SAE International®

SURFACE VEHICLE INFORMATION REPORT

SAE J2931/4 JUL2012

Issued 2012-07

Broadband PLC Communication for Plug-in Electric Vehicles

RATIONALE

This SAE Recommended Practice is intended to provide a common set of requirements, including testing and certification guidance, as various suppliers build their product and interface with several Plug-In Electric Vehicle manufacturers and the HAN/EMS/Utility infrastructure providers to assure smart grid interoperability compliance.

TABLE OF CONTENTS

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 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 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 Green PHY PLC technology and specifies specific parameters and methods required to use HomePlug Green 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 consistent 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. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System, May 2012.

HomePlug Powerline Alliance, HomePlug Green PHY Specification, Release Version 1.1, 2012

SAE[2] J1772™ SAE Electric Vehicle Conductive Charge Coupler (Surface Vehicle Recommended Practice).

SAE[2] J2836/1™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid (Surface Vehicle Information Report

2.2 Related Publications (Optional)

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

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 J2847/1Communication between Plug-in Vehicles and the Utility Grid (Surface Vehicle Recommended Practice).

SAE J2847/2 Communication between Plug-in Vehicles and the Supply Equipment (EVSE) (Surface Vehicle Recommended Practice).

SAE J2847/3 Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow (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.

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

[2] SAE publications are available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.3 Other Publications

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

HomePlug Powerline Alliance, HomePlug Green PHY Interoperability Test Plan, 2012.

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

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

3. DEFINITIONS

3.1 AMPLITUDE MAP

The amplitude map is a table that assigns a maximum transmission power to each subcarrier of the transmit power spectrum.

3.2 ASSOCIATED

Associated, in the automotive case is The logical state where an EVSE and a PEV are determined to be physically paired and ready for logical pairing. Equivalent to “Matched” and opposite of “Unmatched” states used in HomePlug Green PHY 1.1.

3.3 CENTRAL COORDINATOR (CCO)

The Central Coordinator is the master of a HomePlug GreenPHY network.

3.4 COMMUNICATION CHANNEL

In this document, the communication channel is the Control Pilot, a signal defined in J1772™.

3.5 DATA LINK LAYER

Protocol layer used to link the physical layer to the network layer. It encapsulates the MAC sub-layer.

3.6 INTER SYSTEM PROTOCOL (ISP)

The intersystem protocol enables various Broadband Power Line 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 P1901-2010.

3.7 LOGICAL NETWORK

A logical network is a 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.

3.8 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.

3.9 MEDIUM ACCESS CONTROL (MAC)

A 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.

3.10 PHYSICAL LAYER (PHY)

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

3.11 ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

OFDM is a modulation technique that efficiently utilizes the allowed bandwidth by using equally spaced orthogonal carriers over the frequency band of operation. The data rate for each carrier is smaller than it would be if the frequency band were continuous, allowing reduction of inter-symbol interference due to delay spread.

3.12 RECEIVER

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

3.13 RECEIVING NODE

The receiving node refers to a remote transceiver in receive mode.

3.14 ROBO MODES

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.

3.15 SLAC

The Signal Level Attenuation Characterization (SLAC) is a protocol to measure the attenuation of a signal between Green PHY stations acting as PEVs and EVSEs.

3.16 TONE MASK

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

3.17 TONE MAP

A list of the Tone Map contains a list of Modulation Types for all unmasked 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.

3.18 TRANSMITTER

In this document, the term transmitter refers to the set of circuits and algorithms used for data transmission.

4. SAE TECHNICAL REQUIREMENTS

PLC communication 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.

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

SAE J2836/1 and SAE J2847/1 describe digital communications between the utility and the PEV. SAE J2836/2 and SAE J2847/2 describe digital communications between the EVSE and the PEV for DC energy transfer. SAE J2931/1 describes the association to the EUMD and other aspects, and this document describes specifically how the SAE J1772 the main circuits will be used to transport the messages.

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.

The following paragraphs specify the broad band PLC communications details when used on the Control Pilot line.

5. HOMEPLUG GREEN PHY RELEASE VERSION 1.1, 2012

5.1 General Overview

HomePlug Green PHY v1.1 is a subset of HomePlug AV and IEEE 1901-2010 as shown in Table 1, Note in Table 1 that the operating spectrum (2–30 MHz) and multiplexing scheme (OFDM w/1155 subcarriers) are identical.

Smart Grid applications favor reliable communications, low power and low cost, more than higher data rates. HomePlug GP takes advantage of that by reducing the required data rates and bit loading methods used in HomePlug AV. HomePlug GP also uses lower complexity coding, fewer features and a simplified MAC as indicated in Table 1.

TABLE 1 - HOMEPLUG GREEN PHY COMPARISON WITH HOMEPLUG AV/ IEEE 1901

	Parameter	***HPAV/1901***	***HPGP***
PH	**Spectru**	1.8-30 MHz	1.8-30 MHz
	Modulation	OFDM	OFDM
	# Subcarriers	1155	1155
	Subcarrier	24.414 kHz	24.414 kHz
	Supported modulation formats	BPSK, QPSK, 16QAM, 64QAM, 1024	QPSK only
	Data FEC	**Turbo Code** Rate 1/2 or Rate 16/21 (punctured)	**Turbo Code** Rate 1/2 only
	Supported data rates	**ROBO:** 4 Mbps - 10 **Adaptive Bit Loading:** 20 Mbps - 200	**ROBO:** 4 Mbps - 10
MAC	**Channel**	CSMA/CA w/ optional TDMA	CSMA/CA only
	CCo capable?	Yes	Yes
	Channel	Adaptive bit-loading per subcarrier via pre-negotiated tone maps	ROBO eliminates need for pre-negotiated tone

HomePlug Green PHY also contains new PEV-EVSE Association and advanced power management capabilities that were developed for the Smart Grid and automotive applications.

The result is cost and power reductions that retain interoperability with HomePlug AV, HomePlug AV2 and IEEE 1901.

5.2 HomePlug Green PHY Architecture Overview

Figure 1 shows the architecture of Green PHY, boxed within blue lines. The CCo role is part of the EVSE function in automotive applications. The PHY layer connects to the Control Pilot wire.

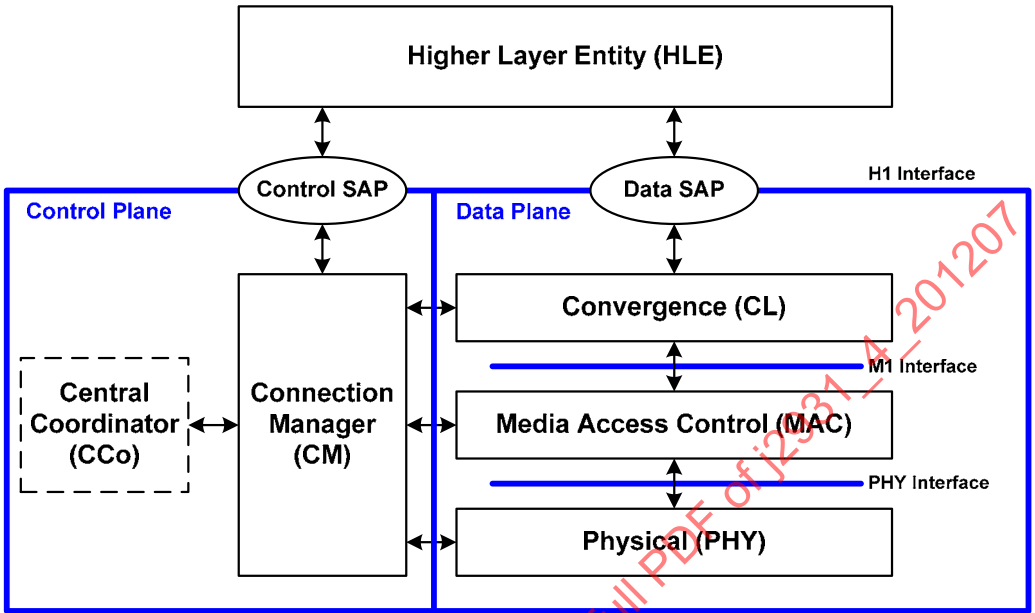

FIGURE 1 - GP 1.1 ARCHITECTURE

5.3 Data Link Control SAP to Layer 3

The HLE of the device supporting EVSE/PEV applications and HomePlug Green PHY 1.1 shall also support the Data link control primitives. See DIN 70121 8.3.7.3.

5.4 PEV-EVSE Association

The PEV/EVSE Association problem illustrated in Figure 2 has been a major concern of groups working on PEV communications. It is possible that crosstalk between cables or through EVSEs could lead to the wrong correlation between EVSEs and PEVs. It is important that the PEV associate with the correct EVSE in environments where there are many EVSE's present to ensure billing accuracy and proper charging control. These environments include apartment buildings and public parking facilities, offices, and shopping areas. (Note: PEV-EVSE Association is differentiated from network "association".)

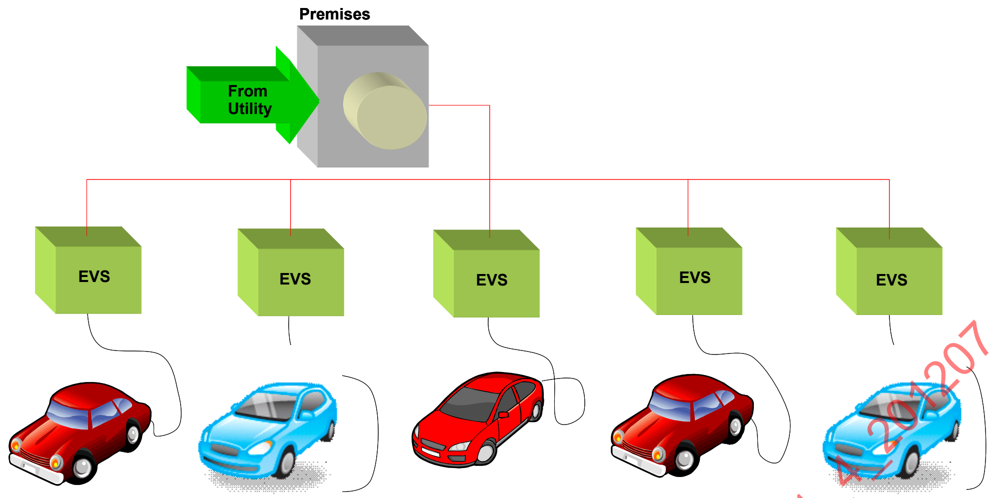

FIGURE 2 - PUBLIC PARKING - MANY EVSES AND PEVS IN CLOSE PROXIMITY

SAE J2931/4 and HomePlug Green PHY work together to correctly associate the correct PEV and EVSE in the presence of crosstalk and cross coupled signals.

6. LAYER 2 INTERFACES

As shown in the Figure 1, the HomePlug Green PHY Data Link Layer provides two interfaces to higher layers: the ETH SAP and the Control SAP.

6.1 Data Link ETH SAP

The Data Link Layer contains a Convergence Layer, to provide an Ethernet (ETH) II-class Service Access Point (SAP) to higher layers. The ETH SAP is specified in section 12.2.1.1 in 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 VLAN tagging.

6.2 Data Link Control SAP

The Data Link layer "Control SAP" is used by the host and is found in the HomePlug Green PHY, section 12.2.2. It allows the HLE to:

- Monitor status and statistics, including SLAC
- Support vendor-specific primitives
- Initialize the station (STA)
- Support Security functions - obtain or set encryption keys

7. PEV-EVSE ASSOCIATION

The PEV-EVSE Association process is described in HomePlug Green PHY, section 13.8.

In order to improve SLAC performance per the HomePlug Green PHY specification the HomePlug Green PHY station on the EVSE side shall respond to SLAC requests from the PEV if and only if:

- The EVSE is connected to a PEV, detected by the completion of the Control Pilot circuit.
- The EVSE is in not already "matched" with a different PEV (a.k.a "Unassociated" state. See DIN 70121, V2G-DC-024, 8.3.4.2).

The HomePlug Green PHY station on the PEV side shall never answer a SLAC request.

7.1 PEV-EVSE Association Trigger

The Association process is triggered (initiated) by the PEV using the CM_SLAC_PARM.REQ command. See HomePlug GP1.1, 13.8.1.2.1.

For automotive applications, the EVSE responds with CM_SLAC_PARM.CNF message. The following parameters are used by this document:

- The default of Num_Sounds shall be 0x08 (8 MPDUs sent)
- The default for Time_Out shall be 0x02 (200 ms)

If the HLE does not receive sufficient results, the following parameters may be used in the next try:

- The default of Num_Sounds shall be 0x10 (16 MPDUs sent)
- The default for Time_Out shall be 0x0A (1,000 ms)

In addition to the primitives listed above, Table 2 recites the SLAC MME parameters that have specific parameters to be used for automotive DC charging applications. (Table 8, of DIN 70121). Additional MMEs are found in HomePlug Green PHY 1.1, 11.5.46-11.5.61, and 12.2.2.50-12.2.2.60.

TABLE 2 - SLAC MME PARAMETER VALUES

Parameter definition	Parameter	Value	Value description
CM_SLAC_PARM.REQ	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	RunID	Random	8 bytes Random Run Identifier of sender
CM_SLAC_PARM.CNF Profile A, first SLAC attempt	M-SOUND_TARGET	0xFFFF FFFF FFFF	Request send in broadcast
	Num_Sounds	0x08	8 M-Sound MPDUs sent
	Time_Out	0x02	TimeOut of 200ms
	Resp_Type	0x00	HLE usage (0x00)
	Fwd_Sta	0x00	No station (not used since Resp_Type=0x00)
	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	CipherSuite	0x00	Value not used, No security

TABLE 2 - SLAC MME PARAMETER VALUES (CONTINUED)

Parameter definition	Parameter	Value	Value description
CM_SLAC_PARM.CNF Profile B, second SLAC attempt	M-SOUND_TARGET	0xFFFF FFFF FFFF	Request send in broadcast
	Num_Sounds	0x10	16 M-Sound MPDUs sent
	Time_Out	0x0A	TimeOut of 1s
	Resp_Type	0x00	HLE usage (0x00)
	Fwd_Sta	0x00	No station (not used since Resp_Type=0x00)
	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
	CipherSuite	0x00	Value not used, No security
CM_START_ATTEN_CHAR.IND	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	NUM_SOUNDS	Value of CM_SLAC_PARM.CNF message	Number of SOUND MPDUS used, same as in CM_SLAC_PARM.CNF message
	Time_Out	Value of CM_SLAC_PARM.CNF message	SOUND MPDU Timeout
	Resp_Type	0x00	HLE usage (0x00)
	Fwd_Sta	0x00	no station (not used since Resp_Type=0x00)
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ message
CM_MNBC_SOUND.IND	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	Sender ID	Sender ID	EV's Identification number,
	Cnt	Countdown counter	Number of Sounds remaining
	RunID	Value of CM_SLAC_PARM.REQ message	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ or CM_START_ATTEN_CHAR.IND messages
	Rnd	Random	Random Value

TABLE 2 - SLAC MME PARAMETER VALUES (CONTINUED)

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

TABLE 2 - SLAC MME PARAMETER VALUES (CONTINUED)

Parameter definition	Parameter	Value	Value description
CM_SLAC_MATCH.REQ	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	MVFLength	Var	MatchVarField Length
	EV ID	Var	EV Identifier
	EV MAC	Var	EV MAC Address
	EVSE ID	Var	EVSE Identifier
	EVSE MAC	Var	EVSE MAC Address
	RunID	Var	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ or CM_START_ATTEN_CHAR.IND messages.
CM_SLAC_MATCH.CNF	APPLICATION_TYPE	0x00	EV-EVSE Association
	SECURITY_TYPE	0x00	No Security
	MVFLength	Var	MatchVarField Length
	EV ID	Var	EV Identifier
	EV MAC	Var	EV MAC Address
	EVSE ID	Var	EVSE Identifier
	EVSE MAC	Var	EVSE MAC Address
	RunID	Var	8 bytes Random Run Identifier of sender, same as in CM_SLAC_PARM.REQ or CM_START_ATTEN_CHAR.IND messages
	NID	Var	Network ID given by the CCo (EVSE). NID can be generated from NMK. See HomePlug GP1.1 section 4.4.3.1 or be a random value
	NMK	Var	Private NMK of the EVSE (random value)

7.2 Association Process

The Association process is found in HomePlug Green PHY, section 13.8.1.

Note that the Validation steps in 13.8.1 (and 13.8.1.4) are optional for HomePlug Green PHY and not required for SAE.

PEV-EVSE Association Security is optional in HomePlug Green PHY. The HomePlug Green PHY PLC node shall be compliant with the unsecured SLAC protocol defined in HomePlug Green PHY. (Note: Only the unsecured SLAC protocol is currently used in this application. Interest in the secured SLAC protocol is TBD.) Note: this is not the same as link security which is a required part of the network management and access control. See section 8.6.

7.3 ATTEN_PROFILE

The HLE decides to which EVSE it will match based on information contained in the signal level attenuation profile (HomePlug Green PHY section 11.5.48.3). The signal threshold are defined in DIN 70121, section 8.3.4.3, V2G-DC-39 to 41).

7.4 Association Results

When the PEV-EVSE Association process is over, i.e.: a CM_VALIDATE.CNF message is received by the PEV, the next step is to make the PEV-EVSE link a private network as described in HomePlug Green PHY, section 13.8.1.7.

8. HOMEPLUG GREEN PHY SYSTEM AND TRAFFIC PARAMETERS

8.1 Message Priority

CAP0, 1, 2 & 3 are “per message” priority levels that are used to prioritize traffic on the network (see HomePlug Green PHY, section 13.1 for priority mapping examples. CAP3 is the highest priority.

During the PEV-EVSE Association process the PLC node shall be configured to use CAP3 priority for SLAC related messages.

8.2 Device Topology Configuration

The EVSE shall always be a CCo. The HomePlug Green PHY APCM_SET_CCo.REQ primitive is used to set this with the SET_CCo_MODE parameter. See HomePlug Green PHY, sections 13.8.1 and 12.2.2.57.

The PEV shall never be a CCo. The HomePlug Green PHY APCM_SET_CCo.REQ primitive is used to set this with the SET_CCo_MODE parameter. See HomePlug Green PHY, sections 13.8.1 and 12.2.2.57.

8.3 Amplitude Map negotiation

Each GP station (PEV or EVSE sides) shall use the Tone Mask defined in Table 3-23 of HomePlug GP.

However, HomePlug Green PHY supports the optional ability for the PEV to negotiate the amplitude map (amplitude of each carrier) with the EVSE after the link it established. This may be initiated by the PEV if it is known to affect or be sensitive to specific carrier frequencies.

The resulting Amplitude map will be the minimum set of the two Amplitude maps. The protocol is defined in HomePlug GP, 13.8.1.8. See DIN 70121, 8.3.4.5.1, [V2G-DC-64]

8.4 Zero Crossing Detection

The EVSE PLC node shall be capable to detect the zero cross of the AC line cycle to support the ISP functionality, described in the IEEE 1901-2010.

The capability to detect the zero cross of the AC line cycle is optional for the GP station on the PEV side.

8.5 Timing

The association and communications timing can be found in SAE J2847/2

8.5.1 Time Outs

Time out parameters specific to automotive control and PEV-EVSE Association are specified in DIN 70121, 8.9.3.6 & 9.6.

8.5.2 Retries

The number of retries allowed after a timeout or failure, and the follow up action, are specified in DIN 70121, 8.3.4.3, V2G-DC-036 and 037 and 8.3.4.7.

8.6 Security

At any time an EVSE switches to a private logical network by sending a CM_SLAC_MATCH.CNF MME, the private NMK shall be set randomly. See DIN 70121, 8.3.4.5.2, Table 10, (See HomePlug GP Table 11-154).

8.7 Distributed Bandwidth Control

The device should use as small a MPDU packet size as practical to optimize transmission effectiveness and low latency.

9. SIGNAL COUPLING

9.1 Overview

The HomePlug Green PHY signals shall be coupled into the Control Pilot line according to DIN 70121, 8.3.6, and the example in 8.3.6.5 included below. Those references also contain the requirements that have to be fulfilled, in order to inject HomePlug GreenPHY signals into the CPLT to enable bidirectional HomePlug GP communication between one EVSE and one EV.

These circuits and levels have been established to achieve reliable bidirectional HomePlug Green PHY communication between an EVSE and a PEV, while also protecting the PWM and AM signals present on the pilot line [V2G-DC-078]. Because PLC signal's 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 PLC injection, the path from EVSE's output to EV's input should not be considered as capacitive only, as it is sufficient for the low frequency control pilot signal. For high frequency PLC, the path should be considered as a transmission line. To take the high frequency into account, the control pilot circuit and the component values have to be specified more detailed.

For the control pilot line, the additional capacitance of the PLC coupling circuit has to be considered. For the PLC signal, the partitioning of the capacitive load of the EV, EVSE and the charge cord is important and is detailed in this section.

9.2 General drawing for PLC injection

All technical requirements described in this chapter assume to have a dedicated pair of PLC chips implemented for the couple (EVSE, EV), linked by a control pilot wire. Figure 3 depicts an example implementation of parallel injection and shows definitions used later in the section. Other designs may be used as long as the PWM signal is protected as mentioned above.