SURFACE VEHICLE INFORMATION REPORT	J2931/4	OCT2014
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Broadband PLC Communication for Plug-in Electric Vehicles

RATIONALE

This SAE Recommended Practice provides a common set of requirements for implementing the broadband communications used to communicate between the Electric Vehicle Supply Equipment (EVSE) and the plug-in vehicle it charges. This version has been updated to harmonize it with the final versions of DIN 70121 and ISO/IEC 15118-3.

SAE J2931/4 has been reaffirmed to comply with the SAE Five-Year Review policy.

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TABLE OF REQUIREMENTS

1. SCOPE

This SAE Technical Information Report SAE J2931/4 establishes the specifications for physical and data-link layer communications using broadband Power Line Communications (PLC) between the plug-In electric vehicle (PEV) and the electric vehicle supply equipment (EVSE) DC off-board-charger. This document deals with the specific modifications or selection of optional features in HomePlug Green PHY v1.1 (HomePlug GP1.1) necessary to support the automotive charging application over Control Pilot lines as described in SAE J1772™. PLC may also be used to connect directly to the Utility smart meter or home area network (HAN), and may technically be applied to the AC mains, both of which are outside the scope of this document.

1.1 Purpose

The purpose of SAE J2931/4 is to describe the broadband PLC communications component to complement SAE J1772™. Specifically, it provides context for HomePlug GP1.1 PLC technology and specifies specific parameters and methods required to use HomePlug GP1.1 PHY for the automotive charging applications.

The use cases for communications between a PEV and the utility are described in SAE J2836/1™ with the message details included in SAE J2847/1. The PEV may also interface with an off-board charger in the EVSE as described in SAE J2836/2™ with the messages defined in SAE J2847/2. SAE J2931/1 describes OSI-layers 3 through 6 to interface between the application messages and SAE J2931/4.

It is an objective of this document to be harmonized with DIN 70121 and also with ISO/IEC 15118 and IEC 61851 series documents.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

DIN, Specification 70121[1], Electromobility - Digital communication between a d.c. PEV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System, December 10, 2013.

HomePlug Powerline Alliance, HomePlug Green PHY™ Specification, Release Version 1.1.1, 2013.
(Version 1.1.1 is an errata version of Green PHY 1.1 that is consistent with SAE and ISO/IEC documents.
The term Green PHY 1.1 is used in this document to represent all subsequent document versions of Green PHY 1.1.)

[1] Content from DIN 70121 has been used with written permission.

2.1.1 SAE International

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1772™ SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler (Surface Vehicle Recommended Practice).

SAE J2836/1™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid (Surface Vehicle Information Report

2.2 Related Publications (Informative)

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

IEC, IEC 61581, Electric vehicle conductive charging system, Part 3. (Modes 3 and 4).

ISO/IEC, ISO/IEC 15118, Road Vehicles- Vehicle to grid communication interface - Part 3: Physical layer and Data Link layer requirements

2.2.1 SAE International

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

SAE J2836/2™ Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE) (Surface Vehicle Information Report).

SAE J2836/3™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow (Surface Vehicle Information Report).

SAE J2836/4™ Use Cases for Diagnostic Communication for Plug-in Vehicles (Surface Vehicle Information Report).

SAE J2836/5™ Use Cases for Communication between Plug-in Vehicles and their customers (Surface Vehicle Information Report).

SAE J2847/1 Communication for Smart Charging of Plug-in Electric Vehicles using Smart Energy Profile (Surface Vehicle Recommended Practice).

SAE J2847/2 Communication Between Plug-In Vehicles and Off-Board DC Chargers (Surface Vehicle Recommended Practice).

SAE J2847/3 Communication for Plug-in Vehicles as a Distributed Energy Resource (Surface Vehicle Recommended Practice).

SAE J2894 Power Quality Requirements for Plug-In Electric Vehicle Chargers (Surface Vehicle Recommended Practice).

SAE J2931/1 Digital communications for Plug-in Electric Vehicles, (Surface Vehicle Information Report).

2.3 Other Publications

HomePlug Powerline Alliance, HomePlug Green PHY Compliance Test Plan, 2012

HomePlug Powerline Alliance, HomePlug Green PHY Interoperability Test Plan, 2013.

OpenHAN Task Force of the UtilityAMI Working Group under the OpenSG Subcommittee of the UCA® International Users Group

IEEE Communications Society, IEEE Std 1901-2010™ - IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical, Dec. 2010.

3. DEFINITIONS

3.1 AMPLITUDE MAP

Specifies a transmit power-reduction factor for each subcarrier related to the Tone Map.

3.2 ASSOCIATED

In the automotive case, the logical state where an EVSE and a PEV are determined to be physically paired and ready for logical pairing. It is equivalent to “Matched” and opposite of “Unmatched” or “unAssociated” states used by HomePlug GP1.1.

3.3 CENTRAL COORDINATOR (CCo)

Master (manager) of a HomePlug Green PHY network.

3.4 CHANNEL ACCESS PRIORITY (CAP)

Method to prioritize the channel access (see HomePlug GP1.1 Specification)

3.5 CHARGING SESSION

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

3.6 COEXISTENCE

Ability of different HomePlug Green PHY systems to share the same physical media and to function simultaneously.

3.7 COMMUNICATION CHANNEL

Medium over which the communication is transported. In this document, the Control Pilot wire as defined in J1772™.

3.8 COMMUNICATION SETUP TIMER

Timer that monitors the time from plug-in until reception of the SessionSetupRes message by the PEV.

3.9 CONNECTION COORDINATION

The entity which provides the whole functionality for EV to EVSE Matching and initialization, via the Data Link Control SAP. This entity also controls the relationships between the Basic Signaling and the upper layers. The entity indicates link status and error information to higher layers. The control of the low-layer communication Network Management parameters is handled over the Data Link Control SAP.

3.10 CONTROL PILOT WIRE

Wire pair in the charging cord that is used to control charging. See Control Pilot Line Transmission (CPLT) in IEC 61851-1 and SAE J1772. Also Control Pilot Line (CPL).

3.11 CROSSTALK

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

3.12 DATA LINK LAYER

Protocol abstract layer of the OSI model used to link the physical layer to the network layer. It encapsulates the MAC sub-layer.

3.13 ELECTRIC VEHICLE COMMUNICATIONS CONTROLLER (EVCC)

The entity which implements the communication to one or multiple SECCs.

3.14 INTER-SYSTEM PROTOCOL (ISP)

Coexistence mechanism that allows various broadband power line communications (PLC) systems to share power line communication resources in time (time domain multiplex), in frequency (frequency domain multiplex), or both. For more information, refer to IEEE Std 1901-2010™.

3.15 LOGICAL NETWORK

Set of PLC stations that possess the same Network Management Key (NMK). Only members of the same logical network are able to exchange encrypted 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.

3.16 MATCHED

The logical state where an EVSE and a PEV are determined to be physically paired and ready for logical pairing. Equivalent to "Associated" and opposite of "Unassociated" states used in ISO/IEC 15118-3.

3.17 MEDIUM ACCESS CONTROL (MAC)

Sub-layer of the data link layer, the MAC is a set of algorithms used for managing the access to the communication channel and mechanics to protect the integrity of transferred data.

3.18 ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

Modulation technique that efficiently utilizes the frequency band of operation by using equally spaced orthogonal carriers over smaller increments of the frequency band of operation. The data rate for each carrier is smaller than it would be if the entire frequency band of operation were used but using smaller bands at lower data rates allows better operation over the entire frequency band and reduces inter-symbol interference due to delay spread.

3.19 PHYSICAL LAYER (PHY)

Set of specifications for the electrical signals used to convey information over a physical medium. It defines the frequencies, signal amplitudes, bit rate and synchronization methods supported by a transmitter and receiver.

3.20 PLUG-IN ELECTRIC VEHICLE

Automobile containing a battery for its primary energy source which needs to be plugged into an external power source for charging. Also used as the generic term "Electric Vehicle" (EV). An EV may have multiple sources of propulsion energy.

3.21 RECEIVER

In this document, the set of circuits and algorithms used for demodulation and data decoding.

3.22 RECEIVING NODE

A remote transceiver node that is in the receive mode.

3.23 ROBO MODE

A communication mode which uses 3 robust orthogonal frequency division multiplexing (OFDM) modes (Mini-ROBO, Standard ROBO and High Speed ROBO) to achieve higher transmission robustness.

3.24 SIGNAL LEVEL ATTENUATION CHARACTERIZATION (SLAC)

Protocol to measure the attenuation of a signal between Green PHY stations acting as PEVs and EVSEs. It is used for Matching.

3.25 SERVICE ACCESS POINT (SAP)

Port or logical connection point to a network protocol layer.

3.26 SIGNAL COUPLING

Circuit that describes the method of coupling the Green PHY signal to the communications media.

3.27 SUPPLY EQUIPMENT COMMUNICATIONS CONTROLLER (SECC)

The entity which implements the communication to one or multiple EVCCs and which may be able to interact with secondary actors.

3.28 TONE MASK

Set of carriers that are not used for OFDM transmissions in order to facilitate regulatory and band-usage constraints.

3.29 TONE MAP

List of the Modulation Types for all unmasked (used) carriers (or tones) that are to be used on a particular unicast communication link between two stations. For example, carriers that are experiencing fades may be avoided, and no information may be transmitted on those carriers. The Tone Map is obeyed by the data modulation modes and ignored when transmitting Frame Control, ROBO_AV, Preamble, and Priority Resolution Symbols.

3.30 TRANSMITTER

In this document, the set of circuits and algorithms used for data modulation and transmission.

4. CONVENTIONS

The conventions described in the following sections are applied in this document.

4.1 Units

4.1.1 Binary representation

Binary fields are used with a prefix of “0b” to indicate the binary (or base-2) nature of the data. The field starts (left justified) with the most significant bit (MSB). For example, decimal 16 can be written in binary as 0b00010000.

4.1.2 Hexadecimal representation

Hexadecimal fields are used with a prefix of “0x” to indicate the hexadecimal (or base-16) nature of the data. The field starts (left justified) with the most significant nibble of the fields. For example, 255 can be written as a hex 0x00FF.

4.2 Definition of Open systems interconnection (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 to 7 according to the OSI layered architecture.

4.3 Requirement structure

The requirements upon which this document is based are identified with a specific format and structure as defined in this section.

4.3.1 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 format is 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 which may start on the same or following line.

For example:

“**[V2G-DC-001]**

This is an example.”

4.3.2 Applicability

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

The requirements of this document will indicate “The PEV shall implement…” if the electric vehicle communication entity is required to implement the functionality, unless explicitly stated otherwise.

The requirements of this document will indicate “The EVSE shall implement…” if at least one EVSE entity is required to implement the required functionality, unless explicitly stated otherwise.

The requirements of this document will indicate “The V2G entities shall implement…” if all V2G entities involved in the V2G communication shall implement the required functionality, unless explicitly stated otherwise.

[V2G-DC-001]

The PEV shall implement all mandatory requirements defined in this document for a PEV.

[V2G-DC-002]

The EVSE shall implement all mandatory requirements defined in this document for an EVSE.

4.3.3 Usage of Request for Comments (RFC) references

When RFCs are referenced all of its normative 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.

4.3.4 Terms

Several terms are used differently in the related standards and recommended practices. In this document, the following are equivalent unless explained otherwise as they are used:

- PEV - EV
- Association – Match
- HomePlug Green PHY™ - Green PHY – HPGP - GP

Note that if EV is part of a title, message or command, (not part of the body text) it may be left as EV (not converted to PEV) so it is harmonized with normative and informative references.

Green PHY 1.0 and Green PHY 1.1 are not equivalent when the reference is specific to Green PHY 1.1 (or its errata version Green PHY 1.1.1).

5. SAE TECHNICAL REQUIREMENTS

The purpose of these SAE technical requirements documents is to provide SAE members (vehicle and EVSE manufacturers, HAN providers and utilities) with relevant information on smart energy technology.

Powerline communication (PLC) over the Control Pilot circuit is described in SAE J1772™. The architecture is shown in SAE J2836/2™ with the connector variations and control both within the PEV and EVSE. The communications messages for DC energy transfer between the PEV and the off-board charger in the EVSE are described in SAE J2847/2. The association of the PEV to the End Use Measurement device (EUMD) is described in SAE J2931/1. Utility program use cases are described in SAE J2836/1™ with the messages in SAE J2847/1.

In general J2836 is the document series for use cases and general info, J2847 is the corresponding document series message details and the J2931 document series describes requirements and protocol.

This Recommended Practice specifies how to set the HomePlug GP 1.1 broadband PLC communications options and how to apply to DC charging communications on the Control Pilot line.

6. HOMEPLUG GREEN PHY

6.1 General Overview

HomePlug Green PHY v1.1 ("HomePlug GP1.1") protocol is used for the PEV-EVSE charging communications over the control pilot wires. HomePlug GP1.1 (and any of its errata versions such as HomePlug GP1.1.1) contains specific features designed for the electric vehicle application, such as Signal Level Attenuation Characterization (SLAC), tone mask negotiation between the PEV and the EVSE, and advanced power management. Note that Green PHY1.0 is designed for the Smart Grid. Devices that are certified only as HomePlug Green PHY1.0 are not certified to be compatible with this recommended practice. Devices certified as HomePlug GP1.1 (or newer) are compatible with this recommended practice and with HomePlug GP1.0 applications. Either protocol (generically referred to as "HomePlug GP") is suitable for communications from the EVSE towards the Utility, or for entertainment communications.

HomePlug GP was design for Smart Grid applications and is compatible and interoperable with HomePlug AV and AV2 networks that are often found in the home.

6.2 HomePlug Green PHY architecture overview

Figure 1 illustrates the control and data plane architecture defined by the HomePlug GP1.1 specification.

- The Data Link Control SAP (“Control SAP” in Figure 1)
- The Data SAP is the interface between the Green PHY technology and the layer 3 (e.g., IPv6)

The Control SAP allows the Higher layer entity (HLE) to control and exchange information with the Data Link layer, such as:

- error information
- status and statistics, including SLAC and link status
- vendor-specific primitives
- initialize the station (STA)
- support Security functions - obtain or set network encryption keys

The EVSE assumes the central coordinator (CCo) role for electric vehicle applications.

The PHY layer connects to the Control Pilot wire.

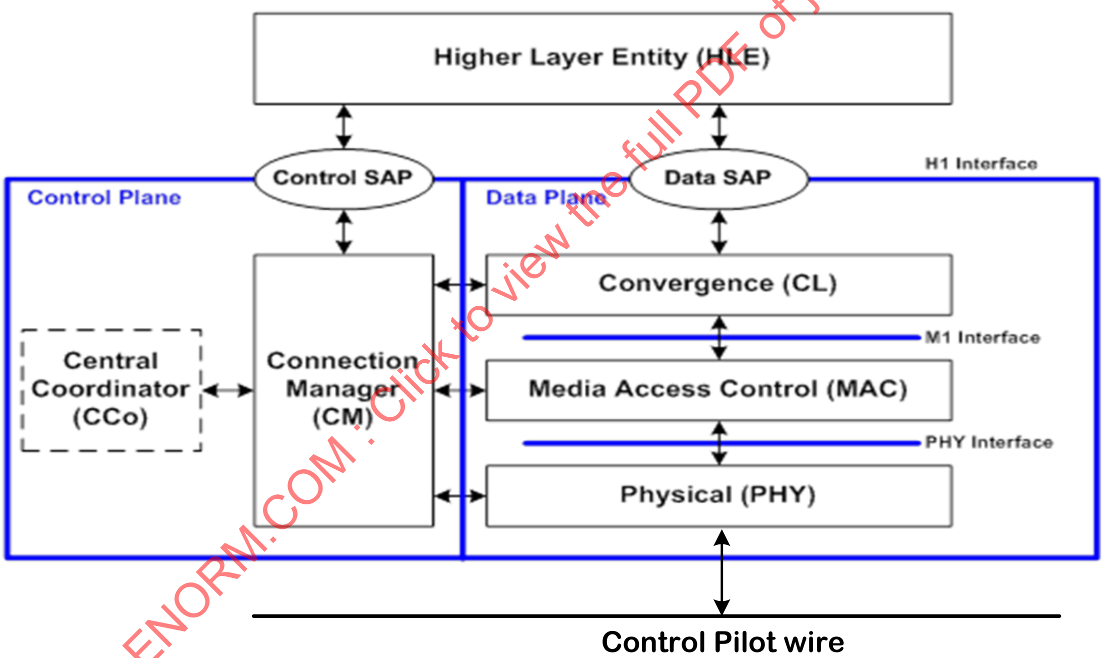


FIGURE 1 – HOMEPLUG GREEN PHY ARCHITECTURE

6.3 Data Link Control service access point (SAP) to layer 3

The higher layer entity (HLE) of the device supporting EVSE-PEV applications (layer 3 and above) and HomePlug Green PHY 1.1 communicate control data through the Data Link Control SAP.

The Data Link Control Service Access Primitives shall be supported to provide methods for indicating the Green PHY Link status, the status of Matching and error messages to higher layers.

[V2G-DC-542]

The D-LINK_READY.indication shall be used to inform higher layers about a change of the Green PHY link status. This indication shall be sent upon any change of the link status. The values of the DLINKSTATUS are independent of the states of the Control Pilot.

Primitive:	**D-LINK_READY.indication**
Entity to support:	**EV, EVSE**
Parameter Name	**Description**
DLINKSTATUS	Status of Green PHY communication Link - no Link - Link established

[V2G-DC-543]

The D-LINK_TERMINATE.request shall force lower layers to terminate the Data Link.

Primitive:	**D-LINK_TERMINATE.request**
Entity to support:	**EV, EVSE**

6.4 DATA SAP

The higher layer entity (HLE) of the device supporting EVSE-PEV applications (layer 3 and above) and HomePlug Green PHY 1.1 communicate data through the Data SAP.

The Data SAP at the Host (H1) interface can implement a generic interface and/or an Ethernet II-class SAP (ETH SAP) interfaces within the convergence/adaptation layer (CL). The Host interface used in this document is the ETH SAP, which is completely covered by the HomePlug Green PHY specification.

This SAP supports applications using Ethernet II class packets, including IEEE 802.3 with or without IEEE 802.2 (BS), IEEE 802.1H (SNAO) extensions, and/or virtual local area network (VLAN) tagging.

The Ethernet II-class SAP includes following service primitives, defined in the HomePlug Green PHY v1.1 specification:

- ETH_SEND.REQ
- ETH_SEND.CNF
- ETH_RECEIVE.IND

7. CONFIGURATION OF A GREEN PHY NODE

This section summarizes key points of the HomePlug Green PHY technology according to the HomePlug Green PHY v1.1 specification which this standard requires.

The Physical Layer of the HomePlug Green PHY technology is fully described in the HomePlug Green PHY v1.1 specification.

7.1 ROBO Modes and Data Rate

The HomePlug Green PHY Technology uses three Robust OFDM (“ROBO”) modes of communication for:

- Beacon, data broadcast, and multicast communication
- Session setup
- Exchange of Management Messages
- Data messages

All ROBO Modes use quadrature phase shift keying (QPSK) modulation. This mechanism introduces redundancy by a factor that depends on the type of ROBO Mode.

TABLE 1 - 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

The Green PHY device should use as small a MAC Protocol Data Unit (MPDU) packet size as practical to optimize transmission effectiveness and low latency.

7.2 Shared Bandwidth Mechanisms

Coexistence mechanisms with other HomePlug and IEEE PLC technologies are addressed in the specifications HomePlug Green PHY v1.1 and IEEE 1901.

7.2.1 Inter System Protocol (ISP)

HomePlug Green PHY implements the ISP as a coexistence mechanism. The ISP, defined by IEEE 1901, 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 Green PHY node 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 Green PHY node on the PEV side.

7.2.2 Coexistence with HomePlug AV Technologies

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

In some cases with a fully loaded HomePlug AV network, the HomePlug Green PHY network may be limited to 7% of the available communications time. This might affect the average data rate.

8. CONNECTION COORDINATION

The following sections specify the coordination of several connection steps (phases).

NOTE: The validation process and messages referred to in these tables and drawings are not used in this recommended practice. For more information refer to DIN 70121 or ISO/IEC 15118-3.

8.1 Plug-In Phase

The Plug-in phase covers the period of time after the charging cable assembly is plugged into the PEV.

[V2G-DC-507]

After the EVSE detects CP State B, the EVSE's Green PHY node shall be ready for communication in less than T_conn_max_comm.

[V2G-DC-564]

An EVSE that supports only DC charging according to DIN SPEC 70121 on a connector shall apply a CP duty cycle of 5% on this connector no later than 1s after its Green PHY node is ready for communication.

[V2G-DC-733]

An EVSE that supports only DC charging according to DIN SPEC 70121 on a connector shall apply a CP duty cycle of 100% (with Vg = 12 V constant voltage, according to IEC 61851-1) on this connector if its Green PHY node is not ready for communication, unless an error condition requires applying a different CP duty cycle or CP voltage.

9. PEV-EVSE MATCHING PROCESS (ASSOCIATION)

9.1 Overview

To ensure billing accuracy and proper charging control, it is important that the PEV associate with the correct EVSE in environments where cross-talk between charging cables may occur and where many EVSE's are present. These environments include apartment buildings and public parking facilities, offices, and shopping areas.

The Matching process is also called "PEV-EVSE Association" which uses the HomePlug GP SLAC feature to first match and then bind the correct PEV and EVSE. (Note: PEV-EVSE Association is differentiated from network "association" which deals with joining a network.)

In order to improve SLAC performance the HomePlug GP station on the EVSE-side shall respond to SLAC requests from the PEV if and only if:

- The EVSE is connected to a PEV as indicated by the completion of the Control Pilot circuit (i.e., the charge cable is plugged in).
- The EVSE or PEV are not already "matched" (i.e., in an "Unassociated" or "Unmatched" state).

When the charging connector is being plugged into the PEV's inlet, the electric vehicle communications controller (EVCC) and supply equipment communications controller (SECC) are initially in the "Unmatched" state.

The HomePlug GP1.1 station on the PEV-side shall never answer a SLAC request.

The following section uses the term "matching" to refer to Layer 2 matching; however matching also requires support (e.g. interpretation of the data) in the HLE.

9.2 Initialization of the Matching Process

The first phase of the Association process is called "Initialization of the matching process". During this phase, the HomePlug GP node is configured in order to enhance the matching process.

[V2G-DC-014]

Each HomePlug Green PHY node shall provide a method to exchange authorized frequencies to be used for the communication in order to be in line with frequency restrictions. A Green PHY node shall respect the spectrum limitation sent by the counterpart node.

NOTE: All EVSEs should be able to update the set of frequencies to be used according to future legislative regulations.

[V2G-DC-018]

The Green PHY node on the PEV side shall be configured to never become the CCo.

NOTE: This could be done with the APCM_SET_CCo.REQ primitive as defined in the HomePlug Green PHY v1.1 specification.

[V2G-DC-019]

The Green PHY node on the EVSE side shall be configured to always be the CCo.

NOTE: This could be done with the APCM_SET_CCo.REQ primitive as defined in the HomePlug Green PHY v1.1 specification.

[V2G-DC-020]

Any SLAC related message transmitted shall be sent with CAP3 priority to speed up the Matching process.

[V2G-DC-024]

A SLAC request shall only be responded by an EVSE's Green PHY node if all of the following conditions are fulfilled:

- the EVSE is connected to a PEV, detected by the CP state
- the EVSE is in "Unmatched" state

9.3 Discovery of the Connected Green PHY Node on EVSE Side

The discovery process used by the PEV to determine which EVSE is directly connected to its charge cord is the HomePlug Green PHY Signal Level Attenuation Characterization (SLAC) method. The PEV will discover all the EVSE Green PHY nodes in range. On the basis of a signal strength measurement for each Green PHY node, the PEV decides to which node it is directly connected.

[V2G-DC-029]

The Green PHY nodes on EVSE and PEV side shall be compliant with the unsecured SLAC protocol defined in the HomePlug Green PHY v1.1 specification.

[V2G-DC-030]

Measurement of the signal strength on EVSE side shall be done according to the HomePlug Green PHY v1.1 Signal Level Attenuation Characterization (SLAC).

[V2G-DC-031]

Only the PEV shall send SLAC requests.

[V2G-DC-032]

Only the EVSE shall answer to SLAC requests. (See also 9.2, requirement [V2G-DC-024]

In case two or more PEVs are plugged in at the same time and experience crosstalk, the EVSEs must answer all SLAC requests. Not only the first one.

[V2G-DC-568]

The SECC shall be able to process and answer five (5) SLAC requests in parallel.

[V2G-DC-034]

The SLAC method shall be concluded by the following possible states:

- EVSE_FOUND,
- EVSE_POTENTIALLY_FOUND, or
- EVSE_NOT_FOUND.

NOTE: The use of EVSE_POTENTIALLY_FOUND is not used in this recommended practice.

[V2G-DC-035]

Each PEV Green PHY node shall consider the status "EVSE_POTENTIALLY_FOUND" as "EVSE_FOUND" or as "EVSE_NOT_FOUND".

[V2G-DC-569]

The ATTEN_PROFILE within the message CM_ATTEN_CHAR.IND shall be calculated by arithmetic mean of the ATTEN_PROFILE of the CM_ATTEN_PROFILE.IND of previous M-SOUNDS corrected by the attenuation of the receive path AttnRxEVSE as described in section 10.4.1 Typical transmission path.

[V2G-DC-570]

The Average_Attenuation used for the Matching decision shall be calculated by the arithmetic mean of all groups in the CM_ATTEN_CHAR.IND.

[V2G-DC-038]

According to the result of the SLAC process, the Green PHY node on the PEV side shall send its decision using the respective messages:

- If EV_Discovering_Status = EVSE_FOUND, the PEV Green PHY node shall inform the EVSE that they are connected, and shall start to set up the Logical Network. The PEV Green PHY node shall use the CM_SLAC_MATCH message.
- If EV_Discovering_Status = EVSE_NOT_FOUND, the Green PHY node shall inform HLE that Matching is not possible using the primitive D-LINK_READY.indication (DLINKSTATUS = no Link) and keep the Green PHY node in the "Unmatched" state.

NOTE: Attenuation measurement is based on the power spectral density (PSD) values of the North American Carrier and Spectral Mask of the Green PHY specification. A -50dBm/Hz PSD level will be interpreted as 0dB of attenuation during SLAC measurement.

As soon as the Green PHY node on the PEV side is active, it may start to discover its connected EVSE.

During this process, the PEV shall send broadcast requests. The EVSE measures the attenuation of this signal for different groups of frequencies, and responds to the PEV. When the PEV receives the results, it decides whether or not the received message was sent by a physically connected EVSE. The closest EVSE is assumed to be the correct device.

In case of doubt (insignificant attenuation difference between multiple EVSEs) the Green PHY node on PEV side may re-launch a SLAC process.

Figure 2 shows a high-level overview of the matching process which involved layers 1, 2 and the HLE. The default state of a Green PHY node at plug-in is "Unmatched". A CP State change from CP State A, B with 100% CP duty cycle, E or F to B with 5% CP duty cycle triggers the matching process (state "Matching" in Figure 2) which determines the correct PEV-EVSE pairing by a signal strength measurement. The matching process may also start at different times (not shown in Figure 3). A successful matching process leads to the state "Matched".

[V2G-DC-751]

Any transition from the state "Matching" to state "Matched" or "Unmatched" shall trigger a call of the primitive D-LINK_READY.indication to indicate a successful or failed Data-Link setup.

[V2G-DC-752]

A failure during the Matching process, a loss of the Control Pilot or a request from HLE shall lead to a reset to state "Unmatched".

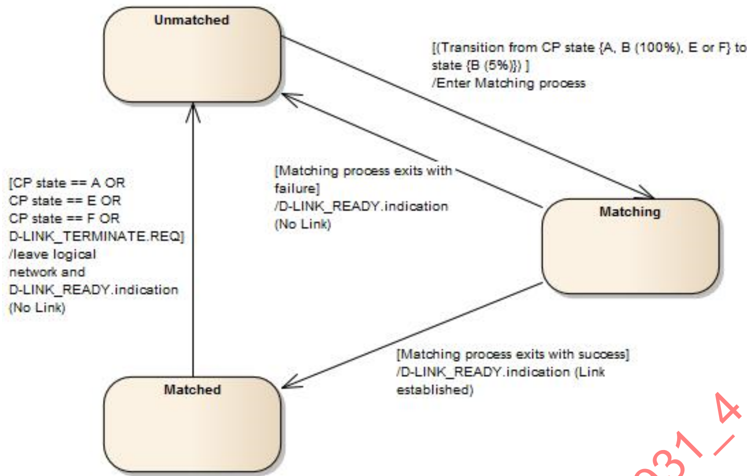


FIGURE 2 - MATCHING STATE MACHINE

9.3.1 Matching Process Sequence Diagram with SLAC Messages

[V2G-DC-571]

The Matching process is based on the messages defined in the HomePlug Green PHY v1.1 specification.

Figure 3 gives the complete sequence chart of the Matching process. It shows the sequence to follow, from the discovery of the other Green PHY nodes to the start of the communication. The Validation process is not used in this recommended practice.

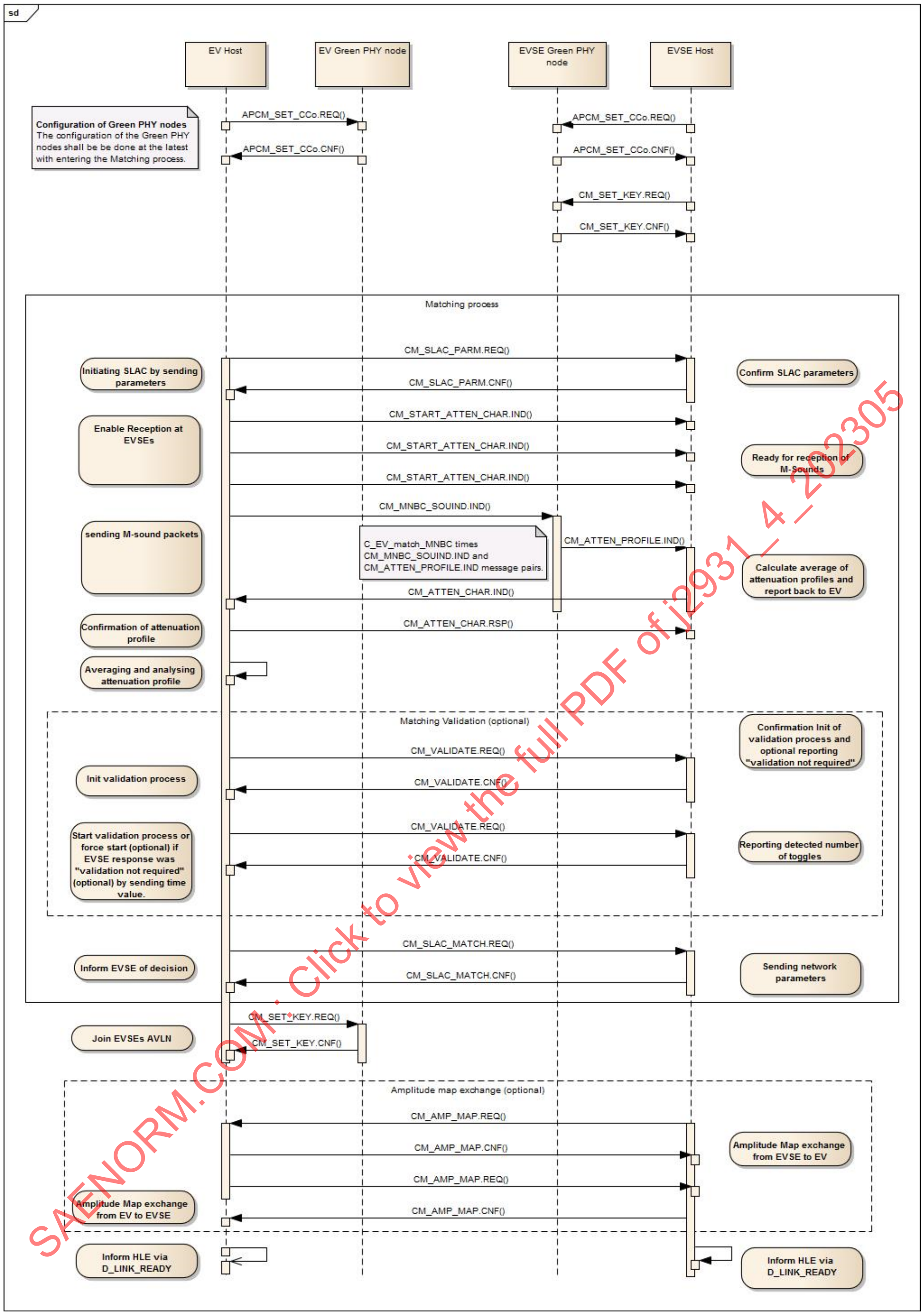


FIGURE 3 - SEQUENCE CHART OF HOMEPLUG GREEN PHY MATCHING PROCESS

9.3.2 MME Content for SLAC

HomePlug Green PHY provides management messages for data exchange between the central coordinator (CCo in the EVSE) and Stations (in the PEV).

[V2G-DC-042]

For the SLAC process, the Green PHY nodes shall use the following set of MMEs of the HomePlug Green PHY v1.1 specification. The parameters to be used within the MMEs are defined in Table 2.

[V2G-DC-572]

The Ethernet Destination MAC Address field shall be filled either as Broadcast or Unicast, as defined in Table 2.

NOTE: All SLAC Messages are sent in multi-network broadcast (MNBC) even if the destination MAC address is unicast. See Annex B for details.

[V2G-DC-573]

The EVCC and SECC shall check the destination MAC address for received SLAC messages. Messages that are defined as Unicast according to Table 2, Table 4, Table 5, Table 6 and Table 7 shall only be accepted if the destination MAC address equals the entities address. Messages that are defined as Broadcast according to Table 2, Table 4 Table 5, Table 6 and Table 7 shall also be accepted as Unicast messages.

[V2G-DC-574]

The EVSE shall generate a random network management key (NMK) after Power-on and after every Plug-Out of an EV, and it shall use this random NMK for setting up a Logical Network.

NOTE: NMK and network identification (NID) should be generated after Plug-Out instead of Plug-In to save time for Data Link setup.

[V2G-DC-575]

The EVSE shall generate the NID out of the NMK as defined in the HomePlug Green PHY v1.1 specification and shall use it for setting up a Logical Network.

[V2G-DC-734]

For setting up a Logical Network the message CM_SET_KEY.REQ shall be used with the generated NMK and NID.

[V2G-DC-735]

On EVSE side, the message CM_SET_KEY shall be send after Power On and after every Plug Out.

[V2G-DC-576]

For NID generation, Security Level = 0b00 shall be used.

Table 2 recites the SLAC MME parameters that have specific parameters to be used for automotive DC charging applications. Additional MMEs are found in HomePlug GP1.1, sections 11.5.44 through 11.5.60, and 12.2.2.53 through 12.2.2.60.

TABLE 2 - SLAC MME PARAMETER VALUES

MME	FIELD	OCTET NO.	FIELD SIZE (Octets)	VALUE	DEFINITIONS
CM_MNBC_SOUND.IND Ethernet Broadcast	APPLICATION_TYPE	0	1	0x00	PEV-EVSE Association (matching)
	SECURITY_TYPE	1	1	0x00	No Security
	MSVarField	-	-	-	M-Sound Variable Field See definition below
MSVarField of CM_MNBC_SOUND.IND	SenderID	0-16	17	Variable	Because the SECURITY_TYPE=0x00 the Sender ID bits should be set to zeros.
	Cnt	17	1	Variable	Countdown counter for number of Sounds remaining
	RunID	18-25	8	-	Random identifier created by the PEV which initiates the SLAC process. This value shall be the same as the one sent in the CM_SLAC_PRAM.REQ message by this sender.
	RSVD	26-33	8	Filled with 0x00	Reserved-
	Rnd	34-49	16	Variable	Random Value
CM_SLAC_PARM.REQ Ethernet Broadcast	APPLICATION_TYPE	0	1	0x00	PEV-EVSE Matching
	SECURITY_TYPE	1	1	0x00	No Security
	RunID	2-9	8	Variable	Random Run Identifier of sender
CM_SLAC_PARM.CNF Ethernet Unicast	M-SOUND_TARGET	0-5	6	0xFFFFFFFFFFFF	Request sent in broadcast
	NUM_SOUNDS	6	1	0x0A	Number of M-Sounds to be transmitted by the PEV GP station during the SLAC process
	Time_Out	7	1	0x06	Timeout for transmission of M-Sound MPDUs in multiple of 100ms 0x00 = 0ms 0x01 = 100ms 0x02 = 200ms and so on
	RESP_TYPE	8	1	0x01	HLE usage (0x01). (Send to another GP STA (PEV))

	FORWARDING_STA	9-14	6	MAC address of the PEV HLE	Station to which the measurement results shall be sent.
	APPLICATION_TYPE	15	1	0x00	Application Type 0x00 : PEV-EVSE Association 0x01-0xFF: Reserved
	SECURITY_TYPE	16	1	0x00	Security in M-Sound Messages 0x00: No Security 0x01: Public Key Signature 0x02-0xFF: Reserved
	RunID	17-24	8	variable	Run identifier of sender. Same as in CM_SLAC_PRAM.REQ message.
	CipherSuite			0x00	Value not used. No security
CM_START_ATTEN_CHAR.IND Ethernet Broadcast	APPLICATION_TYPE	0	1	0x00	PEV-EVSE Association (matching)
	SECURITY_TYPE	1	1	0x00	No security
	ACVarField	-	-	-	Attenuation Characteristics Variable Fields See definition below
ACVarField of CM_START_ATTEN_CHAR.IND	NUM_SOUNDS	0	1	0x0A (same as in CM_SLAC_PARM.CNF message)	Number of M-Sounds transmitted by the GP station during the SLAC process.
	Time_Out	1	1	0x06 (same as in CM_SLAC_PARM.CNF message)	Timeout for transmission of M-Sound MPDUs in multiple of 100ms 0x00 = 0ms 0x01 = 100ms 0x02 = 200ms…
	RESP_TYPE	2	1	0x01	Transmitted to another GP STA’s HLE
	FORWARDING_STA	3-8	6	MAC address of the PEV HLE	Station to which the measurement results shall be sent.
	RunID	9-16	8	variable	Random identifier created by the PEV which initiates the SLAC process

CM_ATTEN_PROFILE.IND	EV MAC	0-5	6	variable	EV MAC Address
	NumGroups	6	1	variable	Number of Groups (=N) 0x00=0 Octets 0x01=1 Octet and so on
	RSVD	7	1	-	Reserved
	AAG[1]	8	1	variable	Average Attenuation of Group -1 0x00=0dB 0x01=1dB and so on
	…				
	AAG[N]	-	1	Variable	Average Attenuation of Group – N 0x00=0 Octets 0x01=1 Octet and so on
CM_ATTEN_CHAR.IND Ethernet Unicast	APPLICATION_TYPE	0	1	0x00	EV-EVSE Matching
	SECURITY_TYPE	1	1	0x00	No Security
	ACVarField	-	-	-	Attenuation Characteristics Variable Fields See definition below
ACVarField of CM_ATTEN_CHAR.IND	SOURCE_ADDRESS	0-5	6	Variable	MAC Address of the PEV which initiates the SLAC process
	RunID	6-13	8	Variable	Random identifier created by the PEV which initiates the SLAC process
	SOURCE_ID	14-30	17	0x00	-
	RESP_ID	31-47	17	0x00	-
	NumSounds	48	1	Variable	Number of M-Sounds used to generate the ATTEN_PROFILE
	ATTEN_PROFILE	-	-	-	Signal Level Attenuation. See definition below

ATTEN_PROFILE of CM_ATTEN_CHAR.IND	NumGroups	6	1	Variable	Number of Groups (=N) 0x00 = 0 Octets 0x01 = 1 Octet and so on
	AAG[1]	-	1	Variable	Average Attenuation of Group 1 0x00 = 0 dB 0x01 = 1 dB 0x02 = 2 dB and so on
	…				
	AAG[N]	-	1	Variable	Average Attenuation of Group N 0x00 = 0 dB 0x01 = 1 dB 0x02 = 2 dB and so on
CM_ATTEN_CHAR.RSP Ethernet Unicast	APPLICATION_TYPE	0	1	0x00	PEV-EVSE Association (matching)
	SECURITY_TYPE	1	1	0x00	No Security
	ACVarField	-	-	-	Attenuation Characteristics Variable Fields See definition below
ACVarField of CM_ATTEN_CHAR.RSP	SOURCE_ADDRESS	0-5	6	6 Bytes	MAC Address of the PEV which initiates the SLAC process
	RunID	6-13	8	8 Bytes	Random identifier created by the PEV which initiates the SLAC process. Same as CM_SLAC_PARM.REQ message
	SOURCE_ID	14-30	17	0x00	Unique identifier of the station that sent the M-Sounds
	RESP_ID	31-47	17	0x00	Unique identifier of the station that is sending this message.
	Result	48	1	0x00	0x00 = Success (0x01-0xFF) are reserved

CM_SLAC_MATCH.REQ Ethernet Unicast	APPLICATION_TYPE	0	1	0x00	EV-EVSE Matching
	SECURITY_TYPE	1	1	0x00	No Security
	MVFLength	2-3	2	0x003E	MatchVarField Length
	MatchVarField	-	-	-	This field is described below
MatchVarField of CM_SLAC_MATCH.REQ	PEV ID	0-16	17	0x00	PEV Identifier
	PEV MAC	17-22	6	Var.	PEV MAC Address
	EVSE ID	23-39	17	0x00	EVSE Identifier
	EVSE MAC	40-45	6	Variable	EVSE MAC Address
	RunID	46-53	8	Variable	Identifier given in the CM_START_ATTEN_CHAR.IND message
	RSVD	54-61	8	-	Reserved
CM_SLAC_MATCH.CNF Ethernet Unicast	APPLICATION_TYPE	0	1	0x00	PEV-EVSE Matching
	SECURITY_TYPE	1	1	0x00	No Security
	MVFLength	2-3	2	0x0056	MatchVarField Length
	MatchVarField	-	-	-	This field is described below
MatchVarField of CM_SLAC_MATCH.CNF	PEV ID	0-16	17	0x00	PEV identifier
	PEV MAC	17-22	6	Variable	PEV MAC Address
	EVSE ID	23-39	17	0x00	EVSE identifier
	EVSE MAC	40-45	6	Variable	EVSE MAC Address
	RunID	46-53	8	Variable	Random identifier created by the PEV which initiates the SLAC process. This value shall be the same as the one sent in the CM_SLAC_PRAM.REQ message by this sender.
	RSVD	54-61	8	-	Reserved
	NID	62-68	7	NID calculated from the random NMK that will be set	Network ID given by the CCo (EVSE)
	RSVD	69	1	-	Reserved
	NMK	70-85	16	Random value	Private NMK of the EVSE (random value)

CM_SET_KEY.REQ Unicast to local Green PHY Node	Key Type	0	1	0x01	Fixed value to indicate "NMK"
	My Nonce	1-4	4	0x00000000	Fixed value, encrypted payload not used
	Your Nonce	5-8	4	0x0000000	Fixed value, encrypted payload not used
	PID	9	1	0x04	Fixed value to indicate "HLE protocol"
	PRN	10-11	2	0x0000	Fixed value, encrypted payload not used
	PMN	12	1	0x00	Fixed value, encrypted payload not used
	CCo Capability	13	1	variable	CCo Capability according to the station role.
	NID	14-20	7	variable	54 LSBs contain the NID 2 MSBs = 0b00
	NewEKS	21	1	0x01	Fixed value to indicate "NMK"
	NewKey	22-37	16	variable	NMK

[V2G-DC-577]

Based on the signal attenuation read by the "CM_ATTEN_CHAR.IND" Message, the EV_Discovering_Status is defined by Table 3.

TABLE 3 - EV_DISCOVERING_STATUS DEFINITION

STATUS	AVERAGE ATTENUATION		DESCRIPTION
	FROM	TO	
EVSE_FOUND	-	C_EV_match_signalattn_direct	The EVSE is identified without any doubt
EVSE_POTENTIALLY_FOUND	C_EV_match_signalattn_direct	C_EV_match_signalattn_indirect	One or several EVSEs are identified. The next step of the Matching process will allow deciding if the most probable candidate is the connected EVSE.
EVSE_NOT_FOUND	C_EV_match_signalattn_indirect	-	No direct connected EVSE is found

9.3.3 Set-Up a Logical Network

After correctly associating the PEV and EVSE, the PEV joins the logical network of the EVSE. Consequently, the broadcast domain is reduced to the two Green PHY nodes which are physically connected by the charging cable.

9.3.3.1 Requirements

[V2G-DC-059]

The PEV Green PHY node shall try to join the Logical Network only if the EV_Discovering_Status is “EVSE_FOUND”.

[V2G-DC-060]

In order to create the Logical Network both PEV and EVSE shall use the "CM_SLAC_MATCH" MMEs defined in the HomePlug Green PHY v1.1 specification using sequences defined in Figure 3.

[V2G-DC-061]

As soon as the PEV has successfully joined the Logical Network of the EVSE both entities are in the state "Matched". The Green PHY node of both PEV and EVSE shall inform HLE via the D-LINK_READY.indication(DLINKSTATUS = Link established) that HLE's binding process can begin.

[V2G-DC-581]

In the “Matched” (“Associated”) state no further SLAC messages other than CM_AMP_MAP.REQ and CM_AMP_MAP.CNF shall be sent or processed.

9.3.3.2 Amplitude Map Exchange

The amplitude map exchange is an optional function to request the counterpart Green PHY node to reduce the transmission power for certain carriers. The requesting device sends a CM_AMP_MAP.REQ command, which has to be confirmed by the counterpart node by a CM_AMP_MAP.CNF message.

The transmission power limitation request is related to the power spectral density (PSD) at the PEVs/EVSEs inlet/connector.

The CM_AMP_MAP.REQ MME has two different functions, depending on the source/destination of the message:

- A CM_AMP_MAP.REQ sent from one host to another host via the Green PHY Link is designated to transmit the requested transmission power per carrier to the destination host to be included in its amplitude map calculation. This message does not have any direct influence on the Green PHY node transmission power, its only used for information exchange.
- A CM_AMP_MAP.REQ sent from one host to the local Green PHY node causes the Green PHY node to modify its transmission power.

All transmission power values within the CM_AMP_MAP MMEs are related to a reference value of -50 dBm/Hz. The resolution of AMDATA is -2 dB, so that an AMDATA value of 0b0011 means a value -6 dB.

The following is an example of requesting a reduction of transmission power. (For simplification within this example its total number of carriers is fictitiously set to 6). In this example, the EVSE requests a limitation of the power of carriers 2 and 3 to -78 dBm/Hz, while the other carriers keep unaffected and the PEV makes no limitation request to the EVSE.

1) The EVSE sends a CM_AMP_MAP.REQ to the PEV host MAC address with the following values: {0, 14, 14, 0, 0, 0}

- AMDATA[0] = 0x00
- AMDATA[1] = 0x0E
- AMDATA[2] = 0x0E
- AMDATA[3] = 0x00
- AMDATA[4] = 0x00
- AMDATA[5] = 0x00

Given that the PSD reference is -50 dBm/Hz, and the requested value is -78 dBm/Hz, the difference is -28 dB. Given a resolution of 2 dB, the value is 14 (0x0E) for 2 dB resolution.

2) The PEV host compares the received values with its default PSD at the inlet, which are assumed to be {-75, -75, -77, -77, -75, -75} dBm/Hz. For carriers 2 and 3 the requested values are less than the default ones:

- Carrier 1: -75 dBm/Hz < -50 dBm/Hz: ok
- Carrier 2: -75 dBm/Hz < -78 dBm/Hz: n.ok. Devation: 3 dBm/Hz
- Carrier 3: -77 dBm/Hz < -78 dBm/Hz: n.ok. Devation: 1 dBm/Hz
- Carrier 4: -77 dBm/Hz < -50 dBm/Hz: ok
- Carrier 5: -75 dBm/Hz < -50 dBm/Hz: ok
- Carrier 6: -75 dBm/Hz < -50 dBm/Hz: ok

The carriers 2 and 3 have to be reduced in power by 3 dBm/Hz and 1 dBm/Hz respectively.

3) The PEV host confirms the CM_AMP_MAP.REQ with a corresponding CM_AMP_MAP.CNF
4) Based on the calculated attenuation values for the carriers 2 and 3 the PEV host subtract these values from the default Green PHY node setting and writes them to the Green PHY node using the CM_AMP_MAP.REQ and its local destination address.

[V2G-DC-064]

In the case that a Green PHY node requires additional carriers to be notched, it shall send the amplitude map to the remote Green PHY node as soon as the logical network is set up. Therefore the sequence described in Figure 3 and section 9.3.3.2 for detailed primitives shall be used. The amplitude map for further communication shall be the intersection of the amplitude map of the local Green PHY node and the received amplitude map from the remote Green PHY node.

[V2G-DC-582]

As long as no exchange of an amplitude map is triggered by one of the Green PHY nodes, the default Amplitude map of Green PHY specification v1.1 shall be used.

NOTE: The EVSE shall guarantee the conformity on local legislation on authorized / forbidden frequencies, in the PLC frequency band from 1.8 to 30 MHz. By this mechanism, the PEV will always comply with the local regulations. The EVSE's tone mask should also be able to be reconfigured to support future evolution of regulations.

[V2G-DC-583]

The Ethernet Destination MAC Address field shall be filled as Unicast, as defined in Table 4 and Table 5.

[V2G-DC-584]

To exchange an Amplitude map, the "CM_AMP_MAP.REQ" message of the HomePlug Green PHY specification shall be used. The content is shown in Table 4.

[V2G-DC-585]

To confirm an Amplitude map exchange, the “CM_AMP.MAP.CNF” message of the HomePlug Green PHY specification shall be used. The content is shown in Table 5.

To exchange an Amplitude Map, the Green PHY node may use the "CM_AMP_MAP.REQ" message defined in the HomePlug Green PHY v1.1 specification. The content depends on the carriers to be used.

TABLE 4 - CM_AMP_MAP.REQ PARAMETERS

MME	FIELD	OCTET NO.	FIELD SIZE (bits)	VALUE	DEFINITION
CM_AMP_MAP.REQ Ethernet Unicast	AMLEN	0-1	16	Variable	Number of Amplitude Data Entries – n 0x00=zero 0x01=one and so on
	AMDATA[0]	2	4	Variable	Amplitude Map Data: First unmasked carrier
	AMDATA[n]	2	4	Variable.	Amplitude Map Data: [n] unmasked carrier

To confirm an Amplitude Map exchange, the Green PHY node shall use the "CM_AMP_MAP.CNF" message defined in the HomePlug Green PHY specification. The message content is shown in Table 5.

TABLE 5 - CM_AMP_MAP.CNF PARAMETERS

MME	FIELD	OCTET NO.	FIELD SIZE (bits)	VALUE	DEFINITION
CM_AMP_MAP.CNF Ethernet Unicast	ResType	0	8	Var.	Response Type: 0x00 = Success 0x01 = Failure

9.3.3.3 Leave the Logical Network

This section describes how to speed up a disconnection / reconnection of another PEV.

Normally, the CCo of the Logical Network (AVLN) needs several minutes to discover that the PEV has left the network. This makes sure that bad links are not unnecessarily dropped. HomePlug Green PHY messages can be used to deliberately terminate a session, thereby reducing the time to disassociate and allow the EVSE to be available to different PEV more quickly.

[V2G-DC-065]

With receiving a D-Link_TERMINATE.request from HLE, the Green PHY node shall leave the logical network within T_match_leave. All parameters related to the current link shall be set to the default value and the Green PHY node shall change to the state "Unmatched".

[V2G-DC-527]

When the Green PHY node leaves the Logical Network, it shall inform HLE via the D-LINK_READY.indication (DLINKSTATUS = no Link).

[V2G-DC-526]

In the following cases, the Green PHY node shall leave the logical network within T_match_leave. All parameters related to the current link shall be set to the default value and the Green PHY node shall change to the state "Unmatched".

- The EVSE detects CP State A, E or F according to IEC 61851-1
- The PEV detects CP State A, E or F according to IEC 61851-1

9.3.4 Timings, Parameters and Error Handling

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

9.3.4.1 Conventions

The following naming convention for timers is used in the Physical and Data Link Layer chapter. Timers are named according to this scheme:

- TP_{EV/EVSE}_NAME = [X; Y] {s/ms}
- TT_{EV/EVSE}_NAME = Y {s/ms}

Where the leading “T” stands for TIMER, followed by:

- T for TIMEOUT
- P for PERFORMANCE
- and X for MINIMUM TIME
- and Y for MAXIMUM TIME

The PEV/EVSE specifies on which side of the link, the timer is running. When nothing specific is specified, the timer runs on both sides of the link.

For examples:

“TP_EV_match_MNBC_interval = [10; 20] ms“

is a Performance Timer on the PEV side for the interval between transmitted M-SOUNDS with a minimum time of 10 ms and a maximum time of 20 ms.

“TT_EV_match_response = 200 ms“

is a Timeout Timer on the PEV side which counts the time between an PEV request and the anticipated response by the EVSE with a timeout value of 200 ms.

9.3.4.2 Difference between Performance and Timeout Timer

A Performance Timer on the EVSE side, for example, shall reach a value larger than the minimum time specified for this timer before the EVSE triggers the event associated with it (e.g., sending a specific message) but the EVSE shall trigger the event before the maximum time value specified for this timer is reached.

If the maximum time value is exceeded, this does not constitute a critical error and no action has to be taken. A Timeout Timer on the opposite side (PEV) is associated with the same event and shall trigger an error handling procedure if it reaches its maximum value specified.

In a Performance Timer and Timeout Timer pair, the maximum value of the Timeout Timer shall always be defined higher than the one of the Performance Timer (at least by twice the maximum possible message propagation time on the power line, but usually more).

[V2G-DC-586]

All Green PHY nodes shall comply with the two-part Figures 4A and 4B.

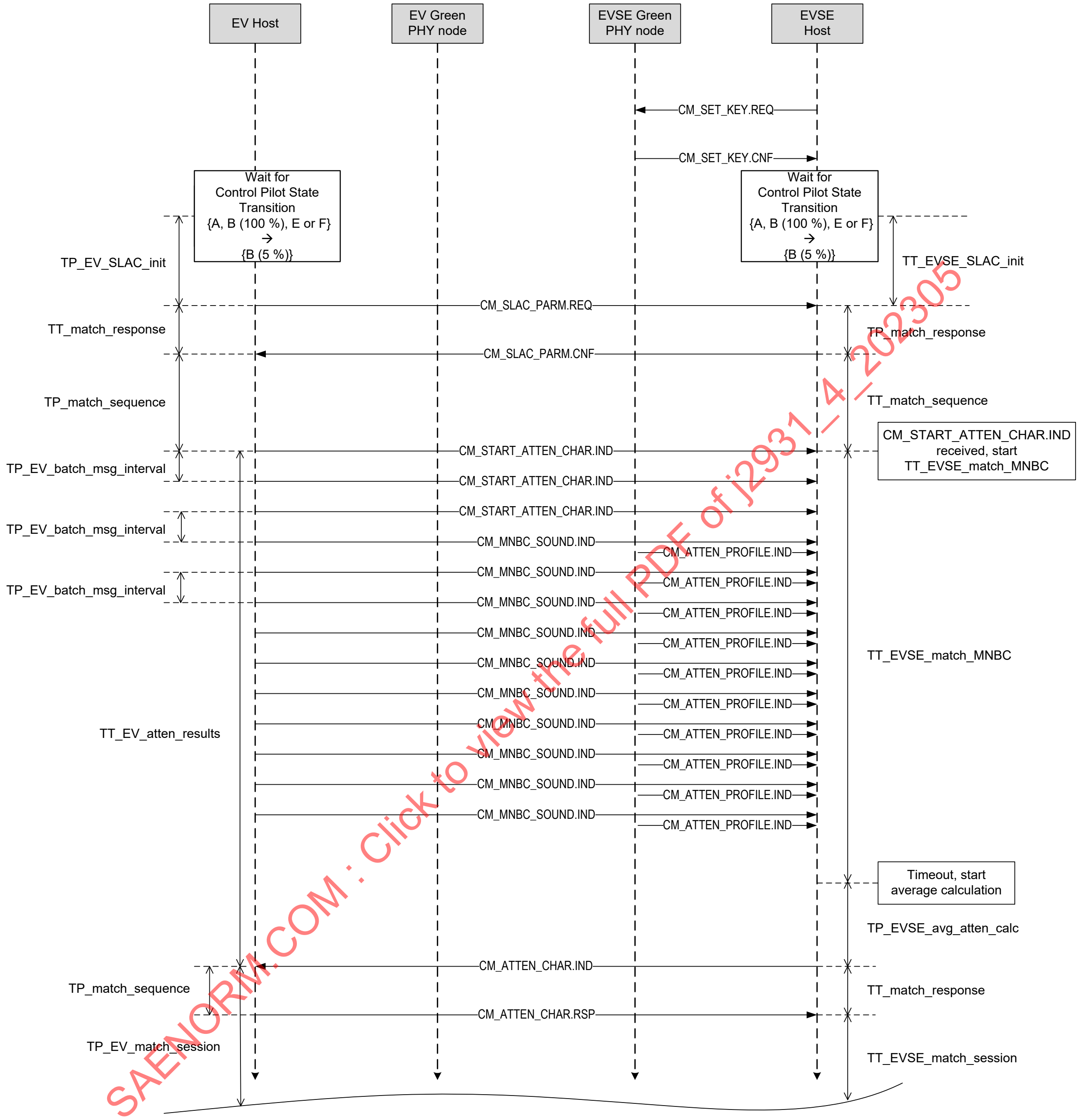


FIGURE 4A - MESSAGE SEQUENCE AND TIMING CHART

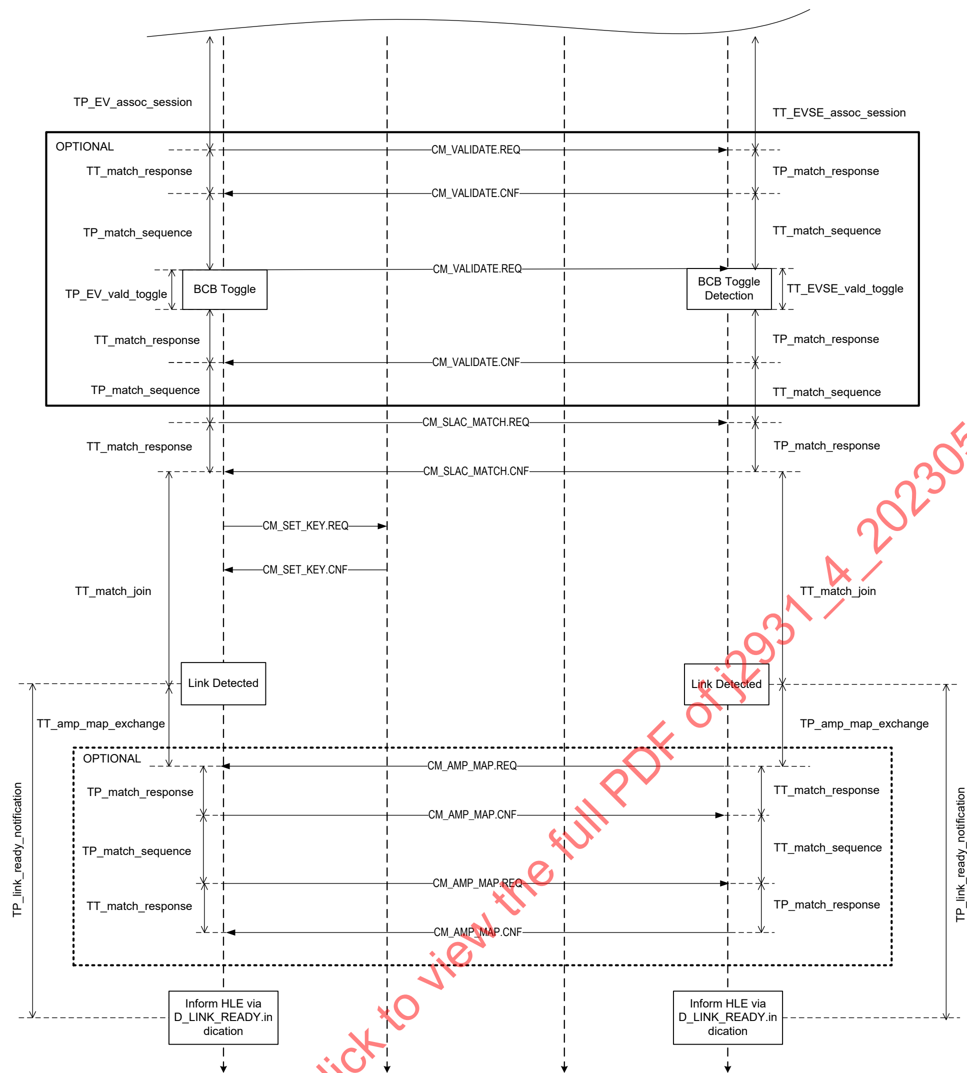


FIGURE 4B - MESSAGE SEQUENCE AND TIMEING CHART (CONTINUED)

[V2G-DC-519]

All Green PHY nodes shall comply with Table 6. Validation parameters are not used in this recommended practice.

TABLE 6 - TIMING AND PARAMETERS

PARAMETER	DESCRIPTION	MIN	TYPICAL	MAX	UNIT
TP_EV_SLAC_init	Time between detection of CP State B with 5% duty cycle or wake-up and sending CM_SLAC_PARM.REQ by the PEV			10	s
TT_EVSE_SLAC_init	Time the EVSE waits for receiving CM_SLAC_PARM.REQ after the EVSE detects CP State B with 5 % CP duty cycle	20			s
C_EV_match_retry	Number of retries of the corresponding message within the Matching process			2	nbr
TP_match_sequence	General performance time for subsequent requests after a response to previous request has been received			100	ms
TP_match_response	General performance time for a response to a request			100	ms
TT_match_response	Time that the PEV/EVSE shall wait for a response from the EVSE/PEV			200	ms
TT_match_sequence	Time that the EVSE/PEV shall wait for a request from the PEV/EVSE			400	ms
TT_EVSE_match_session	Maximum time from CM_ATTEN_CHAR.RSP received and the reception of either CM_SLAC_MATCH.REQ or CM_VALIDATE.REQ (not used in this recommended practice).			10	s
TP_EV_match_session	Performance time for the PEV to start the Validation (not used in this recommended practice) or SLAC_MATCH after sending CM_ATTEN_CHAR.RSP			500	ms
TT_match_join	Maximum time between CM_SLAC_MATCH.CNF and link establishment. If there is no link after this timeout expires, the PEV retries the Matching process and the EVSE resets its state machine.			12	s
TT_amp_map_exchange	Timeout timer that runs on both PEV and EVSE side after link is detected. If an PEV or EVSE does not want to start an AMP MAP Exchange and no request is received by the other side within the timeout value of this timer, then it is to be assumed that no AMP MAP Exchange will take place and a D-LINK_READY.indication notification shall be send to the HLE			200	ms
TP_amp_map_exchange	Performance timer for the start of an AMP MAP Exchange. Either the PEV or the EVSE shall send a CM_AMP_MAP.REQ within the max value of this timer after link is detected in order to trigger an AMP MAP Exchange			100	ms
TP_link_ready_notification	Performance Timer from Data Link detected to HLE information with D_LINK_READY primitive	0.2		1	s
C_vald_nb_toggles	Number of BCB Toggles (not used in J2931/5)	1		3	nbr
T_vald_state_duration	Duration of each CP State B or C within the BCB Toggle (not used in J2931/4)	200		400	ms

TP_EV_vald_toggle	Duration of BCB Toggle sequence (not used in J2931/4)	600		3500	ms
TT_EVSE_vald_toggle	Timeout timer for the EVSE to stop monitoring CP for BCB toggle. Value is received for CM_VALIDATE.REQ (not used in J2931/4)			3500	ms
T_vald_detect_time	Time to detect a variation of the CP State on EVSE side (not used in J2931/4)			200	ms
TP_EV_batch_msg_interval	Interval between two CM_START_ATTEN_CHAR.IND or CM_MNBC_SOUND.IND messages	20		50	ms
C_EV_match_MNBC	Number of M-Sounds sent for the SLAC	-	10	-	nbr
TT_EVSE_match_MNBC	Timeout on the EVSE side that triggers the calculation of the average attenuation profile (The duration is 600 ms ± system tolerances)	600	-	600	ms
TP_EVSE_avg_atten_calc	Performance time for the EVSE to calculate the average attenuation profile after reception of all M-SOUNDs or after TT_EVSE_match_MNBC has expired			100	ms
TT_EV_atten_results	Time the PEV shall wait for CM_ATTEN_CHAR.IND messages from EVSEs. Timer starts with the sending of the first CM_START_ATTEN_CHAR.IND			1200	ms
C_EV_match_signalattn_direct	Limit for signal strength measurement for direct connected EVSE		10		dB
C_EV_match_signalattn_indirect	Limit for signal strength measurement if no direct connected EVSE is found		20		dB
T_match_leave	Maximum time to leave the logical network (e.g. after D-LINK_TERMINATE.request)			1	S
C_EV_start_atten_char_inds	Number of CM_START_ATTEN_CHAR.IND messages to be sent		3		Nbr
T_conn_max_comm	Time after plug-in (detection of CP state B or Proximity pin) until the Green PHY node shall be ready for communication.			8	S

9.3.5 Error Handling

The following chapter defines the error handling for the Matching process and uses the following conventions:

Max(timer_name) is the maximum value a timer is allowed to reach before a timeout occurs.

Min(timer_name) is the minimum value that a timer shall reach before an action bound to this timer is performed.

9.3.6 General Error Handling and Timing Constraints

[V2G3-A09-126]

In any case a plug out is detected during the Matching process, the Matching process shall be quit in state “Unmatched” (see Figure 2).

[V2G3-A09-127]

In any case a Control Pilot state E or state F is detected during the Matching process, the Matching process shall be quite in state “Unmatched” (see Figure 2).

9.3.6.1 Error Handling for Signal Strength Measurement Parameter Exchange

Before the signal strength measurement starts, the PEV broadcasts the parameters to be used for the following signal strength measurement sequence by means of the message CM_SLAC_PARM.REQ. Any "Unmatched" EVSE that receives the parameter exchange broadcast sends a response to the PEV by means of the message CM_SLAC_PARM.CNF as shown in Figure 5.

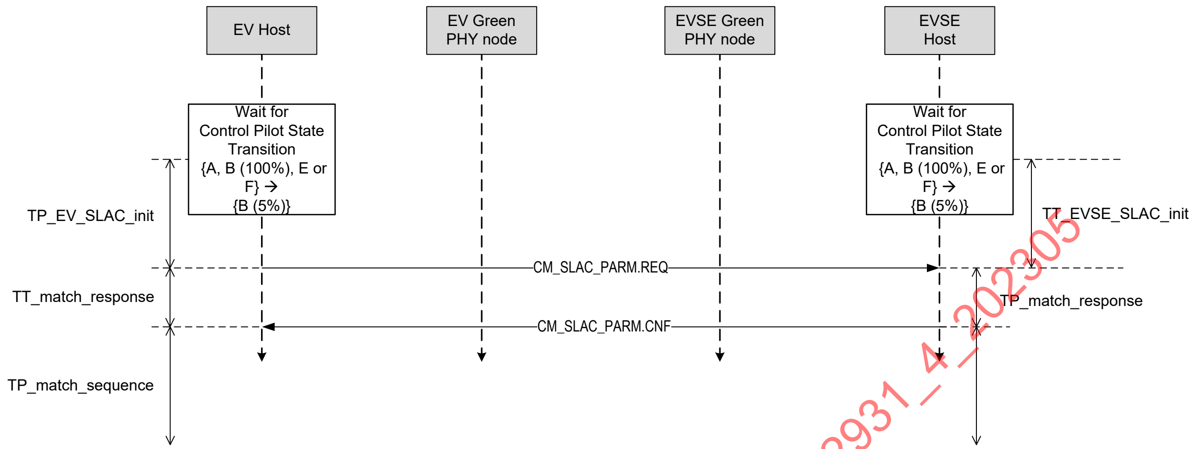


FIGURE 5 - CM_SLAC_PARM.REQ/CNF SEQUENCE CHART

9.3.6.1.1 Requirements for PEV Side

[V2G-DC-587]

If not in state "Matched", the PEV shall send at least one CM_SLAC_PARM.REQ before the timer TP_EV_SLAC_init expires.

[V2G-DC-588]

The start condition of the timer TP_EV_SLAC_init shall be CP State B with a CP duty cycle of 5 %.

[V2G-DC-589]

In the SLAC parameter exchange phase, the PEV shall send a CM_SLAC_PARM.REQ and wait for the maximum value of TT_match_response for CM_SLAC_PARM.CNFs from potential EVSEs.

[V2G-DC-590]

The start condition of TT_match_response shall be the transmission of CM_SLAC_PARM.REQ.

[V2G-DC-591]

If the PEV receives a CM_SLAC_PARM.CNF with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

[V2G-DC-592]

If no valid CM_SLAC_PARM.CNF arrives at the PEV when TT_match_response expires, the PEV shall retransmit the request and wait again for TT_match_response.

The total number of retries is given by C_EV_match_retry. If C_EV_match_retry is reached, the Matching process shall be considered to have FAILED.

9.3.6.1.2 Requirements for EVSE Side

[V2G-DC-593]

If not in state “Matched”, and as long as the timer TT_EVSE_SLAC_init is not expired, the EVSE shall answer to valid CM_SLAC_PARM.REQs.

[V2G-DC-594]

The start condition of the timer TT_EVSE_SLAC_init shall be CP State B with a CP duty cycle of 5 %.

[V2G-DC-596]

If the EVSE receives a CM_SLAC_PARM.REQ with invalid content, the EVSE shall ignore it and shall not stop the timeout timer TT_EVSE_SLAC_init. Content which deviates from the MME definition is invalid.

[V2G-DC-597]

When receiving a CM_SLAC_PARM.REQ, the EVSE shall answer by sending a CM_SLAC_PARM.CNF response within TP_match_response.

[V2G-DC-598]

If during a Matching process the EVSE receives a CM_SLAC_PARM.REQ from the PEV which participates in the ongoing Matching process, the EVSE shall restart its state machine and reply to this request because it shall be considered as a new retry by the PEV.

9.3.6.2 Error Handling for Signal Strength Measurement

Figure 6 illustrates the error handling sequence for signal strength measurement including validation which is not used in this recommend practice.

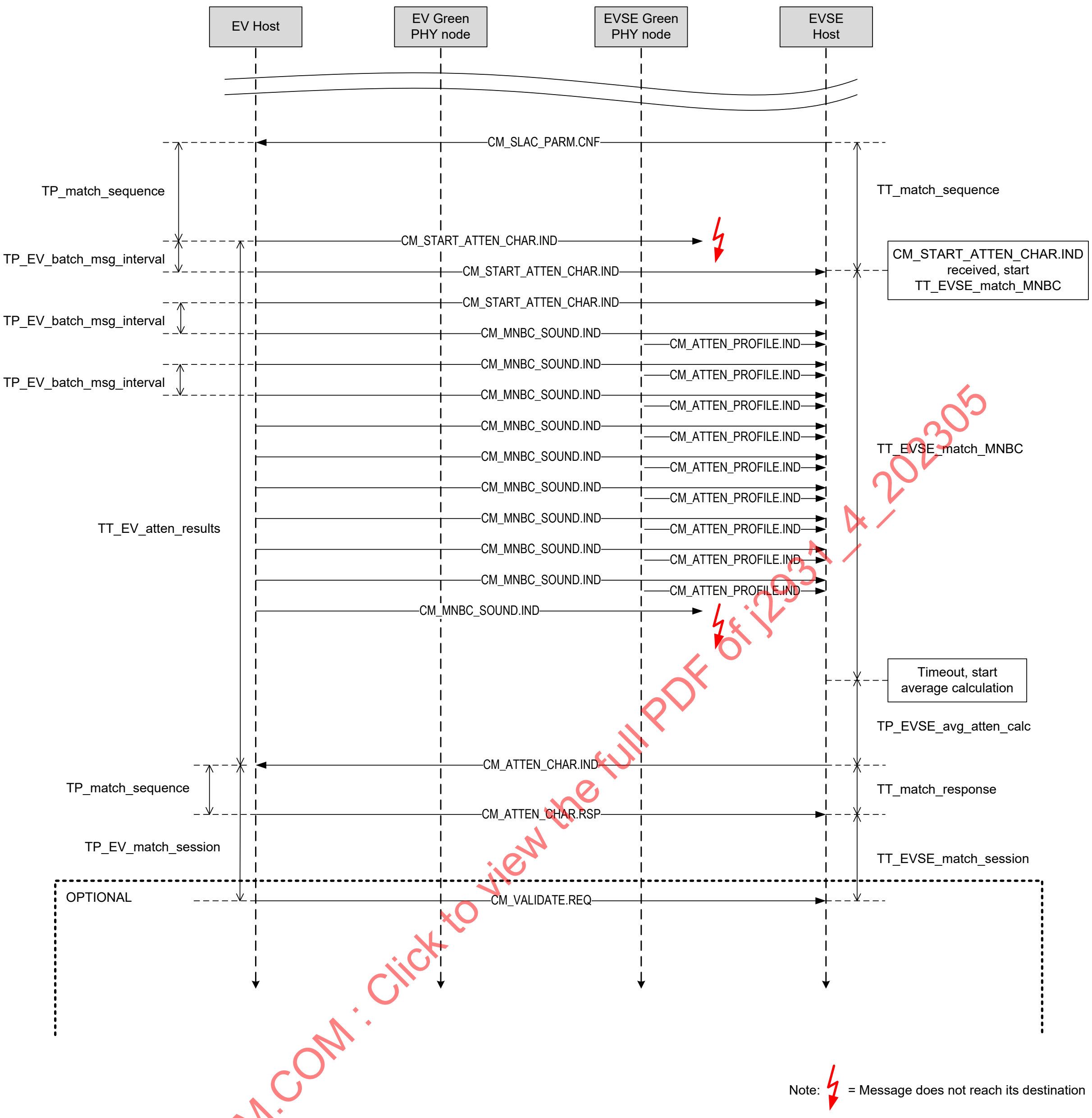


FIGURE 6 - SIGNAL STRENGTH MEASUREMENT SEQUENCE CHART

9.3.6.2.1 Requirements for PEV Side

[V2G-DC-674]

With receiving a CM_SLAC_PARM.CNF the PEV shall start the timer TP_match_sequence. When the TP_match_sequence timer expires the PEV shall send a sequence of C_EV_start_atten_char_inds CM_START_ATTEN_CHAR.IND messages.

[V2G-DC-675]

The time duration between consecutive CM_START_ATTEN_CHAR.IND messages shall be TP_EV_batch_msg_interval.

[V2G-DC-676]

After sending the last message of the CM_START_ATTEN_CHAR.IND message sequence the PEV shall wait for TP_EV_batch_msg_interval before starting the CM_MNBC_SOUND.IND message sequence.

[V2G-DC-677]

Within CM_MNBC_SOUND.IND message sequence the PEV shall transmit the CM_MNBC_SOUND.IND message C_EV_match_MNBC times. With each message the counter field “cnt” shall be decremented.

[V2G-DC-678]

The time duration between consecutive CM_MNBC_SOUND.IND messages is defined to TP_EV_batch_msg_interval.

[V2G-DC-679]

The PEV shall start the timeout timer TT_EV_atten_results when sending the first CM_START_ATTEN_CHAR.IND.

[V2G-DC-680]

While the timer TT_EV_atten_results is running, the PEV shall process incoming CM_ATTEN_CHAR.IND messages. If the CM_ATTEN_CHAR.IND messages from all EVSEs are received, which were recognized during the parameter exchange, the PEV is allowed to stop the TT_EV_atten_results timer and continue the Matching (Association) process.

To be able to service also EVSEs which were not received during the parameter exchange the PEV may wait for incoming CM_ATTEN_CHAR.IND messages until the TT_EV_atten_results timer expires before continuing the Matching (Association) process.

[V2G-DC-681]

If no CM_ATTEN_CHAR.IND is received before TT_EV_atten_results expires, the Matching process shall be considered to have FAILED.

[V2G-DC-682]

If a CM_ATTEN_CHAR.IND is received and its origin is an EVSE that has not sent a CM_SLAC_PARM.CNF before, the message shall be processed and not ignored.

[V2G-DC-683]

If the TT_EV_atten_results timer expires and not all anticipated responses are received, the PEV shall continue the Matching process.

[V2G-DC-684]

If the PEV receives a CM_ATTEN_CHAR.IND with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

[V2G-DC-685]

If the NUM_SOUNDS field in a CM_ATTEN_CHAR.IND is zero, then the ATTEN_PROFILE has no significance and the whole messages shall be ignored. It is up to the PEV to decide what number of M-SOUNDS used for the attenuation profile is sufficient for its decision (i.e. whether to discard CM_ATTEN_CHAR.IND if NUM_SOUNDs is less than C_EV_match_MNBC).

[V2G-DC-686]

On reception of CM_ATTEN_CHAR.IND, the PEV shall answer by sending the CM_ATTEN_CHAR.RSP within TP_match_sequence.

[V2G-DC-687]

After sending a CM_ATTEN_CHAR.RSP, the PEV shall continue the Matching process with the found and/or potentially found EVSEs by sending either a CM_SLAC_MATCH.REQ to the selected EVSE or a CM_VALIDATE.REQ (not used in this recommended practice) to one of the potential EVSEs within TP_EV_match_session.

9.3.6.2.2 Requirements for EVSE side

[V2G-DC-688]

With sending the CM_SLAC_PARM.CNF in the parameter exchange sequence the EVSE shall start a timer TT_match_sequence. The reception of a single valid CM_START_ATTEN_CHAR.IND message shall be sufficient stop the timer TT_match_sequence.

[V2G-DC-689]

If the EVSE has not received a CM_START_ATTEN_CHAR.IND within TT_match_sequence, the Matching process shall be considered to have FAILED.

[V2G-DC-690]

If the EVSE receives a CM_START_ATTEN_CHAR.IND with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

[V2G-DC-691]

Upon reception of a CM_START_ATTEN_CHAR.IND message, the EVSE shall start the TT_EVSE_match_MNBC timer.

[V2G-DC-692]

While the timer TT_EVSE_match_MNBC is running, the EVSE shall receive and process incoming CM_ATTEN_PROFILE.IND messages. If the anticipated number of CM_ATTEN_PROFILE.IND messages is not achieved, the EVSE shall keep listening for incoming CM_ATTEN_PROFILE.IND messages until the timer TT_EVSE_match_MNBC expires.

[V2G-DC-693]

If all M-Sound messages are received by the EVSE or the TT_EVSE_match_MNBC timer expires the EVSE shall compute (analyze and average) all received CM_ATTEN_PROFILE.IND messages within the time window given by the TP_EVSE_avg_atten_calc timer. This performance timer shall be started as soon as TT_EVSE_match_MNBC expires.

[V2G-DC-694]

After having computed all received data, the EVSE shall send a CM_ATTEN_CHAR.IND within TP_EVSE_avg_atten_calc and start the timer TT_match_response.

[V2G-DC-695]

If the EVSE has not received a CM_ATTEN_CHAR.RSP within TT_match_response, it shall retransmit a CM_ATTEN_CHAR.IND when the TT_match_response expires, and reset this timer. After C_EV_match_retry attempts, if no CM_ATTEN_CHAR.RSP is received by the EVSE, the Matching process shall be considered to have FAILED.

[V2G-DC-696]

If the EVSE receives a CM_ATTEN_CHAR.RSP with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

9.3.6.3 Error Handling for Logical Network Parameter Exchange

After the PEV has finished the Matching decision, it requests the parameter for the logical network from the selected EVSE by means of the message CM_SLAC_MATCH.REQ. The selected EVSE responses, as shown in Figure 7, to the PEV request with a CM_SLAC_MATCH.CNF, which contains all parameters to be set to join the logical network of the EVSE.

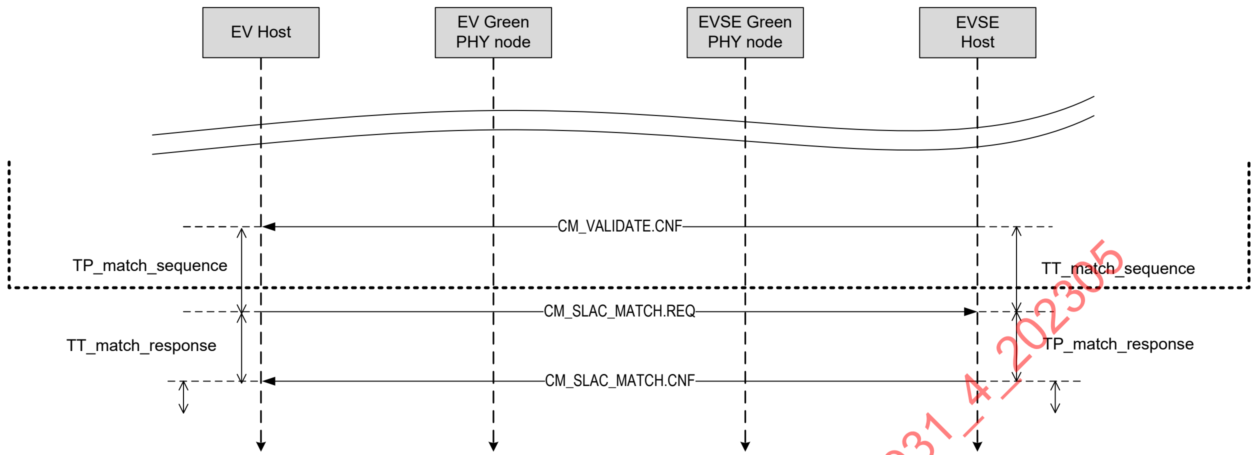


FIGURE 7 - LOGICAL NETWORK PARAMETER EXCHANGE SEQUENCE CHART

9.3.6.3.1 Requirements for PEV side

[V2G-DC-727]

If the PEV has sent a CM_SLAC_MATCH.REQ to the EVSE, but does not receive a valid CM_SLAC_MATCH.CNF within the max(TT_match_response), it shall retransmit the CM_SLAC_MATCH.REQ. The timer shall be restarted with any retry. A maximum of C_EV_match_retry retransmissions shall be performed. If after these retransmissions, the PEV has not received valid response within max(TT_match_response), the Matching process shall be considered to have FAILED.

[V2G-DC-728]

If the PEV receives a CM_SLAC_MATCH.CNF with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

9.3.6.3.2 Requirements for EVSE side

[V2G-DC-729]

According to the decision of the EV, if the EVSE does not receive either CM_SLAC_MATCH.REQ or CM_VALIDATE.REQ (not used in this recommended practice) within the maximum value of TT_EVSE_match_session, the EVSE shall assume that it is not connected to the PEV and shall consider the Matching process to have FAILED.

[V2G-DC-730]

If the EVSE receives another CM_SLAC_MATCH.REQ from the same PEV, this means that the PEV retransmitted its request for some reason (i.e. the CM_SLAC_MATCH.CNF was not received). The EVSE shall respond to the request again.

[V2G-DC-731]

If the EVSE receives a CM_SLAC_MATCH.REQ with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

[V2G-DC-732]

After receiving a CM_SLAC_MATCH.REQ, the EVSE shall answer by a CM_SLAC_MATCH.CNF within TP_match_response.

9.3.6.4 Error Handling for Joining the Logical Network

After the right Matching (Association) between PEV and EVSE is determined and the network parameters are exchanged, the PEV joins the logical network of the EVSE as shown in Figure 8, after which the broadcast domain is reduced to the Green PHY nodes directly connected.

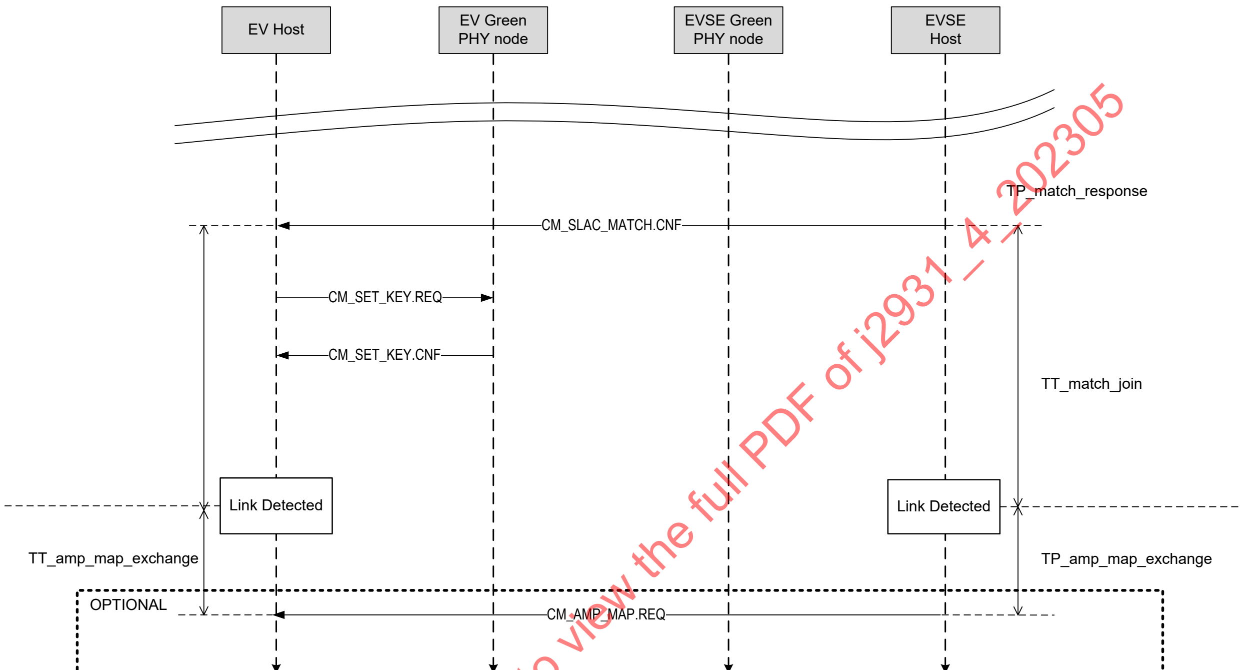


FIGURE 8 - JOINING THE LOGICAL NETWORK SEQUENCE CHART

9.3.6.4.1 Requirements for PEV side

[V2G-DC-599]

After receiving a CM_SLAC_MATCH.CNF from the EVSE, the PEV shall configure its Green PHY node to the values from this message by using the CM_SET_KEY.REQ MME.

NOTE 1: In a specific implementation, other methods than the CM_SET_KEY MMEs may also be used as long as the configuration result is equivalent.

NOTE 2: It is up to the implementation how to handle a negative response in a CM_SET_KEY.CNF or a missing CM_SET_KEY.CNF.

[V2G-DC-600]

If no link is established within the max(TT_match_join) after receiving CM_SLAC_MATCH.CNF, the PEV shall consider the Matching process to have FAILED.

9.3.6.4.2 Requirements for EVSE Side

[V2G-DC-601]

After sending a CM_SLAC_MATCH.CNF containing a NMK and a NID, the EVSE shall start its TT_match_join timer. This timer ends when the CCo detects a link in its logical network.

[V2G-DC-602]

If no link is detected when the TT_match_join timer expires, the EVSE shall consider the Matching process to have FAILED.

[V2G-DC-603]

The EVSE shall configure its Green PHY node to the NID and NMK values sent in CM_SLAC_MATCH.CNF at the latest after sending the CM_SLAC_MATCH.CNF. The configuration can also be done at any time before (e.g., after unplugging a previous PEV). The configuration shall be done by sending a CM_SET_KEY.REQ.

NOTE: If the EVSE needs to configure its NMK and NID after the CM_SLAC_MATCH.CNF, it should consider that the just sent CM_SLAC_MATCH.CNF may get lost and the PEV will send a CM_SLAC_MATCH.REQ retry within TT_match_response. Within this time, the EVSE should not be blind, due to the configuration process, for the incoming CM_SLAC_MATCH.REQ retry.

9.3.6.5 Error Handling for Amplitude Map Exchange

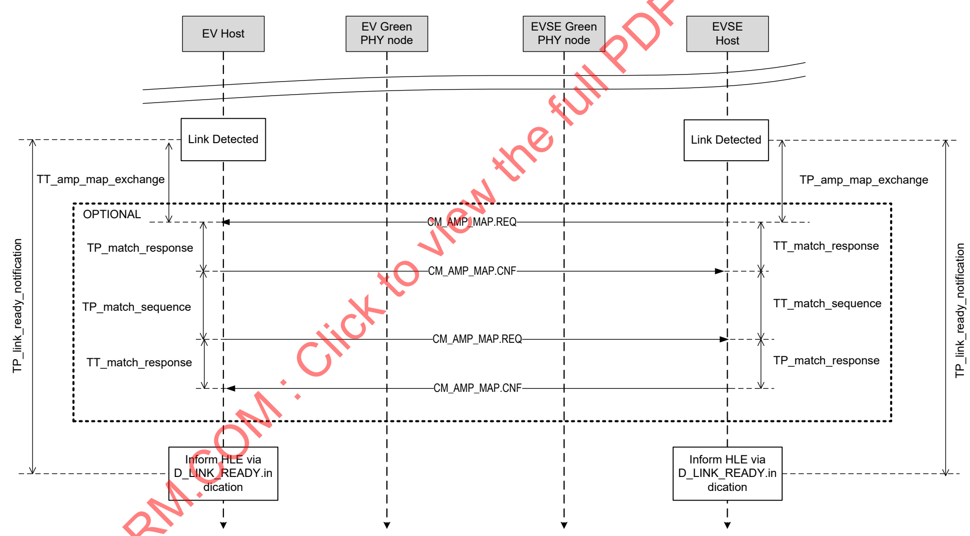


FIGURE 9 - AMPLITUDE MAP EXCHANGE SEQUENCE CHART

9.3.6.5.1 Requirements for PEV and EVSE Side.

[V2G-DC-604]

If a Green PHY node needs to request an amplitude map exchange from the counterpart device, the CM_AMP_MAP.REQ shall be sent within TP_amp_map_exchange. The timer TP_amp_map_exchange shall be started with the detection of other stations in the current logical network after the SLAC_MATCH exchange.

[V2G-DC-605]

If a Green PHY node has sent a CM_AMP_MAP.REQ, but does not receive a valid CM_AMP_MAP.CNF within the max(TT_match_response), it shall retransmit the CM_AMP_MAP.REQ. The timer shall be restarted with any retry. A maximum of C_EV_match_retry retransmissions shall be performed. If after these retransmissions, the Green PHY node has not received valid response within max(TT_match_response), the Matching process shall be considered to have FAILED.

[V2G-DC-606]

If a Green PHY node receives a CM_AMP_MAP.REQ with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

[V2G-DC-607]

If a Green PHY node receives a CM_AMP_MAP.CNF with invalid content, it shall be ignored. Content which deviates from the MME definition is invalid.

[V2G-DC-608]

After receiving a CM_AMP_MAP.REQ within TT_amp_map_exchange, a Green PHY node shall answer with a CM_AMP_MAP.CNF within TP_match_response. The timer TT_amp_map_exchange shall be started with the detection of other stations in the current logical network.

[V2G-DC-609]

If the requested node receives another CM_AMP_MAP.REQ, this means that the PEV retransmitted its request for some reason (i.e., the CM_AMP_MAP.CNF was not received), the requested node shall respond to the request again.

[V2G-DC-610]

If the timer TT_amp_map_exchange expires without receiving a CM_AMP_MAP.REQ from the counterpart Green PHY node and without sending a CM_AMP_MAP.REQ, the D_LINK_READY(LINK_Established) shall be sent to higher layers.

[V2G-DC-611]

If an amplitude map exchange is initiated by one of the Green PHY nodes in the logical network, the higher layer shall be informed about the valid Green PHY Link not before the Link is re-established after the amplitude map exchange and the local configuration of the modified amplitude map is done.

[V2G-DC-612]
The time between the detection of other stations in the current logical network after the SLAC_MATCH exchange and the indication D_LINK_READY(LINK_Established) to higher layers shall not exceed the performance timer TP_link_ready_notification.

9.3.6.6 Miscellaneous Error Handling Rules

[V2G-DC-613]

In case the Matching process fails due to an error, the Matching process shall be quit in “Unmatched” state (see Figure 2). This error shall be handled by the connection coordination module.

[V2G-DC-614]

In case a plug-out is detected during the Matching process by the proximity pin, the Matching process shall be assumed to have FAILED.

[V2G-DC-615]

In case a CP State E or CP State F is detected during the Matching process, the Matching process shall not be interrupted.

9.3.7 EMC Requirements

[V2G-DC-616]

All Green PHY nodes shall notch out (turn off) the carriers listed in Table 7.

TABLE 7 - NOTCHED CARRIERS

CARRIERS
0-85
140-167
215-225
283-302
410-419
570-591
737-748
857-882
1016-1027
1144-1535

NOTE: This table equals to the North American Tone Mask of the HomePlug Green PHY v1.1 specification. Additional EMC requirements are defined in IEC 61851-1 and IEC 61851-23.

10. SIGNAL COUPLING

10.1 Overview

As shown in the previous sub-clauses the physical layer is divided into two parts: The Green PHY communication and the basic signaling 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 control pilot line (CPL) to enable bidirectional HomePlug Green PHY communication between one EVSE and one PEV.

HomePlug Green PHY signals are compliant with the HomePlug Green PHY v1.1 specification. The target is to enable bidirectional HomePlug Green PHY communication between one EVSE and one PEV, while the CPLT simultaneously works according to IEC 61851-1.

As Green PHY signal coupling is directly linked to the Control Pilot, the schematic in IEC 61851-1, Annex A specification is basis for definitions regarding the Control Pilot signal.

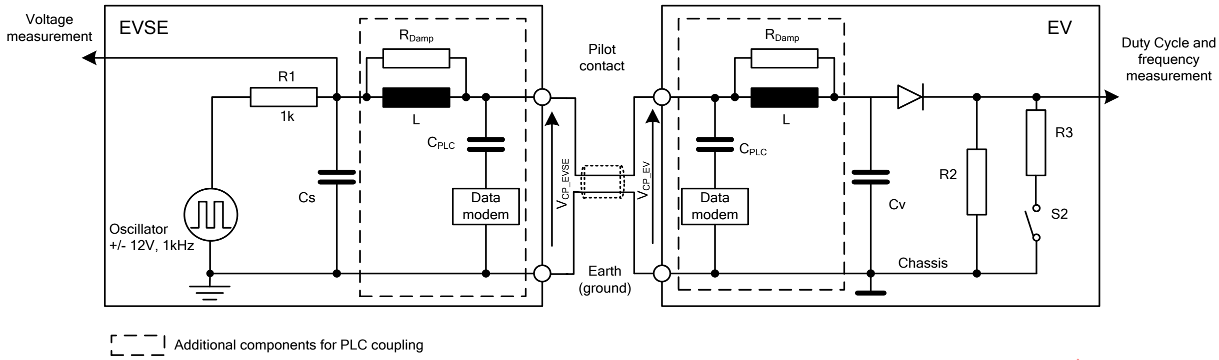
To enable Green PHY injection, the path from EVSE’s output to the PEV’s input should not be considered as capacitive only, as it is sufficient for the low frequency Control Pilot signal. Instead, for HomePlug Green PHY communication (which are high frequency signals), the path should be considered as a transmission line. Taking high frequency into account, the Control Pilot circuit and the component values have are specified more detailed.

For the Control Pilot Line, the additional capacity of the HomePlug Green PHY coupling circuit has to be considered. For the Green PHY signal, the partitioning of the capacitive load of the PEV, EVSE and the charging cord is important and is described in this chapter.

10.2 General Drawing for Green PHY Injection

[V2G-DC-071]

All technical requirements described in this subclause shall assume to have a dedicated pair of Green PHY chips implemented for the couple (EVSE, PEV), linked by a CPL wire. Figure 10 depicts an implementation of parallel injection and gives definitions used further.



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 shown as equivalent components, which can be implemented with more than one component, for example 2 capacitors, as long as the requirements about values given Table 8 below is fulfilled.

NOTE 4: L and R_{Damp} associated with capacitors, form low pass filters, which enable the normal working of the CPL and the PLC communication at the same time. They enable to affect low frequency signals to the CPL and high frequency ones to the PLC. R_{Damp} resistors limit resonance effects of RLC filters thus constituted.

NOTE 5: It is highly recommended to apply at least a 1st order low pass filter with a cutoff frequency of 100 kHz to 200 kHz when making measurements on the control pilot signal (e.g., duty cycle or amplitude), so as not to disturb the measurement by high frequency PLC signals.

FIGURE 10 – IMPLEMENTATION EXAMPLE OF A PARELLEL INJECTION CIRCUIT WITH A PLC COUPLING TRANSFORMER

[V2G-DC-072]

Signal coupling shall operate on a point to point basis with only one Green PHY node on the EVSE side connected to one Green PHY node on the PEV side.

[V2G-DC-075]

In case of parallel injection, the Green PHY signal shall be coupled between the CPL and the Protective Conductor (PE) wire.

[V2G-DC-076]

In case of parallel injection, the Green PHY injection circuit on EVSE side shall be wired to the CPL and the PE. Additional components, such as EMC or ESD protection, should not affect the Green PHY signals.

[V2G-DC-077]

In case of parallel injection, the Green PHY injection circuit on PEV side shall be wired to the CPL and ground. Additional components, such as EMC or ESD protection, should not affect the Green PHY signals.

[V2G-DC-533]

Green PHY communication shall work with any CP duty cycle or CP State as defined in IEC 61851-1.

[V2G-DC-078]

A proper formatting of the CPL raw signal shall be implemented on EVSE side to ensure IEC 61851-1 compliancy in presence of an additional Green PHY communication signal.

10.3 Signal Requirement for Green PHY Injection

The following table gives requirements that physical signals shall comply with in order to enable Green PHY injection into the CPL, according to previous requirements.

NOTE: The Green PHY signal shall be added to the CPLT signal on the CPL. The resulting signal should be the algebraic sum of the PWM CPLT signal and the Green PHY signal.

[V2G-DC-081]

The CPL and the PE wires shall be regarded as a transmission line for the Green PHY signal, with characteristic impedance as defined in Table 8.

TABLE 8 - SIGNAL REQUIREMENTS FOR PARALLEL GREEN PHY INJECTION TO CONTROL PILOT

PARAMETER	CONDITIONS AND COMMENTS	MIN	TYP	MAX	UNIT	NOTE
Length of the charging cable				10	M	
$C_{Green\ PHY}$	See definition above	-	1.35		nF	3,4
R_{Damp}	See definition above	-	220	1000	Ω	4
L	See definition above	-	220		µH	3,4
C_S	See definition in IEC 61852-1				pF	1,3
C_V	See definition in IEC 61851-1				pF	1,3
Power Spectral Density of Green PHY signals at V_{CP_EVSE} and V_{CP_EV} Measurement method defined in 10.4.3	From 1.8 to 30MHz, RBW=9kHz on 50Ω. All used carriers		-75		dBm/Hz	
Peak-Peak Voltage of Green PHY signals at V_{CP_EVSE} and V_{CP_EV}	CPL signal steady at high or low level – 1 Green PHY communication actually emitting at a time (peak to peak) – PEV connected to the EVSE with the charging cord. Measured at max PSD level of Green PHY communication with example of injection circuit given below.	-	1.3		Vpp	2,3
Conducted Green PHY Crosstalk from CPL to the Mains (via power supply) (voltage between any live or neutral wire and PE/CPL)	From 2 MHz to 28 MHz			-40	dB	

NOTE 1: Any capacitance on the CPL which is directly connected between CPL and ground should be as small as possible, so as not to excessively attenuate the Green PHY signal. Most of the capacitive load should be separated from the high frequency Green PHY signal with the inductor L.

NOTE 2: At given impedance, the maximum peak to peak amplitude directly linked to the PSD is also defined in Table 8. For the purpose of limiting the impact of the high frequency Green PHY 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 values of C_s and C_v are defined by IEC 61851-1 Annex A.

NOTE 4: Parameters in Table 8 are to be considered with parallel injection only, as defined in Figure 11.

10.4 Signal Transmission Path and Signal Measurement

This sub-clause defines a typical transmission path for the Green PHY signal. This includes PSDs, attenuations and measurement procedures. Especially the SLAC method for measuring the signal strength needs a well-defined power level for signal transmission.

10.4.1 Typical Transmission Path

Figure 11 shows the transmission path for the Green PHY signal with example values for PSD attenuations and calculations. All PSD and attenuation values are intended as a list of values over carrier groups, single values in the following description are given for simplification only. The attenuations are assumed as example values as follows:

- AttnRxEV is the insertion loss of the receiving path between the Green PHY transceiver and the charge coupler on PEVside. In the example, a value of 5 dB is assumed (e.g. through to transformers, lines, coupling components);
- AttnTxEV is the insertion loss of the transmitting path between the Green PHY transceiver and the charge coupler on PEVside. In the example, a value of 4 dB is assumed (e.g. through to transformers, lines, coupling components);
- AttnRxEVSE is the insertion loss of the receiving path between the Green PHY transceiver and the charge coupler on EVSE side. In the example, a value of 3 dB is assumed (e.g. through to transformers, lines, coupling components);
- AttnTxEVSE is the insertion loss of the transmitting path between the Green PHY transceiver and the charge coupler on EVSE side. In the example, a value of 5 dB is assumed (e.g. through to transformers, lines, coupling components);
- AttnCord is the insertion loss of the charge cord itself. In the example, a value of 2dB is assumed.

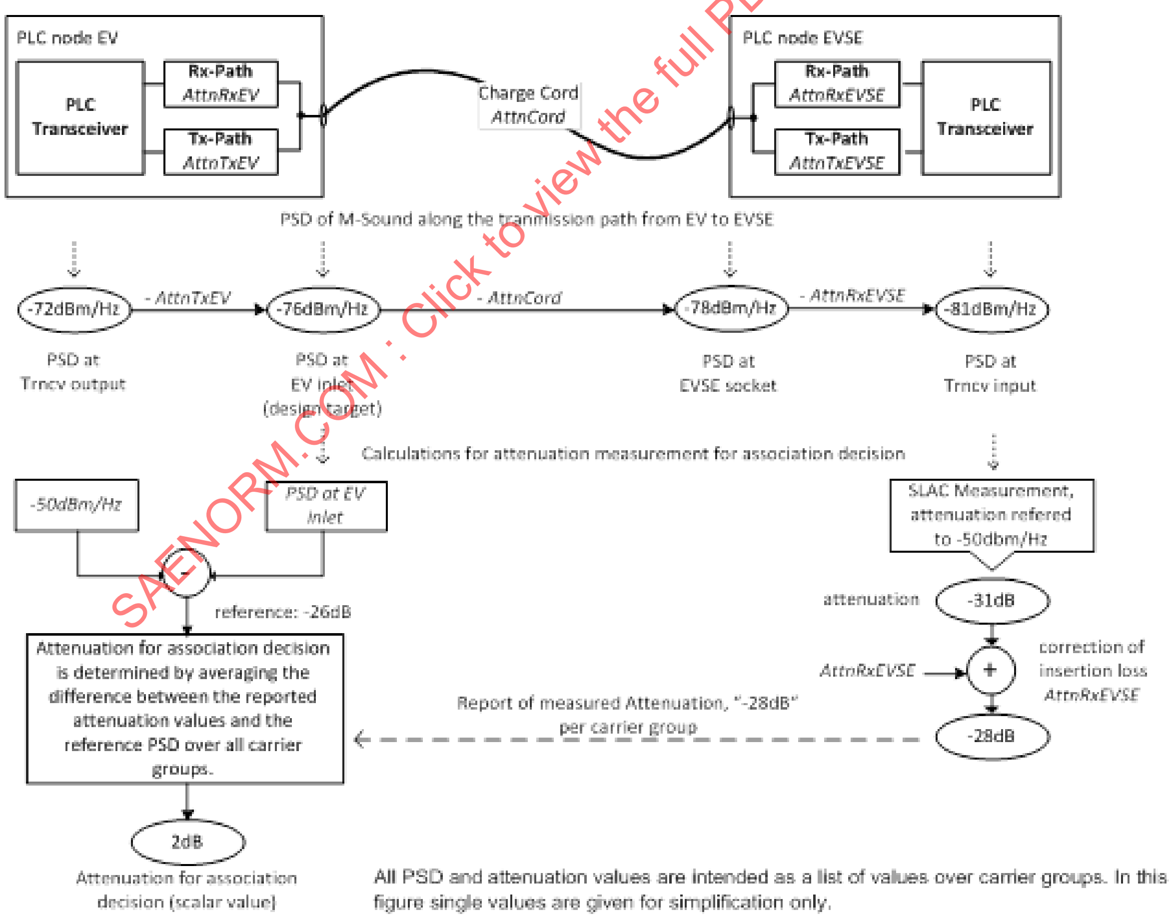


FIGURE 11 - HOMEPLUG GREEN PHY TRANSMISSION PATH EXAMPLE

In the example, the design target is to achieve a PSD at the inlet of device of -76 dBm/Hz over the Green PHY spectrum. Due to insertion losses in the transmission path (AttnTxEV), the output power of the transceiver (-72dBm/Hz) has to be higher to compensate the attenuation AttnTxEV. The way of measuring the PSD for the transmission path is given in 10.4.3.

The charge cord attenuates the Green PHY signal by AttnCord, which leads in the example to a PSD at the counterpart socket-outlet of -78 dBm/Hz. Within the EVSE, the Green PHY signal is also affected by an insertion loss (AttnRxEVSE) of the Rx path from the socket-outlet to the transceiver.

10.4.2 Calibration and Correction

Rx-Path on EVSE side:

The Green PHY node on PEV side does not know the value of AttnRxEVSE. Since this value has an impact on the SLAC measurement, the EVSE has to correct the measurement values by AttnRxEVSE before reporting the values back to the PEV.

Tx-Path:

Any Green PHY node has to comply with the transmission power given by the PSD range in Table 8. The measurement procedure to be used is given in 10.4.3.

Beside the requirement for all Green PHY nodes to comply with the defined PSD values, on the PEV side the exact knowledge of the PSD at the inlet is required as a reference for reported attenuation profiles from EVSEs. Any received attenuation profile from an EVSE has to be compared against the reference value given by the Tx-PSD at the inlet minus the -50 dBm/Hz reference defined for the SLAC measurement.

10.4.3 Conditions of Measurement

This section specified the measurement setup (Figure 12) and procedure to determine the electrical characteristic of the transmitted signal of a V2G-device in the frequency domain by means of a power spectrum density (PSD). The numeric values for the PSD is defined in Table 8 and assures a comparable signal characteristic within a certain tolerance range across V2G devices.

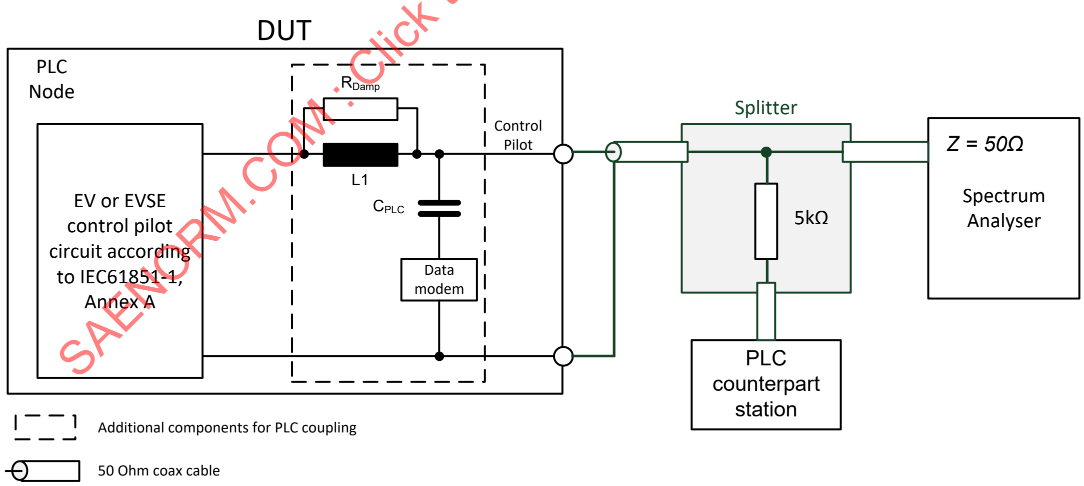


FIGURE 12 - MEASUREMENT SETUP

The process defined in this section assumes a 50 Ohms load between the Control Pilot terminal and the ground conductor. All output voltages are specified as the voltage measured at the Control Pilot and ground terminals of the Green PHY 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 Green PHY counterpart station shall be connected to the device under test (DUT), to allow data communication during the measurement. The counterpart station shall be separated by a 5 kΩ resistor to isolate the station‘s input impedance on the measurement.

[V2G-DC-536]

The Green PHY counterpart station shall be compliant with the specified coupling circuit and transmission power.

[V2G-DC-537]

A spectrum analyzer with 50 Ω input impedance shall be connected to the communication line.

[V2G-DC-538]

All passive components in the signal path shall be 50 Ω compliant parts and their insertion loss shall be taken into account.

[V2G-DC-540]

During the whole measurement process, the DUT shall transmit with at least 20% of the maximum PHY data rate.

[V2G-DC-617]

For the measurement of the Green PHY PSD, the Green PHY node shall support an operation mode which allows to transmit / receive without Control Pilot signal. Otherwise, the measurement resistance of 50 Ohms will force an undefined state on the Control Pilot.

[V2G-DC-541]

The measurement shall be compliant with the following procedure:

1) The input attenuator of the spectrum analyzer should be set in a proper way to avoid overloading the measurement device.
2) The instrument should be set to measure the peak power in a 9 kHz resolution bandwidth (dBm/9 kHz).
3) Record the whole carrier band from 1.8 to 30 MHz with a hold time of at least 10 ms per sample point.
4) Determine the spectrum analyzer’s equivalent noise power bandwidth for the 9 kHz filter.
5) 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).

10.5 Parallel Injection Drawing Example

Based on the signal and signal path specification above, the following section is an implementation example for the parallel Green PHY injection on the CPL.

Figure 13 shows an implementation example based on the generic circuit in Figure 10.

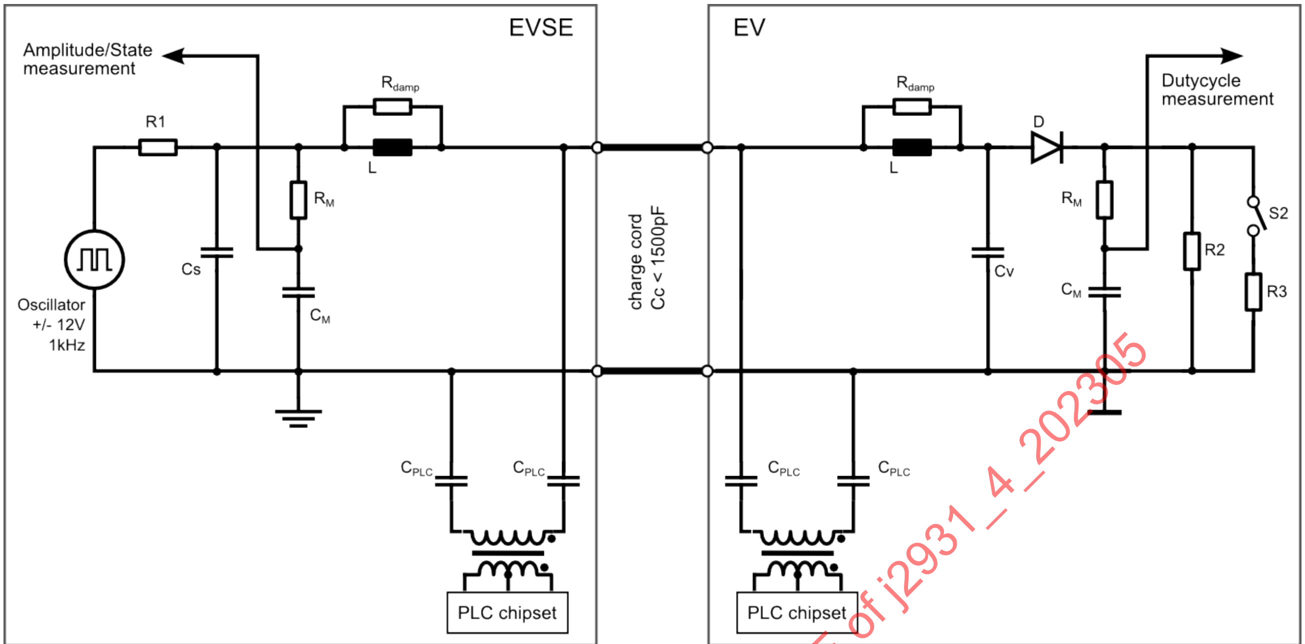


FIGURE 13 - IMPLEMTATION EXAMPWITH GREEN PHY COUPLING TRANSFORMER

For the implementation example in Figure 13, the component values defined in Table 9 should be applied.

TABLE 9 - EXAMPLE GREEN PHY COUPLING IMPLEMENTATION COMPONENT VALUES

COMPONENT	VALUE
R1	IEC 61851-1
R2	IEC 61851-1
R3	IEC 61851-1
R_M	10 kΩ
C_M	100 pF
C_V	IEC 61851-1
C_S	IEC 61851-1
$C_{GreenPHY}$	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 µH
R_{Damp}	220 Ω

10.6 Filtering Requirements

10.6.1 Overview

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

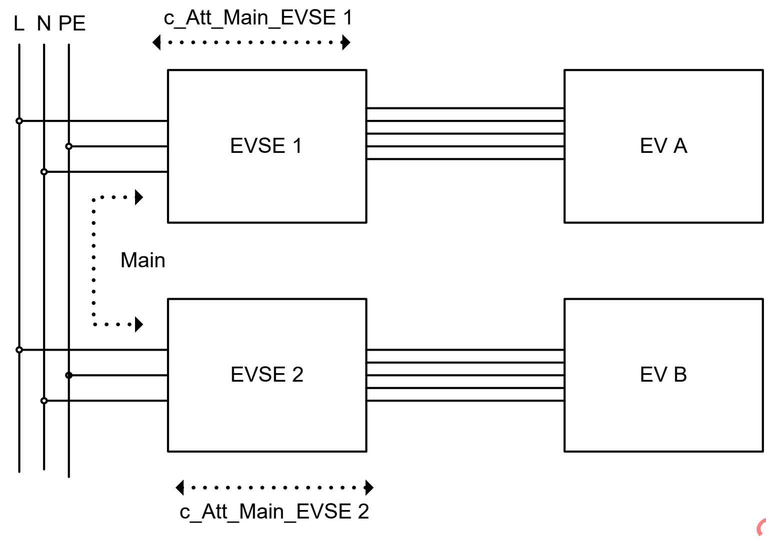


FIGURE 14 - EXAMPLE - SOURCES OF CROSSTALK

[V2G-DC-088]

When designing EVSE and PEV (EV) systems, the operational frequency band of the Green PHY technology (approximately 2 - 30 MHz) shall be taken into account. Filters should only affect the used frequency band.

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

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

10.6.2 Example of Crosstalk Filter Implementation

Figure 15 illustrates an example of a valid filter, in case the Green PHY signal crosstalk to the Mains lines, including the PE. It can be improved with additional serial inductances on Mains' side in order to avoid excessive filtering of other Green PHY networks on their side.

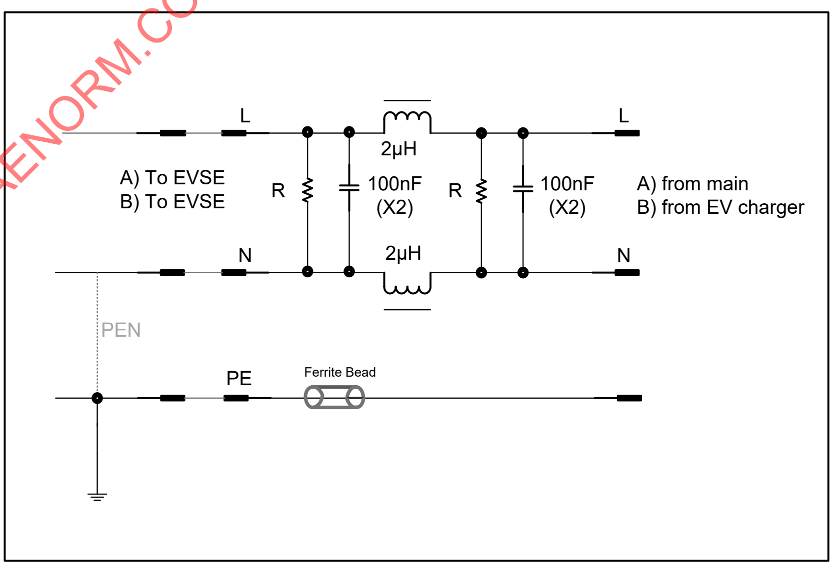


FIGURE 15 - EXAMPLE OF VALID CROSSTALK FILTER

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

11. ACRONYMS

1901	IEEE Std 1901-2010™ Power Line Communications Standard
AC	Alternating Current or PLC Access System
AKA	Also Known As
AM	Amplitude Modulation
CP	Control Pilot
CAP	Channel Access Priority
CCo	Central Coordinator
CP	Control Pilot
CPL	Control Pilot Line
CPLT	Control Pilot Line Transmission
ETH	Ethernet
EUMD	End Use Measurement Device
EV	Electric Vehicle (see also PEV)
EVSE	Electric Vehicle Supply Equipment
HAN	Home Area Network
H1	HLE 1 interface
HLE	Higher Layer Entity
ISP	Inter System Protocol
kHz	kilo Hertz
M1	MAC 1 interface
MAC	Medium Access Controller
MHz	mega Hertz
MME	Management Message Entry
MPDU	MAC Protocol Data Unit
NEK	Network Encryption Key
NMK	Network Management Key
NWP	Network Password
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open System Interconnection
PAL	Protocol Adaptation Layer
PE	Protective Earth
PEV	Plug-in Electric Vehicle (see also EV)
PHY	Physical Layer
PLC	Power Line Communications
RFC	Request for Comments
ROBO	Robust OFDM
SAP	Service Access Point
SLAC	Signal Level Attenuation Characterization
STA	Station
TYP	Typical

12. NOTES

12.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, or in documents that contain editorial changes only.

NOTE: One or more patents may apply to one or more aspects of the standards or the entire standard. By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith.

The patent holder(s) has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license for the purpose of complying with the standard. Details may be obtained from SAE International at: http://www.sae.org/standardsdev/patents.htm

SAE International acknowledges that original DIN SPEC 70121, with DIN permission, was used in relevant parts of this SAE J2931/1 standard.

PREPARED BY THE SAE HYBRID – PEV COMMITTEE

APPENDIX A – BROADCAST DEFINITIONS

(informative)

This section explains the difference between the terms Multi-Network Broadcast, Broadcast, and Unicast because the terms “Broadcast” and “Unicast” used in DIN SPEC 70121 and “Multi-Network Broadcast” used in the Green PHY Spec, this annex will try to clarify the difference.

Multi-Network Broadcast (MNBC) is a term defined in the Green PHY Specification. It is a transmission mechanism that enables exchange of management messages between stations that are not part of the same HomePlug AV logical network (AVLN). The stations may be part of different AVLNs or not associated to an AVLN at all.

Since the purpose of SLAC is to make connected PEV and EVSE Associate (build the correct PEV-EVSE logical network), it makes use of MNBC because in the initial state the PEV and EVSE have different NMK and NID pairs and are not part of the same AVLN. MNBC enables PEV SLAC messages to be received at the EVSE and vice versa.

All SLAC messages are sent as MNBC. An application running in the HLE and sending MMEs cannot choose whether the MMEs shall be sent as MNBC. This decision is made automatically by the Green PHY protocol.

Broadcast and Unicast are terms that describe the destination address in the Ethernet header of an MME. This is the layer above Green PHY, so the terms are in no relation to Multi-Network Broadcast.

If a unicast MME is sent as an MNBC, it will be received by all stations in range (whether or not it is of the same AVLN) but the MAC filter in the Green PHY node will not forward it to the HLE if this unicast address does not match the address of the recipient station. If the Ethernet destination address is broadcast, then the message will be forwarded to the HLE.

On the other hand, an MME that is not part of the SLAC process will not transmitted as an MNBC by the Green PHY node and will only be received by stations part of the same AVLN. It will then be forwarded to their HLEs if it has a broadcast Ethernet destination address or if it is sent as unicast and the address matches the address of the recipient.

Thus, looking at the Green PHY Specification and DIN SPEC 70121, one has to differentiate between MNBC and Broadcast / Unicast. All SLAC messages are sent as MNBC by the Green PHY chip and the user cannot affect this. The user can only choose what the destination address of the Ethernet header will be. Generally, messages from PEV to EVSE shall be sent as broadcast, except CM_ATTEN_CHAR.RSP, CM_VALIDATE.REQ (not used in this recommended practice) and CM_SLAC_MATCH.REQ. Messages from EVSE to PEV shall be sent as unicast. CM_AMP_MAP.REQ/CNF and CM_SET_KEY.REQ shall also be sent as unicast.

APPENDIX B - DIN 70121 CROSS REFERENCE

(Informative)

The following table is intended to cross reference the content of DIN 70121 to J2847/2, J2931/1 and this document, J2931/4.

	DIN Sections	Description	Rqmt	J2847/2		J2931/1		J2931/4	
1	6.2.2	Applicability	**[V2G-DC-001]**	4.1.3.2	Applicability			4.3.2	Applicability
2	6.2.2	Applicability	**[V2G-DC-002]**	4.1.3.2	Applicability			4.3.2	Applicability
3	6.2.3	Usage of RFC references	**[V2G-DC-003]**	4.1.3.3	Usage of RFC references			4.3.3	Usage of RFC references
4	6.2.3	Usage of RFC references	**[V2G-DC-004]**	4.1.3.3	Usage of RFC references			4.3.3	Usage of RFC references
5	8.3.1.1.1	Basic Signaling	**[V2G-DC-005]**	4.1.1	Message sequences				
6	8.3.1.1.1	Basic Signaling	~~**[V2G-DC-006]**~~						
7	8.3.1.1.2	High-Level Communication (HLC)	~~**[V2G-DC-008]**~~						
8	8.3.3.2	Initialization of the Matching process	**[V2G-DC-014]**					9.2	Initialization of the matching process
9	8.3.3.2	Initialization of the Matching process	**[V2G-DC-018]**					9.2	Initialization of the matching process
10	8.3.3.2	Initialization of the Matching process	**[V2G-DC-019]**					9.2	Initialization of the matching process
11	8.3.3.2	Initialization of the Matching process	**[V2G-DC-020]**					9.2	Initialization of the matching process
12	8.3.1.4.2.1	Inter System Protocol (ISP)	**[V2G-DC-021]**					7.2.1	Inter System Protocol (ISP)
13	8.3.3.2	Initialization of the Matching process	**[V2G-DC-024]**					9.2	Initialization of the matching process
14	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-029]**					9.3	Discovery of the connected Green PHY node on EVSE side
15	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-030]**					9.3	Discovery of the connected Green PHY node on EVSE side
16	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-031]**					9.3	Discovery of the connected Green PHY node on EVSE side
17	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-032]**					9.3	Discovery of the connected Green PHY node on EVSE side
18	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-034]**					9.3	Discovery of the connected Green PHY node on EVSE side
19	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-035]**					9.3	Discovery of the connected Green PHY node on EVSE side
20	8.3.3.3	Discovery of the connected Green PHY node on EVSE side	**[V2G-DC-038]**					9.3	Discovery of the connected Green PHY node on EVSE side

	DIN Sections	Description	Rqmt	J2847/2		J2931/1		J2931/4	
21	8.3.3.3.2	MME Content for SLAC	**[V2G-DC-042]**					9.3.2	MME Content for SLAC
22	8.3.3.4	Validation of the Matching EV - EVSE	~~**[V2G-DC-043]**~~						
23	8.3.3.4	Validation of the Matching EV - EVSE	~~**[V2G-DC-049]**~~						
24	8.3.3.4	Validation of the Matching EV - EVSE	~~**[V2G-DC-051]**~~						
25	8.3.3.4	Validation of the Matching EV - EVSE	~~**[V2G-DC-053]**~~						
26	8.3.3.4	Validation of the Matching EV - EVSE	~~**[V2G-DC-056]**~~						
27	8.3.3.4	Validation of the Matching EV - EVSE	~~**[V2G-DC-058]**~~						
28	8.3.3.5.1	Requirements	**[V2G-DC-059]**					9.3.3.1	Requirements
29	8.3.3.5.1	Requirements	**[V2G-DC-060]**					9.3.3.1	Requirements
30	8.3.3.5.1	Requirements	**[V2G-DC-061]**					9.3.3.1	Requirements
31	8.3.3.5.2	Amplitude Map exchange	**[V2G-DC-064]**					9.3.3.2	Amplitude Map exchange
32	8.3.3.6	Leave the Logical Network	**[V2G-DC-065]**					9.3.3.3	Leave the Logical Network
33	8.3.7.2	General drawing for Green PHY injection	**[V2G-DC-071]**					10.2	General drawing for Green PHY injection
34	8.3.7.2	General drawing for Green PHY injection	**[V2G-DC-072]**					10.2	General drawing for Green PHY injection
35	8.3.7.2	General drawing for Green PHY injection	**[V2G-DC-075]**					10.2	General drawing for Green PHY injection
36	8.3.7.2	General drawing for Green PHY injection	**[V2G-DC-076]**					10.2	General drawing for Green PHY injection
37	8.3.7.2	General drawing for Green PHY injection	**[V2G-DC-077]**					10.2	General drawing for Green PHY injection
38	8.3.7.2	General drawing for Green PHY injection	**[V2G-DC-078]**					10.2	General drawing for Green PHY injection
39	8.3.7.3	Signal requirement for Green PHY injection	**[V2G-DC-081]**					10.3	Signal requirement for Green PHY injection
40	8.3.7.6.1	Overview	**[V2G-DC-088]**					10.6.1	Overview
41	8.4.1	V2G communication of the EVCC	**[V2G-DC-096]**			7.5	V2G communication states		
42	8.4.1	V2G communication of the EVCC	**[V2G-DC-097]**			7.5	V2G communication states		
43	8.4.1	V2G communication of the EVCC	**[V2G-DC-098]**			7.5	V2G communication states		
44	8.4.1	V2G communication of the EVCC	**[V2G-DC-100]**			7.5	V2G communication states		
45	8.4.1	V2G communication of the EVCC	**[V2G-DC-101]**			7.5	V2G communication states		
46	8.4.1	V2G communication of the EVCC	**[V2G-DC-102]**			7.5	V2G communication states		

	DIN Sections	Description	Rqmt	J2847/2		J2931/1		J2931/4	
47	8.4.1	V2G communication of the EVCC	**[V2G-DC-103]**			7.5	V2G communication states		
48	8.4.1	V2G communication of the EVCC	**[V2G-DC-105]**			7.5	V2G communication states		
49	8.4.1	V2G communication of the EVCC	**[V2G-DC-106]**			7.5	V2G communication states		
50	8.4.1	V2G communication of the EVCC	**[V2G-DC-107]**			7.5	V2G communication states		
51	8.4.2	V2G communication of the SECC	**[V2G-DC-108]**			7.5	V2G communication states		
52	8.4.2	V2G communication of the SECC	**[V2G-DC-109]**			7.5	V2G communication states		
53	8.4.2	V2G communication of the SECC	**[V2G-DC-110]**			7.5	V2G communication states		
54	8.4.2	V2G communication of the SECC	**[V2G-DC-112]**			7.5	V2G communication states		
55	8.4.2	V2G communication of the SECC	**[V2G-DC-113]**			7.5	V2G communication states		
56	8.4.2	V2G communication of the SECC	**[V2G-DC-115]**			7.5	V2G communication states		
57	8.4.2	V2G communication of the SECC	**[V2G-DC-116]**			7.5	V2G communication states		
58	8.5.2	Applicable RFCs and Limitations and Protocol Parameter Settings	**[V2G-DC-117]**			7.6.2			
59	8.5.2.1	IPv6	**[V2G-DC-118]**			7.6.2.1			
60	8.5.2.1	IPv6	**[V2G-DC-119]**			7.6.2.1			
61	8.5.2.1	IPv6	**[V2G-DC-120]**			7.6.2.1			
62	8.5.2.1	IPv6	**[V2G-DC-121]**			7.6.2.1			
63	8.5.2.1	IPv6	**[V2G-DC-122]**			7.6.2.1			
64	8.5.2.1	IPv6	**[V2G-DC-123]**			7.6.2.1			
65	8.5.2.1	IPv6	**[V2G-DC-124]**			7.6.2.1			
66	8.5.2.1	IPv6	**[V2G-DC-125]**			7.6.2.1			
67	8.5.2.1	IPv6	**[V2G-DC-126]**			7.6.2.1			
			[V2G3-A09-126]					9.3.6	General error handling and timing constraints
68	8.5.2.2	Neighbour Discovery (ND)	**[V2G-DC-127]**			7.6.2.2			
			[V2G3-A09-127]					9.3.6	General error handling and timing constraints
69	8.5.2.2	Neighbour Discovery (ND)	**[V2G-DC-128]**			7.6.2.2			
70	8.5.2.3	Internet Control Message Protocol (ICMP)	**[V2G-DC-129]**			7.6.2.3			

	DIN Sections	Description	Rqmt	J2847/2		J2931/1		J2931/4	
71	8.5.2.3	Internet Control Message Protocol (ICMP)	**[V2G-DC-130]**			7.6.2.3			
72	8.5.2.3	Internet Control Message Protocol (ICMP)	**[V2G-DC-133]**			7.6.2.3			
73	8.5.3.2	Stateless auto address configuration (SLAAC)	**[V2G-DC-134]**			7.6.3.2			
74	8.5.3.2	Stateless auto address configuration (SLAAC)	**[V2G-DC-135]**			7.6.3.2			
75	8.5.3.2	Stateless auto address configuration (SLAAC)	**[V2G-DC-136]**			7.6.3.2			
76	8.5.3.3	Address selection	**[V2G-DC-137]**			7.6.3.3			
77	8.5.5	SECC discovery	**[V2G-DC-138]**			7.6.5			
78	8.6.1.2	Applicable RFCs, Limitations and Protocol Parameter Settings	**[V2G-DC-139]**			7.7.1.2			
79	8.6.1.3	TCP Performance and Checksum Recommendations and Requirements	**[V2G-DC-146]**			7.7.1.3			
80	8.6.2.2	Applicable RFCs, limitations and protocol parameter settings	**[V2G-DC-148]**			7.7.2.2			
81	8.7.2	Supported ports	**[V2G-DC-149]**			7.8.2			
82	8.7.2	Supported ports	**[V2G-DC-151]**			7.8.2			
83	8.7.2	Supported ports	**[V2G-DC-153]**			7.8.2			
84	8.7.2	Supported ports	**[V2G-DC-154]**			7.8.2			
85	8.7.2	Supported ports	**[V2G-DC-155]**			7.8.2			
86	8.7.2	Supported ports	**[V2G-DC-156]**			7.8.2			
87	8.7.2	Supported ports	**[V2G-DC-157]**			7.8.2			
88	8.7.2	Supported ports	**[V2G-DC-158]**			7.8.2			
89	8.7.2	Supported ports	**[V2G-DC-159]**			7.8.2			
90	8.7.2	Supported ports	**[V2G-DC-160]**			7.8.2			
91	8.7.3.1	Structure	**[V2G-DC-161]**			7.8.3.1			
92	8.7.3.1	Structure	**[V2G-DC-162]**			7.8.3.1			
93	8.7.3.1	Structure	**[V2G-DC-163]**			7.8.3.1			
94	8.7.3.1	Structure	**[V2G-DC-164]**			7.8.3.1			
95	8.7.3.1	Structure	**[V2G-DC-165]**			7.8.3.1			
96	8.7.3.1	Structure	**[V2G-DC-166]**			7.8.3.1			

	DIN Sections	Description	Rqmt	J2847/2		J2931/1		J2931/4	
97	8.7.3.2	Header Processing	**[V2G-DC-167]**			7.8.3.2			
98	8.7.3.2	Header Processing	**[V2G-DC-168]**			7.8.3.2			
99	8.7.3.2	Header Processing	**[V2G-DC-169]**			7.8.3.2			
100	8.7.3.2	Header Processing	**[V2G-DC-170]**			7.8.3.2			
101	8.7.3.2	Header Processing	**[V2G-DC-171]**			7.8.3.2			
102	8.7.3.2	Header Processing	**[V2G-DC-172]**			7.8.3.2			
103	8.7.3.2	Header Processing	**[V2G-DC-173]**			7.8.3.2			
104	8.7.3.2	Header Processing	**[V2G-DC-174]**			7.8.3.2			
105	8.8.1.3	EXI Settings for DIN SPEC 70121 Application Messages	**[V2G-DC-175]**			7.9.1.3			
106	8.8.1.3	EXI Settings for DIN SPEC 70121 Application Messages	**[V2G-DC-176]**			7.9.1.3			
107	8.8.1.3	EXI Settings for DIN SPEC 70121 Application Messages	**[V2G-DC-177]**			7.9.1.3			
108	8.8.1.3	EXI Settings for DIN SPEC 70121 Application Messages	**[V2G-DC-178]**			7.9.1.3			
109	8.8.1.3	EXI Settings for DIN SPEC 70121 Application Messages	**[V2G-DC-179]**			7.9.1.3			
110	8.9.3.1	General Information	**[V2G-DC-180]**			7.7.3.1			
111	8.9.3.3.1	Structure	**[V2G-DC-181]**			7.7.3.3.1			
112	8.9.3.3.1	Structure	**[V2G-DC-182]**			7.7.3.3.1			
113	8.9.3.3.1	Structure	**[V2G-DC-183]**			7.7.3.3.1			
114	8.9.3.3.1	Structure	**[V2G-DC-184]**			7.7.3.3.1			
115	8.9.3.3.1	Structure	**[V2G-DC-185]**			7.7.3.3.1			
116	8.9.3.3.1	Structure	**[V2G-DC-186]**			7.7.3.3.1			
117	8.9.3.3.2	Header Processing	**[V2G-DC-187]**			7.7.3.3.2			
118	8.9.3.3.2	Header Processing	**[V2G-DC-188]**			7.7.3.3.2			
119	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-189]**			7.7.3.4			
120	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-190]**			7.7.3.4			
121	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-191]**			7.7.3.4			
122	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-192]**			7.7.3.4			
123	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-193]**			7.7.3.4			

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124	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-194]**			7.7.3.4			
125	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-195]**			7.7.3.4			
126	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-196]**			7.7.3.4			
127	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-197]**			7.7.3.4			
128	8.9.3.4	SECC Discovery Request Message	**[V2G-DC-198]**			7.7.3.4			
129	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-199]**			7.7.3.5			
130	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-200]**			7.7.3.5			
131	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-201]**			7.7.3.5			
132	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-202]**			7.7.3.5			
133	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-204]**			7.7.3.5			
134	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-205]**			7.7.3.5			
135	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-206]**			7.7.3.5			
136	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-207]**			7.7.3.5			
137	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-208]**			7.7.3.5			
138	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-209]**			7.7.3.5			
139	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-210]**			7.7.3.5			
140	8.9.3.5	SECC Discovery Response Message	**[V2G-DC-211]**			7.7.3.5			
141	8.9.3.6	Timing and Error Handling	**[V2G-DC-212]**			7.7.3.6			
142	8.9.3.6	Timing and Error Handling	**[V2G-DC-213]**			7.7.3.6			
143	8.9.3.6	Timing and Error Handling	**[V2G-DC-214]**			7.7.3.6			
144	8.9.3.6	Timing and Error Handling	**[V2G-DC-215]**			7.7.3.6			
145	8.9.3.6	Timing and Error Handling	**[V2G-DC-216]**			7.7.3.6			
146	8.9.3.7	SECC Discovery service primitives	**[V2G-DC-217]**			7.7.3.7			
147	8.9.3.7	SECC Discovery service primitives	**[V2G-DC-218]**			7.7.3.7			
148	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-219]**	6.2.1	Handshake Request-Response Message Pair				
149	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-220]**	6.2.1	Handshake Request-Response Message Pair				

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150	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-221]**	6.2.1	Handshake Request-Response Message Pair				
151	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-222]**	6.2.1	Handshake Request-Response Message Pair				
152	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-223]**	6.2.1	Handshake Request-Response Message Pair				
153	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-224]**	6.2.1	Handshake Request-Response Message Pair				
154	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-225]**	6.2.1	Handshake Request-Response Message Pair				
155	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-226]**	6.2.1	Handshake Request-Response Message Pair				
156	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-227]**	6.2.1	Handshake Request-Response Message Pair				
157	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-228]**	6.2.1	Handshake Request-Response Message Pair				
158	9.2.1	Handshake Request-Response Message Pair	**[V2G-DC-229]**	6.2.1	Handshake Request-Response Message Pair				
159	9.2.2	Message definition supportedAppProtocolReq and supportedAppProtocolRes	**[V2G-DC-230]**	6.2.2	Message definition supportedAppProtocolReq and supportedAppProtocolRes				
160	9.2.2	Message definition supportedAppProtocolReq and supportedAppProtocolRes	**[V2G-DC-231]**	6.2.2	Message definition supportedAppProtocolReq and supportedAppProtocolRes				
161	9.2.2.1	Semantics description supportedAppProtocol messages	**[V2G-DC-233]**	6.2.2.1	Semantics description supportedAppProtocol messages				
162	9.3.2	Message definition	**[V2G-DC-234]**	6.3.2	Message definition				
163	9.3.2	Message definition	**[V2G-DC-235]**	6.3.2	Message definition				
164	9.3.3	Message Header Definition	**[V2G-DC-236]**	6.3.3	Message Header Definition				
165	9.3.4	Message Body Definition	**[V2G-DC-237]**	6.3.4	Message Body Definition				
166	9.4.1.2.1	Session Setup Handling	**[V2G-DC-238]**	6.4.1.2.1	Session Setup Handling				
167	9.4.1.2.1	Session Setup Handling	**[V2G-DC-239]**	6.4.1.2.1	Session Setup Handling				
168	9.4.1.2.1	Session Setup Handling	**[V2G-DC-241]**	6.4.1.2.1	Session Setup Handling				
169	9.4.1.2.2	Session Setup Request	**[V2G-DC-243]**	6.4.1.2.2	Session Setup Request				

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170	9.4.1.2.2	Session Setup Request	**[V2G-DC-244]**	6.4.1.2.2	Session Setup Request				
171	9.4.1.2.3	Session Setup Response	**[V2G-DC-245]**	6.4.1.2.3	Session Setup Response				
172	9.4.1.2.3	Session Setup Response	**[V2G-DC-246]**	6.4.1.2.3	Session Setup Response				
173	9.4.1.2.3	Session Setup Response	**[V2G-DC-247]**	4.2.40 6.4.1.2.3	EVSE ID Session Setup Response				
174	9.4.1.3.2	Service Discovery Request	**[V2G-DC-248]**	6.4.1.3.2	Service Discovery Request				
175	9.4.1.3.2	Service Discovery Request	**[V2G-DC-249]**	6.4.1.3.2	Service Discovery Request				
176	9.4.1.3.3	Service Discovery Response	**[V2G-DC-250]**	6.4.1.3.3	Service Discovery Response				
177	9.4.1.3.3	Service Discovery Response	**[V2G-DC-251]**	6.4.1.3.3	Service Discovery Response				
178	9.4.1.4.1	Service and Payment Selection Handling	**[V2G-DC-252]**	6.4.1.4.1	Service and Payment Selection Handling				
179	9.4.1.4.2	Service and Payment Selection Request	**[V2G-DC-253]**	4.2.95 6.4.1.4.2	Service Payment Selection Request Service and Payment Selection Request				
180	9.4.1.4.2	Service and Payment Selection Request	**[V2G-DC-254]**	6.4.1.4.2	Service and Payment Selection Request				
181	9.4.1.4.3	Service and Payment Selection Response	**[V2G-DC-255]**	6.4.1.4.3	Service and Payment Selection Response				
182	9.4.1.6.2	Charge Parameter Discovery Request	**[V2G-DC-256]**	6.4.1.6.2	Charge Parameter Discovery Request				
183	9.4.1.6.2	Charge Parameter Discovery Request	**[V2G-DC-258]**	6.4.1.6.2	Charge Parameter Discovery Request				
184	9.4.1.6.2	Charge Parameter Discovery Request	**[V2G-DC-259]**	6.4.1.6.2	Charge Parameter Discovery Request				
185	9.4.1.6.3	Charge Parameter Discovery Response	**[V2G-DC-260]**	6.4.1.6.3	Charge Parameter Discovery Response				
186	9.4.1.6.3	Charge Parameter Discovery Response	**[V2G-DC-262]**	6.4.1.6.3	Charge Parameter Discovery Response				
187	9.4.1.7.2	Power Delivery Request	**[V2G-DC-263]**	6.4.1.7.2	Power Delivery Request				
188	9.4.1.7.2	Power Delivery Request	**[V2G-DC-264]**	6.4.1.7.2	Power Delivery Request				
189	9.4.1.7.3	Power Delivery Response	**[V2G-DC-265]**	6.4.1.7.3	Power Delivery Response				
190	9.4.1.7.3	Power Delivery Response	**[V2G-DC-266]**	4.2.6 6.4.1.7.3	Charging Profile (ChargingProfile) Power Delivery Response				
191	9.4.1.7.3	Power Delivery Response	**[V2G-DC-267]**	4.2.6 6.4.1.7.3	Charging Profile (ChargingProfile) Power Delivery Response				
192	9.4.1.7.3	Power Delivery Response	**[V2G-DC-268]**	6.4.1.7.3	Power Delivery Response				