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Road vehicles — Vehicle to grid communication interface —

Part 10: Physical layer and data link layer requirements for single-pair Ethernet

Véhicules routiers — Interface de communication entre véhicule et réseau électrique —

Partie 10: Exigences relatives à la couche physique et à la couche liaison de données pour Ethernet à paire unique

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, SC 31, *Data communication*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 301, *Road vehicles,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 15118 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 atwww.iso.org/members.html.

Introduction

The looming energy crisis and necessity to reduce greenhouse gas emissions has forced vehicle manufacturers to find ways to scale down how much energy their vehicles consume. The vehicles they are currently developing are propelled either entirely or in part by electric energy. If this energy is generated from renewable sources, this will weaken dependency on oil, improve the global energy efficiency and cut CO_2 emissions. However, a dedicated charging infrastructure is needed to charge the batteries that power these vehicles.

Much of the standardization work on dimensional and electrical specifications of the charging infrastructure and the vehicle interface is already treated in the relevant ISO or IEC groups. However, the question of information transfer between the electric vehicles (EV) and electric vehicle supply equipment (EVSE) has not been treated sufficiently.

This communication is key to optimizing energy resources and energy production systems so vehicles can be charged cheaply and efficiently.

In this document, messages are exchanged between the vehicle and the infrastructure over single-pair Ethernet (which is embedded in the cable assembly).

The relevant information on use-case definitions requirements can be found in ISO 15118-1. Network and application protocol requirements can be found in ISO 15118-20, respectively.

Road vehicles — Vehicle to grid communication interface —

Part 10: Physical layer and data link layer requirements for single-pair Ethernet

1 Scope

This document specifies the physical and data link layer of high-level communication (HLC) between electric vehicles (EV) and electric vehicle supply equipment (EVSE) based on single-pair Ethernet communication. Single-pair Ethernet communication uses differential twisted pair wires that are dedicated and balanced. This document applies to 10BASE-T1S only.

This document covers the overall information exchange between all actors involved in electrical energy exchange. The ISO 15118 series applies to charging between EV and EVSE.

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 15118-20:2022, *Road vehicles — Vehicle to grid communication interface — Part 20: 2nd generation network layer and application layer requirements*

IEC 61851-23-3[1)], *Electric vehicle conductive charging system — Part 23-3: DC electric vehicle supply equipment for Megawatt charging systems*

IEEE 802.3:2022, *IEEE Standard for Ethernet*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15118-20 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
basic signalling
analogue communication signal loop between the electric vehicle (EV) and the electric vehicle supply equipment (EVSE) to ensure reliable hardware-based information exchange during energy transfer

Note 1 to entry: The basic communication interface is defined in IEC 61851-23–3.

1) Under preparation. Stage at the time of publication: IEC/CCDV 61851-23-3:2025.

3.2
charge enable function
electronic function using an analogue signal loop between the electric vehicle (EV) and the electric vehicle supply equipment (EVSE) to ensure safety during energy transfer and to transmit information about the operational modes of EV and EVSE, in conformity with IEC 61851-23-3

3.3
communication media
physical media carrying the *low-layer communication* (3.7) signal is given by the cable assembly, which connects the charging infrastructure and the electric vehicle

3.4
data link control SAP
service access point which defines the interface between the connection coordination module and the *low-layer communication* (3.7) technology for managing the link status

3.5
data SAP
service access point that defines the interface between layer 2 and layer 3 for exchange of v2g-related payload

3.6
insertion detection function
electronic function using an analogue signal loop between the electric vehicle (EV) and the electric vehicle supply equipment (EVSE) to ensure the detection of an EV coupler inserted in the EV inlet (e.g. to lock the connector in the inlet and allow for the immobilization of the EV), in conformity with IEC 61851-23-3

3.7
low-layer communication
functions managed by the OSI layer 1 and layer 2 of the modem

3.8
low-layer communication module
functional assembly behind each socket outlet or each connector (depending on the type of electric vehicle connection), which includes the communication code and the connection coordination functionality

3.9
physical connection
physical establishment of connection between the electric vehicle (EV) and the electric vehicle supply equipment (EVSE)

Note 1 to entry: This includes mating between the EV and the EVSE and any *basic signalling* (3.1) that acknowledges that a physical connection has been established (e.g. toggling of a switch to indicate connection).

3.10
single-pair Ethernet
Ethernet technology that operates over a single twisted pair cable

4 Abbreviated terms

BIN	bus interface network
EMC	electromagnetic compatibility
EV	electric vehicle
EVCC	electric vehicle communication controller
EVSE	electric vehicle supply equipment
D-LINK	data link

HLC	high-level communication
HLE	high level entity
MCS	megawatt charging system
OSI	open systems interconnection
SAP	service access point
SECC	supply equipment communication controller
TC	transmission convergence
UTP	unshielded twisted pair
VAS	value added service

5 Conventions

5.1 Definition of OSI based services

This document is based on the OSI service conventions as defined in ISO/IEC 10731.

5.2 Requirement structure

Each individual requirement included in this document has a unique code, as follows:

"**[V2G10-XXX]** requirement text"

where

— "V2G10" represents this document;

— "XXX" represents the individual requirement number;

— "requirement text" includes the actual text of the requirement.

See Table 1 for an example of the requirement structure.

Table 1 — Example

[V2G10–001]	Description of the requirement

6 System architecture

6.1 Communication layers

6.1.1 Architecture

This document defines requirements applicable to layers 1 and 2, including V2G standardized service primitive interface, according to the OSI layered architecture. Layers 3 to 7 are specified in ISO 15118-20. For a diagram, see ISO 15118-20:2022, Figure 2.

In addition to HLC to the upper layers, additional communication (basic signalling) allows for reliable hardware control.

NOTE This document only applies to DC power transfer, not AC.

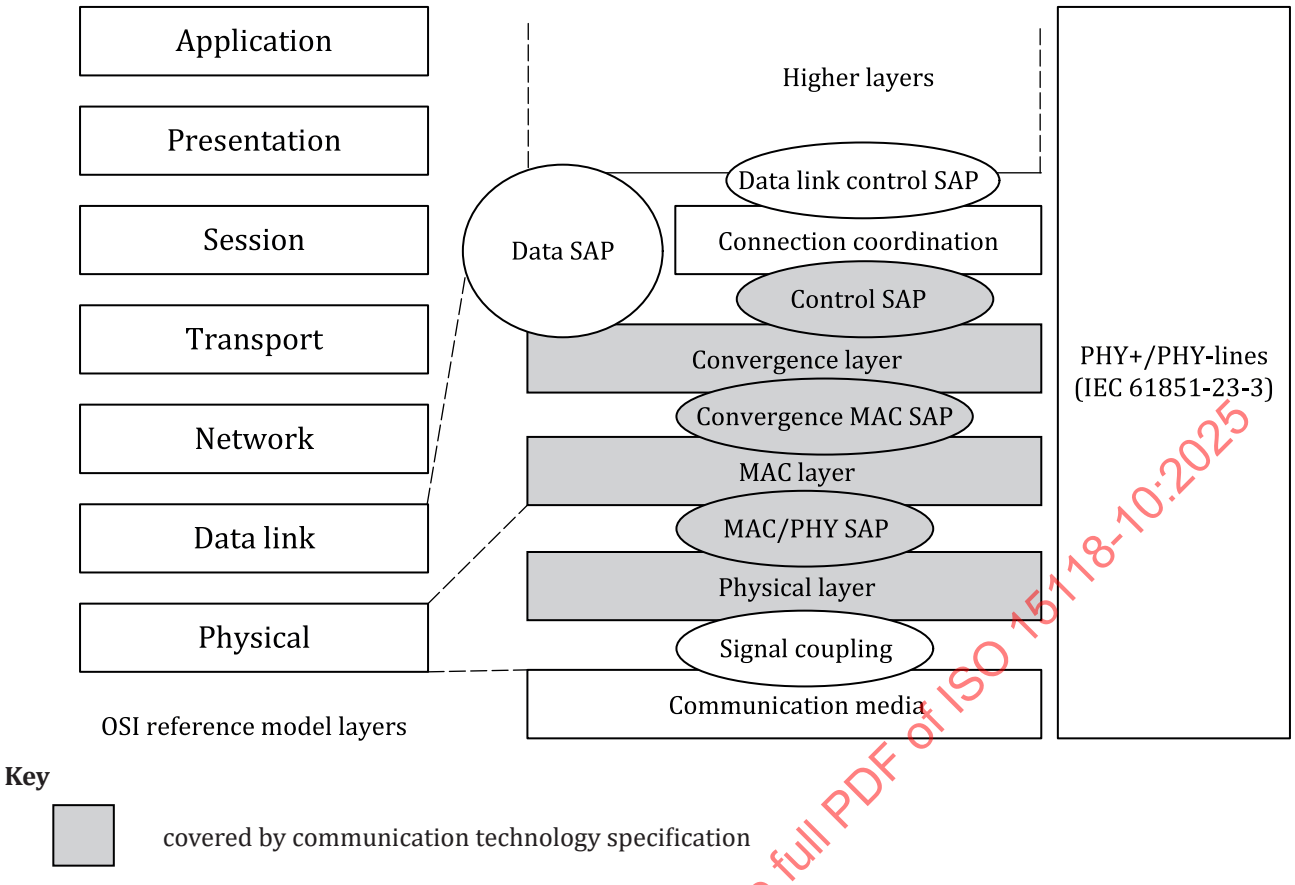

Figure 1 — Relationship to the ISO/IEC OSI reference model

6.1.2 Layer 2 interfaces

This clause describes the terminology primitives used in this document. It explains and defines a unique terminology. This terminology is implementation specific.

As shown in Figure 1, the definition of the data link layer provides two interfaces to higher layers:

— data SAP is the interface between the communication technology (layer 2) and the network layer (layer 3);

— data link control SAP provides link status information, error information and control functionality and is located between layers 2 and 3.

6.1.3 Communication media

Communication media block, as shown in Figure 1, are the PHY+ and PHY- lines (according to IEC TS 63379).

6.1.4 Data SAP

6.1.4.1 General

The network layer/logical link control sublayer data service primitives are defined in ISO/IEC 8802-2.

6.1.4.2 Syntax of service primitives

Service primitives are described using the following syntax:

— [Initial of layer]-[NAME].[primitive type](parameter list);

  — whereas [initial of layer] is one of seven possible primitive types:

    — physical, data link, network, transport, session, presentation, application;

  — whereas [NAME] is the name of the primitive;

EXAMPLE Typical examples for [Name] are CONNECT, DISCONNECT and DATA. Other names are used in this document and in ISO 15118-3.

— whereas [primitive type] is one of four possible primitive types:

  — request, indication, response, confirmation;

— whereas (parameter list) includes a list of parameters, separated by a comma, that the user of the service is supposed to provide when using the respective service primitive. Optional parameters are marked with brackets "[..]".

NOTE In this document, the primitive type ".indication" indicates an event asynchronously to the upper layer.

6.1.4.3 Data link control SAP to layer 3

These primitives are defined in ISO 15118-20. See Tables 2 to 5.

[V2G10-001]	The D-LINK_READY.indication shall be sent with any change in the link status and the charge enable status.

Table 2 — D-LINK_READY.indication primitive

Primitive	D-LINK_READY.indication
Entity to support	EVCC, SECC
Parameter name	Description
LINKSTATUS	Status of communication link: — no link (either no connection or Charge Enable not ready) — link established (Ethernet is operational and state B or B_AUX)
Note	D-LINK_Ready.indication needs to be translated to D_LINK.indication: — OK (link established) — FAIL (no link) D-LINK_Ready.indication only applies to the higher layers of ISO 15118-20. It is allowed for the Ethernet to connect and transmit data prior to or after charging.

The D-LINK_TERMINATE.request requests lower layers to terminate the data link.

Table 3 — D-LINK_TERMINATE.request primitive

Primitive	D-LINK_TERMINATE.request
Entity to support	EVCC, SECC
Note	This function does not do anything other than fulfil the HLC requirements.

The D-LINK_ERROR.request requests information about the error status of the communication link.

Table 4 — D-LINK_ERROR.request primitive

Primitive	D-LINK_ERROR.request
Entity to support	SECC
Note	The higher layer will use this to determine if there is an error in the communication link.

The D-LINK_PAUSE.request requests lower layers to enter a power saving mode.

Table 5 — D-LINK_PAUSE.request primitive

Primitive	D-LINK_PAUSE.request
Entity to support	EVCC, SECC
Note	This function does not do anything other than fulfil the HLC requirements.

6.1.4.4 Communication and signalling

6.1.4.4.1 General

This document describes the general requirements to the two communication channels necessary to establish a charging session: basic signalling, and the HLC.

6.1.4.4.2 Basic signalling

Any charging process, regardless of the presence of HLC, uses the basic communication as defined in IEC 61851-23-3, indicating EV and EVSE-related information on the control of the flow of the energy transfer.

[V2G10-002]	The basic signalling from IEC 61851-23-3 shall be applied.
[V2G10-003]	All timings shall conform to IEC 61851-23-3.

6.1.4.4.3 High-level communication (HLC)

The sequence of the data exchange within the HLC-based charging session shall be done in accordance with the ISO 15118-20 high level communication protocol.

6.1.5 Service primitive concept of OSI layered architecture

See ISO 15118-20 for details on the OSI layered architecture.

6.2 Physical channel

6.2.1 General

This clause specifies the requirements for connecting single-pair ethernet signals to the PHY1 and PHY2 lines using the contact definition from IEC TS 63379.

The physical channel starts at the SECC (node-id 0), moves through the cable to the connector, to the inlet, and then to the EVCC (node-id 1). It is also possible there will be an adaptor between the connector and the inlet, but this is for future development.

There is a maximum of eight nodes for this network. Not all nodes will be present, but this allows for future-proofing.

[V2G10-004]	All nodes shall set aPLCANodeCount to 8.

6.2.2 Nodes

The characteristics of the physical channel are shown in Table 6.

Table 6 — Characteristics of the physical channel

Node ID	Name	Configuration	Mandatory
0	SECC	End node, Coordinator	Yes
1	EVCC	End node	Yes
2	Connector	Drop node	No (optional)
3	Inlet	Drop node	No (optional)
4	Adaptor	Drop node	No (optional)
5	Optional	Drop node	(No)
6	Optional	Drop node	(No)
7	Optional	Drop node	(No)

6.2.3 Requirements for the physical channel

6.2.3.1 General

The physical requirements of the channel are defined in IEC 61851-23-3.

6.2.3.2 EVSE

[V2G10-005]	Each EVSE outlet shall have its own dedicated charge enable function controller.
[V2G10-006]	Each optional node shall not disturb the mandatory nodes in the physical channel.
[V2G10-007]	Each EVSE outlet shall have its own dedicated low-layer communication module.
[V2G10-008]	Each EVSE shall possess its dedicated SECC containing the low-layer communication module.
[V2G10-009]	The EVSE's low-layer communication module shall have a Node-ID of 0.
[V2G10-010]	The EVSE shall have a Node-ID of 2 for the connector.

6.2.3.3 EV

[V2G10-011]	Each EV shall possess its dedicated EVCC containing the low-layer communication module.
[V2G10-012]	Each EVCC shall have its own dedicated charge enable function controller.
[V2G10-013]	Each EVCC shall have its own dedicated low-layer communication module to the SECC.
[V2G10-014]	The EVCC's low-layer communication module shall have a Node-ID of 1.
[V2G10-015]	The EVCC shall have a Node-ID of 3 for the inlet.

6.2.3.4 Adaptor

[V2G10-016]	The adaptor (between EVSE and EV) shall have a Node-ID of 4.

6.2.4 Schematic of the coupling network

The physical channel can be represented as shown in Figure 2. The node on the left is the SECC node (node-id 0) and the node on the right is the EVCC node (node-id 1). The nodes that hang down (i.e. drop nodes) are optional.

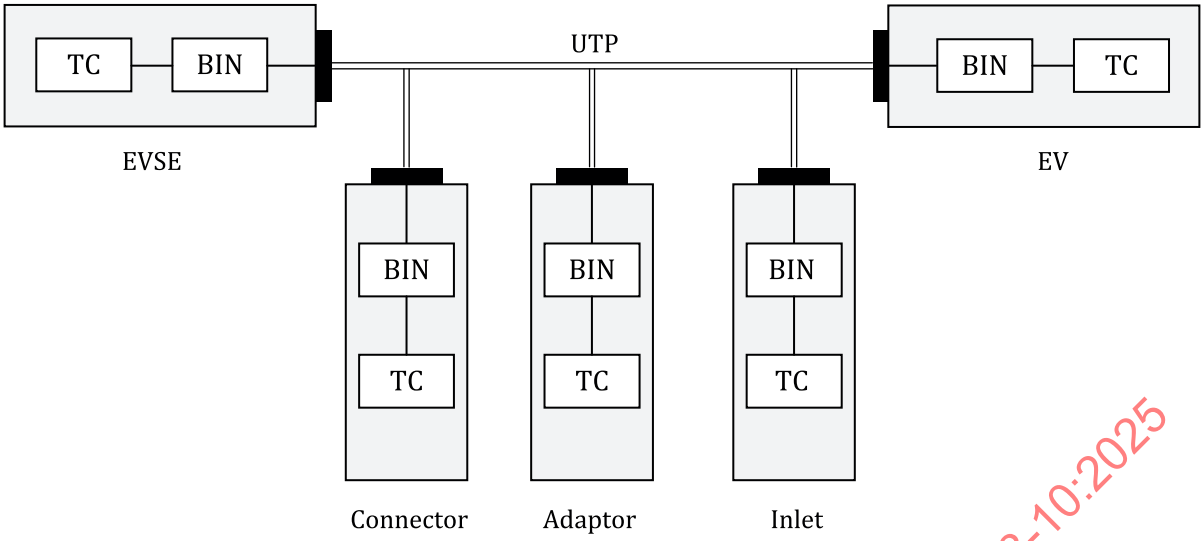

Figure 2 — Single-pair ethernet

6.3 System requirements

6.3.1 Overview of basic signalling

This clause defines general system requirements for basic signalling and HLC for EVs and EVSE. See Table 7.

State transitions are defined in IEC 61851-23-3.

The states defined in IEC 61851-23-3 are used in the following clauses:

Table 7 — Overview of basic signalling states from IEC 61851-23–3 for MCS

Basic signalling state description	State name	Comment
Not mated	A	
Mated/EV and EVSE not ready	B0	If there is no auxiliary power via insertion detection function requested by EV
Mated/EV and EVSE not ready/EV AUX requested	B0_AUX	If there is auxiliary power via insertion detection function requested by EV
Mated/EVSE ready/EV not ready	B	Data link setup occurs and D-LINK_READY.indication primitive is set to ready
Mated/EV not ready / EVSE ready/EV AUX requested	B_AUX	Data link setup occurs and D-LINK_READY.indication primitive is set to ready
Mated/EV and EVSE ready	C	Ready for power transfer (HV and aux. power) This ensures safety-relevant preconditions on both sides, e.g. connector locking or immobilization.
Mated/EV and EVSE ready/EV AUX requested	C_AUX	

Table 7 *(continued)*

Basic signalling state description	State name	Comment
Mated/no LV power	E	No signal (0 V) Shall not be used for signalling purposes.
Mated/emergency shutdown EVSE	Transition from state C to state EC, or state C_AUX to state EC_AUX	Transition from state C or C_AUX to EC or EC_AUX triggered by the EVSE
Mated/emergency shutdown EV	Transition from state C to state B, or state C_AUX to state B_AUX	Transition from state C to B or C_AUX to B_AUX triggered by the EV

6.3.2 Electric vehicle supply equipment (EVSE)

6.3.2.1 Low-layer communication requirements

This clause describes the requirements for the low-layer communication module for the EVSE.

[V2G10-017]	The EVSE shall enable the communication module using D-LINK.request(ENABLE).
[V2G10-018]	The EVSE shall disable the communication module using D-LINK.request(DISABLE).
[V2G10-019]	The EVSE's low-layer communication module shall not use auto negotiation.
[V2G10-020]	The EVSE shall initiate the data link after detection of plug-in.
[V2G10-021]	The EVSE's low-layer communication module shall use half-duplex.
[V2G10-022]	After the data link layer connection is established, the SECC shall initiate the IP address assignment mechanism defined in ISO 15118-20. NOTE This is to allow use of the communication link for VAS and other communications.
[V2G10-023]	Upon detection of state B or B_AUX, and successful data link setup, the EVSE shall send (D-LINK_READY.indication(DLINKSTATUS = Link established)) to the HLE.

6.3.3 Electric vehicle (EV)

6.3.3.1 Low-layer communication requirements

[V2G10-024]	The EVCC shall enable the communication module using D-LINK.request(ENABLE).
[V2G10-025]	The EVCC shall disable the communication module using D-LINK.request(DISABLE).
[V2G10-026]	The EVCC's low-layer communication module shall not support auto negotiation.
[V2G10-027]	The EVCC's low-layer communication module shall use half-duplex.
[V2G10-028]	The EVCC shall initiate the data link after detection of plug-in.
[V2G10-029]	After the data link layer connection is established, the EVCC shall initiate the IP address assignment mechanism defined in ISO 15118-20. NOTE This is to allow use of the communication link for VAS and other communications.
[V2G10-030]	Upon detection of state B or B_AUX, and successful data link setup, the EV shall send (D-LINK_READY.indication(DLINKSTATUS = Link established)) to the HLE.
[V2G10-031]	If the EVCC sends a pause request to the SECC, it shall pause the Data Link (D-LINK_PAUSE.request()) and follow the sleep and wake-up requirements defined in 7.6. NOTE If the EVCC's node goes to sleep, it has no impact on the SECC's node.
[V2G10-032]	If the EVCC wants to stop communication, it shall terminate the Data Link (D-LINK_TERMINATE.request()). NOTE If the EVCC's node is turned off, it has no impact on the SECC's node.

7 Connection coordination

7.1 General

This clause describes the process of establishing a physical connection between the EV and the EVSE. This physical connection combines the mating of the plug and inlet as well as the necessary signalling to begin energy transfer.

7.2 Overview

This clause provides information about the connection setup for EVs and EVSE – for exact details, refer to IEC 61851-23-3.

NOTE 1 A “plug-in” corresponds to a state transition from A to B0 or B0_AUX. A “re-init” corresponds to a state transition from B0 to B or B_AUX of the charge enable function.

NOTE 2 On the transition to state B or B_Aux, the EV will initiate the low-level communication setup with the EVSE.

Once the single-pair ethernet communication is established (see IEC 61851-23-3), the HLC takes place.

7.3 Plug-in phase

7.3.1 General

Upon plug-in, the communication between the single-pair ethernet nodes will be set up. Ideally, the network layer would also be set up (see ISO 15118-20) to allow for VAS and other communication. HLC will not start until detection of state B or B_AUX.

7.3.2 EVSE side

[V2G10-033]	After detection of state B or B_AUX, the SECC shall finish communication setup in less than T_conn_resume.
[V2G10-034]	The SECC shall only apply charge enable function state B if the low-layer communication module is ready for communication.

NOTE There is no requirement for how long the SECC is allowed to stay in state B0 before moving to state B.

7.3.3 EV side

[V2G10-035]	After detection of state B or B_AUX, the EVCC shall finish communication setup in less than T_conn_resume.

7.4 Initialization phase

After the physical link has been established (V2G data link setup finished), the initialization phase is governed by ISO 15118-20.

7.5 Loss of communication

7.5.1 General

This subclause covers when the communication link is lost.

[V2G10-036]	If a data link was established and a D-LINK_READY.indication(link established) was already indicated to higher layers, any detected loss of the data link shall cause a D-LINK_READY.indication(no link) indication to higher layers.

7.5.2 EVSE side

[V2G10-037]	When D-LINK_ERROR.request is detected, the SECC shall attempt to reconnect a maximum of C_conn_retry times.
[V2G10-038]	If the retries in V2G10-037 fail, the EVSE shall move to state B0.

7.5.3 EV side

If the EV detects a loss of communication, it will stop charging. If the loss of communication happens during state C, the EV will switch to state B immediately. Since the EVSE can relaunch the HLC by moving to state B after moving to state EC, the EV can retry communication initialization after indication from the EVSE.

[V2G10-039]	After receiving a D-LINK_ERROR.request from HLE, the EV's communication node shall change to the B state within TP_sync_leave and wait for a new incoming communication trigger (charge enable function state B).

7.6 Sleep mode and wake-up

7.6.1 General

Sleep mode is used for energy saving. The EVCC and SECC can enter sleep mode after negotiating a pause through the HLC.

For the EVSE, sleep mode means that charge enable is in state B0 or B0_Aux, and the low-layer communication module may switch to low power mode.

For the EV, sleep mode means state B and the low-layer communication module may switch off. The wake-up mechanisms may also be used after the charge session was already terminated to allow the counterpart station to re-establish HLC.

Definitions of sleep indications are given in IEC 61851-23-3.

7.6.2 Entering sleep mode

[V2G10-040]	After receiving a D-LINK_PAUSE.request, the EV shall change to state B and may switch the low-layer communication module to low-power mode or power-off mode.
[V2G10-041]	After receiving a D-LINK_PAUSE.request, the EVSE shall switch to state B0 and may switch the low-layer communication module to low-power mode.

7.6.3 Wake-up

7.6.3.1 General

[V2G10-042]	As soon as the lower layers detect a data link after a wake-up and detection of state B or B_AUX, the lower layer shall send a D-LINK_READY.indication (link established) to a higher layer entity.
[V2G10-043]	In case of a wake up trigger (as defined in IEC 61851-23-3) from the counterpart, the communication setup shall be finished in maximum T_conn_resume after the trigger.