SURFACE VEHICLE STANDARD

J3072 MAY2015

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Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems

RATIONALE

A standard is needed to which a vehicle manufacturer can certify conformance by analyses, inspections, and tests that a specific model of a utility-interactive inverter system, which is integrated into the plug-in electric vehicle (PEV), can be interconnected in parallel with an electric power system by way of compatible, conductively-coupled, electric vehicle supply equipment. The requirements herein are intended to be used in conjunction with IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems and IEEE 1547.1 Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems. The IEEE requirements reflect IEEE 1547a Amendment 1 but not IEEE work in progress towards a major new release.

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1. SCOPE

This SAE Standard J3072 establishes interconnection requirements for a utility-interactive inverter system which is integrated into a plug-in electric vehicle (PEV) and connects in parallel with an electric power system (EPS) by way of conductively-coupled, electric vehicle supply equipment (EVSE). This standard also defines the communication between the PEV and the EVSE required for the PEV onboard inverter to be configured and authorized by the EVSE for discharging at a site. The requirements herein are intended to be used in conjunction with IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems and IEEE 1547.1 Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.

1.1 Purpose

This standard assumes that utilities will establish procedures by which a site could be approved for the interconnection of PEVs with onboard inverters on the basis of an application form that requests EVSE model numbers but does not request PEV information. The interconnection agreement for the site would require an EVSE to only authorize a connected PEV to discharge if the EVSE confirms that the Inverter System Model has been certified as conforming to SAE J3072.

It is expected that a Vehicle Manufacturer (VM) will perform the analyses, inspections, and tests to ensure that each Inverter System Model that is authorized by the VM to be installed in one of their PEV models conforms to the requirements of SAE J3072. The VM will issue a certificate of conformance to SAE J3072 for each authorized Inverter System Model.

It is expected that an EVSE Manufacturer (EVSE OEM) will perform the analyses, inspections, and tests to ensure that each EVSE Model that is authorized by the EVSE OEM to be used with a PEV with an onboard inverter system conforms to the requirements of SAE J3072. The EVSE OEM will issue a certificate of conformance to SAE J3072 for each authorized EVSE model. Alternatively, the EVSE model could be listed by a Nationally Recognized Testing Laboratory (NRTL) as conforming to the requirements of SAE J3072 or to an EVSE safety standard which calls out conformance to SAE J3072 as a requirement.

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1.2 Background

Two approvals are needed before a photovoltaic system can be used. A building permit must be secured from the municipality and their code enforcers inspect the installation to ensure that it meets the appropriate National Electrical Code requirements. An application to interconnect to the grid must also be made with the electric utility for both business reasons (such as net metering) and grid safety (which is based on meeting IEEE 1547). If the inverter unit is listed by a NRTL as conforming to UL 1741, this generally satisfies both the local code enforcement and utility technical requirements. The application forms request the model number of the inverter unit and many states maintain a data base of listed and state approved models. Because the PV system is fixed to the site, it is easy to program site-specific settings (such as the reference voltage) directly into the inverter unit. For a V2G application where the inverter is installed in the EVSE, the same process used with PV systems can be followed.

However, a roaming PEV inverter creates some unique technical and interconnection approval issues. SAE J3072 is intended to deal with both. The PEV can easily cross utility service areas and state lines and connect at locations with different site settings. For example, one EVSE could be connected to 208 VAC service and another EVSE could use 240 VAC service. For an onboard inverter that needs to meet an IEEE 1547 requirement to stop discharging if the grid voltage drops below 88% of the reference voltage, the inverter needs to know the reference voltage for the specific EVSE. It is not practicable to allow this to be an explicit inverter setting in the PEV. SAE J3072 defines requirements for these settings to be made in the EVSE and transferred to the PEV when it connects to the EVSE.

There are no established procedures in the electric power industry for handling a DER interconnection application without providing the actual inverter model to be used on the form. The inverters are always fixed to the site and exactly known. PEVs roam and there could be many different PEV models that could possibly connect to a site EVSE, particularly at public sites. Utility DER interconnection application and approval procedures will need to be modified to allow for roaming PEVs with onboard inverters. The utility would approve the site for interconnecting the PEVs based on the EVSE serving as the gatekeeper and only allowing PEV Inverter System Models that have been certified to conform to SAE J3072 to discharge.

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 J2836/3™ PEV Communicating as a Distributed Energy Resource

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 J2953/1 Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

SAE J2953/2 Test Procedures for the Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 1547™ Standard for Interconnecting Distributed Resources with Electric Power Systems

IEEE 1547.1™ Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

2.2 Related Publications

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

2.2.1 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 J1715 Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J2894/1 Power Quality Requirements for Plug-In Electric Vehicle Chargers

2.2.2 Electric Power Research Institute (EPRI) Publications

Available from EPRI, 3420 Hillview Avenue, Palo Alto, California 94304 (www.epri.com)

Common Functions for Smart Inverters, Version 3; EPRI, Palo Alto, CA; 2013. 3002002233

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2.2.3 IEEE Publications

Available from IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 2030.5-2013 IEEE Adoption of Smart Energy Profile 2.0 Application Protocol Standard

2.2.4 International Electrotechnical Commission (IEC) Publication

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 61850-7-420 Communication networks and systems for power utility automation - Part 7-420, Basic communication structure - Distributed energy resources logical nodes

IEC/TR 61850-90-7 Communication networks and systems for power utility automation - Part 90-7: Object models for power converters in distributed energy resources (DER) systems

2.2.5 National Fire Protection Agency Publications

Available from NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org.

NFPA 70®, National Electrical Code® (NEC®)

2.2.6 UL Publication

Available from UL, 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL 1741 Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

UL 2202 Standard for Safety for Electric Vehicle (EV) Charging System Equipment

UL 2594 Standard for Safety for Electric Vehicle Supply Equipment

UL 9741 Outline of Investigation for Bidirectional Electric Vehicle (EV) Charging System Equipment

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3. DEFINITIONS

3.1 BIDIRECTIONAL CONVERTER

Bidirectional converter is the term used for a device that can convert from AC to DC in one direction to serve as a battery charger and then be capable of being reversed and convert from DC to AC in the other direction to serve as an inverter.

3.2 CORE INVERTER SYSTEM

The onboard inverter function is performed by a distributed system of vehicle components and is not a self-contained device within the PEV. The Core Inverter System is a subset of the inverter system and consists of only those onboard hardware, software, and firmware components which the VM considers to be directly associated with communication with the EVSE for the purpose of setting up the inverter system for the site and authorization of discharging, for meeting the requirements of IEEE 1547 and IEEE 1547.1, and for the execution of smart inverter functions.

3.3 DISTRIBUTED ENERGY RESOURCE (DER)

Distributed Energy Resources are small, modular Distributed Generation (DG) and storage technologies that provide electric capacity or energy where it is needed on the distribution grid. DG, which includes gensets, solar panels, and small wind turbines, only serve as a source of energy. Storage is a unique form of DER because, unlike pure DG, the unit can also provide variable demand. Plug-in vehicles are storage systems.

3.4 ELECTRIC POWER SYSTEM (EPS)

The EPS consists of equipment or facilities that deliver electric power to a load. The most common example of an EPS is an electric utility.

3.5 ELECTRICAL CONNECTION POINT (ECP)

Each DER unit has an ECP which is the point of electrical connection between the DER source of energy (generation or storage) and the local electrical power system (EPS).

3.6 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

This is the generic term used to describe the device that is physically connected and provides energy to the vehicle. EVSEs may take several physical forms, and their logical function may likewise differ substantially. Physical forms include a mobile cordset used for 120VAC charging, a fixed or wall-mounted 240VAC charger, or an off-board DC charger. An EVSE may also support reverse power flow (discharging).

3.7 ENERGY MANAGEMENT SYSTEM (EMS)

The term Energy Management System (EMS) is used in this document to describe a computer system that can communicate with a PEV or EVSE for the purpose of controlling the charging or discharging of the PEV battery. An EMS can exist at several tiers: customer premises, distribution level, or system level. These computer systems may go by other names, but the term EMS will be used generically in this document.

3.8 FORWARD POWER FLOW (FPF)

Forward Power Flow means the direction of energy for charging a vehicle.

3.9 FOUR-QUADRANT CONVERTER

This term refers to an electronic device that can produce or absorb both active and reactive power. When a PEV is discharging the device serves as an inverter converting DC current to AC current. It can displace the AC current waveform relative to the AC voltage waveform to generate or absorb reactive power, depending on whether it leads or lags the supplied current relative to the grid voltage. The device converts AC power to DC current to charge the PEV battery. It can also shift the consumed current relative to the grid voltage waveform to produce or absorb reactive power.

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3.10 INVERTER

AC power is generated from a DC source, such as a traction battery, using a device called an inverter. For operation as an off-grid, standalone power source, the inverter regulates the frequency and voltage and the connected loads determine the current flow from the inverter. A grid-connected inverter (i.e., utility-interactive inverter) must act as a current source and synchronize to the frequency of the grid voltage waveform. The grid voltage and frequency are far too stiff for a single inverter to shift them. Bidirectional Converter is the term used for a device that can convert from AC to DC in one direction to serve as a battery charger and also be capable of being reversed and convert from DC to AC in the other direction to serve as an inverter. A grid-tied power converter can be designed to either lead or lag its sourced current relative to the grid voltage during either charging or inverter operation. This is called a Four Quadrant Converter. For simplicity the bidirectional and four quadrant converters are often just referred to as an “inverter” when discussing reverse power flow. That convention will be followed herein.

3.11 INVERTER SYSTEM

Used in this standard to generically refer to both bidirectional and four quadrant power conversion systems used to interface the electrical system of the PEV with the grid. The term inverter system is used to represent a distributed system - not a self-contained device within the PEV.

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3.12 INVERTER SYSTEM MODEL NUMBER

This is a unique 32 character string which is assigned by the VM to each non-interchangeable configuration of the Core Inverter System which is approved by the VM for use within one of their vehicle models.

3.13 PLUG-IN ELECTRIC VEHICLE (PEV)

This is the generic term used to describe any vehicle that plugs in to receive electrical energy. This includes many different classifications of vehicles, such as Battery Electric Vehicle (BEV), Plug-in Hybrid Electric Vehicle (PHEV)), Extended-Range Electric Vehicle (E-REV), and so on.

3.14 POINT OF COMMON COUPLING (PCC)

This is point where the local (premises) and utility electric power systems connect. This would normally be at the electric meter.

3.15 POWER FACTOR

Generally the term Power Factor is used to mean Displacement Power Factor which is defined as the ratio of active (or real) power in Watts to apparent power in Volt-Amps at the fundamental frequency (50Hz / 60 Hz). It is a measure of the phase shift that occurs between line voltage and line current when the AC line is loaded with a linear load having reactive characteristics, such as an AC motor. The line current is sinusoidal in shape, but either leads or lags the line voltage in phase.

3.16 REVERSE POWER FLOW (RPF)

Reverse Power Flow means the direction of energy for discharging a Vehicle.

3.17 STAND-ALONE INVERTER

An inverter intended to supply a load and does not provide power back to the electric utility. This type of inverter regulates the voltage and frequency for the delivered power to the connected loads.

3.18 UTILITY-INTERACTIVE INVERTER

An inverter intended for use in parallel with an electric power system to supply common loads and sometimes deliver power to the utility. This is also called a grid-connected inverter.

4. TECHNICAL REQUIREMENTS

4.1 System Concept

Figure 1 provides a system concept for a Plug-in Electric Vehicle (PEV) with an onboard inverter system interconnecting to the electric power system (EPS) by way of a conductive coupling to Electric Vehicle Supply Equipment (EVSE). The blocks in the figure are not intended to represent specific components – they are just notional functions. Selected functions of the EVSE are shown on the left side of the figure and selected functions of the PEV are shown on the right side of the figure. The figure does not attempt to show all of the components or functions of the EVSE or PEV that interact with the inverter system. For example, the battery and battery management system are not shown. The figure shows that the onboard inverter function is really performed by a distributed system within the PEV - it is not a self-contained device within the PEV. The term "inverter" is used in this standard to generically refer to both bidirectional and four quadrant power conversion systems. The software functions may be distributed across many intelligent devices. For simplicity, selected software functions are grouped in the large blue boxes labelled PEV Computer(s) and EVSE Computer(s).

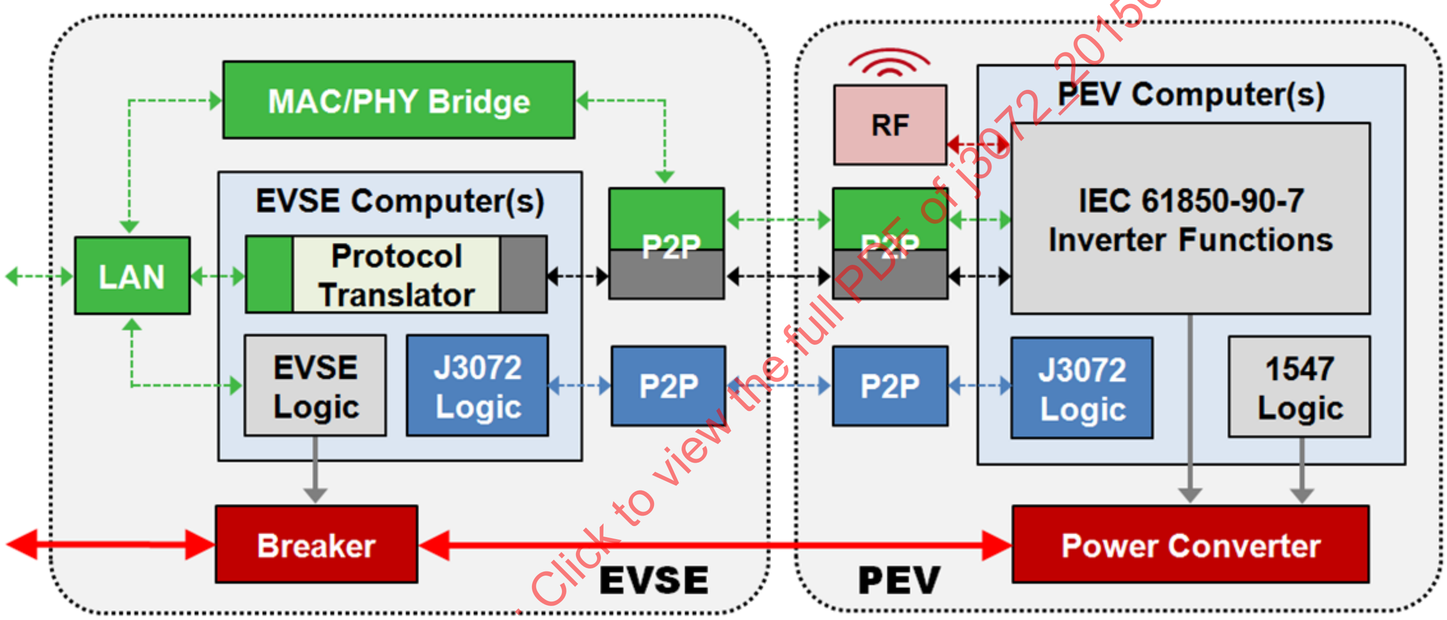

Figure 1 - System concept example

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A primary focus of this document is to define requirements for the information that must be shared between the EVSE and the PEV for the purpose of setting up the onboard inverter system for discharging at the EVSE site and for the EVSE to authorize the PEV inverter to discharge. The logic required by the EVSE and PEV to perform these functions will be defined. This document will also define the specific communication protocols to be used for this purpose. These functions are illustrated by the dark blue boxes.

A key requirement in this document is that the inverter system must meet the requirements of IEEE 1547. The figure shows a block labeled "1547 Logic" to recognize that specific functionality will be required in the PEV inverter system to be able to meet the IEEE 1547 requirements. However, this standard will not define the specific logic for how the inverter system is expected to meet these requirements.

The EVSE will be connected to the facility local area network (LAN). The LAN could use Ethernet, Wifi, or some other physical media. The green block labeled LAN is intended to show this physical interface. The EVSE will be able to communicate with a facility energy management system (EMS) which would be connected to the LAN. The EVSE may also be able to engage a utility or aggregator EMS by connecting to the internet by way of the LAN. The key is that the EVSE is a device which can be engaged by an EMS for direct EMS-EVSE communication. Some SAE J3072 logic performed by the EVSE may require the EVSE to access information from an EMS. However, the EVSE to EMS communication is outside the scope of this document.

While it may be useful for a vehicle operator to be able to manually start the PEV inverter and program it to discharge at a specific power level for a specific duration, vehicle to grid (V2G) applications are based on the PEV inverter interacting with a facility, utility, or aggregator EMS. IEC/TR 61850-90-7 defines the logic and the associated information model for many smart inverter functions. It is expected that inverters will follow this information model for those functions which are selected for implementation. IEC/TR 61850-90-7 does not mandate which functions must be implemented. SAE J2836/3™ recommends specific functions which may be suitable for implementation in a PEV. The software block labeled IEC 61850-90-7 Inverter Functions designates the logic associated with implementing these functions.

At this time, this standard does not require that any specific IEC 61850 smart inverter function be implemented or define specific conformance testing for those functions which may be implemented by a PEV inverter. This standard does not define the communication protocol to be used by the PEV to engage with an EMS for the purposes of engaging the PEV smart inverter functions in a V2G application. However, it is important to understand how the PEV could engage with an EMS to perform a V2G application.

Figure 1 shows three ways that a PEV smart inverter could engage with a facility, utility, or aggregator EMS. If the PEV uses a protocol which is the same as that used by the EMS, the EVSE could be set up to bridge the internet messages directly from the PEV to the LAN and beyond. This path is shown by the green dashed arrows. If the PEV uses IEEE 2030.5 Smart Energy Profile 2.0 (SEP2), this approach could be used to communicate directly with a home EMS that uses SEP2. SEP2 supports many IEC 61850-90-7 functions and all of those identified in J2836/3™.

If the PEV protocol is not compatible with the EMS protocol, the EVSE could perform bidirectional protocol translation. This path is shown by the black dashed arrows from the PEV to the protocol translation software in the EVSE. If the PEV uses the IEC/ISO 15118 protocol for point to point communication between the EVSE and the PEV, the EVSE could perform the translation to the EMS protocol. An EVSE would most likely only provide either a bridge or a translator, but not both. Several bridge EVSEs could be connected to a single translation gateway device which is connected to the facility LAN.

A PEV could use a wireless link to engage the EMS. This could be a Wifi link to a router in the facility. It could also be a proprietary telematics link to a vehicle manufacturer telematics system which would in turn connect to an EMS using a standard protocol. Figure 1 shows telematics being used for IEC 61850 purposes. However, there are many other reasons why a PEV would provide a telematics link.

It is important to differentiate the SAE J3072 point to point messaging between the EVSE and the PEV which are defined by this standard from the higher level V2G engagement between an EMS and the PEV smart inverter. Although it could be possible for the same physical point to point channel between the EVSE and PEV to be used to carry both message streams.

This example does not show all of the possible communication channels. For example, the pulse width modulated control pilot used with SAE J1772 EVSE-PEV is not shown. Some EVSE-PEV system types would not include a control pilot. There will be some requirements which will be unique for each specific System Type as described in 4.2.

4.2 System Types

A PEV with an onboard inverter system and the connected EVSE jointly operate as a single integrated DER. A PEV cannot connect to the EPS without an EVSE and the EVSE does not perform any actual power conversion. The PEV inverter system must be able to interconnect with and be interoperable with the EVSE. This standard is intended to support several EVSE and PEV configurations.

4.2.1 System Type A1 (SAE J1772 AC L2 SEP2)

The EVSE and PEV conform to the requirements of SAE J1772 which apply to AC Level 2 Transfer. The PEV can provide either an SAE J1772 C1 or C1 Combo receptacle (in which case only pin 1 (L1) and pin 2 (L2/N) of the coupler are used to transfer AC power between the EVSE and PEV). The facility reference (nominal supply) voltage will not be less than 208 VAC or greater than 240 VAC. The facility maximum continuous AC charging current will not be more than 80 A RMS. Information which is defined by this standard to be directly exchanged between the EVSE and PEV will be transferred using P2P PLC over the SAE J1772 control pilot in accordance with SAE J2931/4. The higher OSI-layers follow SAE J2931/1 and IEEE 2030.5 to the extent needed to meet the requirements herein.

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4.2.2 System Type B1 (J3068 CAN)

Reserved: to be defined after J3068 is issued.

4.3 Inverter System Models

The Vehicle Manufacturer (VM) is expected to perform conformance testing to J3072 requirements for one of the configurations of each Inverter System Model which is installed into a production vehicle or might arise as a result of an authorized repair by a licensed dealer. Unfortunately, the inverter system functionality is not isolated to one or two removable electronic boxes in the vehicle. The inverter functionality can be widely distributed across many vehicle components which are provided by many different suppliers. Conformance testing may actually be performed using a complete vehicle. But this still requires the VM to be able to define the hardware, software, and firmware components that constitute the inverter system and have a configuration management system that defines how changes to a designated inverter system component can create a new model which would need to be certified.

4.3.1 Define the Core Inverter System

The VM shall define the hardware, software, and firmware components of the vehicle which are considered by the VM to constitute the Core Inverter System.

The Core Inverter System shall consist of at least those onboard components which the VM considers to be directly associated with communication with the EVSE for the purpose of setting up the inverter system for the site and authorization of discharging, for meeting the requirements of IEEE 1547 and IEEE 1547.1, and for the execution of smart inverter functions.

Some vehicle hardware or software components may interact with the Core Inverter System and could be considered to be a part of the inverter system, but are not considered by the VM to be directly relevant to meeting the requirements of this standard and are not considered to be part of the Core Inverter System. For example, a multifunction display system could be used to provide certain settings to the Core Inverter System, but this could be simulated by test equipment during conformance testing to this standard.

4.3.2 Identify Inverter System Models

A collection of interchangeable configurations of the Core Inverter System are defined to be of the same Inverter System Model. A vehicle using any one of the configurations could be used to perform the conformance testing for the Inverter System Model.

The VM shall establish a configuration management approach for identifying interchangeable and non-interchangeable configurations of the components that comprise the Core Inverter System to define Inverter System Models.

This could be done directly using an established VM configuration management system, by using a standalone system constructed by the VM for this purpose, or some combination.

4.3.3 Inverter System Model Number Format

The VM shall assign an Inverter System Model Number to each Inverter System Model. This is in addition to any designation that the VM uses in their internal systems to identify inverter system models. This number is intended to be unique across all VMs which will facilitate the creation of a searchable data base of all certified models.

Table 1 - Inverter system model number format

1-2	3	4-6	7-32
Type	B/4	WMI	VM designation of an Inverter System Model

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The Inverter System Model Number shall consist of a string of 32 characters (UTF-8) as defined by Table 1 and explained below.

Characters 1-2 shall be the System Type as defined in 4.2. (e.g. A1, B1, …)

Character 3 shall be either “B” if the system is a bidirectional converter or “4” if it is a four-quadrant converter.

Characters 4-6 shall be a World Manufacturer Identification (WMI) which has been assigned to the VM. WMI, which is defined by SAE J853, is a three character code which is used by the VM for its vehicle identification numbers (VIN). The WMI used for this model designation does not need to be that for the location of manufacture of the specific vehicle. The sole purpose is to create a unique model identity between manufacturers, so the WMI only needs to be assigned to the VM (i.e., the VM may use the same WMI for all Inverter System Models regardless of which vehicle it is installed in).

The VM shall use the last 26 characters (7-32) of the Inverter System Model Number to uniquely link the Inverter System Model to the VM configuration management system. These characters shall be traceable to a configuration management system which is used by the VM to define the hardware, software, and firmware components within the vehicle that comprise the Core Inverter System. The VM may choose to use notation which comes directly from the VM configuration management system or may elect to use a “more user friendly” notation which is indirectly linked to the VM configuration management system. This VM portion of the Inverter System Model Number shall:

- Use characters that conform to UTF-8 (Universal Character Set Transformation Format 8-bit).
- Include at least 10 non-blank characters and not more than 26 characters
- Be unique and not depend on characters one through six of the Inverter System Model Number for uniqueness.

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4.3.4 Inverter System Model Example

Figure 2 provides an example of a configuration management approach for identifying Inverter System Models and assigning Inverter System Model Numbers.

The first step is for the VM to identify all of the potential hardware, software, and firmware components that could perform some function of the Inverter System and are necessary for the inverter system compliance to this standard. This is a list of parts which are labeled as Part A through Part ZZ. Only five parts (A to E) are defined by the VM to comprise the Core Inverter System. The VM could create an assembly drawing and parts list for the Core Inverter System which would provide the part numbers for each part. In an actual parts list, the description of the part would be provided and Part A might be a vehicle management computer, Part B might be the VMC software, Part E might be power conversion electronics.

In this example, the specific part numbers are designated by A1, C2, E2, etc. In an actual drawing system A1 might look like 326A1234P1. The left column provides the first configuration which is designated by A1 through E1. In the second column Part C is changed from C1 to C2. This is a non-interchangeable part with C1 but it is interchangeable at the top assembly level. This can be tracked using a revision level but the top assembly is not changed. It is “xxxG01” which might actually look something like 299A4000G01 in an actual drawing system. In the fourth column the change to Part E2 creates a new top assembly because it is not interchangeable. This is designated by changing the top assembly to a G02 in this example. In the VM configuration management system the Inverter System Models are defined by the top assembly numbers where “xxx” would be the base drawing, such as 299A4000, and the group numbers differentiate the models.

The first six characters of the Inverter System Model Number are defined by this standard. In this example, the System Type is A1 and uses a four quadrant converter. It is also assumed that this system is in a Jeep with WMI of 1J4. This results in the first six characters being A141J4. The VM can assign up to 26 characters to complete the Inverter System Model Number. One way would be to directly use the top assembly number so A141J4aaa might be defined as A141J4299A4000G01. Alternatively, the VM might want to use descriptive characters that are only linked to the actual drawing system. A model number of A141J4JEEP4Q5K301 might be used to designate a Jeep, 4-Quadrant Converter, 5 KW, series 301. It is only required that the VM can link the assigned model number to the configuration management system that defines the configurations associated with each inverter system model.

Inverter System Model Number		
A141J4aaa	A141J4bbb	A141J4ccc

Top Assembly	Inverter System Models						
	xxxG01			xxxG02		xxxG03	
Revision	-	A	B	-	A	-	A

	Description	Core Inverter System Configurations							
Core Inverter System	Part A	A1	A1	A1	A1	A1	A2	A2	Inverter System
	Part B	B1	B1	B1	B1	B1	B1	B1	
	Part C	C1	C2	C2	C2	C3	C3	C4	
	Part D	D1	D1	D2	D2	D2	D2	D2	
	Part E	E1	E1	E1	E2	E2	E2	E2	
	Part F Part G ... Part ZZ	COMPONENTS NOT SELECTED BY VM TO BE PART OF INVERTER SYSTEM MODEL							

NOTE: All Changes are Class I at Part Level
C2 are Class II at Top Assembly Level (Rev Letter)
E2 are Class I at Top Assembly Level (Group Change)

Figure 2 - Example of inverter system models

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4.3.5 Configuration Control for Inverter System Models

The VM shall have configuration control procedures which will ensure that the configuration of hardware and software components of the Core Inverter System which are installed in each delivered vehicle conform to an Inverter System Model which has been defined and certified by the VM.

The VM shall have a process for providing guidance to their licensed dealers to also ensure the configuration of the Core Inverter System following any repairs conforms to a defined and certified Inverter System Model.

The VM shall provide warnings to the vehicle owner in manuals or other media against any unauthorized modification of the Core Inverter System configuration during any repair or modification which is not performed by a licensed dealer.

4.4 Certification of Inverter System Model to SAE J3072

The VM shall prepare a certification plan which will ensure conformance to the requirements of SAE J3072 for a specific Inverter System Model.

The VM or their designated agents shall perform the analyses, inspections, and tests defined by the certification plan.

After the successful completion of the certification activities defined by the plan, the VM shall prepare a dated certificate of conformance to SAE J3072 for the specific Inverter System Model.

The VM shall maintain a copy of the certification plans, associated detailed procedures, and test results for a duration which is consistent with the VM document retention policies for similar types of records.

4.4.1 Impact of Configuration Changes on Certification Process

The VM shall perform complete conformance testing for the first of a new Inverter System Model. This establishes the baseline model. Figure 3 defines a process for a VM to assess the impact that changes to the inverter system may have on recertification requirements. Changes to the inverter system may happen often and many will not result in the VM creating a new model designation. Also a full certification by the VM may not be warranted for new models that are very similar to the baseline model.

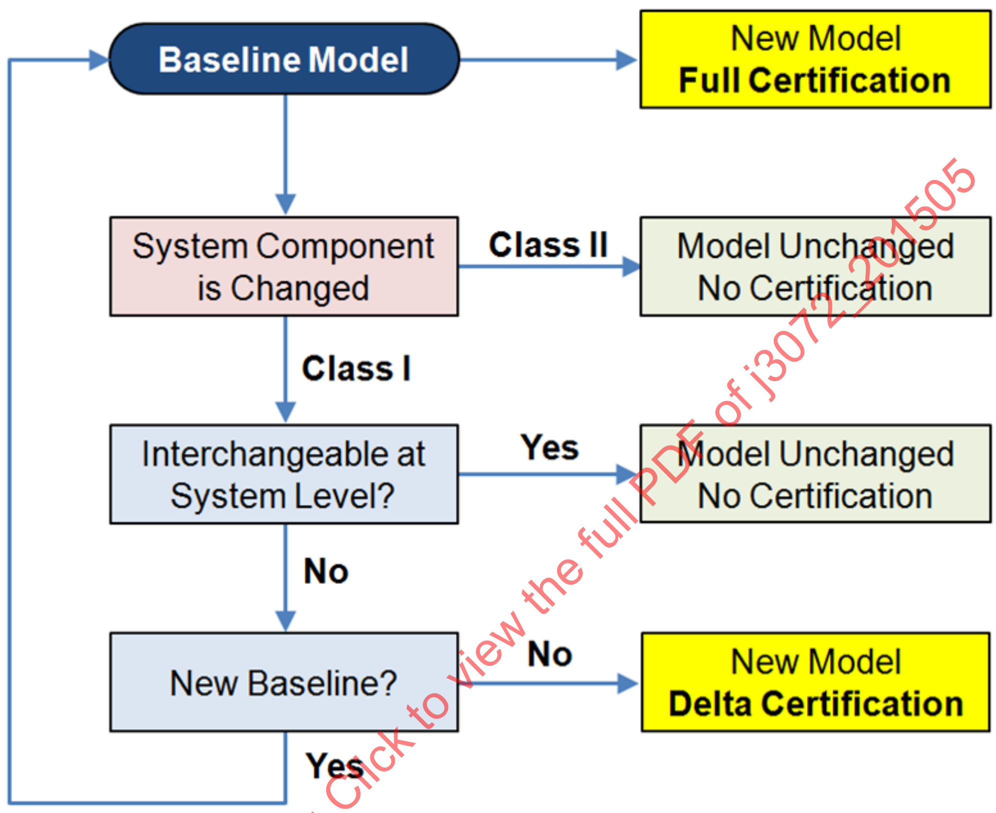

Figure 3 - Certification and changes

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4.4.1.1 Class II Change

If a hardware or software component of the system is changed, the VM may consider the change to be a minor revision (Class II) which is fully interchangeable, forward and backward. The base part number would not normally be changed and many configuration management systems would consider this to be a revision level change. Because the parts are interchangeable, this could have no effect on the higher level system. As part of the VM configuration management process, a configuration control board would expect to see some assurance, which may include regression testing, that this, in fact, is an interchangeable part. These changed configurations would not result in a new model designation and no formal certification testing would be performed.

4.4.1.2 Interchangeable Class I Change

Some changes to a system component may not be interchangeable at the component level, but may not be relevant at the system level in the judgment of the VM. For example, the software in a vehicle computer that includes DER functions may also include functions for time of use charging. The software for time of use may be changed and this could result in the software not being interchangeable. It would be important for the VM to ensure that the DER functions were not impacted, so some analysis and regression testing may be needed to provide this assurance. But because the change has no impact on the inverter system, this could be considered to be interchangeable for the inverter system assembly and a new model would not need to be designated. Recertification to this standard would not be required.

4.4.1.3 Change Results in New Model Designation

Class I changes to a system component that directly impacts inverter system form, fit, or function will result in the creation of a new Inverter System Model. This will require a certification plan for the new model and a new certificate would be issued for this derivative model. The plan could build on the baseline plan and identify exactly what delta testing is needed to certify the new model. The VM must assess whether the magnitude of the change is appropriate for using a delta approach or whether to establish a new baseline and perform the full certification.

4.4.2 System Test Configuration for PEV Inverter System Model

For certification testing the PEV Inverter System Model shall be connected to a "Test EVSE" which shall be either an actual EVSE or an EVSE simulator which conforms to the requirements of SAE J3072. However, any testing which is required to ensure this AC charging compatibility would not be part of the specific testing required to ensure conformance to this standard. The test configuration shall allow the rate of charging and discharging to be set

4.4.2.1 SAE J1772 System Types (A1)

For System Types based on SAE J1772 AC Level 2 EVSE and PEV, the EVSE and PEV shall conform to SAE J1772 requirements for AC Level 2. The EVSE and PEV shall conform to the SAE J2953/1 technical requirements for AC Level 2 charging (SAE J2953/1 section 4). The EVSE and PEV shall be tested using the AC Interoperability Test Procedures of SAE J2953/2 for Tier 1 (Section 4.5), Tier 2 (Section 4.6), and Tier 3 Ampacity Control Test (Section 4.7.1).

4.4.2.2 System Type B1

Reserved: to be defined after SAE J3068 is issued.

4.4.3 Notice of Certification to SAE J3072

The VM shall provide notification with each new vehicle that includes a statement of conformance to SAE J3072, the installed Inverter System Model Number, and the date of certification. This notice may be made available to any user onboard the vehicle electronically on demand using a vehicle display with instructions about finding it printed in a user manual.

The VM shall establish a process where a licensed dealer following any repair which changes the installed Inverter System Model Number would provide the vehicle owner with the statement of conformance to SAE J3072 for the new configuration. This notice may be made available to user onboard the vehicle electronically on demand using a vehicle display with instructions about finding it printed in a user manual.

The VM shall make a copy of the actual certificate of conformance available on request to a party with specific interest, such as a current vehicle owner, a utility, or a state regulator. This requirement can be satisfied by providing internet access to retrieve copies for specific Inverter System Model Numbers.

4.5 Certification of EVSE to SAE J3072

The EVSE Manufacturer (EVSE OEM) shall perform the analyses, inspections, and tests required to ensure that an EVSE Model that is authorized by the EVSE OEM to be used to interconnect a PEV with an onboard inverter system conforms to the requirements in 4.6. The EVSE OEM shall issue a certificate of conformance to SAE J3072 for each authorized EVSE model. The EVSE shall be marked to indicate that it conforms to SAE J3072.

Alternatively, the EVSE Model could be listed by a Nationally Recognized Testing Laboratory (NRTL) as conforming to the requirements to an EVSE safety standard which calls out conformance to SAE J3072 as a requirement. The EVSE shall be marked to indicate that it conforms to SAE J3072.

The EVSE Model shall be connected to either an actual PEV or a PEV Inverter System simulator which conforms to the requirements of 4.6.

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4.6 EVSE Authorization of PEV to Discharge

The EVSE shall be the gatekeeper for authorizing the PEV to discharge at a specific site. This section describes the information to be exchanged between the EVSE and PEV and the logical decisions to be performed by both the EVSE and PEV before the EVSE can authorize the PEV to discharge.

4.6.1 Connection of PEV to EVSE

The vehicle operator connects the PEV to the EVSE by inserting the vehicle connector into the vehicle inlet. This will initiate the normal sequencing logic for AC charging. This basic EVSE and PEV interoperability is not a specific requirement of this standard, but it is a precondition for engaging as a DER. See 4.4.2.

4.6.2 Establish Point to Point (P2P) Communication

The EVSE and PEV shall establish P2P communication as defined by the protocol used for the System Type.

This P2P link shall be used to transfer information which is defined by this standard to be directly exchanged between the EVSE and PEV.

4.6.2.1 System Type A1

System Type A1 shall use the IEEE 2030.5 Smart Energy Profile (SEP2) for P2P communication between the EVSE and the PEV. The OSI physical and data link layers shall conform to SAE J2931/4. This uses high bandwidth power line communication superimposed on the SAE J1772 control pilot. SAE J2931/1 defines the higher layers of the stack which include protocols such as IP, TCP, and HTTP(S).

The EVSE shall act as a SEP2 host server for the PEV SEP2 client for the P2P link. The SEP2 objects to be used by the EVSE and PEV for the P2P communication are defined in Appendix C.

4.6.2.2 System Type B1

Reserved: to be defined after SAE J3068 is issued.

4.6.3 Initial Transfer of EVSE Parameters

After P2P communication is established, the PEV shall acquire the parameters listed in Table 2 from the EVSE.

The EVSE shall set the values of these parameters consistent with the definitions provided in Appendix B.

The EVSE shall set the value of Authorization to Discharge to a value of FALSE until the EVSE confirms that it is appropriate to set the value to TRUE as defined by this standard.

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Table 2 - EVSE parameters for PEV

Parameter	Units
Authorization to Discharge	True/False
EVSE Maximum Forward Power	Watts
EVSE Maximum Reactive Power	VAR
EVSE Maximum Reverse Power	Watts
EVSE Minimum Power Factor	Magnitude Only
EVSE Reference Voltage	Volts RMS
EVSE Reference Voltage Offset	Volts RMS
EVSE Updated Time	Date & Time

4.6.4 Initial Transfer of PEV Parameters

The PEV shall provide the parameters listed in Table 3 to the EVSE after it has received and processed the EVSE parameters. These parameters are defined in Appendix B. The expected use of the EVSE parameters by the PEV to prepare the parameters in this table is described below.

Table 3 - PEV parameters for EVSE

Parameter	**Units**
Inverter System Model Number	32 Character String
SAE J3072 Certified	True/False
SAE J3072 Certification Date	Date & Time
Maximum Forward Power	Watts
Maximum Reactive Power	VAR
Maximum Reverse Power	Watts
Minimum Power Factor	Magnitude Only
Reference Voltage	Volts RMS
Reference Voltage Offset	Volts RMS
Updated Time	Date & Time

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4.6.4.1 Reference Voltage

The PEV shall set the value of Reference Voltage to the value of the EVSE Reference Voltage if it is within the range for the System Type.

If the value of EVSE Reference Voltage is lower than or greater than that allowed for the PEV system type:

- The PEV shall not discharge during the session.
- Maximum Reactive Power shall be set to a value of zero.
- Maximum Reverse Power shall be set to a value of zero.
- Minimum Power Factor shall be set to a value of unity.
- Reference Voltage shall be set to a default value for the System Type.

For System Type A1, if the EVSE does not provide a value for EVSE Reference Voltage to the PEV or it provides an EVSE Reference Voltage that is lower than 208 VAC or greater than 240 VAC, the PEV shall use a default value of 200 VAC for Reference Voltage.

4.6.4.2 Reference Voltage Offset

The PEV shall set the value of Reference Voltage Offset to the value of EVSE Reference Voltage Offset.

If the PEV considers the value to not be valid, it shall set Reference Voltage Offset to a value of zero VAC.

4.6.4.3 Maximum Forward Power

The PEV shall set the value for the Maximum Forward Power to the lower of

- The value of Basic Maximum Forward Power,
- The value of EVSE Maximum Forward Power
- The value computed using the current limit provided by the control pilot signal, if available for the System Type. The PEV shall calculate the control pilot power limit as the product of the current limit and the Reference Voltage.

4.6.4.4 Maximum Reverse Power

The PEV shall set the value for the Maximum Reverse Power to the lower of

- The value of Basic Maximum Reverse Power
- The value of EVSE Maximum Reverse Power
- The value computed using the current limit provided by the control pilot signal, if available for the System Type. The PEV shall calculate the control pilot power limit as the product of the current limit and the Reference Voltage.

The value of Maximum Reverse Power shall be set to zero if the values for Reference Voltage and EVSE Reference Voltage do not agree.

4.6.4.5 Maximum Reactive Power

If the PEV does not have a four quadrant converter the value of Maximum Reactive Power shall be set to zero.

If the PEV has a four quadrant converter the Maximum Reactive Power shall be set to the lower of

- The value of Basic Maximum Reactive Power.
- The value of EVSE Maximum Reactive Power.

The value of Maximum Reactive Power shall be set to zero if the values for Reference Voltage and EVSE Reference Voltage do not agree.

4.6.4.6 Minimum Power Factor

If the PEV does not have a four quadrant converter the value of Minimum Power Factor shall be set to unity.

If the PEV has a four quadrant converter the Minimum Power Factor shall be set to the greater of

- The value of Basic Minimum Power Factor.
- The value of EVSE Minimum Power Factor.

The value of Minimum Power Factor shall be set to unity if the values for Reference Voltage and EVSE Reference Voltage do not agree.

4.6.4.7 Inverter System Information

The VM shall provide a means for an authorized person to set and store the values for the Inverter System Model Number, the SAE J3072 Certification Date, and SAE J3072 Certified. The Inverter System Model Number should correspond to the actual installed Inverter System Model in the PEV.

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4.6.5 EVSE Evaluates PEV Parameters

The EVSE shall evaluate the information received from the PEV as part of the authorization to discharge process. If any of the conditions below is not met, the EVSE shall not authorize the PEV to discharge and the EVSE shall set the Authorization to Discharge parameter to FALSE. Otherwise the EVSE shall change the Authorization to Discharge parameter from FALSE to TRUE.

4.6.5.1 Maximum Forward Power

The value of Maximum Forward Power shall not exceed the lower of

- The value of EVSE Maximum Forward Power.
- The value of the product of the Reference Voltage and the current limit which is defined by the EVSE setting for the SAE J1772 Control PWM Signal (if available for the System Type).

4.6.5.2 Maximum Reactive Power

The value of Maximum Reactive Power shall not exceed the lower of

- The value of EVSE Maximum Reactive Power.
- The value of the product of the Reference Voltage and the current limit which is defined by the EVSE setting for the SAE J1772 Control PWM Signal (if available for the System Type).

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4.6.5.3 Maximum Reverse Power

The value of Maximum Reverse Power shall not exceed the lower of

- The value of EVSE Maximum Reverse Power.
- The value of the product of the Reference Voltage and the current limit which is defined by the EVSE setting for the SAE J1772 Control PWM Signal (if available for the System Type).

4.6.5.4 Minimum Power Factor

The value of Minimum Power Factor shall not be less than the value of EVSE Minimum Power Factor.

4.6.5.5 Reference Voltage

The value of Reference Voltage shall be equal to the value of EVSE Reference Voltage.

4.6.5.6 Reference Voltage Offset

The value of Reference Voltage Offset shall be equal to the value of EVSE Reference Voltage Offset.

4.6.5.7 SAE J3072 Certified

The value of SAE J3072 Certified shall be TRUE.

4.6.5.8 Inverter System Model Number

If required by the site DER interconnection agreement, the Inverter System Model Number shall be approved by the utility or other responsible authority. The means used by the EVSE to verify that Inverter System Model Number has been approved is outside the scope of this standard.

4.6.6 Active Update and Monitoring During Session

The PEV shall maintain P2P communication with the EVSE during any session during which the PEV may engage as a DER and discharge.

The PEV shall not discharge unless the value of the Authorization to Discharge parameter received from the EVSE is TRUE.

The PEV shall check the Authorization to Discharge parameter at least every second and stop discharging if not continually authorized.

If the EVSE detects that the PEV is discharging and the EVSE has not authorized discharge, the EVSE shall disconnect the PEV from the grid by use of the circuit breaker, or use other positive means as appropriate.

4.7 Smart Inverter Functions

This standard shall apply to a vehicle with an onboard inverter system which may only be capable of discharging at a fixed power level as manually set by the vehicle operator using vehicle controls and displays. The controls and displays and operating modes to be used by the vehicle operator to establish the time to start and stop discharging and the rate of discharging for a session are outside the scope of this standard. For certification to this standard, it is only necessary to be able to start, stop, and set the rate of discharging as part of the test setup. Verification of the embedded logic for any manual control function is outside the scope of this standard.

While it is expected that an onboard inverter system would implement one or more of the smart inverter functions described in SAE J2836/3™ Use Cases U6 and U7, IEC/TR 61850-90-7, and EPRI Common Functions for Smart Inverters, this standard does not require that any specific function shall be implemented by the onboard inverter system. However, it is recommended that at least the Basic DER function (U6) defined in SAE J2836/3™ be implemented. Further, this standard does not define conformance testing for smart inverter functions which are voluntarily implemented by the VM. The smart inverter functions all require the PEV to communicate with an EMS which will serve as a controller for the PEV inverter system. The associated communication hardware and software protocols are also outside the scope of this standard.

If certain of the smart inverter functions become mandatory for approval of interconnection of PEVs with onboard inverter systems, this standard may be revised to include requirements for implementation and conformance testing.

NOTE: IEEE 1547a provides default settings for abnormal voltage and frequency and associated clearing times. IEEE 1547a also specifies that under mutual agreement between the utility and DER operator, other voltage and frequency and clearing time settings shall be permitted. As described in 4.8, testing to this standard shall be based on using these default settings. The communication defined by 4.6 does not provide a capability to transfer site-specific abnormal voltage and frequency settings from the EVSE to the PEV. There are smart inverter functions known as Low Voltage Ride-Through (LVRT), High Voltage Ride-Through (HVRT), Low Frequency Ride-Through (LFRT), and High Frequency Ride-Through (HFRT) that provide the capability for a utility EMS to provide settings to a compatible DER. As described above this standard does not require that these functions shall be implemented and does not define conformance testing to ensure that they would be properly implemented by the inverter system. A VM could elect to implement and validate these functions.

4.8 Utility Interaction

The inverter system shall meet the requirements of IEEE 1547-2003 and Amendment 1 (January 2014) except as modified by Table 4.

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Table 4 - IEEE 1547 clarification and modifications

Paragraph	Comment
4.1.1 Voltage regulation	Only a PEV with a four quadrant converter shall permitted to actively participate to regulate the voltage by changing real and reactive power and only when authorized by the EVSE.
4.1.7 Isolation device	This requirement shall be achieved by uncoupling the PEV from the EVSE. A Lockout tag could be attached to the EVSE cord during an emergency or during maintenance as required by by facility safety practices.
4.2.3 Voltage	Voltage shall be measured at the output side of the inverter system power conversion unit. The inverter system shall use the default values defined in Amendment 1 for certification testing to this standard.
4.2.4 Frequency	The inverter system shall use the default values defined in Amendment 1 for certification to this standard.
4.2.6 Reconnection to Area EPS	The delay applies to discharging. The PEV shall use a fixed delay of five minutes.
5.3 Interconnection installation	Not applicable to roaming PEV
5.4 Commissioning tests	Not applicable to roaming PEV
5.5 Periodic interconnection tests	Not applicable to roaming PEV

NOTE: For the purpose of demonstrating conformance to IEEE 1547a section 4.2.3, the inverter shall use the default settings for voltage range and clearing time of IEEE 1547a Table 1 “Interconnection system default response to abnormal voltages.” For the purpose of demonstrating conformance to IEEE 1547a section 4.2.4, the inverter shall use the default settings for frequency and clearing time of IEEE 1547a Table 2 “Interconnection system default response to abnormal frequencies.” SAE J3072 does not define communication between the EVSE and PEV and associated logic to allow the EVSE to provide site-specific, adjustable clearing times to the PEV and for the PEV to use them.

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The inverter system shall be tested in accordance with the IEEE 1547.1-2005 except as modified by Table 5.

Table 5 - IEEE 1547.1 clarification and modifications

Paragraph	Comment
5.1 Temperature stability	
5.2 Abnormal voltages	
5.3 Abnormal frequency	
5.4 Synchronization	Use method 2 (5.4.4)
5.5 Interconnection integrity	
5.6 DC injection	
5.7 Unintentional islanding	
5.8 Reverse power	
5.9 Open phase	
5.10 Reconnect	
5.11 Harmonics	
5.12 Flicker	
6. Production tests	
7. Commissioning tests	Not applicable to roaming PEV
8. Periodic interconnection tests	Not applicable to roaming PEV

5. NOTES

5.1 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, nor in documents that contain editorial changes only.

PREPARED BY THE SAE HYBRID - EV COMMITTEE

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APPENDIX A - ACRONYMS

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

A	Amperes
AC	Alternating Current
BMS	Battery Management System
CAN	Controller Area Network data bus
CP	Control Pilot (J1772)
DER	Distributed Energy Resources
DC	Direct Current
DG	Distributed Generation
ECP	Electrical Connection Point
EMS	Energy Management System
EPRI	Electric Power Research Institute
EPS	Electric power systems
EVSE	Electric Vehicle Supply Equipment
FPF	Forward Power Flow
HAN	Home Area Network
HVRT	High Voltage Ride Through
IEC	International Electrotechnical Commission
KW	Kilowatts
KWH	Kilowatt-Hours
LAN	Local Area Network
LVRT	Low Voltage Ride Through
NEC®	National Electrical Code®
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology
NRTL	Nationally Recognized Testing Laboratory (OSHA)
OSHA	Occupational Safety and Health Administration
P2P	Point to Point Communication Link
PCC	Point of Common Coupling
PEV	Plug-In Electric Vehicle
PLC	PowerLine Carrier
PV	Photovoltaic (solar)
PWM	Pulse Width Modulation
RMS	Root Mean Square
RPF	Reverse Power Flow
SEP2	Smart Energy Profile 2.0
SGIP	Smart Grid Interoperability Panel
SOC	State of Charge
TCIN	Time Charge Is Needed
UTC	Universal Time, Coordinated
UTF-8	Universal Character Set Transformation Formula 8-bit
V	Volts
V2G	Vehicle to Grid
VA	Volt-Amperes
VAR	Volt-Amperes Reactive
VIN	Vehicle Information Number
VM	Vehicle Manufacturer
VRef	Reference Voltage
VRefOfs	Reference Voltage Offset
W	Watts
WADL	Web-Application Descriptive Language
WMI	World Manufacturer Identification

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APPENDIX B - INFORMATION DEFINITIONS

This appendix defines some of the information which is exchanged between the PEV and EVSE which are referenced in this document.

B.1 BACKGROUND INFORMATION

This section defines some information which is used internally by the PEV to calculate certain of the information which is then shared with the EVSE.

Figure B1 shows profiles for an inverter engaging in charging and discharging of the PEV battery where the primary constraint is the rated power capacity of the inverter. A discharging profile is shown in blue at the top and a charging profile is shown in red at the bottom. For a distributed energy resource (DER) production of energy (discharging) is considered to be a positive power flow and consuming energy (charging) is considered to be a negative power flow. The opposite convention is often used when discussing PEV charging, but the DER convention will be followed by this standard.

For a DER it is necessary to define a flat power level for charging or discharging that can be used by the inverter over a broad range of battery SOC. For the case of charging, the Basic Maximum Forward Power would be defined by the vehicle manufacturer (VM) to try to achieve the greatest area (energy) between an SOC of close to zero and the SOC where a proposed value for Basic Maximum Forward Power intersects the charging profile. A similar approach would be used for discharging to define the value for the Basic Maximum Reverse Power. Even though an inverter and its battery may be capable of higher power flow at a specific SOC, it is important for a DER to establish flat ratings across a broad operating range.

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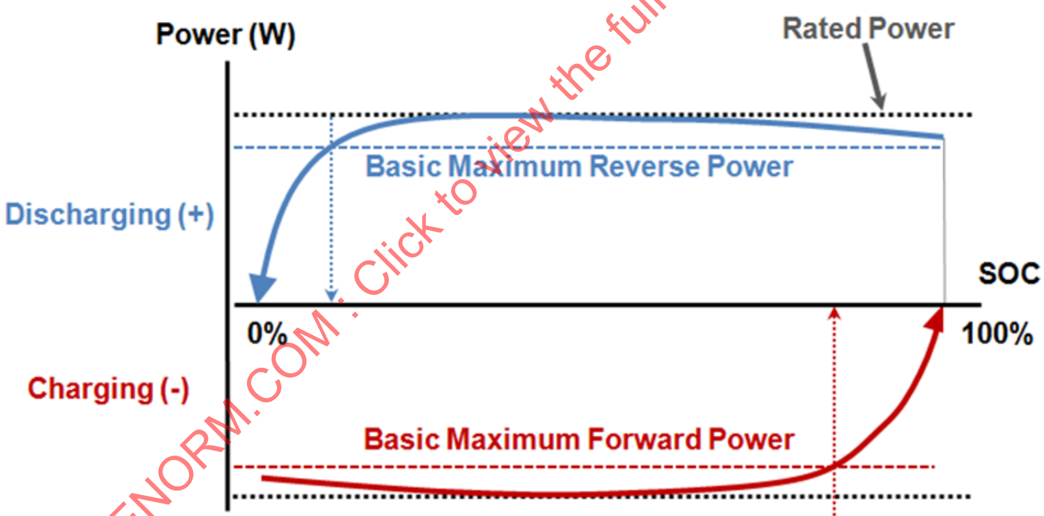

Figure B1 - Battery charging and discharging profiles

Figure B2 shows the first quadrant for a four quadrant inverter system. The red arc indicates the rating of the inverter in VA. For operation at zero active power, the Basic Maximum Reactive Power is equal to the inverter rating in volt-amperes reactive (VAR). The Basic Maximum Reverse Power is selected as described above and will always be lower than the rated value of the inverter. The cosine of the angle formed by the intercept of the arc with the vertical line at the Basic Maximum Reverse Power is defined as the Basic Minimum Power Factor. The Available Reactive Power is also determined by the same intercept. This is the maximum value of reactive power than can be achieved across the entire range of active power. Some IEC 61850 DER functions are based on a percent of Maximum Reactive Power and others are based on a percent of Available Reactive Power. If the Basic Maximum Forward Power is lower than the Basic Maximum Reverse Power, it would be used to determine the Basic Maximum Reactive Power and the Basic Minimum Power Factor.

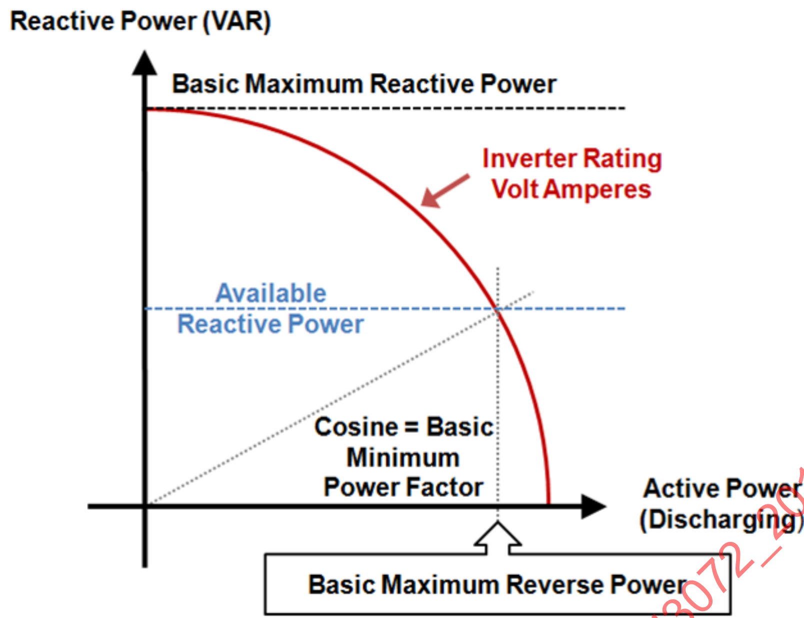

Figure B2 - Reactive power and power factor

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B.1.1 Basic Maximum Forward Power

Source: PEV Internal Parameter
Units: Watts

The maximum flat rated level of power that can be consumed by the PEV over a broad range of SOC as defined by the VM. This reflects the capacity of the inverter system and the capability of the vehicle battery system.

B.1.2 Basic Maximum Reactive Power

Source: PEV Internal Parameter
Units: Volt-Amperes Reactive (VAR)

This parameter is set to the volt-ampere rating of the inverter if it is a four-quadrant converter. For a bidirectional converter a value of zero is used.

B.1.3 Basic Maximum Reverse Power

Source: PEV Internal Parameter
Units: Watts

The maximum flat rated level of power that can be supplied by the PEV over a broad range of SOC as defined by the VM. This reflects the capacity of the inverter system and the capability of the vehicle battery system.

B.1.4 Basic Minimum Power Factor

Source: PEV Internal Parameter
Units: none (0.000 to 1.000)

This parameter is set to the cosine of the angle formed by the intercept of the lower of the Basic Maximum Forward Power or the Basic Maximum Reverse Power with the associated arc defined by the volt-ampere rating of a four-quadrant converter. For a bidirectional converter a value of unity is used.

B.2 EVSE INFORMATION

The upper limit for the value of each EVSE parameter shall be the most conservative value provided to the EVSE operator based on the EVSE itself, the local facility, an associated microgrid, or the distribution utility. This information is not related to the capability of the PEV which may be connected to the EVSE. The values shall never be set to exceed any physical constraints of the utility, microgrid, facility, or the EVSE, although lower values may be set for operational reasons.

B.2.1 Authorization to Discharge

Source: EVSE
Units: TRUE/FALSE

The EVSE would set the value of this parameter to TRUE to authorize the PEV to discharge during a session. The EVSE would set the value to FALSE whenever a PEV is not connected to the EVSE. The EVSE would only change the value from FALSE to TRUE when the EVSE confirms that is acceptable to authorize a connected PEV to discharge. If at any time during a session the EVSE determines that it is no longer acceptable for the PEV to discharge, the EVSE would set the value to FALSE. The PEV is expected to continually monitor this parameter and would not start discharging or would cease discharging if the value is FALSE.

B.2.2 EVSE Maximum Forward Power

Source: EVSE
Units: Watts

This is the maximum energy transfer rate during charging which the PEV is authorized to draw from the EVSE.

The upper limit for this parameter is defined as the product of the EVSE Reference Voltage and the maximum RMS current which can be allowed by the branch circuit and the EVSE. However, a lower value may be provided by the EVSE.

The EVSE may change the value of this parameter during a session.

Note: The EVSE SAE J1772 control pilot PWM signal could be independently set by the EVSE to define an active power limit that has a higher or lower value than this parameter and the PEV is expected to not exceed the lower of the two settings.

B.2.3 EVSE Maximum Reactive Power

Source: EVSE

Units: VAR
This is the maximum reactive power that the PEV is authorized to supply or consume through the EVSE.

The upper limit for this parameter is defined as the product of the EVSE Reference Voltage and the maximum RMS current which can be allowed by the branch circuit and the EVSE. However, a lower value may be provided by the EVSE.

The EVSE may change the value of this parameter during a session.

If the site and EVSE does not support the production or consumption of reactive power by the PEV, the value would be set to zero.

Note: The EVSE SAE J1772 control pilot PWM signal could be independently set by the EVSE to define a reactive power limit that has a higher or lower value than this parameter and the PEV is expected to not exceed the lower of the two settings.

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B.2.4 EVSE Maximum Reverse Power

Source: EVSE
Units: Watts

This is the maximum energy transfer rate during discharging which the PEV is authorized to supply to the EVSE.

The upper limit for this parameter is defined as the product of the EVSE Reference Voltage and the maximum RMS current which can be allowed by the branch circuit and the EVSE. However, a lower value may be provided by the EVSE.

The EVSE may change the value of this parameter during a session.

Note: The EVSE SAE J1772 control pilot PWM signal could be independently set by the EVSE to define an active power limit that has a higher or lower value than this parameter and the PEV is expected to not exceed the lower of the two settings.

B.2.5 EVSE Minimum Power Factor

Source: EVSE
Units: None

This parameter defines the magnitude of the minimum power factor that the PEV inverter system is authorized by the EVSE to operate at while charging or discharging.

If the facility and EVSE cannot support the production or consumption of reactive power by the PEV inverter system, the EVSE would set this parameter to a value of unity.

If the facility and EVSE can allow reactive power to be produced or absorbed without any constraint on power factor, the EVSE would set this parameter to a value of zero.

If the facility and EVSE need to limit power factor of the PEV inverter system, the EVSE would set this parameter to a value between zero and unity.

The value of this parameter and the value of EVSE Maximum Reactive Power do not have to be consistent with the vector relationships of an actual inverter.

B.2.6 EVSE Reference Voltage

Source: EVSE
Units: Volts

This parameter is set to the nominal line voltage at the point of common coupling. This value is not to be adjusted for any planned difference in the target voltage that a utility may have for the PCC versus the actual nominal voltage. A utility might set the substation voltage to 242 VAC to achieve a voltage of at least 238 VAC at the end of a feeder for a nominal 240 VAC system. The EVSE Reference Voltage would be 240 VAC and would not be set to 238 VAC for a PCC at the end of the feeder.

B.2.7 EVSE Reference Voltage Offset

Source: EVSE
Units: Volts

There is no clear guidance on how this parameter should be set for the EVSE. The default value should be zero without specific guidance from the utility.

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NOTE: This parameter is only defined within IEC/TR 61850-90-7 as a constant that is added to the measured voltage at the inverter terminals to create an adjusted voltage which is used by the inverter functions in place of the actual measured voltage. There is debate on how this parameter is measured or calculated as well as for which inverter functions this offset should be applied to the measured voltage at the inverter. IEC/TR 61850-90-7 Ed1 shows it to be an offset between the voltage at the PCC and the voltage at the inverter. But this offset can vary as a function of the rate of charging or discharging of the PEV itself. Some have proposed using this offset to correct for planned differences of the utility target voltage from the reference at the PCC. It is expected that curve functions (such as volt-VAR) would use the parameter to shift the x-axis and can be consider just as another control parameter rather than having different curve functions along a feeder.

B.2.8 EVSE Updated Time

Source: EVSE
Units: UTC

This is the date and time that the information has been updated.

B.3 PEV INFORMATION

B.3.1 Inverter System Model Number

Source: PEV
Units: String 32 Characters

The Inverter System Model Number is a string of 32 characters which is defined in 4.3.3.

The VM shall provide a secure means for an authorized person to set and store the values for the Inverter System Model Number in the PEV. The VM and their licensed dealers shall ensure that the Inverter System Model Number corresponds to the actual installed Inverter System Model in the PEV.

B.3.2 SAE J3072 Certified

Source: PEV
Units: TRUE/FALSE

The value shall be set to TRUE if the VM has certified the Inverter System Model to this standard.

The VM shall provide a secure means for the VM or an authorized dealer to set and store the value in the PEV.

B.3.3 SAE J3072 Certification Date

Source: PEV
Units: UTC

This is the date of SAE J3072 Certificate.

The VM shall provide a secure means for the VM or an authorized dealer to set and store the value in the PEV.

B.3.4 Maximum Forward Power

Source: PEV
Units: Watts

This is the maximum energy transfer rate during charging which the PEV is allowed to consume.

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The PEV shall set the value for the Maximum Forward Power to the lower of:

- The value of Basic Maximum Forward Power,
- The value of EVSE Maximum Forward Power
- The value computed using the current limit provided by the control pilot signal, if available for the System Type. The PEV shall calculate the control pilot power limit as the product of the current limit and the Reference Voltage.

B.3.5 Maximum Reactive Power

Source: PEV
Units: VAR

This is the maximum reactive power that a PEV is allowed to supply or absorb.

If the PEV does not have a four quadrant converter the value of Maximum Reactive Power shall be set to zero.

If the PEV has a four quadrant converter the Maximum Reactive Power shall be set to the lower of:

- The value of Basic Maximum Reactive Power.
- The value of EVSE Maximum Reactive Power.

The value of Maximum Reactive Power shall be set to zero if the values for Reference Voltage and EVSE Reference Voltage do not agree.

Note: The inverter is only capable of producing the Maximum Reactive Power when the active power flow is zero. This limit would be used in conjunction with an IEC 61850 function which controls inverter VAR as a percent of the Maximum Reactive Power and active power must be set to zero. Alternatively, an IEC 61850 VAR function could be set up to control VAR as a percent of available reactive power. A flat value could be defined for available reactive power by using the value of the reactive at the Minimum Power Factor intercept – this level of reactive power is available at any active power level from zero to the maximum.

B.3.6 Maximum Reverse Power

Source: PEV
Units: Watts

This is the maximum energy transfer rate during discharging which the PEV is allowed to supply.

The PEV shall set the value for the Maximum Reverse Power to the lower of:

- The value of Basic Maximum Reverse Power
- The value of EVSE Maximum Reverse Power
- The value computed using the current limit provided by the control pilot signal, if available for the System Type. The PEV shall calculate the control pilot power limit as the product of the current limit and the Reference Voltage.

The value of Maximum Reverse Power shall be set to zero if the values for Reference Voltage and EVSE Reference Voltage do not agree.

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B.3.7 Minimum Power Factor

Source: PEV
Units: None (0.000 to 1.000)

This parameter defines the magnitude of the minimum power factor that the PEV inverter system can be authorized to operate at while charging or discharging.

If the PEV does not have a four quadrant converter the value of Minimum Power Factor shall be set to unity.

If the PEV has a four quadrant converter the Minimum Power Factor shall be set to the greater of:

- The value of Basic Minimum Power Factor.
- The value of EVSE Minimum Power Factor.

The value of Minimum Power Factor shall be set to unity if the values for Reference Voltage and EVSE Reference Voltage do not agree.

Note: This parameter would be primarily used with IEC 61850 functions that controlled active power and power factor. It is also used to calculate the available reactive power for use in IEC 61850 VAR modes. If the inverter system is engaged in an IEC 61850 VAR mode, the actual power factor could be smaller than the defined Minimum Power Factor.

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B.3.8 Reference Voltage

Source: PEV
Units: Volts

This is the nominal voltage which the PEV uses to compute percent of nominal for purposes of setting abnormal voltage limits as defined by IEEE 1547. It can also be used in IEC/TR 61950-90-7 smart inverter functions.

The PEV shall set Reference Voltage to the value of EVSE Reference Voltage if it is within the valid range for the System Type.

Otherwise a default value shall be used as defined based on the System Type. A default value close to but not equal to the minimum value for the System Type is needed to allow a reasonable value to be calculated as the product of the current limit defined by a control pilot signal and the Reference Voltage.

- For System Type A1, if the value for EVSE Reference Voltage is lower than 208 VAC or greater than 240 VAC, the PEV shall set a default value of 200 VAC for Reference Voltage.

B.3.9 Reference Voltage Offset

Source: PEV
Units: Volts

The PEV shall set Reference Voltage Offset to the value of EVSE Reference Voltage Offset.

If the PEV determines that the EVSE value is not valid or unavailable, the PEV shall set a default value of zero volts.

B.3.10 Updated Time

The date and time the PEV information has been updated.

APPENDIX C - P2P USING SMART ENERGY PROFILE 2.0

This appendix shall be followed for those System Types that use IEEE 2030.5 Smart Energy Profile 2.0 (SEP2) to exchange the information between the EVSE and PEV which is required by this standard (i.e., the J3072 information).

This appendix is not intended to be a comprehensive guide to communication protocols and the use of SEP2. The IEEE 2030.5 documents will serve that purpose. SAE J2847/3 provides some useful guidance on the use of the DER function set of SEP2. This appendix only defines certain aspects of the use of SEP2 which are unique to how specific aspects of the SEP2 Model are used to exchange SAE J3072 information. It is critical that the EVSE and PEV use the exact SEP2 resource objects and attributes defined in this appendix for information exchange.

Figure C1 shows an EVSE and PEV configuration which use the SEP2 protocol for SAE J3072 communication. The physical link between the PEV and EVSE uses high bandwidth, power line communication (PLC) over the SAE J1772 control pilot which is defined by SAE J2931/4. This example also shows that the PEV is able to connect directly to the Home Area Network (HAN) by bridging SEP2 internet messages at the MAC/PHY layers in the EVSE. These are two separate SEP2 communication channels with different purposes.

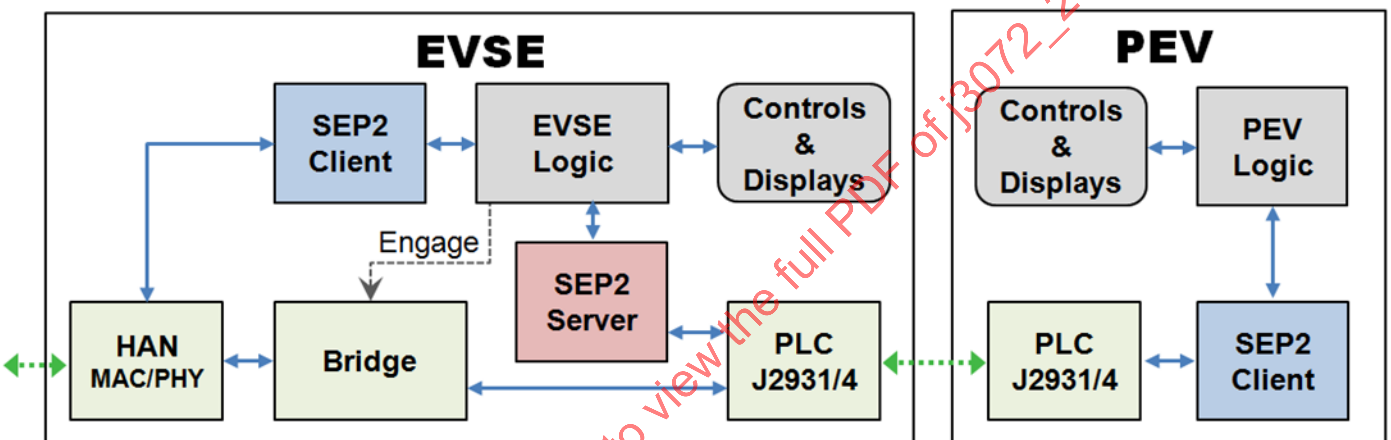

Figure C1 - EVSE as SEP2 server for SAE J3072 communications

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In the example the bridge is used for the PEV to communicate with an EMS that will act as a controller for a V2G application. SAE J2847/3 discusses the use of SEP2 for these engagements. When the bridge is active the PEV SEP2 client can place its resources on a SEP2 server connected to the HAN or even outside the facility on the internet. However, the EVSE will not activate the bridge until it has performed some security verification of the connected PEV. So even without considering SAE J3072 requirements there is a need for the PEV client to engage with an EVSE SEP2 server to provide some information to the EVSE to allow it to make the decision to activate the bridge. This process is also out of scope for this appendix.

For the purposes of SAE J3072 communication it does not matter whether or not SEP2 is used in parallel for communication between the PEV and the EMS. The focus here is only on the direct communication between the PEV and the EVSE for the purpose of exchanging SAE J3072 information. All of the EVSE and PEV resources associated with SAE J3072 communication are hosted on the EVSE server. This appendix will not discuss the SEP2 processes used by the PEV to locate the EVSE server, to discover EVSE resources on it, or to discover where to host its resources on the EVSE server. These methods are all defined by the IEEE 2030.5 documents.

Only three SEP2 resource objects are specifically required to perform the SAE J3072 information transfer between the EVSE and PEV: one from the EVSE and two from the PEV. These will be discussed in detail because it is critical for interoperability between any EVSE and PEV model for the meaning and use to be very clear. Other SEP2 resources such as those needed to establish the communications and to comply with the SEP2 protocol standard may also be needed, but these will be governed by the SEP2 standard.

The HTTP protocol is used by the PEV to request (GET) resources from the EVSE server and to place (PUT) resources on the EVSE server. Table C1 shows excerpts from the SEP2 WADL (Web-Application Description Language) which is defined by IEEE 2030.5. The use of the WADL is also described in SAE J2847/3.

Table C1 - Excerpts from SEP2 WADL

Resource	Sample URI	HTTP Method				GET Response
		GET	PUT	POST	DEL	
EVSE Resources						
DERSettings	URI: /edev/{id1}/der/{id2}/derg	M	E	E	E	DERSettings
PEV Resources						
DERSettings	URI: /edev/{id1}/der/{id2}/derg	M	M	E	E	DERSettings
DeviceInformation	URI: /edev/{id1}/di	M	M	E	O	DeviceInformation

The EVSE is the host server for the PEV client and uses out of band processes to place its resources on its own server. Even though the EVSE is not a DER it will use the SEP2 DERSettings Resource Object to provide its SAE J3072 information to the PEV. This is the only DER Resource needed, although it may be required by the SEP2 protocol to include others which will not be requested by the PEV. The PEV will discover this resource on the EVSE server. The PEV will use the HTTP GET process to request the transfer of the information from the EVSE to the PEV. The EVSE is not actually a DER but the EVSE can present itself as a DER to the PEV for the purposes of performing the information exchange.

The attributes of the EVSE's DER Settings Object are shown in Table C2. The text in red identifies that SAE J3072 information assigned to each attribute.

Table C2 - EVSE SAE J3072 information for PEV

EVSE SAE J3072 ONLY - DER Settings Resource Object		
Attribute	**Type**	**SAE J3072 Parameter**
setGenConnect	Boolean	NOT USED
setGradW	UInt16	Set to 10000
setMaxChargeRate	ActivePower	**EVSE Maximum Forward Power**
setMaxDischargeRate	ActivePower	**EVSE Maximum Reverse Power**
setMaxVA	ApparentPower	NOT USED
setMaxVAr	ReactivePower	**EVSE Maximum Reactive Power**; Else 0
setMaxVArNeg	ReactivePower	NOT USED
setMaxW	ActivePower	**EVSE Maximum Reverse Power**
setMinPF	FixedPointType	**EVSE Minimum Power Factor**; Else 1
setMinPFNeg	FixedPointType	NOT USED
setStorConnect	Boolean	**Authorization to Discharge**
setVRef	VoltageRMS	**EVSE Reference Voltage**
setVRefOfs	VoltageRMS	**EVSE Reference Voltage Offset**
updatedTime	TimeType	**EVSE Updated Time**

The PEV hosts two SEP2 resource objects on the EVSE server for the purpose of SAE J3072 information transfer. One is DER Settings which is shown in Table C3 and the other is Device Information which is shown in Table C4. The text in red defines the SAE J3072 information. The PEV discovers where to host this information on the EVSE server and then uses HTTP PUT commands to place the information on the server. The attributes which do not have an associated SAE J3072 parameter shown in red, may be required to be implemented by the SEP2 Object Model and suggested default values are provided or optional values may be provided. These are not used for SAE J3072 purposes.

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