

ICS 43.120; 29.160.40

**Elektromobilität –
Digitale Kommunikation zwischen einer Gleichstrom-Ladestation und
einem Elektrofahrzeug zur Regelung der Gleichstromladung im
Verbund-Ladesystem**

Electromobility –

Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System

Électromobilité –

Communication digitale entre la borne de recharge à courant continu et la véhicule électrique pour régler la charge à courant continu dans le système de charge combiné (CCS)

Zur Erstellung einer DIN SPEC können verschiedene Verfahrensweisen herangezogen werden:
Das vorliegende Dokument wurde nach den Verfahrensregeln einer Vornorm erstellt.

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Nationales Vorwort

Dieses Dokument wurde vom Arbeitskreis NA 052-01-03-17 AK „Kommunikationsschnittstelle vom Fahrzeug zum Stromnetz (V2G CI)“ des Normenausschusses Automobiltechnik erarbeitet.

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Introduction

The time consumption for electrical vehicles (EVs) charging process is determined by the maximum power which can be transferred to the EV. The alternating current (AC) charging has a fixed limited voltage (e.g. 400 V in Europe) and therefore an increasing of power supply can only be achieved by higher currents. This approach is limited by the cable weight, because a higher current requires a greater cross section of the copper cable. As the user must be able to connect the EV with the EVSE the charging cable should not be heavier than a typical fuel tube of a filling station today. A further disadvantage of the AC charging approach is that the rectifier must be placed in the EV. This results in an increase of the overall EV weight and complexity of it as depending on a size of the rectifier, a special liquid cooling system may be required for it. The weight of a rectifier however increases with the power it can handle. These disadvantages can be prevented by using a DC charging approach. In this case the rectifier is placed in the EVSE and the used voltage is limited by the maximum battery voltage (typically 400 - 800 V), which is normally higher than the AC voltage.

The drawback of the DC charging solution is that the communication real time requirements on the EV-EVSE interface increases as the rectifier and the battery management system must be able to communicate via this interface. The prevention of an incorrect charging state requires a real time communication, which is tailored to the charging process. The real time requirements depend on the battery system and are subjects of further investigations.

The main aspects of this specification are

- Support of Combo-Charging based on IEC 61851-23 (Type 2 connector for AC and DC);
- Aligned charging process with SAE 2847-2 and IEC 61851-24;
- Ease of integration of SEP2.0 or similar XML based approach for V2G Communications.

1 Scope

This document specifies the DC specific communication between battery electric vehicles (BEV) or plug-in hybrid electric vehicles (PHEV) and the Electric Vehicle Supply Equipment (EVSE, also known as charge spot) as shown in Figure 1. In the following, the BEV and PHEV are also named Electrical Vehicle (EV). Information exchange to other actors is out of scope of this document. For communication to other actors the definitions in ISO/IEC DIS 15118-1, ISO/IEC DIS 15118-2, and ISO/IEC CD 15118-3 apply.

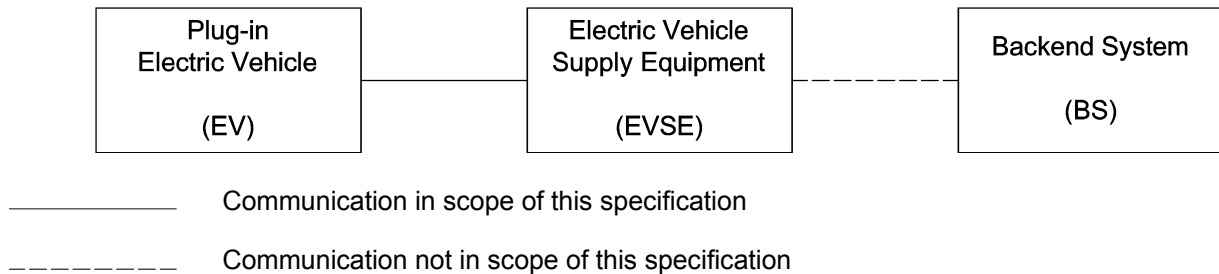


Figure 1 — Communication relationship between EV, EVSE, and BS

2 Normative References

The following referenced documents are indispensable for the application 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 DIS 15118-1, *Road vehicles — Vehicle to grid communication interface — Part 1: General information and use-case definition*

ISO/IEC DIS 15118-2, *Road vehicles — Vehicle to grid communication interface — Part 2: Network and application protocol requirements*

ISO/IEC CD 15118-3, *Road vehicles — Vehicle to grid communication interface — Part 3: Physical and data link layer requirements*

IEC 61851-1, *FDIS: Electric vehicle conductive charging system — Part 1: General requirements (Edition 2.0)*

IEC 61851-23, *Electric vehicle conductive charging system — Part 23: d.c. electric vehicle charging station (Edition 1.0)*

IEC 61851-24, *Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging*

IEC 62196-2, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories (Edition 1.0)*

IEC 62196-3, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 3: Dimensional compatibility interchangeability requirements for d.c. pin and contact-tube vehicle couplers*

HomePlug Green PHY, *HomePlug Green PHY Specification Release (Version 1.1)*

NOTE Since HomePlug Green PHY specification v1.1 is not published while writing this specification, HomePlug Green PHY Specification v1.0 (14-June, 2010) and the HomePlug Green PHY Draft Association Text r9 (January 03, 2012) can be used for fast prototyping.

IETF RFC 768, *User Datagram Protocol (August 1980)*

IETF RFC 793, *Transmission Control Protocol - DARPA Internet Program - Protocol Specification (September 1981)*

IETF RFC 1323, *TCP Extensions for High Performance (May 1992)*

IETF RFC 1624, *Computation of the Internet Checksum via Incremental Update (May 1994)*

IETF RFC 1981, *Path MTU Discovery for IP version 6 (August 1996)*

IETF RFC 2018, *TCP Selective Acknowledgment Options (October 1996)*

IETF RFC 2460, *Internet Protocol, Version 6 (IPv6) Specification (December 1998)*

IETF RFC 2988, *Computing TCP's Retransmission Timer (November 2000)*

IETF RFC 3122, *Extensions to IPv6 Neighbor Discovery for Inverse Discovery Specification (June 2001)*

IETF RFC 3484, *Default Address Selection for Internet Protocol version 6 (IPv6) (February 2003)*

IETF RFC 3782, *The NewReno Modification to TCP's Fast Recovery Algorithm (April 2004)*

IETF RFC 4286, *Multicast Router Discovery (December 2005)*

IETF RFC 4291, *IP Version 6 Addressing Architecture (February 2006)*

IETF RFC 4294, *IPv6 Node Requirements (April 2006)*

IETF RFC 4429, *Optimistic Duplicate Address Detection (DAD) for IPv6*

IETF RFC 4443, *Internet Control Message Protocol (ICMP v6) for the Internet Protocol version 6 (IPv6) specification (March 2006)*

IETF RFC 4861, *Neighbour Discovery for IP version 6 (IPv6)*

IETF RFC 4862, *IPv6 Stateless Address Autoconfiguration (September 2007)*

IETF RFC 4884, *Extended ICMP to Support Multi-Part Messages (April 2007)*

IETF RFC 5095, *Deprecation of Type 0 Routing Headers in IPv6 (December 2007)*

IETF RFC 5220, *Problem Statement for Default Address Selection in Multi-Prefix Environments: Operational Issues of RFC 3484 Default Rules (July 2008)*

IETF RFC 5482, *TCP User Timeout Option (March 2009)*

IETF RFC 5681, *TCP Congestion Control (September 2009)*

IETF RFC 5722, *Handling of Overlapping IPv6 Fragments (December 2009)*

IETF RFC 5871, *IANA Allocation Guidelines for the IPv6 Routing Header (May 2010)*

IETF RFC 6298, *Computing TCP's Retransmission Timer* (June 2011)

IETF RFC 6335, *Internet Assigned Numbers Authority (IANA) Procedures for the Management of the Service Name and Transfer Protocol Port Number Registry* (August 2011)

DIN 91286, *Electric mobility –Schemes of identifiers for E-Roaming – Contract ID and Electric Vehicle Supply Equipment ID*

SAE J1772, *SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler*

SAE J2847/2, *Communication between Plug-in Vehicles and Off-Board DC Chargers*

W3C EXI 1.0, *Efficient XML Interchange (EXI) Format 1.0, W3C Recommendation* (March 2011)

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply in addition the terms and definitions given in ISO/IEC DIS 15118-1.

NOTE In the context of this document, the term EVSE refers to the charging equipment, external to the EV.

3.1

Association Control

Entity, that provides the whole functionality for EV to EVSE association and initialization, via the Data Link Control SAP. This entity also controls the relationships between the basic signalling and the upper layers. The entity indicates link status and error information to higher layers. The control of PLC network management parameters is handled over the Control SAP

3.2

Charging session

Time between the beginning (connection of the cable) and the end (disconnection of the cable) of a charging process

NOTE During a charging session the EV may have none, one, or many periods of charging the battery, doing pre-conditioning or post-conditioning

3.3

Coexistence

ability of different PLC systems to share the same physical media, and to function simultaneously, with an acceptable level of performance for a certain application

3.4

Communication Media

the physical media carrying the PLC signal is given by the cable assembly, which connects the charging infrastructure and the EV

3.5

Communication Setup Timer

Timer that monitors the time starting with the physical cable connection to the EV (plugging-in) until the Session Setup message is broadcasted

3.6

Connection cycle

all activities and interaction between the EV and the EVSE from plugging in the charging cable assembly to unplugging the charging cable assembly

3.7

Control Service Access Point (SAP)

Port or logical connection point to a network layer protocol

3.8

CP_EVSE_Function

summary of functionalities according to IEC 61851-1 within the EVSE, e.g. generation control pilot duty cycle; control interface; to turn on/off charging power; safety control functions

3.9

CPLT

Control Pilot Line Transmission according to IEC 61851-1 and SAE J1772

3.10

Crosstalk

Capacitive or inductive coupling between two individual electric circuits, each providing a media for a PLC network, in a way that the two networks are influenced by each other

3.11

Data Link Control Service Access Point (SAP)

Port or logical connection point between data link and network layer

3.12

Frame

Message on data link layer level

NOTE A Frame can include a IP-packet in its payload (framing the higher level packet and adding additional information required on data link layer as e.g. synchronization information)

3.13

Global address

IP address with unlimited scope

3.14

Initialization

process of interaction between the EV, the EVSE and an external trigger, beginning from plug-in of the charging cable assembly until the decision for the charging mode to be applied

3.15

I/O Service Access Point (SAP)

I/O control path interfaces hardware I/O control (e.g. control pilot duty cycle) and the control pilot wire. This entity provides an I/O SAP which is defined in Annex A

3.16

(IP-) Address

IP-layer identifier for an interface or a set of interfaces

3.17

Layer 2 association

process to uniquely identify the PLC node of an EVSE to the PLC node of the EV that the EVSE is physically connected to in an unambiguous way. In this document, the term "association" always refers to "Layer 2 association"

3.18

Link-layer address

Link-layer identifier for an interface (e.g. Ethernet address)

3.19**Link-local address**

IP address with link-only scope that can be used to reach neighbouring nodes attached to the same link

3.20**Logical Network**

Network defined solely on OSI-layer 2. This is a set of PLC stations, which possess the same network key. Only members of the same logical network are able to exchange encrypted payload data and are visible for each other on higher layers. Different logical networks may exist on the same physical media at the same time and are typically used for network segmentation

3.21**MAC address**

unique identifier assigned to network interfaces for communication on the data link layer

3.22**Maximum Transfer Unit (MTU)**

maximum size of the data link layer that can be utilized by the network layer.

3.23**Message set**

set of mandatory V2G messages and parameters for the EVCC or SECC covering one or multiple use case elements

3.24**Message timer**

Timer that monitors the exchange of a pair of request/response messages

3.25**Network segment**

collection of devices that can exchange data on data link layer level directly via data link addresses

EXAMPLE Ethernet: All devices which can see each other via MAC addresses).

3.26**Network segment size**

Number of devices that are handled in one network segment

3.27**Nominal duty cycle**

5 % or 10 – 96 % duty cycle, according to IEC 61851-1

3.28**Node**

Device that is part of a communication network

EXAMPLE A device implementing IPv6 in an IP network.

3.29**Performance time**

non-functional timing requirement defining the time a V2G entity shall not exceed when executing or processing certain functionality

3.30**PHY**

connects a link layer device to a physical medium. Layer 1 in Open Systems Interconnection model (OSI model)

3.31

Pilot Function Controller

System that manages the control Pilot line on the EVSE side, according to IEC 61851-1

3.32

PLC Bridge

System that allows an EVSE to communicate on an external network of the EVSE, by converting ISO/IEC CD 15118-3 PHY to any other PHY. This bridge acts on OSI-layer 2.

3.33

PLC module

functional assembly behind each socket outlet (case B) or each connector (case C) which includes the PLC modem, and the layer 2 association functionality

3.34

PLC node

functional assembly behind each socket outlet (case B) or each connector (case C) which includes the PLC modem, and the layer 2 association functionality

3.35

Profile

Group of mandatory and optional message sets covering a set of similar charging scenarios for a specific identification means

3.36

Ready to Charge Timer

Timer that monitors the time from plug-in until the first power delivery message

3.37

Ready to Charge Time

Device or piece of software used in an implementation for measuring time. Depending on the specific use case a timer is used to trigger certain system events as well

3.38

Request-Response Message Pair

request message transmitted between sender and receiver and its corresponding response message that is invoked by the request message in the receiver

3.39

Request-Response Message Sequence

sequence of multiple Request-Response Message Pairs

3.40

SDP Client

V2G entity that uses the SDP server to retrieve configuration information about the SECC being able to access the SECC

3.41

SDP Server

V2G entity providing configuration information for accessing the SECC

3.42

Sequence Timer

Timer that monitors a Response-Request Message Sequence

3.43**Shared bandwidth**

different PLC technologies or different networks of the same technology on a shared media influenced by crosstalk. This may lead to a reduction of the data rate of each individual PLC system

3.44**Signal Coupling**

Circuit that describes the method of coupling the PLC signal on the communication media and is described in the relevant clauses

3.45**TCP_DATA**

Socket/interface for data transfer based on TCP connection

3.46**Timeout**

specific time a V2G entity monitors the communication system for a certain event to occur. If the specified time is exceeded, the respective V2G entity initiates the related error handling

3.47**Timer**

Device or piece of software used in an implementation for measuring time. Depending on the specific use case a timer is used to trigger certain system events as well

3.48 V2G Communication Session

Association of two specific V2G entities for exchanging V2G messages

3.49**V2G Entity**

primary or secondary actor participating in the V2G communication

3.50**V2G Message**

message exchanged on application layer

3.51**V2GTP Entity**

V2G entity supporting the V2G transfer protocol

3.52**Valid duty cycle**

Duty cycle that is 5 % or in a range of 10 – 96 % according to IEC 61851-1. For DC charging only a duty cycle of 5 % is used

3.53**Virtual network segment**

Network segment that is not defined by the physical communication range of the physical and data link layer but by additional mechanisms

NOTE A Virtual network segment shows the same behaviour with respect to the networks segment size for higher layers. Because multiple virtual network segments may coexist in (e.g. in a shared media) the available communication capacity may be different to a network segment that is defined by the physical communication range. The available physical capacity is shared between all virtual network segments.

4 Symbols and abbreviated terms

For the purposes of this document, the following abbreviations apply:

AFE	Analog Front End
BEV	Battery Electric Vehicle
CAP	Channel Access Priority
CCo	Central Coordinator
CP	Control Pilot
CPLT	Control Pilot Line Transmission
DLINK	Data Link
EIM	External Identification Mean
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVSE	Electric Vehicle Supply Equipment
EXI	Efficient XML Interchange
$f_{\text{NMK}}(x)$	Function to derive the Network Management Key from a given string x, according to the "Intellon, Overview of HomePlug Privacy" document
HLE	Higher Layers Entities
HPGP	HomePlug Green PHY
IP	Internet Protocol
ISP	Intersystem Protocol
LC	Link Control (control and status of the PLC link)
MAC	Media Access Control
MME	Management Message Entry
NACK	Negative Acknowledgement
NEK	Network Encryption Key
NMK	Network Management Key
NWP	Network Password
OEM	Original Equipment Manufacturer
PE	Protective Earth

PDU	Protocol Data Unit
PHEV	Plug-in Hybrid Vehicle
PLC	Power Line Communication
PnC	Plug and Charge
PSD	Power Spectrum Density
PWM	Pulse Wide Modulation
RESS	Rechargeable Electric Storage System
RF	Radio Frequency
RFC	Request for comments
SAML	Security Assertions Markup Language
SAP	Service Access Point
SDP	SECC Discovery Protocol
SDU	Service Data Unit
SE	Supply Equipment
SECC	Supply Equipment Communication Controller
SLAC	Signal Level Attenuation Characterization
SLAAC	Stateless address auto configuration
SNR	Signal to noise ratio
TCP	Transmission Control Protocol
TSO	Transmission System Operator
V2G	Vehicle to Grid Communication (ISO/IEC 15118)
V2G CI	Vehicle-to-Grid Communication Interface
V2GTP	V2G Transfer Protocol
V2GTPPT_EXI	V2G Transfer Protocol Payload Type for EXI messages
UDP	User Datagram Protocol
XML	Extensible Markup Language

5 Relation to other standards

The interface between EV and EVSE is defined in ISO/IEC 15118 series. The definition process of these standards is not finalized yet. Nevertheless, the implementation of the EV-EVSE interface described in this document follows the definitions in ISO/IEC 15118 as close as possible.

The assumptions on DC electric vehicle charging station in this document are based on the definitions in IEC 61851-23. The basic signalling is based on the definitions in IEC 61851-1.

6 Conventions

The conventions in this document apply to the conventions in ISO/IEC 15118 and IEC 61851.

6.1 Definition of OSI based services

This document is based on the conventions discussed in the OSI Service Conventions (refer to ISO 10731) as they apply for the individual layers specified in this document.

This document describes requirements applicable to layer 1 - 7 according to the OSI layered architecture.

6.2 Requirement structure

6.2.1 Requirement format

This document uses a requirement structure i.e. a unique number identifies each individual requirement included in this clause. This requirement structure allows for easier requirement tracking and test case specification. The following formats are used:

"[V2G-DC-xyz]" requirement text where:

- "V2G-DC" represents the DIN SPEC 70121 standard;
- "xyz" represents the individual requirement number and;
- "requirement text" represents the actual text of the requirement.

EXAMPLE **[V2G-DC-001]** This shall be an example

NOTE Requirements in DIN SPEC 70121 and ISO/IEC 15118 are aligned but the numbering is different for editing reasons.

6.2.2 Applicability

This clause specifies the requirements to be implemented by the EV and the EVSE in order to allow communication between both entities. Usually the requirements of this standard are implemented by one vehicle entity and additionally at least by one EVSE entity depending on the EVSE network architecture.

The requirements of this specification will refer to as "The EV shall implement..." implying that the vehicle communication entity shall implement the required functionality if not explicitly stated otherwise.

The requirements of this specification will refer to as "The EVSE shall implement..." implying that at least one EVSE entity shall implement the required functionality if not explicitly stated otherwise.

The requirements of this specification will refer to as "The V2G entities shall implement..." implying that all V2G entities involved in the V2G communication shall implement the required functionality if not explicitly stated otherwise.

[V2G-DC-001] The EV shall implement all mandatory requirements of EV defined in this document.

[V2G-DC-002] The EVSE shall implement all mandatory requirements of EVSE defined in this document.

6.2.3 Usage of RFC references

When RFCs are referenced all “must/ must not” requirements are mandatory.

[V2G-DC-003] If a referenced RFC has been updated by one or several RFC, the update is fully applicable for this standard.

[V2G-DC-004] If an update or part of an update applicable to an RFC referenced herein is not compatible with the original RFC or the implementation described by this standard the update shall not apply.

6.3 Notation used for XML schema diagrams

This standard makes use of XML as a description format for V2G messages. For details with regards to the XML schema diagram notation used in this document refer to Altova XMLSpy Manual.

Allowing for an easy way to distinguish the types used for the XML schema definitions in this document, the following naming conventions apply:

- complex type use capitalized first letters;
- simple types use non capitalized first letters.

7 DC Charging System Architecture

7.1 DC Charging Use Case

The DC charging described in this document is based on the use case definitions and general information as described in ISO/IEC DIS 15118-1 (see also Table 1. Depending on the integration of the DC charging system into an infrastructure, all use cases may apply.

Table 1 — Use Cases as defined in ISO/IEC DIS 15118-1

No.	Use case element name / grouping
A1	<i>Begin of charging process with forced high-level communication</i>
A2	Begin of charging process with concurrent IEC 61851-1 and high-level communication
B1	<i>EVCC/SECC communication setup</i>
C1	Certificate update
C2	Certificate installation
D1	Authentication from EV with local Authorization
D2	Authentication from EV with Authorization from secondary actors
D3	<i>Identification at EVSE</i>
D4	<i>Identification at the EVSE with validation from secondary actor</i>
E1	AC charging with load levelling based on high-level communication
E2	Optimized charging with scheduling to secondary actor
E3	Optimized charging with scheduling at EV
E4	<i>DC charging with load levelling based on high-level communication</i>
E5	Resume to Authorised Charge Schedule
F0	Charging loop
F1	Charging loop with metering information exchange
F2	Charging loop with interrupt from the SECC
F3	Charging loop with interrupt from the EVCC or user
F4	Reactive power compensation
F5	Vehicle to grid support
G1	Value added services
G2	Charging details
H1	<i>End of charging process</i>

This standard focuses on the DC-charging use case for fast charging. Therefore, the use cases according to ISO/IEC DIS 15118-1 for the charging profile “DC Charging EIM” are applicable accordingly. This covers the use cases A1, B1, D3 (optional), D4 (optional), E4 and H1.

Table 2 — Use case A1 as defined in ISO/IEC DIS 15118-1, clause 7.2.1 in DIS version

No.	Type	Description
1	Use case element name	Begin of charging process with forced high-level communication (ISO/IEC 15118 in compliance with IEC 61851-1)
2	Use case element ID	A1
3	Objectives	Establishing of high-level communication
4	Description	This use case covers the initial PWM signalling (IEC 61851-1) from the EVSE, with a 5 % duty cycle in order to enable high-level communication and mode 3 or mode 4 charging. NOTE Charge spot owner may offer a fall back solution if high-level communication fails by enabling charging according IEC 61851-1 with authorisation by any other means. The involved primary actors are EV, EVSE, EVCC, SECC Basic sequence description: ▪ Connect the cable between the EV and EVSE ▪ EVSE indicates the PWM duty-cycle ▪ EV interprets the PWM duty-cycle ▪ EVCC and SECC establish the physical and data link layers connection (The detailed sequence is defined in ISO/IEC CD 15118-3). Communication setup (B) is able to start
5	Prerequisites	▪ The EV shall be connected physically to the EVSE. ▪ The EV and EVSE require pilot function and basic signalling in accordance with IEC 61851-1 ▪ The EV and EVSE shall have a higher level communication device in accordance with ISO/IEC DIS 15118-2 and ISO/IEC CD 15118-3
6	Requirements	▪ Successful set up of high-level communication at the data link layer ▪ Timing for the initialization process shall be according to ISO/IEC CD 15118-3 ▪ Triggers: ○ for EVSE: EV is connected properly to the EVSE ○ for EV: Plug present and PWM duty cycle indicating high level communication required according IEC 61851-1
7	End conditions	<u>Success end conditions:</u> ▪ Successful set up of high-level communication at the data link layer <u>Failure end conditions:</u> ▪ No establishment of high-level communication at the data link layer or failure of PWM signal

Table 3 — Use case B1 as defined in ISO/IEC DIS 15118-1, clause 7.3.1 in DIS version

No.	Type	Description
1	Use case element name	EVCC/SECC communication setup
2	Use case element ID	B1
3	Objectives	The goal of this use case element is the establishment of a communication link between EVCC and SECC and correct association.
4	Description	The primary actors are the SECC and the EVCC. There is no information exchange between the EVCC and the SECC at application layer.
5	Prerequisites	Plug in process according use case elements A1 or A2 shall be established successfully
6	Requirements	- The SECC and EVCC shall be capable of being associated one-to-one. - The EVCC shall be bound to the SECC by the protocol described in ISO/IEC DIS 15118-2. The timing of this binding shall be in line with the requirements given by ISO/IEC DIS 15118-2 and -3. - EVCC and SECC shall exchange information about the supported ISO/IEC DIS 15118-2 protocol versions and use the latest common protocol version. NOTE The protocol version of either SECC or EVCC may not be the latest version. In such case, "common" latest protocol version will be used for communication between EVCC and SECC.
7	End conditions	<u>Success end conditions:</u> - SECC and the EVCC are associated and bound correctly, i.e. EVCC is able to send the first request to SECC on application layer according to the negotiated ISO/IEC DIS 15118-2 protocol version. <u>Failure end conditions:</u> - No correct association of SECC and EVCC or timeout in the binding process occurs. - Negotiation of the ISO/IEC DIS 15118-2 protocol version failed.

Table 4 — Use case D3 as defined in ISO/IEC DIS 15118-1, clause 7.5.5 in DIS version

No.	Type	Description
1	Use case element name	Identification at the EVSE
2	Use case element ID	D3
3	Objectives	Identification at the EVSE
4	Description	User identifies himself at the EVSE by using one of the offered identification methods. NOTE Depending on the type of identification the EVSE operator may not have the possibility to authenticate the ID and therefore might not authorize the service. The SECC may decide to forward the IDs (Provider ID and Contract ID) associating its own IDs (Spot Operator ID and Power Outlet ID) to the secondary actors. Service should start after successful verification of the IDs The actors involved are: ▪ Primary actors: USER, EVSE, HMI, SECC ▪ Secondary actors: FCH, E-Mobility Operator
5	Prerequisites	▪ Communication setup according use case element B1 shall be established successfully
6	Requirements	▪ USER shall activate the identification within a specific time after connecting the EV to the EVSE or the EVSE shall have an HMI or any other method to authorise the restart of the identification process ▪ USER shall use for example a HMI to type in the identification code or any other offered identification method at the EVSE. ▪ USER shall plug in and shall activate the identification method ▪ SECC shall evaluate the identification and, if accepted, proceed the communication flow ▪ Trigger: ○ EV and EVSE are required to be in state B according to IEC 61851-1 ○ Identification shall be made at the EVSE and activated by the USER
7	End conditions	<u>Success end conditions:</u> Identification process is successful, a session ID is defined and the required service (charging or value added) starts <u>Failure end conditions:</u> ▪ Identification process fails ▪ The required service does not start ▪ User might be informed about the reason of failure (i.e. identification means has expired, contract has been blocked – stolen car, stolen contract, procedure to be restarted, identification means out of order)

Table 5 — Use case D4 as defined in ISO/IEC DIS 15118-1, clause 7.5.6 in DIS version

No.	Type	Description
1	Use case element name	Identification at the EVSE with validation from secondary actor
2	Use case element ID	D4
3	Objectives	Identification with validation from secondary actor
4	Description	This use case covers the process of how identification should be validated by a secondary actor. User identifies himself at the EVSE by using one of the offered identification methods. NOTE Depending on the type of identification the EVSE operator may not have the possibility to authenticate the ID and therefore might not authorize the service. Basic sequence: - SECC forwards the IDs (Spot Operator ID, Power Outlet ID, provider ID and Contract ID) to the secondary actor for validation. - The secondary actor replies with an agreement or non-agreement - Service Starts after successful verification of the IDs Involved actors - Primary actors: USER, EVSE, SECC, HMI - Secondary actors: FCH, E-Mobility Operator
5	Prerequisites	- Communication setup according use case element B1 shall be established successfully - Online connection between SECC and secondary actors is required
6	Requirements	- USER shall activate the identification within a specific time after connecting the EV to the EVSE or the EVSE shall have an HMI to authorise the restart of the identification process - USER shall use identification method at EVSE (e.g. HMI) - EVCC shall send the ID to secondary actor for validation - Trigger: - EV and EVSE are required to be in state B according to IEC 61851-1 - Identification shall be made at the EVSE and activated by the USER
7	End conditions	<u>Success end conditions:</u> Identification process is successful, a session ID is defined and the required service (charging or value added) starts <u>Failure end conditions:</u> - Identification process fails - The identification performed by the USER at the EVSE is not validated from the secondary actor - The required service does not start - User might be informed about the reason of failure (i.e. contract has expired, contract has been blocked, stolen car or contract, procedure to be restarted, identification server not available)

Table 6 — Use case E4 as defined in ISO/IEC DIS 15118-1, clause 7.6.4 in DIS version

No.	Type	Description
1	Use case element name	DC charging with load levelling based on high-level communication
2	Use case element ID	E4
3	Objectives	Charging without consideration of complex grid situations and secondary actors Dynamically adjustment of the max. DC power to be drawn by the EV within the limits of the local installation.
4	Description	The EVSE and EV will exchange information about the DC power limits using high-level communication. The EVSE will communicate to the EV the max. DC power that can be drawn from the outlet in order to protect the supply equipment. The EV and the EVSE exchange control information for the battery management system. The involved primary actors are: EV, EVCC, SECC, EVSE
5	Prerequisites	▪ If authorization according use case elements D is applied, it shall be established successfully.” ▪ Mode 4 charging (according to IEC 61851-1) shall be selected
6	Requirements	▪ EV shall ask for the max. DC power, voltage and current limits from the EVSE ▪ EVSE shall reply with the limits ▪ EV shall provide information about demanded voltage and current ▪ loop charging will begin
7	End conditions	<u>Success end conditions:</u> ▪ The EVSE shall deliver DC power within the max. local limits of installation ▪ EV shall be charge within the given local limits of EVSE ▪ EVSE shall deliver power until the user disconnect <u>Failure end conditions:</u> ▪ The EVSE will not deliver DC power, due to contactor failure ▪ Negotiation between EV and EVSE failed ▪ No power delivery from EVSE to EV

Table 7 — Use case H1 as defined in ISO/IEC DIS 15118-1, clause 7.9.1 in DIS version

No.	Type	Description
1	Use case name	End of charging process
2	Use case element ID	H1
3	Objectives	Closing down the charging process in a safe and secure way with exchanging all relevant information needed for later procedures.
4	Description	This use case covers the basic ending charging process Basic elementary use case description: ▪ User returns to the EV / EVSE and initiate ending the charge process a. If the user is indicating this on EV side the EVCC will tell the SECC that the charging process will end. b. If the user is indicating this on EVSE side, e.g. using authentication by alternative means the SECC will tell the EVCC that the charging process will end. ▪ EV switches to state B according to IEC 61851-1. ▪ EVSE opens main switches according to IEC 61851-1. a. If there is a meter present, the EVCC requests the last meter readout before the charge process ends. b. EVSE replies with a meter readout. c. EVCC signs the meter readout and ask the SECC to release the connector. ▪ The SDR is generated on the EVSE side. This may be transferred to the EVCC or to authorized secondary actors. ▪ If applicable, the EVSE release the connector on the EVSE or wait for that until state A according to IEC 61851-1 is recognised. Between the EVCC and SECC the information end charging process is exchanged. Between SECC and EVCC the meter reading and connector unlocked information are exchanged. NOTE The exact sequence and nature of each step depends on the preceding use cases.
5	Prerequisites	▪ Charge controlling and re-scheduling according use case elements F2 or F3 shall be established successfully or ▪ End of charging according conditions defined in ISO/IEC DIS 15118-2
6	Requirements	Trigger ▪ Charging loop shall be completed ▪ User / EVSE / EV initiates end of charge process
7	End conditions	<u>Success end conditions:</u> ▪ The billing procedure is terminated normally <u>Failure end conditions:</u> ▪ The procedure is not terminated normally and information is lost ▪ The EVSE will not deliver power, due to contactor failure

7.2 System Schematics of DC charging system

This document assumes a DC charging system as specified in IEC 61851-23, Annex C. For further details, please refer to IEC 61851-23.

7.3 Pilot Function

This specification assumes the charging mode 4 as defined in IEC 61851-1. Mode 4 is used for DC charging.

The pilot function is based on a PWM conforming to IEC 61851-1, Annex A. For further details, please refer to IEC 61851-1.

7.4 Communication Stack

The communication stack for DC charging is subset of the definition in ISO/IE 5118-2 and ISO/IEC CD 15118-3. Following Figure 2 shows the stack for DC charging covered in this specification.

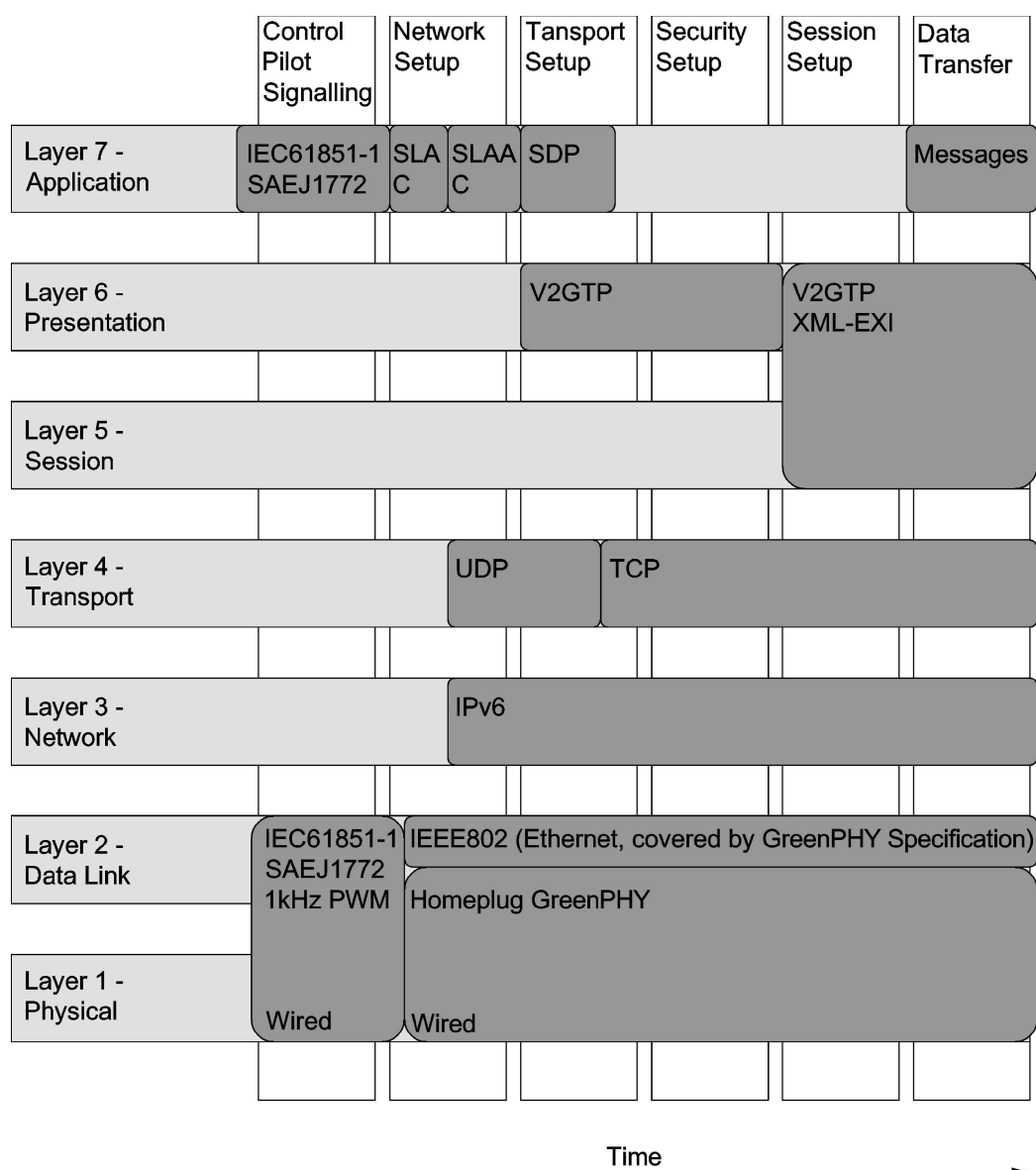


Figure 2 — Protocol stack for DC charging control without security

8 EV-EVSE Communication

8.1 Basic requirements for V2G Communication

8.1.1 General information and definitions

After establishing a physical connection an IP based session has to be established. Within this session messages are transferred between EV and EVSE. Communication is needed for controlling a battery charging session and the interaction between EV and EVSE.

The requirements established by this specification describe the implementation of the V2G use cases defined in clause 7.1.

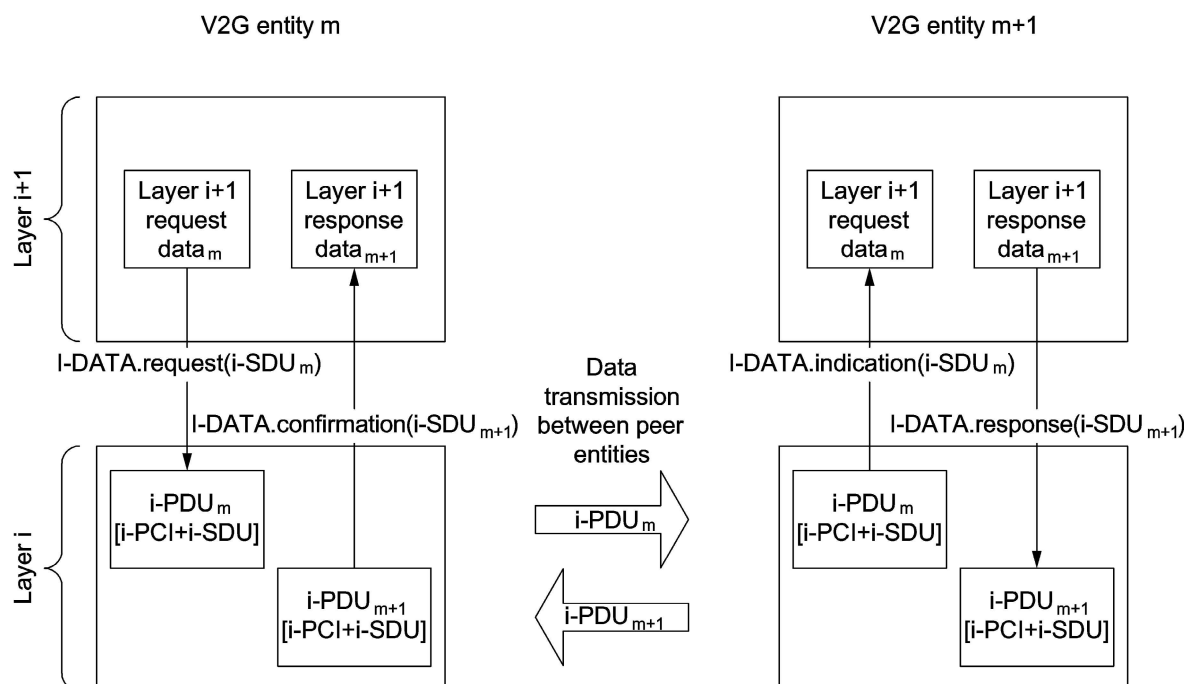
8.2 Service primitive concept of OSI layered architecture

8.2.1 Overview

This subclause explains how the OSI layered architecture is applied for the purpose of this document. It is intended to provide simple means for describing the interfaces between the individual communication protocol layers required by this document and furthermore allows for defining timing requirements more precisely.

Services are specified by describing the service primitives and parameters that characterize a service. This is an abstract definition of services and does not force a particular implementation.

Figure 3 depicts a simplified view of OSI layer interaction sufficient to understand the OSI layered architecture principles for the context of this document.



Key

PDU_m: Protocol Data Unit of network entity m

PCI: Protocol Control Information

SDU_m: Service Data Unit of network entity m

Figure 3 — OSI layered architecture principles

When a layer $i+1$ instance of V2G entity m exchanges data with a layer $i+1$ instance of V2G entity $m+1$ each instance uses services of an instance of layer i . A service is defined as a set of service primitives.

8.2.2 Syntax of service primitives

Service primitives are described with the following syntax:

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

whereas [initial of layer] is one out of the following seven:

[Physical, Data Link, Network, Transport, Session, Presentation, Application]

whereas [NAME] is the name of the primitive

EXAMPLE Typical examples for [Name] are CONNECT, DISCONNECT, DATA; other names are used in this document.

whereas [primitive type] is one out of the following four:

[request, indication, response, confirmation]

whereas (parameter list) includes a list of parameters separated by comma 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" always indicates an event asynchronously to the upper layer.

8.3 Physical and Data Link Layer

8.3.1 System Architecture

8.3.1.1 Definition of High Level Communication and Basic Signalling

8.3.1.1.1 Basic Signalling

[V2G-DC-005] The basic signalling follows IEC 61851-1. All the timings shall be compliant with the IEC 61851-1 Annex A.

Such a charging process uses the bidirectional signalling according to IEC 61851-1, indicating EV related information via control pilot states and EVSE related information via the duty cycle of the control pilot signal.

[V2G-DC-006] For DC charging Mode 4 with 5 % Control Pilot duty cycle according to IEC 61851-1 shall be used.

[V2G-DC-007] For DC charging Vehicle State C or D and 5 % Control Pilot duty cycle shall be used during energy transfer.

8.3.1.1.2 High Level Communication (HLC)

High level communication in DC charging is used for exchange of charging parameters e.g. voltage and current.

[V2G-DC-008] The HLC shall be used in addition to the basic signalling in order to enable a bidirectional communication for charging control.

[V2G-DC-485] This data link is performed via the Power Line Communication technology HomePlug Green PHY according to the Specification HomePlug Green PHY.

8.3.1.2 Identification requirements

Identification is out of scope of this document. Refer to ISO/IEC15118-3.

8.3.1.3 System requirements

8.3.1.3.1 Overview

This chapter describes startup of EV and EVSE after the plug-in of the charging cable.

This chapter also defines how the EVSE and the EV shall be designed for properly triggering the process of association and initialization.

8.3.1.3.2 EVSE Architecture

8.3.1.3.2.1 Control Pilot Requirements

[V2G-DC-471] Each EVSE outlet shall have its own dedicated pilot function controller.

The MAC association is done between the PLC module locally assigned to each socket-outlet, on the EVSE side, and the PLC module on the EV side.

A DC charging system requires one dedicated PLC node on EVSE and EV side.

NOTE 1 The present document only describes point to point relationship between the PLC modules on EV and EVSE sides.

NOTE 2 Only "IEC 61851-1 Mode 4" EVSEs, that include an HLC module, are in the scope of DIN SPEC 70121.

8.3.1.3.3 EV Architecture

8.3.1.3.3.1 PLC requirements

[V2G-DC-505] The EV shall launch the Association process when the PWM is in a state Bx according to IEC 61851-1.

NOTE Bx are states B1 or B2 in new revision of IEC 61851-1 (under work).

[V2G-DC-506] The Association process shall not stop when started, independently of the PWM duty cycle indicated, and any changes.

8.3.1.4 Configuration of a PLC module

This section is a summary of some key points of the HomePlug Green PHY technology according to the Specification HomePlug Green PHY which this standard requires.

The Physical Layer of the HomePlug Green PHY technology is fully described in the Specification HomePlug Green PHY.

8.3.1.4.1 ROBO Modes and Data Rate

HomePlug Green PHY Technology uses three robust modes of communication for:

- Beacon, data broadcast, and multicast communication
- Session setup

- Exchange of Management Messages
- Data messages

All ROBO Modes use QPSK modulation. This mechanism introduces redundancy by a factor that depends on the type of ROBO Mode.

Table 8 — ROBO Modes and PHY Data Rate

ROBO Mode	Number of Copies	PHY Rate (Default Tone Mask)
MINI-ROBO_AV	5	3.7716 Mbps
STD-ROBO_AV	4	4.9226 Mbps
HS-ROBO_AV	2	9.8452 Mbps

8.3.1.4.2 Shared bandwidth mechanisms

Coexistence mechanisms with other HomePlug technologies are addressed in the specifications HomePlug Green PHY and IEEE1901.

8.3.1.4.2.1 ISP

HomePlug Green PHY implements the ISP as a coexistence mechanism. The ISP, defined by IEEE P1901, allows coexistence between devices that implement non-interoperable protocols. Using ISP, 1901 access, 1901 wavelet, 1901 FFT, LRWBS and ITU-T G.hn devices are able to coexist.

[V2G-DC-021] The PLC module on the EVSE side shall be capable to detect the zero cross of the AC line cycle to support coexistence functionality. Zero cross detection is optional for the PLC node on the EV side.

8.3.1.4.2.2 Coexistence with HomePlug AV technologies

In addition to the coexistence mechanisms with other HomePlug technologies, there is a specificity regarding the HomePlug AV technology.

In some cases, in case of coexistence with a fully loaded HomePlug AV, the HomePlug Green PHY may be limited to 7 % in time. This might affect the data rate.

8.3.2 Connection Coordination

8.3.2.1 Overview

This chapter describes the behaviour of the system, at different phases of a charging session, between a plug-in and a plug-out .

8.3.2.2 Plug-in phase

This phase covers the plug-in up to the beginning of the charge.

[V2G-DC-507] After successful “Proximity” pin detection, the PLC module shall be ready for communication in less then T_conn_max_comm.

[V2G-DC-508] If the Association process requires a Validation step with toggling the S2, this has to be done and finished prior to the D-LINK_Ready.indication.

8.3.2.3 Loss of communication

This chapter covers the situation where the PLC channel is lost while the charging session was happening (C2 state), i.e. between a plug-in and a plug-out.

- [V2G-DC-509]** When the loss of communication is detected, the EVSE shall turn-off the oscillator (C1 state), no matter the duty cycle is.
- [V2G-DC-510]** The oscillator shall be turned on T_conn_osci_on after entering the B1 state, to reach the B2 state.
- [V2G-DC-511]** If the EVSE receives the signal for the association (launched by the EV), it shall turn on the oscillator.
- [V2G-DC-512]** The EVSE shall create a transition B1 -> B2, after any sequence at state E or F.
- NOTE The transition B1 -> B2 will force the EV to relaunch the Association process if needed.
- [V2G-DC-513]** At any time, when detecting a transition B1-> B2, the EV shall relaunch the association procedure.
- [V2G-DC-514]** The EV shall relaunch the Association process maximum C_conn_max_assoc times in series within a plug-in and a plug-out phasis. After C_conn_max_assoc unsuccessful trials, the EV shall stay in the Basic Signaling mode. A successful attempt shall reset the retry_counter.

8.3.2.4 Plug-out phase (with hint)

This phase supposes that the customer gave a hint to the system that he wants to leave.

- [V2G-DC-515]** The customer shall inform the system that he wants to plug-out. The system shall trigger the procedure to stop the communication.
- [V2G-DC-516]** At least, the PLC modules on EV and EVSE sides shall leave the logical network.
- [V2G-DC-517]** The EVSE shall reset its PLC module to unassociated state.
- [V2G-DC-518]** EV and EVSE shall go to unassociated state within T_assoc_leave after reveiving the D-LINK_TERMINATE.request

8.3.3 Timings and Parameters

This section summarizes all Physical and Date Link Layer timings used in DIN SPEC 70121.

- [V2G-DC-519]** All PLC devices shall comply with Table 9.

Table 9 — Timings and Paramters

Parameter	Description	Min	Typical	Max	Unit
T_conn_max_comm	Maximum time of PLC module availability after Proximity pin detection			2	s
T_assoc_leave	Maximum time to leave the logical network			1	s
T_conn_osci_on	Minimum time to turn on the oscillator after entering B1 state	5			s
T_conn_init_HLC	Minimum B state duration after a state F, D or C	200			ms
T_assoc_max_ssm	Duration of the Signal Strength Measurement	500	1 000	1 500	ms
C_assoc_retry	Number of retries of the Signal Strength Measurement			3	nbr
T_vald_toggle	Duration of the BCB Toggle sequence	600		2 800	ms
T_vald_detect_time	Time to detect a variation of the state on EVSE side			200	ms
T_vald_state_duration	Duration of each state B or C within the BCB Toggle	200		400	ms
T_assoc_session_max	Maximum time between CM_ATTN_CHAR.RSP and either CM_VALIDATE.REQ or CM_SLAC_MATCH.REQ			3	s
T_assoc_response	Time between a SLAC request and SLAC response message			100	ms
T_assoc_alive	Time without any SLAC message transfer			2	s
T_assoc_join	Time to join the logical network			5	s

8.3.4 Association EV – EVSE procedure

8.3.4.1 Overview

Crosstalk of PLC signal could lead to wrong correlation between EVCC and SECC. A unique association between the EV and a specific charge coupler of the supply equipment is necessary. After this association process in Layer 1 and 2, upper layers are able to proceed with their binding process. Depending on the PLC signal paths, the association process depends on the infrastructure topology.

After plug-in the EVCC and SECC are in the "unassociated state".

In the following chapter, the term "Association" refers to "Layer 2 association".

NOTE This standard covers a point-to-point association.

Despite association is mandatory at layer 2, it is also mandatory for higher layers.

Figure 4 gives an overview about communication startup

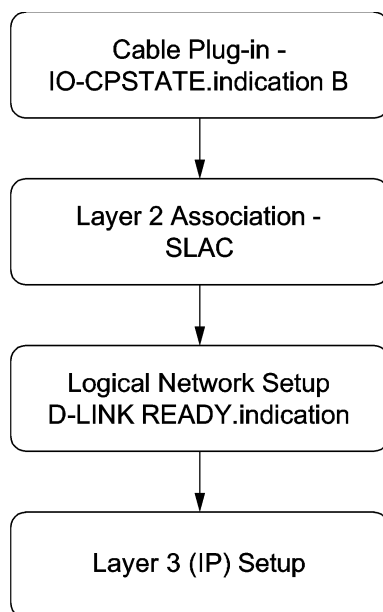


Figure 4 — Communication start-up

8.3.4.2 Initialization of Association process

The first phase of the association procedure is called configuration of the PLC nodes. During this phase, the node shall be configured in order to enhance the association process.

- [V2G-DC-014]** Each PLC node shall provide a method to negotiate a set of frequencies to be used for communication to comply with regulatory restrictions.
- [V2G-DC-018]** The PLC node on the EV side shall be configured in order to never become the CCo with the APCM_SET_CCo.REQ primitive as defined in the Specification HomePlug Green PHY.
- [V2G-DC-019]** The PLC node on the EVSE side shall be configured in order to always be the CCo with the APCM_SET_CCo.REQ primitive as defined in the Specification HomePlug Green PHY.
- [V2G-DC-020]** Any SLAC related message transmitted shall be sent with CAP3 priority to speed up the association process.
- [V2G-DC-024]** The PLC node, on the EVSE side shall activate/deactivate its response on incoming SLAC requests according to the following conditions: A SLAC request shall only be responded to if all of the following conditions are fulfilled:
 - The EVSE is connected to an EV, detected by the Control Pilot circuit.
 - The EVSE is in "unassociated state".
- [V2G-DC-025]** The PLC node on the EV side shall never answer to a SLAC request.
- [V2G-DC-023]** The PLC node on EV and EVSE side must be able to notch additional carriers by means of firmware update.

8.3.4.3 Discovery of the connected PLC module

During the discovery process, the EV determines which EVSE is directly connected to its charge cord.

The method used to discover the EVSE is based on a measurement of the signal strength. The EV will discover all the PLC modules in range. On the basis of a signal strength measurement for each PLC module, the EV decides which module it is directly connected to.

[V2G-DC-029] The PLC node shall be compliant with the unsecured SLAC protocol defined in the Specification HomePlug Green PHY

[V2G-DC-030] Measurement of signal strength shall be done with Specification HomePlug Green PHY Signal Level Attenuation Characterisation (SLAC).

[V2G-DC-031] Only the EV shall send SLAC requests

[V2G-DC-032] Only the EVSE shall answer to SLAC requests

[V2G-DC-033] SLAC method shall be done in a certain time. See Table 9 for details.

[V2G-DC-034] The SLAC method shall be concluded by:

- EVSE found;
- EVSE potentially found;
- No EVSE found.

NOTE EVSE Potentially Found is optional and maybe deleted in the final document.

[V2G-DC-035] According to the use cases, each PLC node shall consider the status “EVSE Potentially Found” as “EVSE Found” or “No EVSE Found”.

[V2G-DC-036] The EV shall retry the SLAC method C_assoc_retry time before considering the Association process as definitively failed.

NOTE The discovering process is split into two major parts: a first step, with a quick SLAC process with a low resolution in order to detect the environment. In most cases, this step will be enough to identify the connected EVSE. The second step occurs only if the environment disturbs the nominal behaviour: the SLAC process is re-launched a second time, with higher precision. See Table 10 Profile B. According to the result, an additional validation may be required.

[V2G-DC-038] According to the result of the SLAC process, the PLC node on the EV side shall sent its decision using the relevant messages:

- If EV_Discovering_Status = EVSE_FOUND, the EV PLC node shall inform the EVSE that they are connected, and start to set-up the “Private Logical Network”. The EV PLC node shall use the CM_SLAC_MATCH message
- If EV_Discovering_Status = EVSE_POTENTIALLY_FOUND, the EV PLC node shall inform the most probable EVSE that it will start a validation process by using CM_VALIDATE messages
- If EV_Discovering_Status = EVSE_NOT_FOUND, the PLC node shall inform HLE that association is not possible using the primitive D-LINK_READY.indication with the status “no Link” and keep the PLC node in the “Unassociated” state.

[V2G-DC-039] The best attenuation of a direct connection is defined to be 8 dB. If the attenuation is between 0 dB and 8 dB, EV_Discovering_Status shall be EVSE_FOUND.

[V2G-DC-040] The worst attenuation of a direct connection is defined to be 16 dB. If the attenuation is between 8 dB and 16 dB, EV_Discovering_Status shall be EVSE_POTENTIALLY_FOUND

[V2G-DC-041] If the attenuation is higher than 16 dB EV_Discovering_Status shall be EVSE_NOT_FOUND

NOTE 1 These values differ from ISO/IEC CD 15118-3 first committee draft

NOTE 2 Attenuation measurement is based on the PSD values of the NorthAmerican Carrier and Spectral Mask of the Green PHY specification. -50dBm/Hz will give 0dB attenuation during SLAC measurement

As soon as the PLC node on the EV side is active, it shall start to discover its connected EVSE.

During this process, the EV shall send broadcast requests only. The EVSE measures the attenuation of this signal for different groups of frequencies, and answers to the EV. When the EV receives the results, it has to decide whether or not the received message was sent by connected EVSE.

In case of doubt, the PLC node on EV side can re-launch a more precise SLAC process (see Table 10 – Profile B) and/or ask the EVSE for a validation step.

Figure 5 gives an overview of the Association process from EV side. It shows the sequence to follow, from the discovery of the other PLC nodes to the start of the nominal communication.

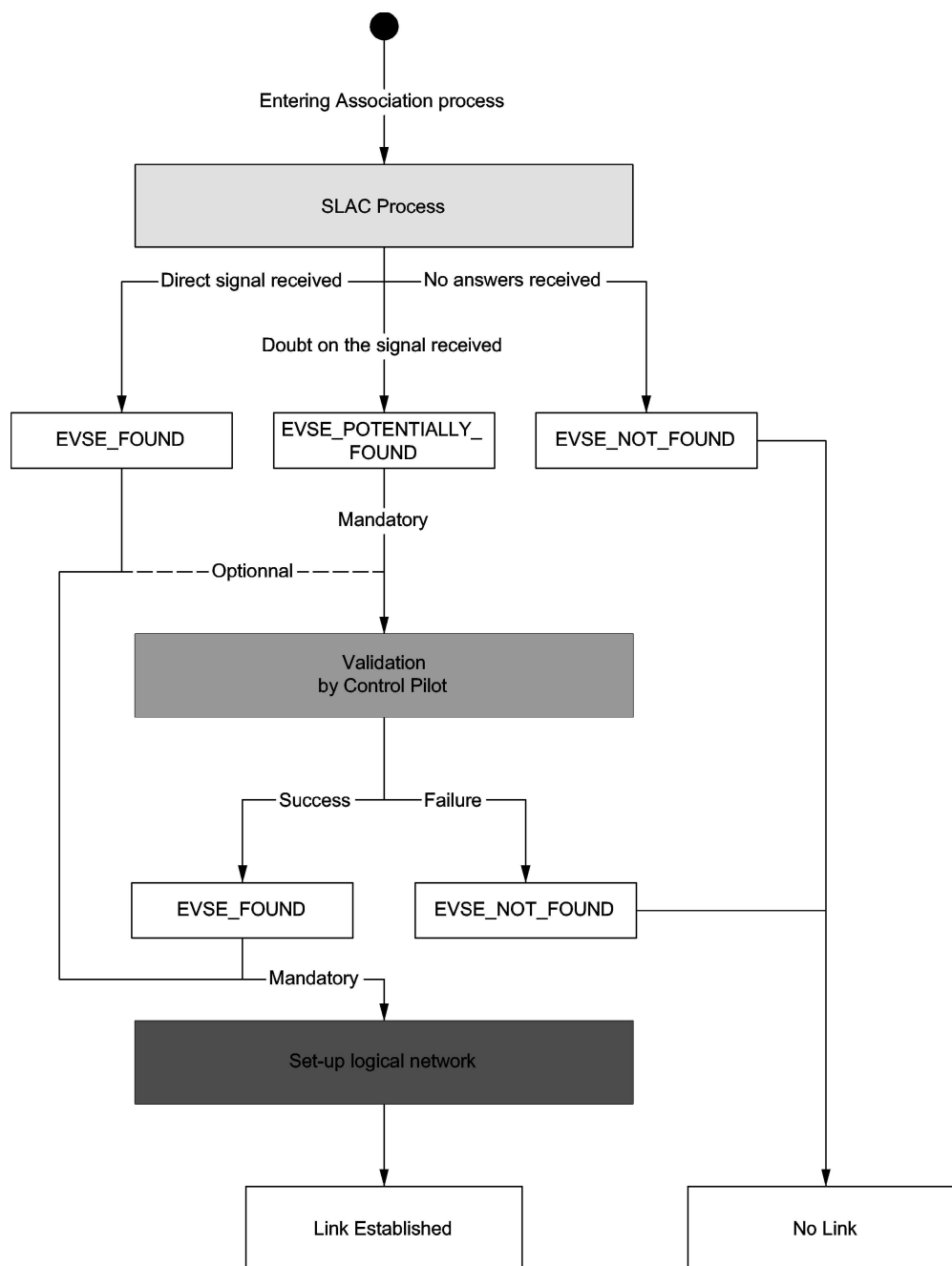


Figure 5 — Overview of HomePlug Green PHY Association procedure from EV side

NOTE Validation of the association is optional and may be deleted in a future version of this specification.

8.3.4.3.1 Association sequence diagram with SLAC messages

The Figure 6 gives the complete sequence chart of the Association process. It shows the sequence to follow, from the discovery of the other PLC modules to the start of the nominal communication.

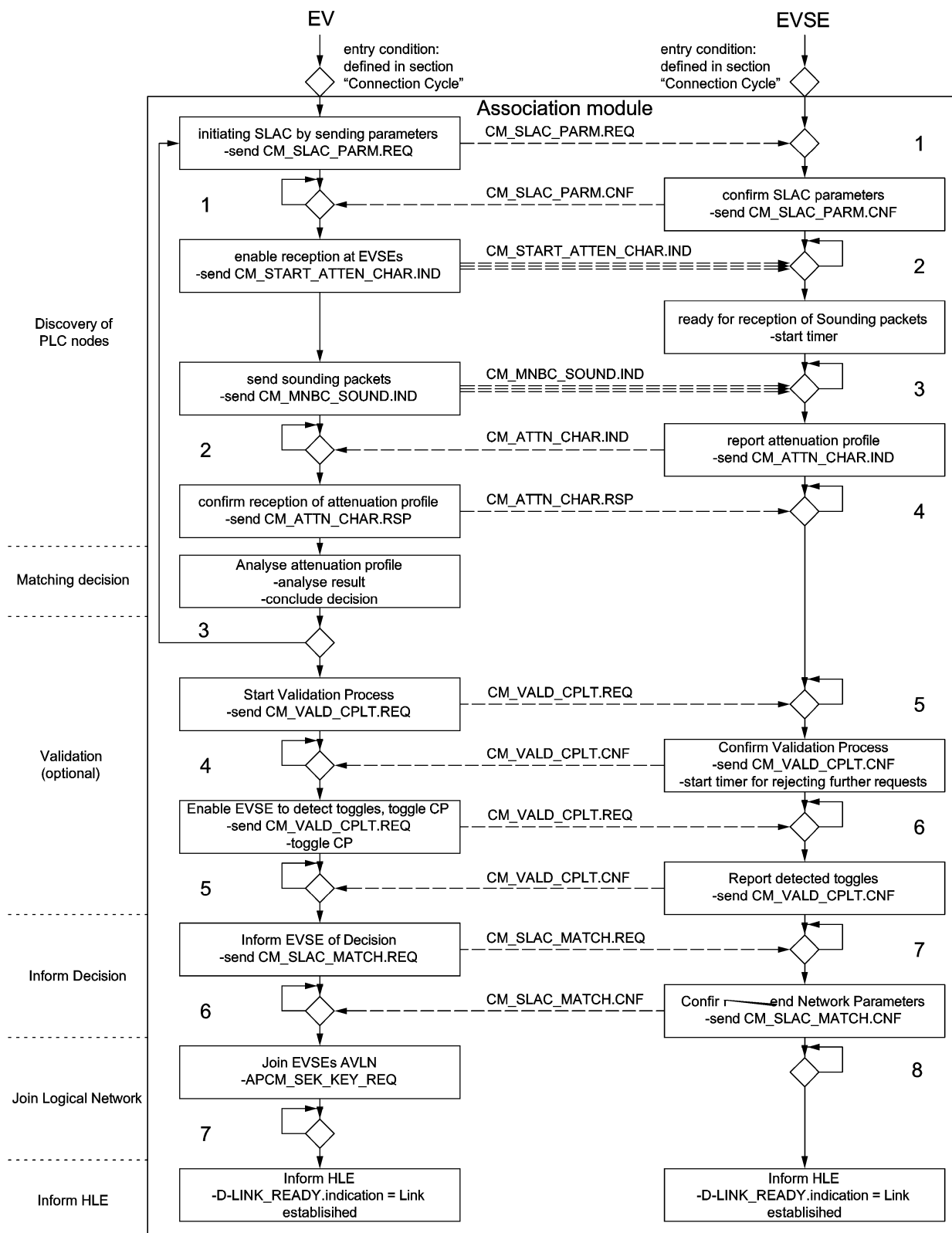


Figure 6 — Sequence chart of HomePlug Green PHY Association procedure

8.3.4.3.2 MME Content for SLAC

HomePlug Green PHY provides Management Messages for data exchange between Central Coordinator and stations.

[V2G-DC-042] For the SLAC process, the PLC nodes shall use the following set of MMEs defined in the referred sections of the Specification HomePlug Green PHY. The parameters to be used within the MMEs are defined in the following tables:

Table 10 — SLAC MME parameter values

Parameter definition	Parameter	Value	Value description
CM_SLAC_PARM.REQ	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	RunID	random	8 bytes Random Run Identifier of sender
CM_SLAC_PARM.CNF Profile A, first SLAC attempt	M-SOUND_TARGET	0xFFFF FFFF FFFF	Request send in broadcast
	Num_Sounds	0x03	3 M-Sound MPDUs sent
	Time_Out	0x02	TimeOut of 200 ms
	Resp_Type	0x00	HLE usage
	Fwd_Sta	0x00	no station (not used since Resp_Type=0x00)
	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	CipherSuite	0x00	Value not used, No security
CM_SLAC_PARM.CNF Profile B, second SLAC attempt	M-SOUND_TARGET	0xFFFF FFFF FFFF	Request send in broadcast
	Num_Sounds	0x10	16 M-Sound MPDUs sent
	Time_Out	0x0A	TimeOut of 1 s
	Resp_Type	0x00	HLE usage
	Fwd_Sta	0x00	no station (not used since Resp_Type=0x00)
	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security

Table 10 (continued)

	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	CipherSuite	0x00	Value not used, No security
CM_START_ATTEN_CHAR.IND	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	NUM_SOUNDS	Value of CM_SLAC_PARM.CNF message	Number of SOUND MPDUS used, same as in CM_SLAC_PARM.CNF message
	Time_Out	Value of CM_SLAC_PARM.CNF message	SOUND MPDU Timeout
	Resp_Type	0x00	HLE usage
	Fwd_Sta	0x00	no station (not used since Resp_Type=0x00)
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
CM_MNBC_SOUND.IND	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	Sender ID	Sender ID	EV's Identification number,
	Cnt	Countdown counter	Number of Sounds remaining
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	Rnd	Random	Random Value
CM_ATTEN_CHAR.IND	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	SOURCE_ADDRESS	MAC Address EV	MAC Address of EV initiating the SLAC

Table 10 (continued)

	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	SOURCE_ID	Identifier EV	Unique identifier of the station that sent the M-Sounds
	RESP_ID	EVSE Identifier	Unique identifier of the station that is sending this message
	NumSounds	Number of M-Sounds received	Number of M-Sounds used in generating the ATTEN_PROFILE
	NumGroups	Var	Number of Groups 0x00 = 0 Octets ...
	AAG[1]	Var	Average Attenuation of Group -1
	AAG[N]	Var	Average Attenuation of Group -N
CM_ATTEN_CHAR.RSP	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	SOURCE_ADDRESS	Var	MAC Address of EV initiating the SLAC
	RunID	Var	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	SOURCE_ID	Var	Unique identifier of the station that sent the M-Sounds
	RESP_ID	Var	Unique identifier of the station that is sending this message
	Result	Var	0x00 – Success 0x01-0xFF Reserved
CM_SLAC_MATCH.REQ	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	MVFLength	Var	MatchVarField Length
	EV ID	Var	EV Identifier
	EV MAC	Var	EV MAC Address

Table 10 (continued)

	EVSE ID	Var	EVSE Identifier
	EVSE MAC	Var	EVSE MAC Address
	RunID	Var	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
CM_SLAC_MATCH.CNF	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	MVFLength	Var	MatchVarField Length
	EV ID	Var	EV Identifier
	EV MAC	Var	EV MAC Address
	EVSE ID	Var	EVSE Identifier
	EVSE MAC	Var	EVSE MAC Address
	RunID	Var	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	NID	Var	Network ID given by the CCo (EVSE)
	NMK	Var	Private NMK of the EVSE (random value)

The following table describes the possible values for the EV_Discovering_Status

Table 11 — EV_Discovering_Status

State description	State	Description
EV_Discovering_Status	EVSE_FOUND	The EVSE is identified without any doubt signal attenuation < 8 dB
	EVSE_POTENTIALLY_FOUND	One or several EVSEs are identified. The next step of the Association procedure will allow to decide if the most probable candidate is the connected EVSE 8 dB < signal attenuation < 16 dB
	EVSE_NOT_FOUND	No directly connected EVSE is found No EVSE with signal attenuation < 16 dB

8.3.4.4 Validation of the Association EV - EVSE

[V2G-DC-043] Validation of the association is optional and may be deleted in a future version of this specification.

The Validation of the Association is a method to validate the signal strength measurement via an additional independent path, based on the hardwired control pilot line.

After the signal strength measurement, the EV can decide on the basis of the results to request the EVSE for an additional validation. As soon as the EVSE is ready to hear the CPLT, the EV sends a random timer value to the EVSE T_vald_toggle. After sending the message, the EV switches the control pilot state in the sequence B-C-B. This switching sequence is called BCB-Toggle in the following.

According to the EVSE architecture, the EVSE can answer to the request by a "Not Required" state. This is just a recommendation from the EVSE, the EV decides either to follow the EVSE and to perform the Validation process, or to skip it.

During the time T_vald_toggle, the EV performs multiple BCB toggles. The number of toggles is chosen randomly in the available time.

At the end of the timer, the EVSE sends a PLC frame with the number of toggles seen on the line and waits for the decision value.

If the result of the SLAC process is "EVSE_POTENTIALLY_FOUND", a validation step through the CPLT is optional.

This step allows the use of the PWM states, in order to assure the physical link between EV and EVSE.

The following requirements are optional:

[V2G-DC-044] Both EVs and EVSEs shall be compliant with a method to validate the EV-EVSE connection, based on the signal sequence "EV signal to the EVSE" defined in IEC 61851-1 Annex A.

[V2G-DC-056] In accordance to IEC 61851-1, the EV shall perform a "BCB Toggle" as defined in Figure 7

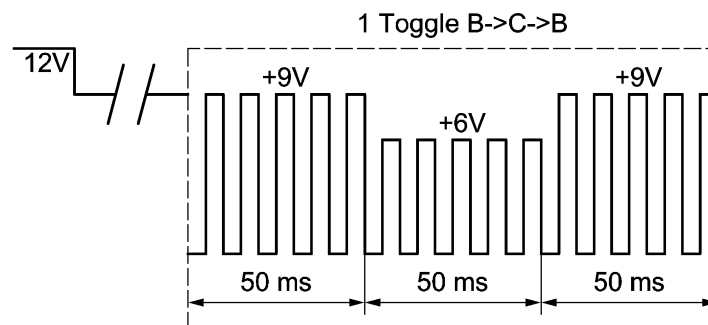


Figure 7 — Example of toggle sequence with 2 toggles

[V2G-DC-050] If the EV_Discovering_Status is "EVSE_FOUND", the validation step is optional.

[V2G-DC-051] If the EV_Discovering_Status is "EVSE Potentially Found", the EV shall start the Validation process. According to the grid architecture, the EVSE can inform the EV that it is allowed to abort the Validation step. The EV can decide to abort this step.

[V2G-DC-053] The EVSE shall be able to detect a state variation on the CPLT within T_vald_detect_time.

[V2G-DC-520] The duration of each state during the toggle sequence is defined as T_vald_state_duration.

[V2G-DC-057] The EV shall choose a timer value T_vald_toggle.

[V2G-DC-058] The EV shall perform at least one and a maximum of three BCB toggle(s) during the Validation step, and shall adjust the T_vald_toggle in coherence with the number of BCB Toggles..

[V2G-DC-521] The CPLT Duty Cycle has no impact on the validation step.

[V2G-DC-049] Since the PLC node on EV side concludes the signal strength measurement, the PLC node on EV side shall also conclude this mechanism. This method shall be concluded by:

- EVSE Found
- No EVSE Found

NOTE At this stage, the Validation is physically performed with the CPLT. The "EVSE Potentially Found" state is not possible.

[V2G-DC-522] The EVSE shall answer to a CM_VALIDATE.REQ with a "Ready" state to only one EV request for Validation if it receives multiple requests. The EVSE shall answer with "Not_Ready" state otherwise.

[V2G-DC-523] According to the EVSE Architecture, the EVSE can decide to answer with "Not_Required" state. In this case, the EV shall decide:

- Either to continue the Validation process, by resending the request CM_VALIDATE.REQ.
- Either to skip the Validation process, by informing the EVSE of the decision, using the CM_SLAC_MATCH.REQ.

[V2G-DC-524] Both EV and EVSE shall comply with the sequence diagrams defined in Figure 6.

[V2G-DC-525] Both EV and EVSE shall use the CM_VALIDATE messages to exchange the Control Pilot duty cycle values, using the parameters defined in the Table 12.

Table 12 — MME parameters for Validation

MME	Field	Size	Values
CM_VALIDATE.REQ	Signal Type	1 Byte	Signal Type 0x00 = PEV S2 toggles on CPLT line 0x01-0xFF = reserved
	Timer	1 Byte	Time during the EVSE has to hear the CPLT in ms: 0x01 = 100ms
	Result	1 Byte	Result code: 0x00 = Not Ready 0x01 = Ready 0x02 = Success 0x03 = Failure 0x04 = Not Required
CM_VALIDATE.CNF	Signal Type	1 Byte	Signal Type 0x00 = PEV S2 toggles on CPLT line 0x01-0xFF = reserved
	ToggleNum	1 Byte	Number of detected Toggle sequences:

			0x00 = 0 0x01 = 1 ... and so on
	Result	1 Byte	Result code: 0x00 = Not Ready 0x01 = Ready 0x02 = Success 0x03 = Failure 0x04 = Not Required

8.3.4.5 Joining the Logical Network

After the right Association between EV and EVSE was determined, the EV joins the logical network of the EVSE. Therefore, the broadcast domain is reduced to the PLC nodes directly connected.

8.3.4.5.1 Requirements

- [V2G-DC-059]** The PLC node shall try to join the "Private Logical Network" only if the EV_Discovering_status is EVSE_FOUND
- [V2G-DC-060]** In order to create the "Private Logical Network" both EV and EVSE shall use the "CM_SLAC_MATCH" MMEs defined in the Specification HomePlug Green PHY.
- [V2G-DC-061]** As soon as the EV has successfully joined the Logical Network of the EVSE both entities are in the status "associated". The PLC node shall inform HLE via the D-LINK_READY.indication = Link established, that HLE's binding process can begin.
- [V2G-DC-526]** In the following cases, the PLC node shall leave the logical network within T_assoc_leave. All parameters related to the current link shall be set to the default value and shall change to the status "Unassociated".
- The state A is detected on EVSE side
 - The state E is detected on EV side
- [V2G-DC-062]** At any time an EVSE switches to a private logical network by sending a CM_SLAC_MATCH.CNF MME, the private NMK shall be set randomly.
- [V2G-DC-063]** The Connection Coordination on Layer 2 shall receive a confirmation by higher layers that the whole association process is finished.
- [V2G-DC-064]** The PLC node on the EVSE side may send the Amplitude map (unmasked carriers) to the PLC node on the EV side as soon as the logical network is set-up. Optionally, the PLC node on the EV side can answer with its own Amplitude map. The used Amplitude map will be the minimum of the 2 Amplitude maps.

NOTE 1 The EVSE shall guarantee to comply on local legislation on authorized / forbidden frequencies, in the frequency band 2 – 30 MHz. By this mechanism, the EV will always comply with the local legislation.

NOTE 2 Before the sending of the Amplitude map, a default Amplitude map should be used.

NOTE 3 At this state, the association process is over, and the nominal PLC communication shall start.

8.3.4.5.2 MME Content for Amplitude Map exchange

To exchange an amplitude mask, the EVSE may use the "CM_AMP_MAP.REQ" primitive defined in the Specification HomePlug Green PHY. The content depends on the carriers to be used.

Table 13 — CM_AMP_MAP.REQ

Parameter definition	Parameter	Value	Value description
CM_AMP_MAP.REQ	AMLEN	2 bytes	Number of entries
	AMDATA[0]	4 bytes	Amplitude Map Data: First Unmasked Carrier
	AMDATA[n]	4 bytes	Amplitude Map Data: [n] unmasked carrier

To confirm an amplitude mask exchange, the EV shall use the "CM_AMP_MAP.CNF" primitive defined the Specification HomePlug Green PHY. The content is shown in Table 14.

Table 14 — CM_AMP_MAP.CNF

Parameter definition	Parameter	Value	Value description
CM_AMP_MAP.CNF	ResType	var	0x00 = success 0x01 = failure 0x02-0xFF = reserved

8.3.4.6 Leave the Logical Network

This section allows speeding up a disconnection / reconnection of another car. This sub section avoids that the CCo of the Logical Network needs several minutes to discover that the car has left the network.

[V2G-DC-065] With receiving a D-Link_Termination.request from HLE, the PLC node shall leave the logical network within T_assoc_leave. All parameters related to the current link shall be set to the default value and shall change to the status "Unassociated". PLC nodes shall follow the section "Leaving an AVLN" defined in the Specification HomePlug Green PHY.

[V2G-DC-527] When the PLC module leaves the Logical Network, it shall inform HLE via the D-LINK_READY.indication = no Link.

8.3.4.7 SLAC Error handling

[V2G-DC-037] The number of SLAC process retries is limited to C_assoc_retry. A retry is considered as one full process of SLAC, including the two sub steps.

[V2G-DC-528] The EV shall react to the potential EVSE with either a CM_VALIDATE.REQ or a CM_SLAC_MATCH.REQ message within T_assoc_session_max after receiving a CM_ATTEN_CHAR.RSP response. Otherwise, the EVSE is allowed to timeout the association session with the certain EV.

The following table defines error cases during the Association process. Every error case is mapped to an Error Handling procedure. The numbering of the steps is related to Figure 6.

Table 15 — SLAC Error Handling

Point of Error	Error cases	Error Handling Procedure
EVSE / EV	Node receives request message with a non valid message content	EHP_01 (No answer)
EVSE / EV	Node receives response message with a non valid message content	EHP_02 (Resend request, counter)
EVSE / EV	Node does not receive confirmation message within T_assoc_response	EHP_02 (Resend request, counter)
EVSE / EV	Node does not detect any message flow for T_assoc_alive	EHP_03 (Initiate restart, counter)
EV	No matching EVSE in "Analyse Attenuation Profile"	EHP_03 (Initiate restart, counter)
EV, step 7	EV is not able to join the logical network within T_assoc_join	EHP_03 (initiate restart, counter)
EVSE	Timeout, no EV joins the EVSE's logical network	EHP_04 (resend matching confirmation, counter)

[V2G-DC-529] In error handling procedure EHP_01, the node shall not answer to the last request. Error will be solved by timeout.

[V2G-DC-530] In error handling procedure EHP_02, the node shall resend the last request. The number of retries per message type is limited to C_assoc_retry. The retry counter shall be reset as soon as a valid response follows a retry.

[V2G-DC-531] In error handling procedure EHP_03, the node shall leave the association module returning a failure message to the connection cycle module.

[V2G-DC-532] In error handling procedure EHP_04, the node shall resend the matching confirmation. The number of retries per message type is limited to C_assoc_retry.

8.3.5 EMC requirements

EMC requirements are defined in IEC 61851-1 and IEC 61851-23

8.3.6 Coupling Circuit

8.3.6.1 Overview

As shown in the previous sub-clauses the physical layer is divided into two parts: The PLC high level communication and the basic signalling in accordance with IEC 61851-1.

This subclause defines the requirements that have to be fulfilled, in order to inject HomePlug Green PHY signals into the CPLT.

HomePlug Green PHY signals are compliant with the Specification HomePlug Green PHY. The target is to enable bidirectional HPGP communication between one EVSE and one EV, while the CPLT works according to IEC 61851-1.

As PLC's signal coupling is directly linked to the control pilot, the schematic in IEC 61851-1, Annex A specification shall be the basis for the definitions regarding the control pilot signal.

To enable PLC injection, the path from the EVSE's output to the EV's input should not be considered as capacitive only, as it is sufficient for the low frequency control pilot signal. Instead, for high frequency PLC, the path should rather be considered as a transmission line. Taking high frequency into account, the control pilot circuit and the component values have to be specified more in detail.

For the control pilot line, the additional capacity of the PLC coupling circuit has to be considered. For the PLC signal, the partitioning of the capacitive load of the EV, the EVSE and the cable is important and is described in this subclause.

8.3.6.2 General drawing for PLC injection

[V2G-DC-071] All technical requirements described in this subclause shall assume to have a dedicated pair of PLC chips implemented for the couple (EVSE, EV), linked by a CPLT wire. Figure 8 depicts an implementation of parallel injection and gives definitions used further.

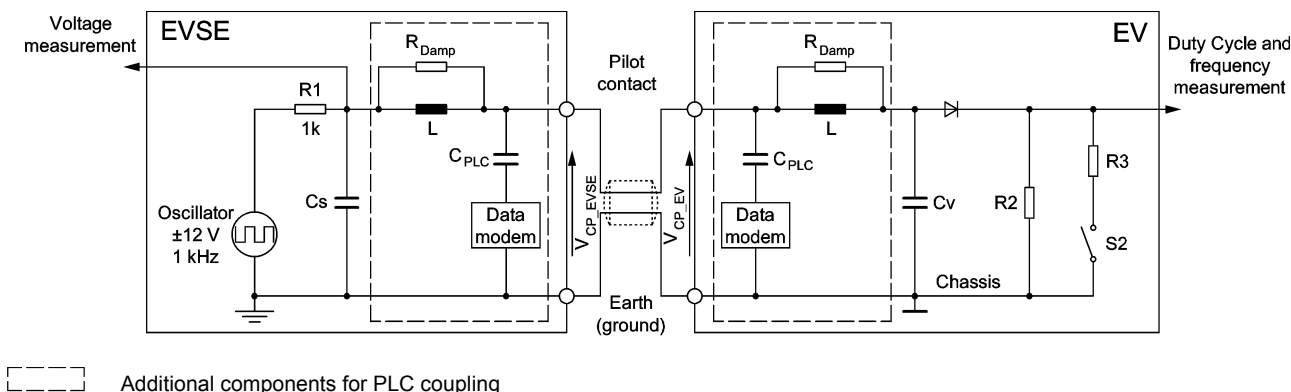


Figure 8 — Implementation of parallel injection

NOTE 1 Different topologies like point-to-multipoint are not covered and may require adaptations.

NOTE 2 The coupling drawing is valid for cases A, B and C, as defined in the IEC 61851-1.

NOTE 3 The coupling capacitors are equivalent components, which can be implemented with more than one component, for example 2 capacitors, as soon as the requirements about values given in the table below is fulfilled.

NOTE 4 L and RDamp associated with capacitors, form low pas filters, which enable the normal working of the CPLT and the PLC communication at the same time. They enable to affect low frequency signals to the CPLT and high frequency ones to the PLC. RDamp resistors limit resonance effects of RLC filters thus constituted.

[V2G-DC-072] The signal coupling shall operate on a point to point basis with only one PLC node on EVSE side connected to one PLC node on EV side. EVSE systems that have multiple EV nodes connected to one central EVSE nodes shall operate with vehicles that have been designed to operate in one to one configurations.

[V2G-DC-075] In case of parallel injection, the PLC signal shall be coupled between the CPLT wire and the PE (Protective Earth) wire.

[V2G-DC-076] In case of parallel injection, the PLC injection circuit on EVSE side shall be wired to the CPLT and the PE. Additional components, such as EMC or ESD protection, should not affect the PLC signals.

[V2G-DC-077] In case of parallel injection, the PLC injection circuit on EV side shall be wired to the CPLT and the ground. Additional components, such as EMC or ESD protection, should not affect the PLC signals.

[V2G-DC-533] PLC shall work with any duty cycle and level applied to the CPLT.

[V2G-DC-078] A proper formatting of the Control Pilot raw signal shall be implemented on EVSE side, to assure IEC 61851-1 compliancy in presence of an additional PLC signal.

NOTE DIN SPEC 70121 highly recommends to apply at least a 1st order low pass filter with a cutoff frequency of 100 kHz to 200 kHz for measurements on the control pilot signal (e.g. duty cycle or amplitude), not to disturb the measurement by high frequency PLC signals.

8.3.6.3 Signal requirement for PLC injection

The following table gives requirements that physical signals shall comply with, in order to enable parallel PLC injection into the CP, according to previous requirements.

NOTE The PLC signal shall be added to Control Pilot signal on the CPLT. The resulting signal should be the algebraic sum of PWM Control Pilot signal and of the PLC signals.

[V2G-DC-081] The CPLT and the PE wires shall be considered as a transmission line for the PLC signal, with characteristic impedance as defined in Table 16.

Table 16 — Signal requirements for parallel PLC injection to control pilot

Parameter	Conditions and comments	min	typ	max	unit	Note
Characteristic Impedance of the CPLT wires	Tightly linked to physical parameters of allowed charging cord. From 2 to 28 MHz	90		150	Ω	
Length of the charging cable				10	M	
C_{PLC}	See definition above	-	1.35		nF	3,4
R_{Damp}	See definition above	-	220	1k	Ω	4
L	See definition above	-	220		μH	3,4
C_S	See definition in IEC 61851-1				pF	1,3
C_V	See definition in IEC 61851-1				pF	1,3
Power Spectral Density of PLC signals at V_{CP_EVSE} and V_{CP_EV} Measurement method defined in 8.3.6.4	From 1.8 to 30 MHz, RBW=9 kHz on 50 Ω . All used carriers	-75	-73	-71	dBm/Hz	
Peak-Peak Voltage of PLC signals at V_{CP_EVSE} and V_{CP_EV}	Control Pilot signal steady at high or low level – 1 PLC actually emitting at a time (peak to peak) – EV connected to the EVSE with the charging cord. Measured at max PSD level of PLC with example of injection circuit given below.	-	1.3		Vpp	2,3
Conducted PLC Crosstalk from any PLC to the Mains (via power supply) (voltage between any live or neutral wire and PE/CP)	From 2 MHz to 28 MHz			-40	dB	

NOTE 1 Any capacity on the control pilot line which is directly connected between CP and ground should be as small as possible, not to attenuate the PLC signal in an excessive way. Most of the capacitive load should be separated from the high frequency PLC with the inductor L .

NOTE 2 At given impedance, the maximum peak to peak amplitude is directly linked to the PSD also defined in the table. For the purpose of limiting the impact of the high frequency PLC signal on the control pilot line, a simplification from definition in frequency domain to a peak to peak voltage is sufficient.

NOTE 3 The maximum value is defined by IEC 61851-1 Annex A.

NOTE 4 These parameters are to consider with parallel injection only, as defined in Figure 8.

8.3.6.4 Conditions of measurement

In the following, a measurement setup and procedure is defined to determine the electrical characteristic of the transmitted signal of a V2G-device in frequency domain by means of a power spectrum density (PSD). The numeric values for the PSD is defined in Table 16 and assures a comparable signal characteristic within a certain tolerance range across V2G devices. Especially the SLAC method for measuring the signal strength needs a well-defined power level for signal transmission.

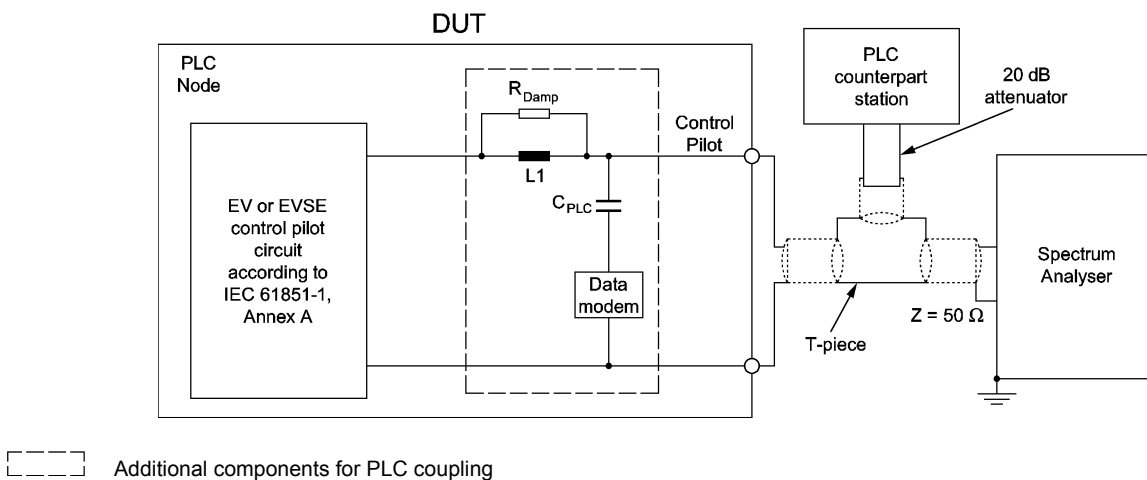


Figure 9 — Measurement setup

The process defined in this section assumes a 50 Ω load between the control pilot terminal and the ground/earth conductor. All output voltages are specified as the voltage measured at the control pilot and ground terminals of the PLC node.

- [V2G-DC-534]** Measurements shall be made by using equipment confirming to CISPR16 specifications with a resolution bandwidth of 9 kHz.
- [V2G-DC-535]** A PLC counterpart station shall be connected to the DUT, to allow data communication.
- [V2G-DC-536]** The PLC counterpart station shall be conform to DIN SPEC 70121 regarding coupling circuit and transmission power.
- [V2G-DC-537]** A spectrum analyzer shall be connected to the communication line.
- [V2G-DC-538]** All passive components in the signal path shall be 50 Ω compliant parts and there insertion loss shall be taken into account.
- [V2G-DC-539]** A 20 dB attenuator shall be placed in series to the PLC counterpart device to assure that emitted signals can be neglect for the measured peak values of the DUT.
- [V2G-DC-540]** During the whole measurement process, the DUT shall transmit with at least 20 % of the maximum data rate.

[V2G-DC-541] The measurement shall be compliant with the following procedure:

- The input attenuator of the spectrum analyzer should be set in a proper way to avoid overloading the measurement device
- The instrument should be set to measure the peak power in a 9 kHz resolution bandwidth (dBm/ 9 kHz)
- Record the whole carrier band from 1.8 – 30 MHz with a hold time of at least 10 ms per sample point.
- Determine the spectrum analyser's equivalent noise power bandwidth for the 9 kHz filter.
- Calculate the power spectrum density for the DUT by taking the values obtained in step 3 and subtracting 10 log (equivalent noise power bandwidth / 1 Hz).

8.3.6.5 Parallel injection drawing example

Based on the signal and signal path specification above, the following chapter give an implementation example for the parallel PLC injection on the CPLT.

The following schematic shows an implementation example based on the generic circuit in Figure 8

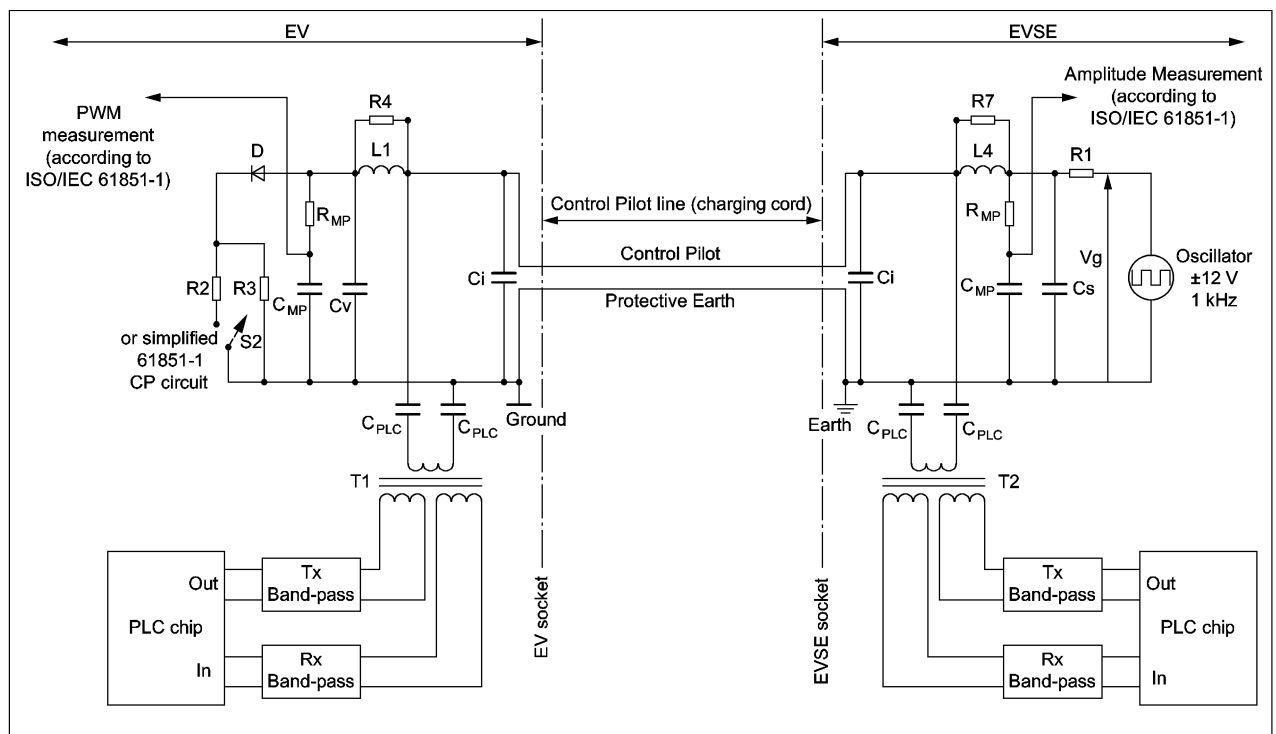


Figure 10 — Implementation example with a PLC coupling transformer

For the implementation example in Figure 10, the components values defined in Table 17 should be applied.

Table 17 — Component values of PLC coupling Implementation example

Component	Value
$R1$	IEC 61851-1
$R2$	IEC 61851-1
$R3$	IEC 61851-1
R_M	10 k Ω
C_M	100 pF
C_V	IEC 61851-1
C_S	IEC 61851-1
C_{PLC}	2.7 nF
$T1 / T2$	Example: 3:3:3 Coupling transformer (Depends on the chips and the TX / RX band-pass filter)
D	IEC 61851-1
L	220 μ H
R_{Damp}	220 Ω

8.3.6.6 Filtering requirements

8.3.6.6.1 Overview

An important source of crosstalk is the PLC signal crosstalk from the CPLT to the mains via the charging cord, which is then conducted by mains connection to another charging cord, and crosstalks again to the other CPLT. In order to reduce this source of crosstalk, a filter should be implemented on the mains wires, making it efficient on all such linked CPLTs.

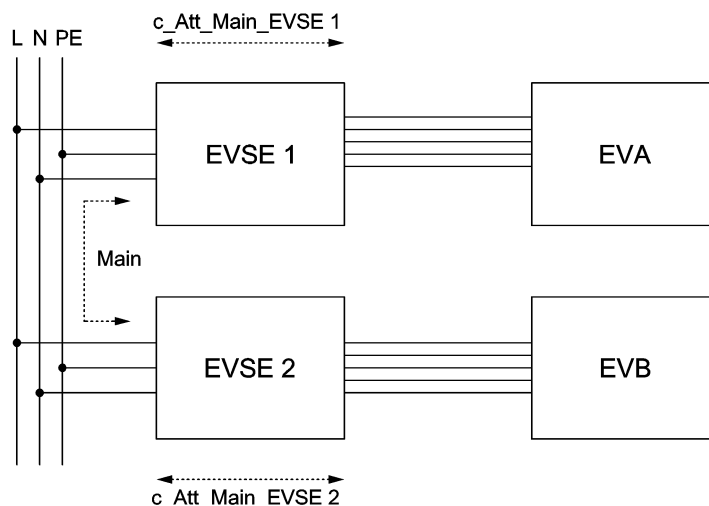


Figure 11 — Overview Sources of Crosstalk

[V2G-DC-088]

For the design of EVSE and EV systems, the operation frequency band of the PLC technology shall be taken into account, in order to filter the used frequency band only.

A ratio of 70 dB can be targeted between the wanted and the crosstalked signal on CPLTs, especially to guarantee the SLAC function. The following requirement is based on an assumption of a 20 dB amplitude decrease when the PLC signal crosstalks inside each charging cord.

It is highly recommended that the system should have attenuation better than 30 dB between the Mains supplying the EVSE and the CPLT in the charging cable, for whole HomePlug Green PHY PLC spectrum.

8.3.6.6.2 Example of crosstalk filter implementation

The Figure 12 gives an example of a valid filter, in the case of crosstalking HPGP signal to the Mains lines, including the PE. It can be improved with additional serial inductances on Mains' side, in order to avoid too high filtering of other PLC networks on their side.

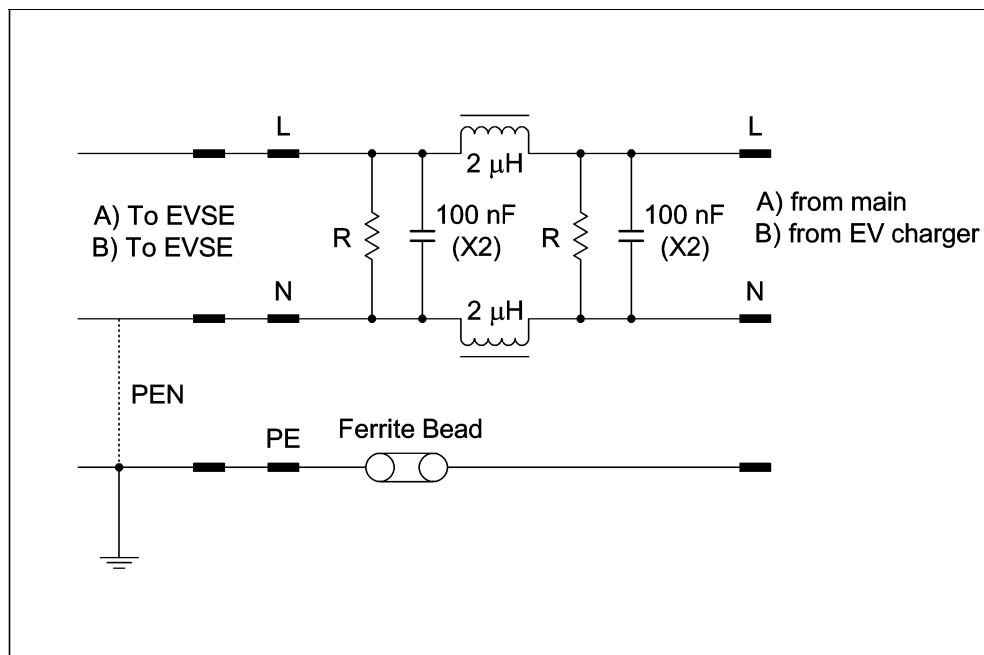


Figure 12 — Example of valid crosstalk filter in the case of HPGP signals

The resistor R is intended to discharge the capacitor and prevent electrical shocks.

8.3.7 Layer 2 Interfaces

8.3.7.1 Overview

As shown in  **Covered PLC Technology Specification**

Figure 13, the definition of the Data Link Layer provides two interfaces to higher layers,

- The Data Link Data SAP is the interface between the PLC technology and the layer 3 (e.g. IPv6)
- The Data Link Control SAP provides link status information, error information, control functionality and is located between the Connection Coordination and higher layers.

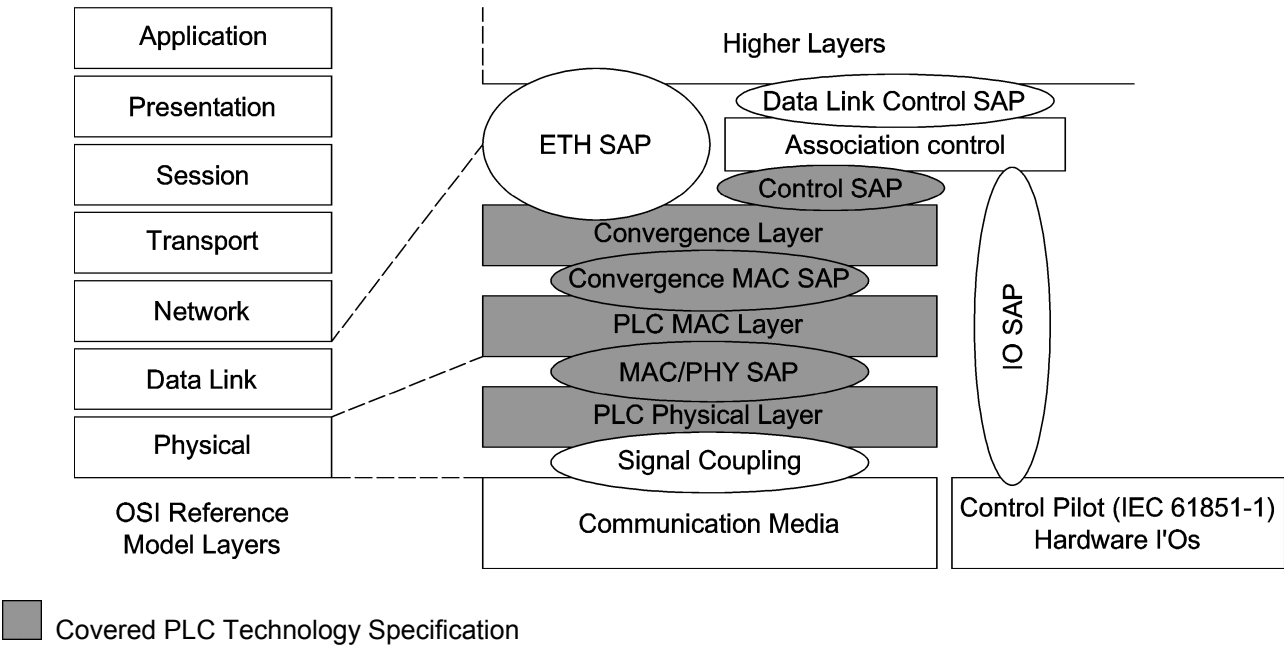


Figure 13 — DIN SPEC 70121 OSI Layer 1-3 Overview

8.3.7.2 Hardware I/O Control

The hardware I/O Control Service Primitives provides methods for controlling, triggering and signalling interaction between the high-level digital communication and the connection coordination to the IEC 61851-1 Basic Signalling.

This interface is primarily accessed by higher layers and the connection coordination module to trigger on status changes and influence the status indicated via the Control Pilot.

The IO-CPSTATE.indication notifies higher layers about a change in the current control pilot state. This indication shall be sent on any change of the control pilot status.

Table 18 — IO-CPSTATE.indication

Definition	Description
Primitive	IO-CPSTATE.indication
Supported entity	EVCC, SECC
Parameter Name: CPState	State of Control Pilot (A, B, C, D, E, F)

IO-GET_CPDUTYCYCLE.confirmation confirms the IO-SET_ CPDUTYCYCLE.request request by sending the current duty cycle within the parameter CPDUTYCYCLE.

Table 19 — IO-GET_CPDUTYCYCLE.confirmation

Definition	Description
Primitive	IO-GET_CPDUTYCYCLE.confirmation
Supported entity	EV, SE
Parameter Name: CPDUTYCYCLE	Duty cycle value of the control pilot (0 – 100 %)