



SURFACE VEHICLE INFORMATION REPORT

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(R) Use Cases for Communication Between Plug-in Vehicles
and Off-Board DC Charger

RATIONALE

This document is being updated to match changes in SAE J1772.

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1. SCOPE

This SAE Information Report, SAE J2836-2, establishes use cases and general information for communication between plug-in electric vehicles (PEVs) and the DC off-board charger. Where relevant, this document notes, but does not formally specify, interactions between the vehicle and vehicle operator.

This applies to the off-board DC charger for conductive charging, which supplies DC current to the vehicle battery of the electric vehicle through a SAE J1772 hybrid coupler or SAE J1772 AC Level 2-type coupler on DC power lines, using the AC power lines or the pilot line for power line communication (PLC), or dedicated communication lines that are further described in SAE J2847-2.

The specification supports DC energy transfer via forward power flow (FPF) from grid-to-vehicle.

The relationship of this document to the others that address PEV communications is further explained in Section 5.

1.1 Purpose

The purpose of SAE J2836-2 is to document the general information which must be supported by SAE Recommended Practice SAE J2847-2.

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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1772	SAE Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler
SAE J2836-1	Use Cases for Communication Between Plug-in Vehicles and the Utility Grid
SAE J2836/3	Use Cases for Plug-in Vehicle Communication as a Distributed Energy Resource
SAE J2847-1	Communication for Smart Charging of Plug-in Electric Vehicles Using Smart Energy Profile 2.0
SAE J2847-2	Communication Between Plug-in Vehicles and Off-Board DC Chargers
SAE J2847/3	Communication for Plug-in Vehicles as a Distributed Energy Resource
SAE J2931/1	Digital Communications for Plug-in Electric Vehicles
SAE J2931/4	Broadband PLC Communication for Plug-in Electric Vehicles
SAE J2953/4	Plug-in Electrical Vehicle Charge Rate Reporting and Test Procedures

2.1.2 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

IEC 61851-1	Electric vehicle conductive charging system – Part 1: General requirements
IEC 62196-3-1	Plugs, Socket-outlets and Couplers for industrial and similar applications, and for Electric Vehicles

3. DEFINITIONS

3.1 AVAILABLE LINE CURRENT (ALC)

ALC is transmitted by the electric vehicle supply equipment (EVSE) using the pilot duty cycle identified in SAE J1772. This indicates to the vehicle the maximum current draw for this premises. The purpose of this is for the vehicle not to request more current than this, and to not trip the premises circuit breaker.

3.2 CHARGER

The charger can either be on-board the vehicle or off-board. On-board chargers require AC energy transfer to the vehicle (either 120 V or 240 V single phase). Off-board chargers are within the EVSE and require DC energy transfer to the vehicle.

3.3 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

The conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, and other components intended to deliver energy to an electric vehicle.

3.4 ENERGY PORTAL

Energy portal is any charging point for a PEV. At a minimum, the energy portal is a 120 V, 15 A outlet, but can also be a 240 V EVSE outlet connected to the premises circuit.

3.5 ENERGY TRANSFER

Energy transfer is the process of flowing energy to the EV from the EVSE.

3.6 ENERGY TRANSFER STRATEGY

A strategy that accounts for all of the electrical energy needs of an EV and the present status of all on-board equipment, including the EV storage battery. It determines the rate that energy is to be transferred to the EV, and how the ETS shall be operated to accomplish this.

3.7 FORWARD POWER FLOW (FPF)

FPF means the direction of energy for charging a vehicle is from the source to the vehicle.

3.8 HOME AREA NETWORK (HAN)

A HAN is an energy-related network, contained within a premises used for communicating with devices within the premises. HANs do not necessarily require connectivity outside the premises, but may be connected to one or more external communication networks (e.g., utility advanced metering infrastructure [AMI], internet, cell phone network, etc.) using gateways, bridges, and interfaces.

3.9 INTEROPERABILITY

The condition where components of a system, relative to each other, are able to work together to perform the intended operation of the total system. Information interoperability is the capability of two or more networks, systems, devices, applications, or components to share and readily use information securely and effectively with little or no inconvenience for the user. As an example, a 10-mm box-end hand wrench and a 10-mm socket wrench are interoperable, relative to a 10-mm hex-head bolt. The wrench and the bolt are both parts of a fastening system. The fact that the system will perform as required with either wrench establishes the interoperability of the wrenches and the bolt.

3.10 OFF-BOARD/ON-BOARD BOUNDARY

Off-board/on-board boundary is the point where the ETS is divided into two physical parts. One part becomes realized within the off-board EVSE. The other part becomes realized within an electric vehicle. This boundary will be in different places, depending on the system architecture.

3.11 POWER FLOW

See FPF (3.7) and RPF (3.13) for further definitions.

3.12 RECHARGEABLE ENERGY STORAGE SYSTEM (RESS)

RESS means a system that stores energy for delivery of electric energy and which is rechargeable.

3.13 REVERSE POWER FLOW (RPF)

RPF means the direction of energy for discharging a vehicle is from the vehicle to the load.

3.14 PLUG-IN ELECTRIC VEHICLE (PEV)

Plugs into an energy portal (see actor definition) at a premises to charge vehicle. A PEV may be a battery electric vehicle (BEV) that relies only on electric propulsion. A PEV may also be a plug-in hybrid vehicle (PHEV) that also includes an alternative source of propulsion power.

3.15 POWER FLOW

See FPF (3.7) and RPF (3.13).

3.16 POWER LINE COMMUNICATION (PLC)

Also called power line carrier, mains communication, power line telecom (PLT), or power line networking (PLN)—terms describing several different systems for using electric power lines to carry information over the power line.

Electrical AC power is transmitted over high-voltage transmission lines, distributed over medium voltage, and used inside buildings and homes at lower voltages. PLCs can be applied at each stage. Most PLC technologies limit themselves to one set of wires (for example, premises wiring), but some can cross between two levels (for example, both the distribution network and premises wiring). In most cases, these technologies may be used on DC lines and in the absence of power.

Since the power wiring was designed for the transmission of power and not for communications, many challenges exist, such as faultless communications in the presence of noise and over long distances.

PLC systems operate using a variety of modulation techniques (including frequency, phase, or orthogonal frequency-division multiplexing [OFDM] modulation schemes), and in different frequency bands. In general, the lower band solutions (in the 10 to 490 kHz range) are used in applications with data rates less than 256 kbps. The upper band (2 MHz and above), has been used for broadband applications. As there are many different incompatible proprietaries, alliance specifications, and standards, the issue of co-existence is a major concern. The medium can extend beyond the consumer's premises and may be used for multiple different applications, from simple lighting control to video distribution in the home, to communicating to the utility electrical meter outside.

3.17 SMART ENERGY PROFILE (SEP) 2.0

The SEP 2.0 application protocol is primarily a layer seven protocol, built on top of an internet protocol stack.

3.18 SMART CHARGING

Smart charging describes a system in which PEVs communicate with the power grid in an effort to optimize vehicle charging or discharging rate with grid capacity and time-of-use cost rates.

3.19 UTILITY

Utility provides electrical energy and typically refers to a collection of systems that include the customer information system (CIS), AMI, rates, and revenue. The utility makes energy available to PEV through the ESCI pricing tables or discrete events. The utility also supplies information such as tariff rate, interval for metered kW·h consumption, validation of PEV program for PEV ID, etc.

4. TECHNICAL REQUIREMENTS

Plug-in vehicles are expected to interface with AC Level 1 (120 VAC) and AC Level 2 (240 VAC) EVSE and use an on-board charger for the energy session.

Another option for the customer is to use an off-board charger that is included in the EVSE. This is intended for higher power levels, whereas this off-board charger would not have to meet the packaging and environmental conditions on the on-board chargers.

SAE J1772 includes the system architecture for AC Levels 1 and 2, and DC Levels 1 and 2 energy transfer. It also identifies the connector variations that are required for DC Level 2. Table 1 shows the various levels of AC and DC.

Table 1A - SAE charging configurations and ratings terminology

Charge Method	Nominal Supply Voltage (V)	Max Current (A—Continuous)
AC Level 1	120 VAC, 1-phase	≤50 A
AC Level 2	208 to 240 VAC, 1-phase	≤80 A

Note: AC branch circuit rating governed by local regulation.

Table 1B - SAE charging configurations and ratings terminology

Charge Method	EVSE DC Output Voltage (VDC)	Max Current (A—Continuous)
DC Level 1	50-1000*	80
DC Level 2	50-1000*	500**

Notes:

* Operational range, not a requirement.

** This is a nominal current limit and value is subject to change, depending on specified design requirements of SAE J1772 and IEC 62196-3-1.

4.1 Private Offerings

There are advantages to the customer by installing a home DC EVSE that includes the off-board charger, since they don't purchase this larger onboard charger with every PEV, as it stays with the EVSE in the home, not the vehicle. Environmental requirements may also be less complicated, since a larger packaging is not as restricted as it would be on-board a vehicle. Less weight of installing larger on-board chargers also relate to improved mileage.

The home EVSE can be connected to several circuit breaker sizes, but some of the most popular would be a 40 A that is capable of delivering 32 A continuous, or 7.68 kW, even though the maximum power for Level 2 is 80 A (19.2 kW). If the home has higher service available, the EVSE could be installed with up to a 100 A circuit breaker that includes this max power but is less likely in most homes. The EVSEs may also be capable of delivering more power than the PEV is capable of receiving, since they may only include a 3 to 5 kW on-board charger.

Table 1 shows the range of circuit breakers and available line current (ALC) that the SAE J1772 pulse-width modulation (PWM) identifies to the PEV.

Table 2 - Wiring and circuit breaker size and ALC values

	Wiring Size		CBR/outlet Rating		Available Line Current (ALC) = 80% CBR/outlet		EVSE PWM
	Premise	EVSE	Voltage (VAC)	Current (amps)	Power (kW)	Current (amps)	
Typical Values	14 AWG	16 AWG	240	15	2.88	12	20.00%
	12 AWG	14 AWG	240	20	3.84	16	26.70%
	10 AWG		240	30	5.76	24	40.00%
	8 AWG		240	40	7.68	32	53.30%
			240	50	9.60	40	66.60%
			240	60	11.52	48	80.00%
			240	70	13.44	56	86.40%
			240	80	15.36	64	89.60%
			240	90	17.28	72	92.80%
	6 AWG		240	100	19.20	80	96.00%

4.2 Public Offerings

DC Level 2 energy transfer is offered at public locations for faster charge times and is expected to follow a "gasoline pump" model for these units for displays and controls. DC Level 1 may be at EVSEs that offer multiple ports, but most general public EVSEs are expected to be AC Levels 1 and 2.

Figure 1 indicates where customers will use EVSEs and the types offered at these locations. It is expected that home energy transfer is the primary location with workplace and public smaller sections.

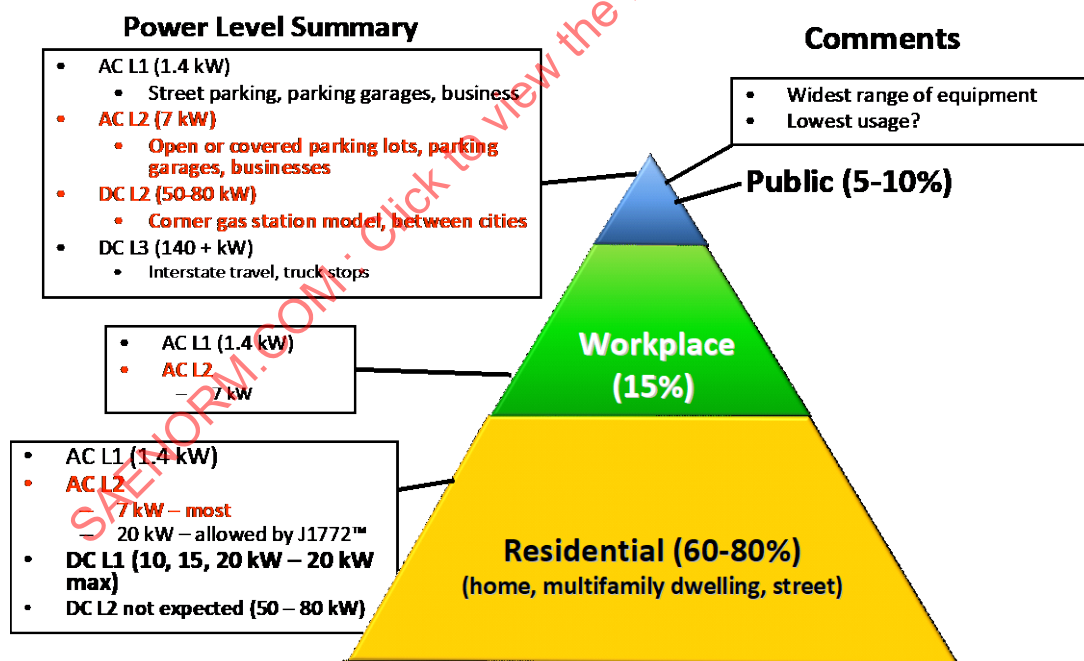
**Figure 1 - Charging locations and types of EVSEs expected**

Figure 2 identifies the connectors and variations for the AC and DC Level 1 using the Type 1 connector and inlet and DC Level 2 using the combo or CCS1 connector and inlet.



Figure 2 - Connector and power level variations

Figure 3 identifies the PEV and EVSE combinations as the customer interfaces with AC Levels 1 and 2, and DC Level 1 energy combinations.

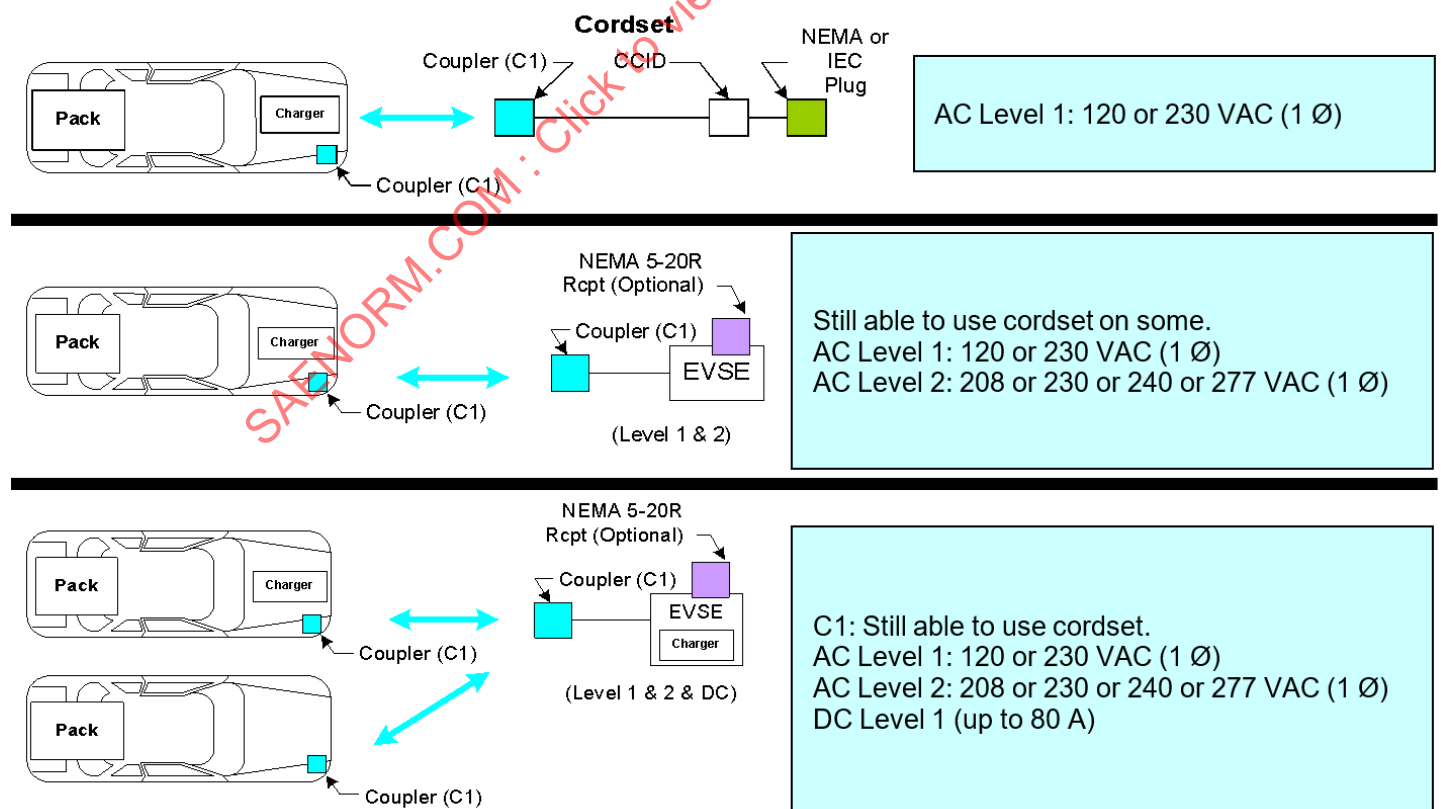


Figure 3 - PEV and EVSE combinations for AC Levels 1 and 2 and DC Level 1

4.3 System Definition

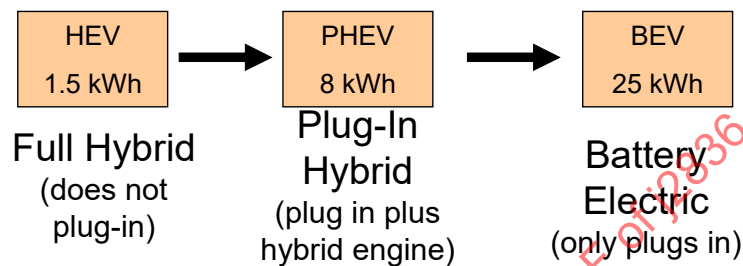
It is expected for the customer to choose DC charging to reduce charge times and potentially shift cost from the PEV to the EVSE at home installations. Public EVSEs would be more likely to include the DC charge capability at highway locations where travelers would need a shorter charge time.

Figure 4 shows the general variation from hybrid to PHEVs and BEVs.

Generalized Vehicle & EVSE Statistics

Typical Vehicle Rechargeable Energy Storage System (RESS)

Capacity size variations:



Electric Vehicle Supply Equipment (EVSE)

Connection architectures:

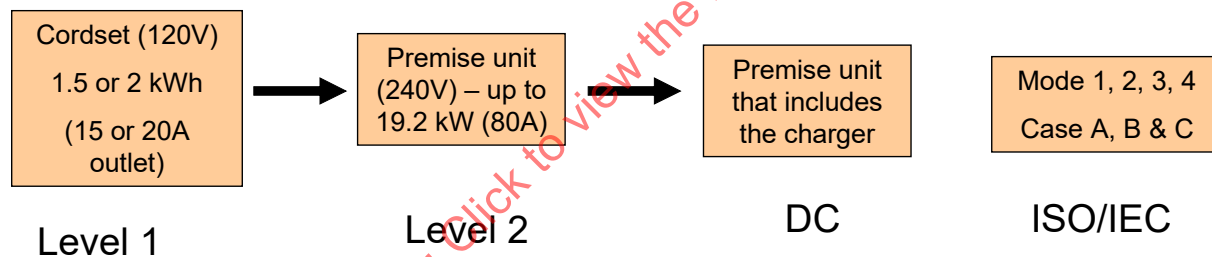


Figure 4 - Generalized vehicle and EVSE variations

Charge rates for these charging levels are identified in SAE J2953/4.

4.4 Architecture

The PEV architecture will vary as to AC or DC, and also with variations in power levels selected. SAE J1772 includes more detail in the architecture, but the following diagrams show the basic power variations. This includes both inband signaling and PLC using the power circuits as different circuit paths for the communication process. DC energy flow requires additional communication and Figures 5 through 7 identify the two paths currently planned. Figure 5 identifies the inband signaling and PLC connections with AC energy transfer, and Figures 6 and 7 show the variations for DC energy transfer using the standard and hybrid connector variations.

1) AC Charging – Level 1 (120V) or 2 (240V)
J1772™ connector, on-board charger.

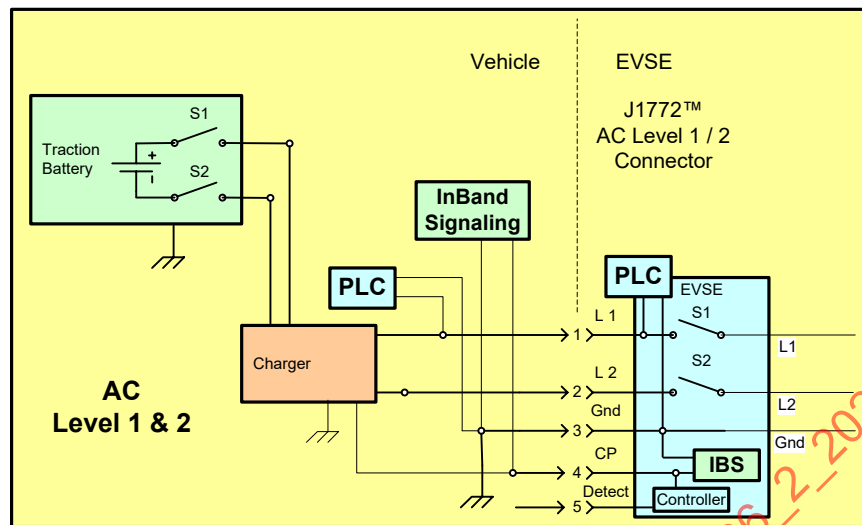


Figure 5 - AC charging architecture

2) DC Level 1 Charging (up to 19.2 kW @ home and 36 kW public to off-board charger - in EVSE)
J1772™ connector, and added S3 & 4.

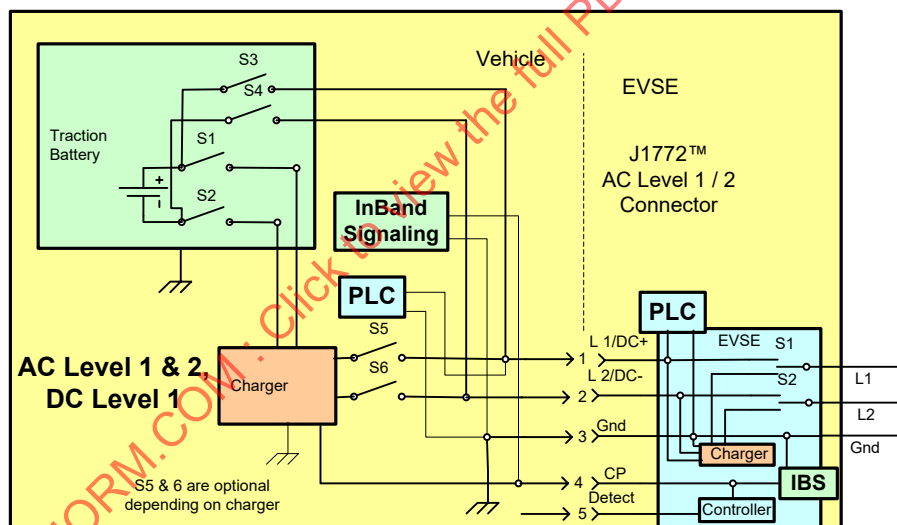


Figure 6 - DC charging architecture (DC Level 1)

3) DC Level 2 Charging (up to 80 kW)
J1772™ hybrid connector - added S7 & 8.

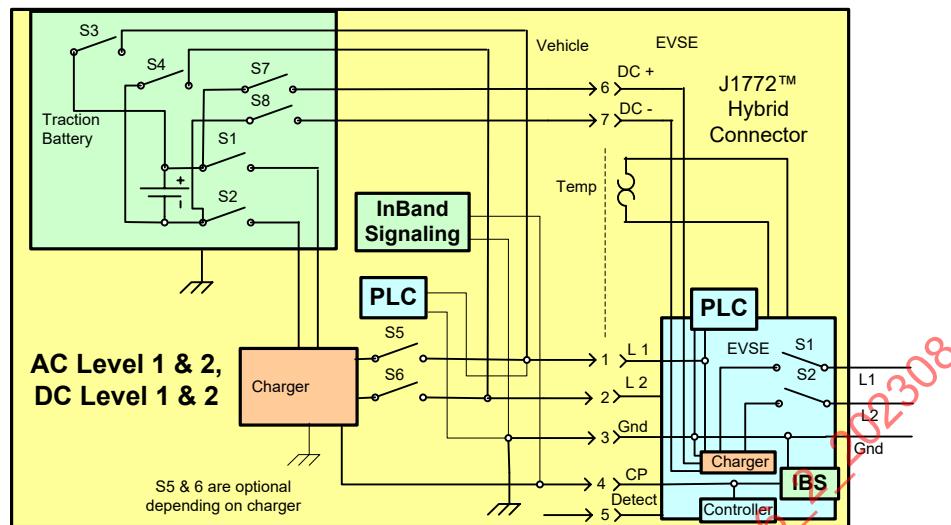


Figure 7 - DC charging architecture (DC Level 2)

4.5 Communication Sequence

4.5.1 Communication Sequence

SAE J1772 describes the control pilot that wakes up the PEV and identifies the ALC. The ALC for AC energy transfer ranges from a 10 to 96% PWM duty cycle. The PWM is at a 5% duty cycle for DC energy. If the EVSE is capable of DC energy transfer (which includes the off-board charger), it starts with the 5% PWM, then waits for the PEV to start sending messages that identifies it is also capable of accepting DC energy. If the PEV doesn't send any messages within the time allocated in SAE J1772, the EVSE reverts to the AC PWM but still waits for the PEV to close a switch, letting the EVSE know it is ready to accept AC energy.

4.5.2 Inband Signaling

Inband signaling is the term used to describe PLC communication using the SAE J1772 control pilot as the path. The communication requirements are identified in SAE J2931/1.

4.5.3 PLC Using the Mains

PLC using the main power circuits between the PEV and EVSE is an alternative and further electromagnetic compatibility (EMC) and functional tests are required to insure its robustness. This would allow the PEV to communicate with the home area network (HAN) or utility, assuming they had the same type of PLC, but if they include a different type of PLC, a bridge would be required to transmit messages. The EVSE or HAN are both considered as primary candidates for the bridging device locations since both of these devices may also contain other mediums based on consumer preferences such as Wi-Fi, cell, or others. This approach is available for Modes 1 and 2 per IEC 61851-1, and AC Level 1 per SAE J1772. Mode 1 does not include a control pilot and is not allowed in some countries, while Mode 2 and AC Level 1 have the control pilot but it is in the EVSE cordset and not at the premises connection. Only the mains pass from the PEV to the premises in Modes 1 and 2.

4.5.4 Sequence Diagrams

When the PEV reads the control pilot and is able to communicate with the EVSE, the inband signaling communication is expected to start, then the PEV and EVSE would close contactors allowing power to transfer, then PLC would be used, if available on the power circuits. SAE J2847-2 identifies the complete sequence diagrams for the PEV to communicate.

Figures 8 through 10 identify the sequence for DC Level 1.

2) DC Level 1 Charging (up to 19.2 kW off-board charger - in EVSE) J1772™ connector, and added S3 & 4.

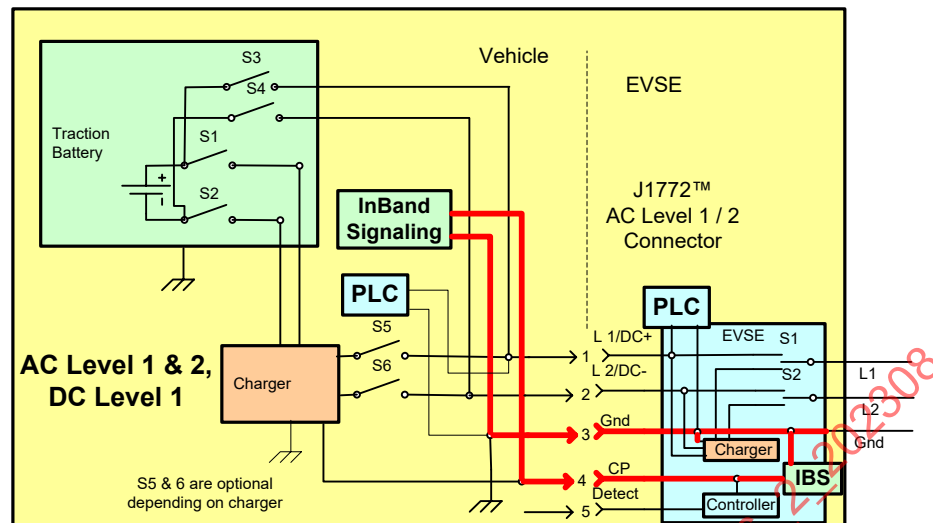


Figure 8 - First sequence: inband signaling communication established

2) DC Level 1 Charging (up to 19.2 kW off-board charger - in EVSE) J1772™ connector, and added S3 & 4.

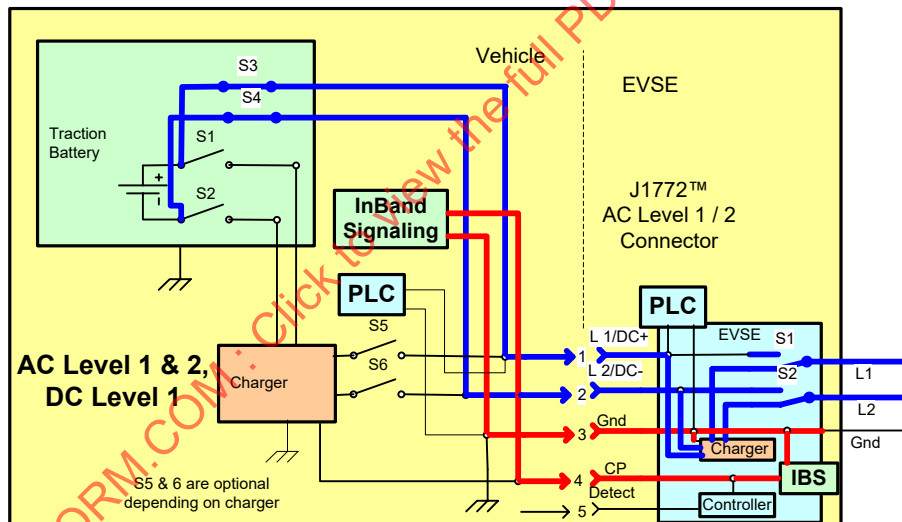


Figure 9 - Second sequence: power is applied