 — PHY control state diagram to replace the ISO/IEC/IEEE 8802-3:2021 PHY control state diagram

7 CTP test system and CTC structure

7.1 General

The CTCs specified 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. CTCs are organized into groups, primarily in order to reduce set-up time in the lab environment. The different groups typically also tend to focus on specific aspects of device functionality. A three-part numbering system is used to organize the CTCs, where the first number indicates the subclause of Clause 96 of the ISO/IEC/IEEE 8802-3:2021 specification on which the CTP is based. The second and third numbers indicate the CTC's group number and test number within that group, respectively. This format allows for the addition of future tests to the appropriate groups without requiring the renumbering of the subsequent tests.

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

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

The references specify 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.

7.2 Test system set-up – Transmit test system

The test set-up consists of a test system and a system under test (SUT) connected via the physical medium. The test system implements an UT and a LT. The UT uses the test control protocol ([Figure 5](#) key 2) or the UT point of control and observation (PCO) test system operator to control the LT. The LT supports the functionality required to test the OSI layer ([Figure 5](#) key 5) of the IUT. The test system uses SUT-specific set-up parameters ([Figure 5](#) key 1) for testing the communication with the IUT.

The control and measurement functionality is provided by direct logical access to the service interface (dashed line) ([Figure 5](#) key 3) and the associated parameters of the OSI layer. The UT in the IUT ([Figure 5](#) key 4) supports an equivalent part of the service interface (PCO) (dashed line) ([Figure 5](#) key 3) and the associated parameters to control and measure the state(s) of IUT.

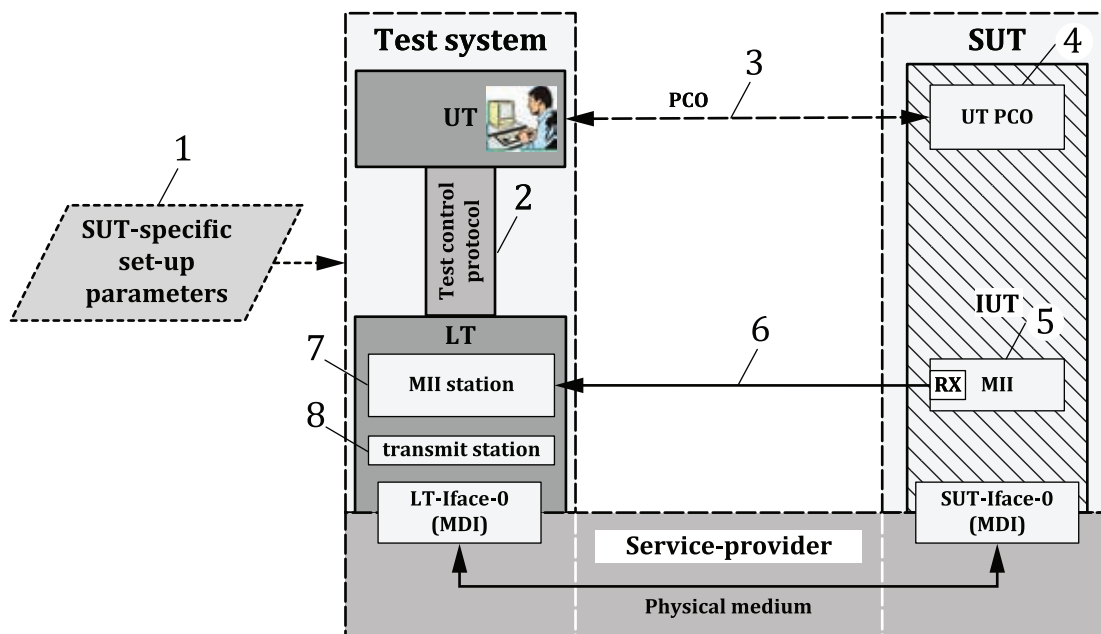
The UT PCO test system operator as part of the UT in the test system manipulates the service interface parameters of the OSI layers to fulfil the purpose of each conformance test case (CTC).

The MII station and the transmit station are part of the LT.

The purpose of the MII station ([Figure 5](#) key 6) is to directly interact with the MII of the IUT ([Figure 5](#) key 8); monitoring ([Figure 5](#) key 5) the RX pins of the IUT MII ([Figure 5](#) key 8), to verify that PHY frames received at the SUT-Iface-0 (MDI) are converted appropriately to bits recognizable by the MAC of the LT.

The purpose of the transmit station ([Figure 5](#) key 7) is to act as a link partner with the IUT. The transmit station transmits ISO/IEC/IEEE 8802-3:2021 PAM3 encoding such that the IUT can achieve a link and receive ternary symbol sequences designed to stress the IUT implementation.

[Figure 5](#) shows the transmit test system set-up.



Key

- 1 SUT-specific set-up parameters (node's electronic data sheet)
- 2 test control protocol
- 3 points of control and observation and abstract service primitives
- 4 UT PCO test system operator interface
- 5 IUT MII interface
- 6 monitoring of the RX pins of the IUT MII interface
- 7 MII station
- 8 transmit station (link partner of IUT)

Figure 5 — Test system set-up – Transmit test system

7.3 Test system set-up – Receive test system

The test set-up consists of a test system and a system under test (SUT) connected via the physical medium. The test system implements an UT and a LT. The UT uses the test control protocol ([Figure 6](#) key 2) or the UT point of control and observation (PCO) test system operator to control the LT. The LT supports the functionality required to test the OSI layer ([Figure 6](#) key 5) of the IUT. The test system uses SUT-specific set-up parameters ([Figure 6](#) key 1) for testing the communication with the IUT.

The control and measurement functionality is provided by direct logical access to the service interface (dashed line) ([Figure 6](#) key 3) and the associated parameters of the OSI layer. The UT in the IUT ([Figure 6](#) key 4) supports and equivalent part of the service interface (PCO) (dashed line) ([Figure 6](#) key 3) and the associated parameters to control and measure the state(s) of IUT.

The UT PCO test system operator as part of the UT in the test system manipulates the service interface parameters of the OSI layers to fulfil the purpose of each conformance test case (CTC).

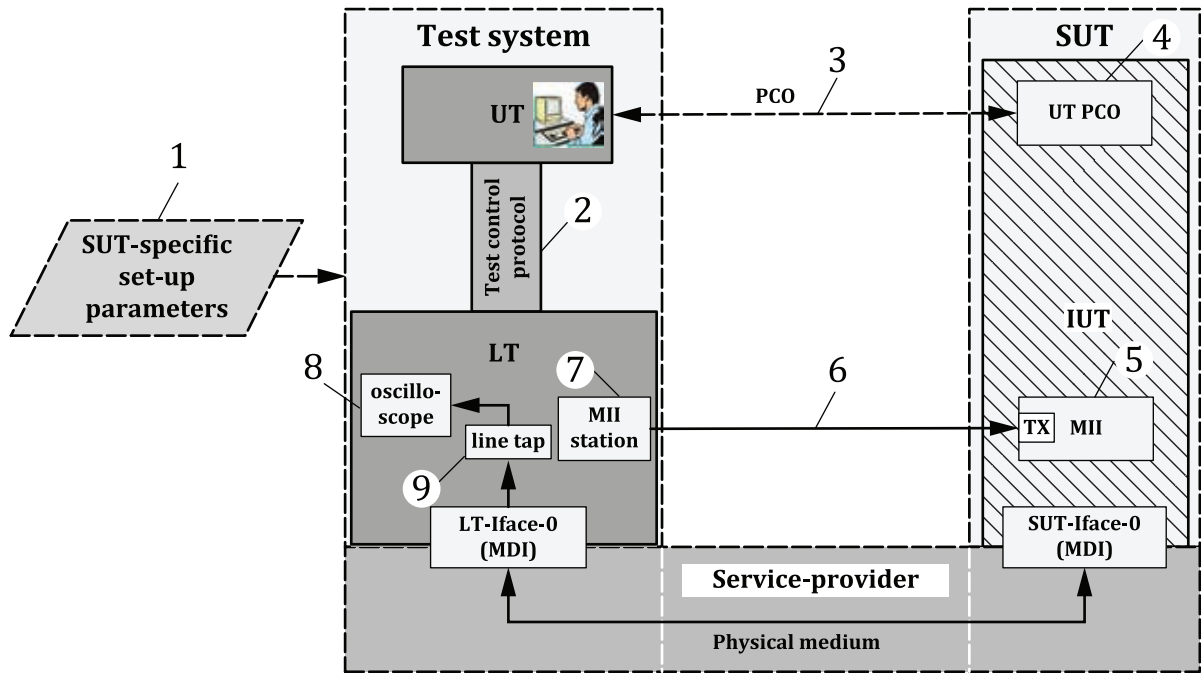
The MII station, line tap, and the oscilloscope are part of the LT.

The purpose of the MII station ([Figure 6](#) key 7) is to directly interact ([Figure 6](#) key 5) with the MII of the IUT; manipulating the TX pins of the IUT MII, to verify that the signals transmitted by the MII station of the LT are properly converted to PAM3 PHY frames transmitted by the IUT MDI via the SUT-Iface-0.

The purpose of the line tap (Figure 6 key 9) is to allow directional monitoring of the signalling from the physical medium. The receive signal from the LT-Iface-0 is then captured on the oscilloscope (Figure 6 key 7).

The purpose of the oscilloscope (Figure 6 key 8) is to measure the PAM3 signalling transmitted by the IUT MDI, allowing for capture and decoding of the ISO/IEC/IEEE 8802-3:2021 ternary symbols.

Figure 6 shows the receive test system set-up.



Key

- 1 SUT-specific set-up parameters (node's electronic data sheet)
- 2 test control protocol
- 3 points of control and observation and abstract service primitives
- 4 UT PCO test system operator interface
- 5 IUT MII interface
- 6 manipulation of IUT MII TX interface
- 7 MII station
- 8 oscilloscope measures the PAM3 signalling transmitted by the IUT MDI
- 9 line tap

Figure 6 — Test system set-up – Receive test system

7.4 CTC structure

CTCs are independent of one another. Each CTC checks the behaviour of the IUT for a particular purpose.

CTCs, which require variations of individual parameters, shall be repeated for each value of the parameter.

The CTC specifications are intended to provide a high-level description of the motivation, resources, procedures, and methodologies pertinent to each test. Each CTC is specified according to a common CTC structure as shown in Table 2.

Table 2 — CTC structure

Item	Content
CTC # – Name	CTC_x.y.z-a – CTC structure
Purpose	The purpose is a brief statement outlining what the test attempts are to achieve. The test is written at the functional level.
Reference	The purpose of the reference is to specify source material external to the test suite, including 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.
Prerequisite	The purpose of the prerequisites is to specify the test hardware and/or software needed to perform the CTC. This is generally expressed in terms of minimum requirements. In some cases, specific equipment manufacturer/model information may be provided.
Set-up	The purpose of the set-up is to describe 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 below.
Step	The test procedure includes the test description, which contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing and may be interspersed with observable results. Each test step shall have a numeric number in ascending order.
Iteration	The purpose of the test iterations is to include test procedure definitions, which are repeated more than once.
Expected response	The purpose of the expected response is to describe the expected results to be examined by the tester in order to verify that the IUT is operating. When multiple values for an observable are possible, this description 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.
Remark	The purpose of the remarks is to describe known issues with the test procedure, which can affect test results in certain situations. It can also refer the reader to test suite annexes and/or white papers that can provide more detail regarding these issues.

8 PHY – Control IUT conformance test plan (with MII access)

8.1 PHY – Group 1: PHY control and timers (with MII access)

8.1.1 Overview

The CTCs specified in [8.1](#) verify the PHY control and timers as specified in ISO/IEC/IEEE 8802-3:2021, 96.4.5. Refer to [Annex A](#) for additional low-level technical details about the PHY control test suite.

8.1.2 CTC_4.1.1 – PMA reset (with MII access)

The PMA reset function causes the transition to the LINK DOWN state and the IUT should set link_status = FAIL.

[Table 3](#) specifies the CTC_4.1.1 – PMA reset (with MII access).

Table 3 — CTC_4.1.1 – PMA reset (with MII access)

Item	Content
CTC # – Name	CTC_4.1.1 – PMA reset (with MII access)
Purpose	This CTC verifies that the PMA initialises upon receipt of a reset request from the management entity.
Reference	ISO/IEC/IEEE 8802-3:2021, 96.4.1 PMA reset function

Table 3 (continued)

Item	Content
Prerequisite	The UT shall have access to the PMA reset. The UT shall have access to the <code>link_status</code>^a. The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 6. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the link partner via the line tap or to the test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall establish a valid link with the IUT. 3. The LT shall monitor the transmissions from the IUT and shall cause the management to request a PMA reset while simultaneously ceasing transmissions from the LT. 4. The UT shall configure the IUT as SLAVE. 5. The LT shall establish a valid link with the IUT. 6. The LT shall monitor the transmissions from the IUT and shall cause the management to request a PMA reset while simultaneously ceasing transmissions from the LT.
Iteration	Not applicable
Expected response	After step 3: The IUT stops transmitting with <code>tx_mode = SEND_N</code> and starts transmitting with <code>tx_mode = SEND_I</code>. The IUT sets <code>link_status = FAIL</code>. After step 6: The IUT stops transmitting. The IUT sets <code>link_status = FAIL</code>.
Remark	^a The delay from the internal setting of <code>link_status</code> to the externally observable <code>link_status</code> signal shall be defined by the IUT supplier. If the ability to control the PMA reset request is not available, this CTC cannot be performed. If the <code>link_status</code> indication is not available, the expected response concerning <code>link_status = FAIL</code> cannot be completed. If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested. If it is not possible to synchronise asserting PMA reset and ceasing transmissions from the test system, ensure that the test system does not transmit a sequence that would cause the IUT to set <code>scr_status = OK</code> or <code>loc_rcvr_status = OK</code>.

8.1.3 CTC_4.1.2 – Value of `minwait_timer` – `minwait_timer` in TRAINING state (with MII access)

[Table 4](#) specifies the CTC_4.1.2 – Case 1 – Value of `minwait_timer` – `minwait_timer` in TRAINING state (with MII access).

Table 4 — CTC_4.1.2 – Case 1 – Value of `minwait_timer` – `minwait_timer` in TRAINING state (with MII access)

Item	Content
CTC # – Name	CTC_4.1.2 – Case 1 – Value of <code>minwait_timer</code> – <code>minwait_timer</code> in TRAINING state (with MII access)
Purpose	This CTC verifies that the IUT implements correctly the <code>minwait_timer</code> of $1,8 \mu\text{s} \pm 0,18 \mu\text{s}$.
Reference	ISO/IEC/IEEE 8802-3:2021:

Table 4 (continued)

Item	Content
	— 96.4.7.2 timers; — Figure 96-18 PHY control state diagram; — Figure 96-19 link monitor state diagram.
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system (see Figure 5 key 7) and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. UT PCO test system operator shall configure the IUT as MASTER or as SLAVE. 2. The LT shall monitor the transmissions from the IUT and shall restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT establishes a link. 3. The LT shall start transmitting a valid training signal from the transmit station as soon as the IUT restarts the training process. If the IUT is a MASTER then the transmit test system should begin transmissions with <code>loc_rcvr_status = OK</code>. If the IUT is a SLAVE then the transmit test system should not set <code>loc_rcvr_status = OK</code> until after the IUT starts transmitting the idle training pattern. 4. The LT shall monitor how long the IUT sends the idle training pattern in the <code>TRAINING</code> state before transitioning to the <code>SEND IDLE OR DATA</code> state.
Iteration	a) REPEAT step 2 to step 4 with the IUT configured as MASTER, 10 times. b) REPEAT step 2 to step 4 with the IUT configured as SLAVE, 10 times.
Expected response	After step 4 iterations a): The IUT transmits the idle training pattern for $1,8 \mu\text{s} \pm 0,18 \mu\text{s}$. After step 4 iterations b): The IUT transmits the idle training pattern for $1,8 \mu\text{s} \pm 0,18 \mu\text{s}$.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested. It also cannot be performed, if the IUT needs longer than the <code>minwait_timer</code> to set the <code>loc_rcvr_status</code> to <code>TRUE</code> .

[Table 5](#) specifies the CTC_4.1.2 – Case 2 – Value of `minwait_timer` – `minwait_timer` in `SEND IDLE OR DATA` state (with MII access).

Table 5 — CTC_4.1.2 – Case 2 – Value of `minwait_timer` – `minwait_timer` in `SEND IDLE OR DATA` state (with MII access)

Item	Content
CTC # – Name	CTC_4.1.2 – Case 2 – Value of <code>minwait_timer</code> – <code>minwait_timer</code> in <code>SEND IDLE OR DATA</code> state (with MII access)
Purpose	This CTC verifies that the IUT implements the <code>minwait_timer</code> of $1,8 \mu\text{s}$ and its tolerance.
Reference	ISO/IEC/IEEE 8802-3:2021: — 96.4.7.2 timers; — Figure 96-18 PHY control state diagram; — Figure 96-19 link monitor state diagram.
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.

Table 5 (continued)

Item	Content
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall have the ability to configure the IUT as MASTER or SLAVE. 2. The LT shall monitor the transmissions from the IUT and shall restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall establish a valid link with the IUT, but shall stop transmitting as soon as the IUT transitions to <code>tx_mode = SEND_N</code>. 4. The LT shall monitor how long the IUT transmits with <code>tx_mode = SEND_N</code> before restarting training.
Iteration	a) REPEAT step 2 to step 4 with the IUT configured as MASTER, 10 times. b) REPEAT step 2 to step 4 with the IUT configured as SLAVE, 10 times.
Expected response	After step 4 iterations a): The IUT transmits with <code>tx_mode = SEND_N</code> for at least 1,62 μs and no more than 1 ms. After step 4 iterations b): The IUT transmits with <code>tx_mode = SEND_N</code> for at least 1,62 μs and no more than 1 ms.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration is tested. It also cannot be performed if the IUT needs longer than the <code>minwait_timer</code> to drop <code>loc_rcvr_status</code>.

[Table 6](#) specifies the CTC_4.1.2 – Case 3 – Value of `minwait_timer` – `minwait_timer` between SEND IDLE to SEND IDLE OR DATA state (with MII access).

Table 6 — CTC_4.1.2 – Case 3 – Value of `minwait_timer` – `minwait_timer` between SEND IDLE to SEND IDLE OR DATA state (with MII access)

Item	Content
CTC # - Name	CTC_4.1.2 – Case 3 – Value of <code>minwait_timer</code> – <code>minwait_timer</code> between SEND IDLE to SEND IDLE OR DATA state (with MII access)
Purpose	This CTC verifies that the IUT implements the <code>minwait_timer</code> of 1,8 μ s $\pm$ 0,18 μ s while in the SEND IDLE.
Reference	ISO/IEC/IEEE 8802-3:2021: — 96.4.7.2 timers; — Figure 96-18 PHY control state diagram; — Figure 96-19 link monitor state diagram.
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.

Table 6 (continued)

Item	Content
Step	1. The UT shall configure the IUT as MASTER or SLAVE. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall establish a valid link with the IUT. 4. The UT shall instruct the LT to transmit with <code>tx_mode = SEND_I</code> with <code>loc_rcvr_status = OK</code>. 5. The UT shall instruct the LT to transmit with <code>loc_rcvr_status = NOT_OK</code> for less than <code>minwait_timer</code> as soon as the IUT begins transmitting with <code>tx_mode = SEND_N</code>. 6. As soon as the IUT begins transmitting with <code>tx_mode = SEND_I</code>, instruct the test system to transmit with <code>loc_rcvr_status = OK</code>. 7. The UT shall observe how long the IUT transmits with <code>tx_mode = SEND_I</code>.
Iteration	a) REPEAT step 2 to step 7 with the IUT configured as MASTER, 10 times. b) REPEAT step 2 to step 7 with the IUT configured as SLAVE, 10 times.
Expected re-sponse	After step 7 iterations a): The IUT transmits with <code>tx_mode = SEND_I</code> for $1,8\ \mu\text{s} \pm 0,18\ \mu\text{s}$. After step 7 iterations b): The IUT transmits with <code>tx_mode = SEND_I</code> for $1,8\ \mu\text{s} \pm 0,18\ \mu\text{s}$.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested. It also cannot be performed, if the IUT needs longer than the <code>minwait_timer</code> to <code>set rem_rcvr_status = TRUE</code> .

Table 7 specifies the CTC_4.1.2 – Case 4 – Value of `minwait_timer` – `minwait_timer` between SEND IDLE OR DATA to SEND IDLE state (with MII access).

Table 7 — CTC_4.1.2 – Case 4 – Value of `minwait_timer` – `minwait_timer` between SEND IDLE OR DATA to SEND IDLE state (with MII access)

Item	Content
CTC # – Name	CTC_4.1.2 – Case 4 – Value of <code>minwait_timer</code> – <code>minwait_timer</code> between SEND IDLE OR DATA to SEND IDLE state (with MII access)
Purpose	This CTC verifies that the IUT implements the <code>minwait_timer</code> of $1,8\ \mu\text{s} \pm 0,18\ \mu\text{s}$ while in the SEND IDLE OR DATA.
Reference	ISO/IEC/IEEE 8802-3:2021: — 96.4.7.2 timers; — Figure 96-18 PHY control state diagram; — Figure 96-19 link monitor state diagram.
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.

Table 7 (continued)

Item	Content
Step	1. The UT shall configure the IUT as MASTER or SLAVE. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall establish a valid link with the IUT. 4. The UT shall instruct the LT to transmit with <code>tx_mode = SEND_I</code> with <code>loc_rcvr_status = NOT_OK</code>. 5. As soon as the IUT begins transmitting with <code>tx_mode = SEND_I</code>, the LT shall be instructed to transmit with <code>loc_rcvr_status = OK</code>. 6. The LT shall be instructed to transmit with <code>loc_rcvr_status = NOT_OK</code> as soon as the IUT begins transmitting with <code>tx_mode = SEND_N</code>. 7. The UT shall observe how long the IUT transmits with <code>tx_mode = SEND_N</code>.
Iteration	a) REPEAT step 2 to step 7 with the IUT configured as MASTER, 10 times. b) REPEAT step 2 to step 7 with the IUT configured as SLAVE, 10 times.
Expected response	After step 7 iterations a): The IUT transmits with <code>tx_mode = SEND_N</code> for $1,8\ \mu\text{s} \pm 0,18\ \mu\text{s}$. After step 7 iterations b): The IUT transmits with <code>tx_mode = SEND_N</code> for $1,8\ \mu\text{s} \pm 0,18\ \mu\text{s}$.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested. It also cannot be performed, if the IUT needs longer than the <code>minwait_timer</code> to drop <code>rem_rcvr_status</code>. Ambiguity between <code>SEND_I</code> and <code>SEND_N</code> code-groups may cause an additional error in the observed timer value. This error can be reduced by repeating the impacted test part until observing fewer ambiguous <code>SEND_I</code> and <code>SEND_N</code> code groups.

8.1.4 CTC_4.1.3 – Value of `maxwait_timer` (with MII access)

Table 8 specifies the CTC_4.1.3 – Value of `maxwait_timer` (with MII access).

Table 8 — CTC_4.1.3 – Value of `maxwait_timer` (with MII access)

Item	Content
CTC # - Name	CTC_4.1.3 – Value of <code>maxwait_timer</code> (with MII access)
Purpose	This CTC verifies that the IUT implements the <code>maxwait_timer</code> of $200\ \text{ms} \pm 2\ \text{ms}$.
Reference	ISO/IEC/IEEE 8802-3:2021: — 96.4.7.2 timers; — Figure 96-18 PHY control state diagram; — Figure 96-19 link monitor state diagram.
Prerequisite	The UT shall have access to the <code>link_status</code>^a. The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.

Table 8 (continued)

Item	Content
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall establish a link and ensure that <code>link_status</code> = OK. 3. The LT shall monitor the transmissions and <code>link_status</code> from the IUT. 4. The LT shall stop transmitting signalling to the IUT. 5. Determine when the IUT sets <code>tx_mode</code> $\neq$ SEND_N and mark this as TIME A. 6. Determine when the IUT sets <code>link_status</code> = FAIL and mark this as TIME B. 7. The UT shall measure <code>max_wait_timer</code> as the difference between TIME A and TIME B. 8. The UT shall configure the IUT as SLAVE. 9. The LT shall establish a link and ensure that <code>link_status</code> = OK. 10. The LT shall monitor the transmissions and <code>link_status</code> from the IUT. 11. The LT shall stop transmitting signalling to the IUT. 12. Determine when the IUT sets <code>tx_mode</code> $\neq$ SEND_N and mark this as TIME A. 13. Determine when the IUT sets <code>link_status</code> = FAIL and mark this as TIME B. 14. The UT shall measure <code>max_wait_timer</code> as the difference between TIME A and TIME B.
Iteration	Not applicable
Expected re- sponse	After step 7: The IUT implements a <code>max_wait_timer</code> of 200 ms $\pm$ 2 ms when configured as MASTER. After step 14: The IUT implements a <code>max_wait_timer</code> of 200 ms $\pm$ 2 ms when configured as SLAVE.
Remark	^a The delay from the internal setting of <code>link_status</code> to the externally observable <code>link_status</code> signal shall be defined by the IUT supplier. This CTC cannot be completed if access to <code>link_status</code> is not available. Also, some devices cannot be configured as MASTER or SLAVE, in which case only the supported configuration is tested.

8.1.5 CTC_4.1.4 – Value of `stabilize_timer` (with MII access)

[Table 9](#) specifies the CTC_4.1.4 – Value of `stabilize_timer` (with MII access).

Table 9 — CTC_4.1.4 – Value of `stabilize_timer` (with MII access)

Item	Content
CTC # – Name	CTC_4.1.4 – Value of <code>stabilize_timer</code> (with MII access)
Purpose	This CTC verifies that the IUT implements the <code>stabilize_timer</code> of 1,8 μ s $\pm$ 0,18 μ s.
Reference	ISO/IEC/IEEE 8802-3:2021: — 96.4.7.2 timers; — Figure 96-18 PHY control state diagram; — Figure 96-19 link monitor state diagram.
Prerequisite	The UT shall have access to the <code>link_status</code>^a. The UT shall have the ability to configure the IUT as MASTER or SLAVE.

Table 9 (continued)

Item	Content
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER or SLAVE. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall start transmitting a valid training signal from the transmit station as soon as the IUT restarts the training process. 4. After the IUT sets <code>loc_rcvr_status = OK</code>, continue to send the valid signal for 0,36 μs, then stop transmitting. 5. The UT shall check the value of <code>link_status</code>.
Iteration	a) REPEAT step 2 to step 5, 1 time, with the IUT configured as MASTER and the test system configured as SLAVE, increasing the duration that the test system sends a valid signal in step 4 by 0,36 μs until the IUT reports <code>link_status = OK</code>. This is the value for <code>stabilize_timer</code>. b) REPEAT step 2 to step 5, 1 time, with the IUT configured as SLAVE and the test system configured as MASTER.
Expected response	After step 5 iteration a): LT expects the value of <code>stabilize_timer</code> to be 1,8 μs $\pm$ 0,18 μs when configured as MASTER. After step 5 iteration b): LT expects the value of <code>stabilize_timer</code> to be 1,8 μs $\pm$ 0,18 μs when configured as SLAVE.
Remark	^a The delay from the internal setting of <code>link_status</code> to the externally observable <code>link_status</code> signal shall be defined by the IUT supplier. This CTC cannot be performed if real-time access to <code>link_status</code> is not available. Also, some devices cannot be configured as MASTER or SLAVE, in which case only the supported configuration is tested.

8.2 PHY – Group 2: PHY control state diagram (with MII access)

8.2.1 Overview

The CTCs specified in [8.2](#) verify the PHY control state diagram defined for ISO/IEC/IEEE 8802-3:2021 capable PHYs in ISO/IEC/IEEE 8802-3:2021, 96.4.5. Refer to [Annex A](#) for additional low-level technical details about the PHY control test suite.

8.2.2 CTC_4.2.1 – PHY control state diagram - DISABLE TRANSMITTER state (with MII access)

[Table 10](#) specifies the CTC_4.2.1 – PHY control state diagram - DISABLE TRANSMITTER state (with MII access).

Table 10 — CTC_4.2.1 – PHY control state diagram - DISABLE TRANSMITTER state (with MII access)

Item	Content
CTC # - Name	CTC_4.2.1 – PHY control state diagram - DISABLE TRANSMITTER state (with MII access)
Purpose	This CTC verifies that the IUT disables the transmitter while in the DISABLE TRANSMITTER state.

Table 10 (continued)

Item	Content
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram
Prerequisite	The UT shall have access to the PMA reset. The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5 . The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and cause the management to request a PMA reset. 3. The UT shall observe if the IUT disables the transmitter upon entering the <code>DISABLE TRANSMITTER</code> state. 4. The UT shall configure the IUT as SLAVE. 5. The LT shall monitor the transmissions from the IUT and cause the management to request a PMA reset. 6. The UT shall observe if the IUT disables the transmitter upon entering the <code>DISABLE TRANSMITTER</code> state.
Iteration	Not applicable
Expected re- sponse	After step 3: The IUT disables the transmitter upon entering the <code>DISABLE TRANSMITTER</code> state when configured as MASTER. After step 6: The IUT disables the transmitter upon entering the <code>DISABLE TRANSMITTER</code> state when configured as SLAVE.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested. It also cannot be performed, if the control of the PMA reset request is not available.

8.2.3 CTC_4.2.2 – PHY control state diagram - SLAVE SILENT state (with MII access)

[Table 11](#) specifies the CTC_4.2.2 – PHY control state diagram - `SLAVE SILENT` state (with MII access).

Table 11 — CTC_4.2.2 – PHY control state diagram - `SLAVE SILENT` state (with MII access)

Item	Content
CTC # – Name	CTC_4.2.2 – PHY control state diagram - <code>SLAVE SILENT</code> state (with MII access)
Purpose	This CTC verifies that the IUT does not transmit while in the <code>SLAVE SILENT</code> state and that the IUT transitions out of this state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5 . The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.

Table 11 (continued)

Item	Content
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT by sending invalid ternary codes after the IUT has established a link. 3. The LT shall observe that the IUT immediately transitions out of the <code>SLAVE SILENT</code> state without waiting for <code>scr_status = OK</code>. 4. The LT shall not immediately send a valid idle training pattern. 5. The LT shall send a valid idle training pattern and observe that the IUT begins transmitting a valid idle training pattern. 6. The UT shall configure the IUT as SLAVE. 7. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT by sending invalid ternary codes after the IUT has established a link. 8. The LT shall observe that the IUT immediately transitions out of the <code>SLAVE SILENT</code> state without waiting for <code>scr_status = OK</code>. 9. The LT shall not immediately send a valid idle training pattern. 10. The LT shall send a valid idle training pattern and observe that the IUT begins transmitting a valid idle training pattern.
Iteration	Not applicable
Expected re- sponse	After step 5: The IUT transitions out of the <code>SLAVE SILENT</code> state without waiting for <code>loc_rcvr_status = OK</code>. After step 10: The IUT does not transition out of the <code>SLAVE SILENT</code> state until it receives a valid idle training pattern.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested.

8.2.4 CTC_4.2.3 – PHY control state diagram – TRAINING state (with MII access)

The ISO/IEC/IEEE 8802-3:2021, Figure 96-18 PHY control state diagram states that the device remains in the `TRAINING` state until it has `loc_rcvr_status = OK` and `minwait_timer` has finished. If the link partner does not have `loc_rcvr_status = OK` then the device transits to the `SEND IDLE` state. If the link partner does have `loc_rcvr_status = OK` then the device transits to the `SEND IDLE OR DATA` state. The link partner's value for `rem_rcvr_status` is determined based on the scrambler sequence transmitter by the link partner.

Table 12 specifies the CTC_4.2.3 – Case 1 –PHY control state diagram – IUT remains in the `TRAINING` state (with MII access).

Table 12 — CTC_4.2.3 – Case 1 –PHY control state diagram – IUT remains in the `TRAINING` state (with MII access)

Item	Content
CTC # – Name	CTC_4.2.3 – Case 1 –PHY control state diagram – IUT remains in the <code>TRAINING</code> state (with MII access)
Purpose	This CTC verifies that the IUT remains in the <code>TRAINING</code> state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.

Table 12 (continued)

Item	Content
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall transmit a valid idle training pattern to the IUT, then the LT shall observe that the IUT continues to transmit a valid idle pattern with <code>tx_mode = SEND_I</code> and the scrambler for <code>loc_rcvr_status = NOT_OK</code>. 4. The UT shall configure the IUT as SLAVE. 5. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 6. The LT shall transmit a valid idle training pattern to the IUT, then stop transmitting as soon as the IUT begins transmitting. 7. The LT shall observe that the IUT does not exit the training state and continues transmitting a valid idle pattern with <code>tx_mode = SEND_I</code> and the scrambler for <code>loc_rcvr_status = NOT_OK</code>.
Iteration	Not applicable
Expected re-sponse	After step 3: The IUT continues transmitting a valid idle training pattern with <code>tx_mode = SEND_I</code> and <code>loc_rcvr_status = NOT_OK</code> when configured as MASTER. After step 7: The IUT continues transmitting a valid idle training pattern with <code>tx_mode = SEND_I</code> and <code>loc_rcvr_status = NOT_OK</code> when configured as SLAVE.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested.

[Table 13](#) specifies the CTC_4.2.3 – Case 2 – PHY control state diagram – IUT transitions to the `SEND_IDLE` state (with MII access).

Table 13 — CTC_4.2.3 – Case 2 – PHY control state diagram – IUT transitions to the `SEND_IDLE` state (with MII access)

Item	Content
CTC # – Name	CTC_4.2.3 – Case 2 – PHY control state diagram – IUT transitions to the <code>SEND_IDLE</code> state (with MII access)
Purpose	This CTC verifies that the IUT exits from the <code>TRAINING</code> state and transitions to the <code>SEND_IDLE</code> state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.

Table 13 (continued)

Item	Content
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall transmit a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code>. 4. The LT shall observe that the IUT continues transmitting with <code>tx_mode = SEND_I</code>. 5. The UT shall configure the IUT as SLAVE. 6. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 7. The LT shall transmit a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code>. 8. The LT shall observe that the IUT continues transmitting with <code>tx_mode = SEND_I</code>.
Iteration	Not applicable
Expected re-sponse	After step 4: The IUT continues transmitting a valid idle training pattern with <code>tx_mode = SEND_I</code> and <code>loc_rcvr_status = OK</code>. After step 8: The IUT continues transmitting a valid idle training pattern with <code>tx_mode = SEND_I</code> and <code>loc_rcvr_status = OK</code>.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested.

[Table 14](#) specifies the CTC_4.2.3 – Case 3 – PHY control state diagram – IUT transitions to the SEND IDLE OR DATA state (with MII access).

Table 14 — CTC_4.2.3 – Case 3 – PHY control state diagram – IUT transitions to the SEND IDLE OR DATA state (with MII access)

Item	Content
CTC # - Name	CTC_4.2.3 – Case 3 – PHY control state diagram – IUT transitions to the SEND IDLE OR DATA state (with MII access)
Purpose	This CTC verifies that the IUT exits from the TRAINING state and transitions to the SEND IDLE OR DATA state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE. The IUT shall have the ability to send and receive PHY frames. This can be accomplished through a loopback, responding to ICMP requests, or by forwarding traffic through two ports.

Table 14 (continued)

Item	Content
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and the UT shall restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT establishes a link. 3. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = OK</code>. 4. The LT shall observe that the IUT begins transmitting with <code>tx_mode = SEND_N</code> and is capable of sending and receiving PHY frames. 5. The UT shall configure the IUT as SLAVE. 6. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 7. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code>. 8. The LT shall begin transmitting a valid idle training pattern with the scrambler for <code>loc_rcvr_status = OK</code> as soon as the IUT sets <code>scr_status = OK</code>. 9. The LT shall observe that the IUT begins transmitting with <code>tx_mode = SEND_N</code> and is capable of sending receiving PHY frames.
Iteration	Not applicable
Expected response	After step 4: The IUT begins transmitting with <code>tx_mode = SEND_N</code> and is capable of transmitting and receiving PHY frames when configured as MASTER. After step 9: The IUT begins transmitting with <code>tx_mode = SEND_N</code> and is capable of transmitting and receiving PHY frames when configured as SLAVE.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested. In step 9, the implementation may not allow to set <code>scr_status = OK</code> without also setting <code>loc_rcvr_status = OK</code> at the same time. In this case, the IUT transitions to the <code>SEND_IDLE</code> state and this CTC cannot be performed.

8.2.5 CTC_4.2.4 – PHY control state diagram – SEND IDLE state (with MII access)

ISO/IEC/IEEE 8802-3:2021, Figure 96-18 PHY control state diagram states that the device remains in the `SEND_IDLE` state while it has `loc_rcvr_status = OK` and `rem_rcvr_status = NOT_OK`. The IUT transits to the `SEND_IDLE_OR_DATA` state once `rem_rcvr_status = OK` or to the `SLAVE_SILENT` state if `loc_rcvr_status = NOT_OK`. The link partner's value for `loc_rcvr_status` is determined based on the scrambler sequence transmitter by the link partner.

[Table 15](#) specifies the CTC_4.2.4 – Case 1 – PHY control state diagram – IUT remains in the `SEND_IDLE` state (with MII access).

Table 15 — CTC_4.2.4 – Case 1 – PHY control state diagram – IUT remains in the SEND IDLE state (with MII access)

Item	Content
CTC # - Name	CTC_4.2.4 – Case 1 – PHY control state diagram – IUT remains in the SEND IDLE state (with MII access)
Purpose	This CTC verifies that the IUT exits from the SEND IDLE state when the IUT remains in the SEND IDLE state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code>. 4. The LT shall observe that the IUT continues transmitting a valid idle training pattern. 5. The UT shall configure the IUT as SLAVE. 6. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 7. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code>. 8. The LT shall observe that the IUT continues transmitting a valid idle training pattern.
Iteration	Not applicable
Expected re-sponse	After step 4: The IUT as MASTER continues transmitting a valid idle training pattern with <code>loc_rcvr_status = OK</code>. After step 8: The IUT as SLAVE continues transmitting a valid idle training pattern with <code>loc_rcvr_status = OK</code>.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration is tested.

[Table 16](#) specifies the CTC_4.2.4 – Case 2 – PHY control state diagram – IUT transitions to the SLAVE SILENT state (with MII access).

Table 16 — CTC_4.2.4 – Case 2 – PHY control state diagram – IUT transitions to the SLAVE SILENT state (with MII access)

Item	Content
CTC # - Name	CTC_4.2.4 – Case 2 – PHY control state diagram – IUT transitions to the SLAVE SILENT state (with MII access)
Purpose	This CTC verifies that the IUT exits from the SEND IDLE state when the IUT transitions to the SLAVE SILENT state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram

Table 16 (continued)

Item	Content
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code> for at least <code>minwait_timer</code>. 4. The LT shall stop transmitting to the IUT. 5. The LT shall observe that the IUT transitions to the <code>SLAVE SILENT</code> state. 6. The UT shall configure the IUT as SLAVE. 7. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 8. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code> for at least <code>minwait_timer</code>. 9. The LT shall stop transmitting to the IUT. 10. The LT shall observe that the IUT transitions to the <code>SLAVE SILENT</code> state.
Iteration	Not applicable
Expected response	After step 5: The IUT as MASTER transmits with <code>tx_mode = SEND_I</code> for at least 3,24 μs and no more than 1 ms before transmitting with <code>tx_mode = SEND_Z</code> indicating a transition to the <code>SLAVE SILENT</code> state. After step 10: The IUT as SLAVE transmits with <code>tx_mode = SEND_I</code> for at least 3,24 μs and no more than 1 ms before transmitting with <code>tx_mode = SEND_Z</code> indicating a transition to the <code>SLAVE SILENT</code> state.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration is tested.

[Table 17](#) specifies the CTC_4.2.4 – Case 3 – PHY control state diagram – IUT transitions in the `SEND_IDLE` OR `DATA` state (with MII access).

Table 17 — CTC_4.2.4 – Case 3 – PHY control state diagram – IUT transitions in the `SEND_IDLE` OR `DATA` state (with MII access)

Item	Content
CTC # – Name	CTC_4.2.4 – Case 3 – PHY control state diagram – IUT transitions in the <code>SEND_IDLE</code> OR <code>DATA</code> state (with MII access)
Purpose	This CTC verifies that the IUT exits from the <code>SEND_IDLE</code> state when the IUT transitions in the <code>SEND_IDLE</code> OR <code>DATA</code> state.
Reference	ISO/IEC/IEEE 8802-3:2021, Figure 96-18 – PHY control state diagram

Table 17 (continued)

Item	Content
Prerequisite	The UT shall have the ability to configure the IUT as MASTER or SLAVE. The IUT shall have the ability to send and receive PHY frames. This can be accomplished through a loopback, responding to ICMP requests, or by forwarding traffic through two ports.
Set-up	The test system set-up shall be in accordance with Figure 5. The test system shall be parameterized in accordance with the SUT-specific set-up parameters (node's electronic data sheet). The UT shall connect the IUT to the ISO/IEC/IEEE 8802-3:2021 transmit test system and the ISO/IEC/IEEE 8802-3:2021 monitor test system. The IUT shall be powered on and shall be linked-up with the test system.
Step	1. The UT shall configure the IUT as MASTER. 2. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 3. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code> for at least <code>minwait_timer</code>, then transmit with <code>loc_rcvr_status = OK</code>. 4. The LT shall observe that the IUT begins transmitting with <code>tx_mode = SEND_N</code> and is capable of sending and receiving PHY frames. 5. The UT shall configure the IUT as SLAVE. 6. The LT shall monitor the transmissions from the IUT and restart the training process on the IUT, either through management or by sending invalid ternary codes after the IUT has established a link. 7. The LT shall send a valid idle training pattern to the IUT with the scrambler for <code>loc_rcvr_status = NOT_OK</code> for at least <code>minwait_timer</code>, then transmit with <code>loc_rcvr_status = OK</code>. 8. The LT shall observe that the IUT begins transmitting with <code>tx_mode = SEND_N</code> and is capable of sending and receiving PHY frames.
Iteration	Not applicable
Expected response	After step 4: The IUT as MASTER begins transmitting with <code>tx_mode = SEND_N</code> and is capable of transmitting and receiving PHY frames when configured as MASTER. After step 8: The IUT as SLAVE begins transmitting with <code>tx_mode = SEND_N</code> and is capable of transmitting and receiving PHY frames when configured as SLAVE.
Remark	If the IUT is not configurable as MASTER or as SLAVE, then only the supported configuration will be tested.

8.2.6 CTC_4.2.5 – PHY control state diagram – SEND IDLE OR DATA state (with MII access)

ISO/IEC/IEEE 8802-3:2021, Figure 96-18 PHY control state diagram states that the device remains in the SEND IDLE OR DATA state until it has `loc_rcvr_status = NOT_OK` and `TX_EN = FALSE`. The IUT transits to the SLAVE SILENT state if `loc_rcvr_status = NOT_OK` while `TX_EN = FALSE`. The IUT transits to the SEND IDLE state if `rem_rcvr_status = NOT_OK`.

[Table 18](#) specifies the CTC_4.2.5 – Case 1 – PHY control state diagram – IUT exits from the SEND IDLE OR DATA state (with MII access).