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

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

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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].

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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.

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ISO 21111-2 specifies the interface between reconciliation sublayer and physical entity including reduced gigabit media independent interface (RGMII), 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.

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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.

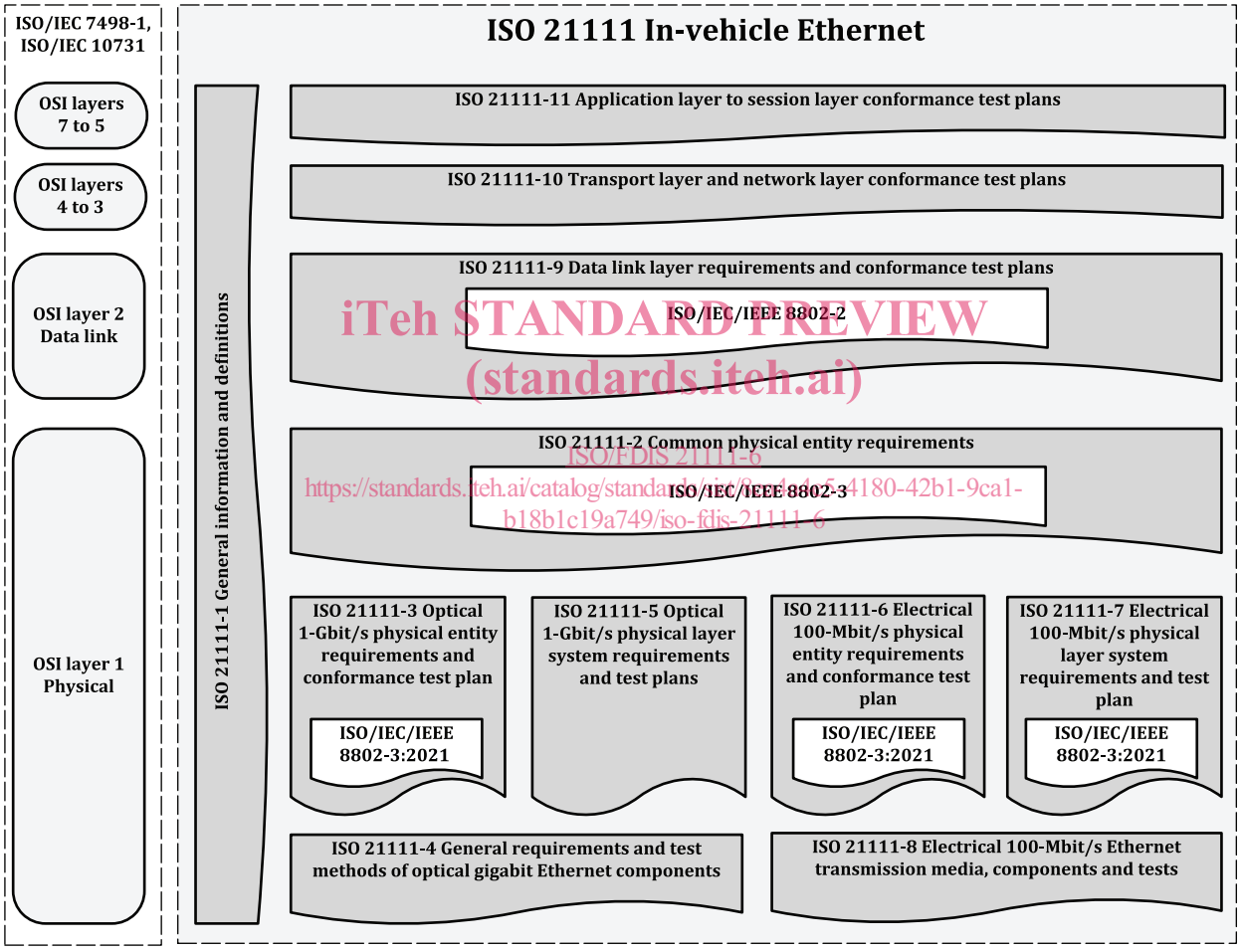

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Figure 1 — In-vehicle Ethernet document reference according to OSI model

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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.

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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 terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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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

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4.1 Symbols

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–	empty table cell or feature undefined
L_{CL}	longitudinal conversion loss ($\frac{Sdc11}{Sdc22}$)
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

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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

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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

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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 handshake protocol.	

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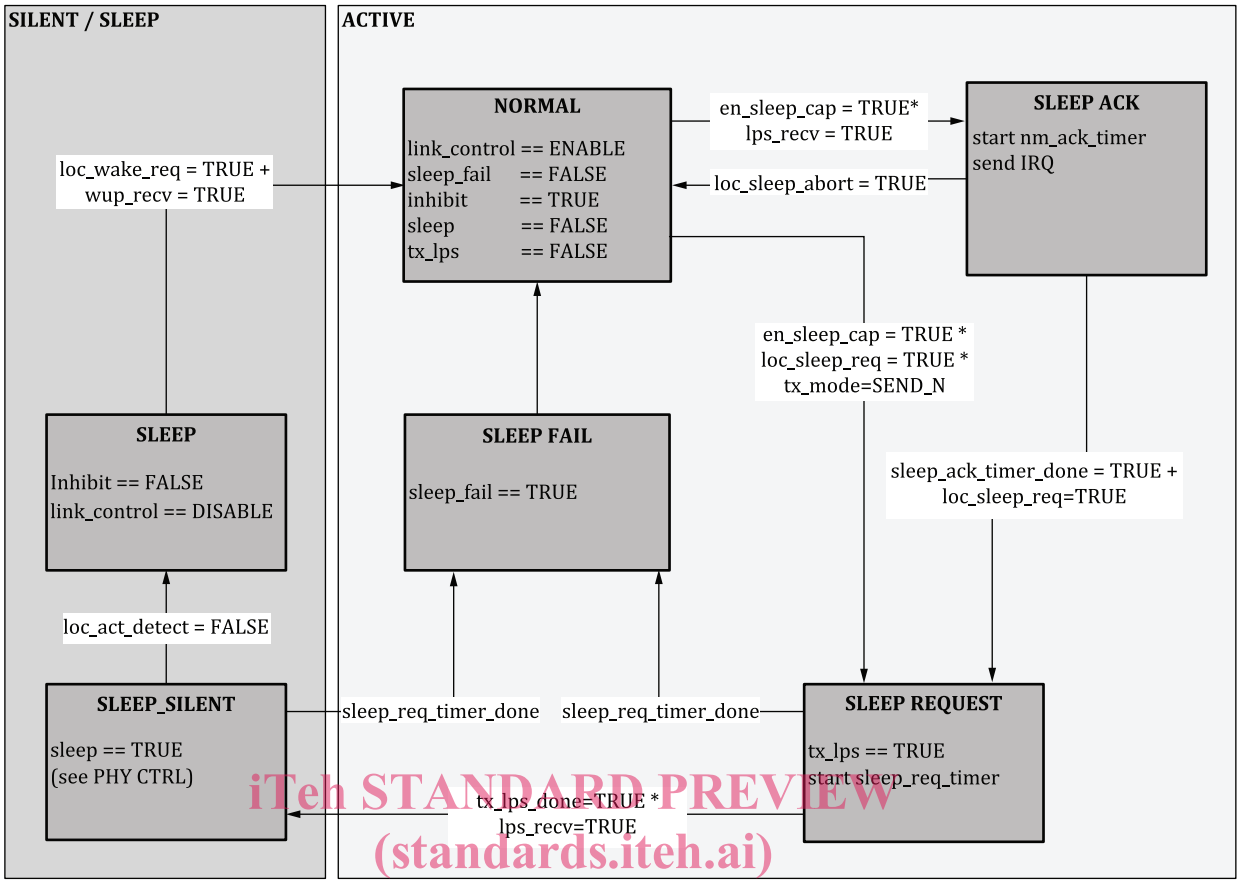

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Figure 2 — Power sequencing ISO/IEC/IEEE 8802-3:2021

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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 `Wakeup.request` (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.	

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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_recv`) or if a local wake-up request (`loc_wake_req`) or a WUR is received (`wur_recv`). 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_recv = 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.	

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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.

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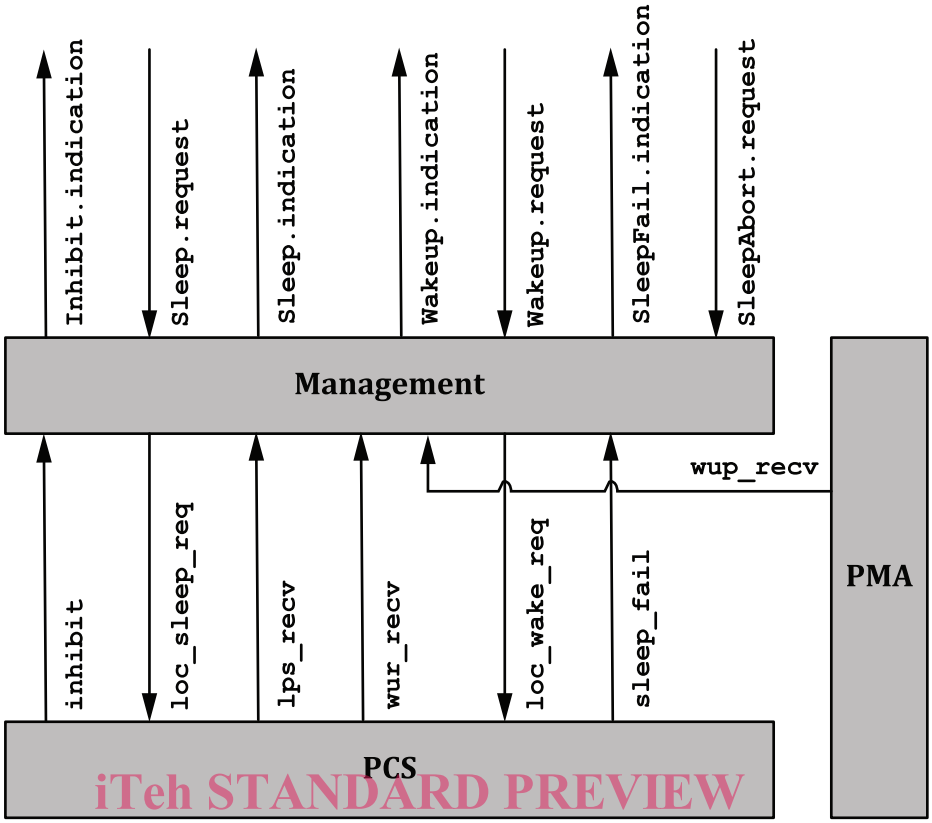

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Figure 3 — ISO/IEC/IEEE 8802-3:2021 service primitives

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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.	

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