



SURFACE VEHICLE STANDARD

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Superseding J3072 MAY2015

(R) Interconnection Requirements for Onboard, Grid Support Inverter Systems

RATIONALE

The California Public Utility Commission issued Rulemaking 17-07-007 in July 2017 that, in part, asked “should the Commission consider issues related to the interconnection of electric vehicles and related charging infrastructure and devices and, if so, how?” A special working group, associated with this rulemaking and Rulemaking 18-12-006, was established to consider V2G-AC interconnection issues and the use of SAE J3072. Recommendations and gaps were documented in a December 2019 report. This revision is intended to address concerns raised by this report with SAE J3072. While SAE J3072 needs to support IEEE 1547-2018 and IEEE 1547.1-2020 for four-quadrant inverters, some utilities may allow for pure bidirectional inverters to be used for V2G-AC. Therefore, SAE J3072 shall continue to optionally support IEEE 1547-2003 and IEEE 1547.1-2005. This revision will also serve as a general Five-Year Review to address other issues since the original release.

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1. SCOPE

This SAE J3072 Standard establishes requirements for a grid support inverter system function which is integrated into a plug-in electric vehicle (PEV) which 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 function 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 and IEEE 1547.1. This standard shall also support interactive inverters which conform to the requirements of IEEE 1547-2003 and IEEE 1547.1-2005, recognizing that many utility jurisdictions may not authorize interconnection.

1.1 Purpose

Utilities or local jurisdictions will establish procedures by which a site could be approved for the interconnection of PEVs with onboard inverters based partially on testing and certification to SAE J3072 and other required standards.

The vehicle manufacturer (VM) or their designated agents will perform the analyses, inspections, and tests to ensure that each inverter system model that is installed in one of their PEV models conforms to the requirements of SAE J3072. The VM or third party testing body will issue a certificate of conformance to SAE J3072 for each authorized inverter system model.

The EVSE manufacturer (EVSE OEM) or a Nationally Recognized Testing Laboratory (NRTL) will perform the analyses, inspections, and tests to ensure that each EVSE model to be used with a PEV with an onboard inverter system conforms to the requirements of SAE J3072 or to an EVSE standard which calls out conformance to SAE J3072, as well as other required and applicable United Laboratory (UL) standards. The EVSE OEM or NRTL will issue a certificate of conformance to SAE J3072 or other EVSE standard for each authorized EVSE model.

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, site-specific settings (such as the reference voltage) can be directly entered into the inverter unit. For a V2G-DC application where the inverter is installed in the EVSE, the same process used with PV systems can be followed.

However, a roaming V2G-AC PEV inverter creates some unique technical and interconnection approval issues. 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 V2G-AC 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 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 J1766	Recommended Practice for Electric, Fuel Cell, and Hybrid Electric Vehicle Crash Integrity Testing
SAE J1772	SAE Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler
SAE J2344	Guidelines for Electric Vehicle Safety
SAE J2578	Recommended Practice for General Fuel Cell Vehicle Safety
SAE J2836/3	Use Cases for Plug-in Vehicle Communication as a Distributed Energy Resource
SAE J2847/3	Communication for Plug-in Vehicles as a Distributed Energy Resource
SAE J2894/1	Power Quality Requirements for Plug-in Electric Vehicle Chargers
SAE J2894/2	Power Quality Test Procedures for Plug-in Electric Vehicle Chargers
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)
SAE J3068	Electric Vehicle Power Transfer System Using a Three-Phase Capable Coupler

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 1547-2003	Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE 1547-2018	Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE 1547.1-2005	Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
IEEE 1547.1-2020	Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces
IEEE 2030.5-2018	IEEE Standard for Smart Energy Profile Application Protocol

2.1.3 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 4; EPRI, Palo Alto, CA; 2016. 3002008217

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

2.2.2 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 61850-7-420 ED2 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

2.2.3 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 20653:2013 Road Vehicles - Degrees of Protection (IP Code) - Protection of Electrical Equipment Against Foreign Objects, Water, and Access

2.2.4 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®)

2.2.5 UL Publications

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

3. DEFINITIONS

3.1 BIDIRECTIONAL INVERTER

Bidirectional inverter is a 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. This term is not used for devices that are capable of injecting or absorbing reactive power while charging or discharging (see [3.9](#)).

3.2 CONFIGURATION INFORMATION

IEEE 1547-2018 10.4 defines Configuration Information which shall be available through a local DER communication interface. These are “as-configured” values for associated Nameplate Information. IEEE 2030.5 considers these as attributes for its DERSettings object.

3.3 CORE INVERTER SYSTEM (SAE J3072-Defined Term)

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.

3.4 DISTRIBUTED ENERGY RESOURCE (DER)

Distributed energy resources are small, modular generation and storage technologies that provide electric capacity or energy where needed on the distribution grid. Generation, 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 generation, the unit can also provide variable demand. Plug-in vehicles are storage systems.

3.5 DER MANAGING ENTITY (DME)

IEEE 1547-2018 defines a DME is an entity that monitors and manages the DER through the local DER communication interface and could be, for example, a utility, an aggregator, a building energy management system, or EVSE. This standard considers the EVSE to be the sole DME for provisioning of Configuration Information and providing permission to discharge. There can be more one authorized DME for a specific DER in which case the DER must have well-defined prioritization logic to arbitrate potentially conflicting commands.

3.6 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.

3.7 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 120 VAC charging, a fixed or wall-mounted 240 VAC charger, or an off-board DC charger. For SAE J3072, the EVSE is also the sole DME for provisioning of Configuration Information to the PEV and approves or disapproves discharging.

3.8 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.

3.9 FOUR-QUADRANT INVERTER

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.

3.10 GRID SUPPORT INVERTER

This term is used for an inverter capable of absorbing and injecting reactive power and executing the “smart inverter” functions required by the utility.

3.11 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 was called a utility-interactive inverter in NEC Article 705.

3.12 INVERTER

This is a generic term for power conversion equipment that can take DC current from a PEV traction battery and provide AC power to the electric power system (EPS), a home which has been isolated (islanded) from the grid, or an isolated load. The term is used where the device is also capable of converting energy from the EPS to DC current to charge the battery. There are many types of inverter technology.

3.13 INVERTER SYSTEM (SAE J3072-Defined Term)

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.

3.14 INVERTER SYSTEM MODEL NUMBER (SAE J3072-Defined Term)

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.

3.15 MANAGEMENT INFORMATION

IEEE 1547-2018 10.6 defines Management Information which is used to update functional and mode settings for the DER. The information may be read or written through a local DER communication interface. IEEE 2030.5 uses DERCurve, DefaultDERControl, DERControl, and other objects to transfer Management Information between the EVSE and the PEV.

3.16 NAMEPLATE INFORMATION

IEEE 1547-2018 10.3 defines Nameplate Information which shall be available through a local DER communication interface. These are ratings which may be adjusted to a less demanding value as Configuration Information. IEEE 2030.5 considers these as attributes for its DERCapability object.

3.17 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.

3.18 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.

3.19 POINT OF CONNECTION (PoC)

This is the point that the DER connects to the local electric power system. For V2G-AC, the PoC is the connection of the PEV to the EVSE charging cable.

3.20 POWER FACTOR (PF)

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-amperes at the fundamental frequency (50 Hz/60 Hz). PF 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.

3.21 REFERENCE POINT OF APPLICABILITY (RPA)

The location where the interconnection and interoperability performance requirements of IEEE 1547 apply. This is generally the point of common coupling (PCC) but under certain circumstances the point of connection (PoC) can serve as the RPA.

3.22 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. This is used for V2H and V2L.

3.23 WORLD MANUFACTURER IDENTIFIER (WMI) CODE

The first section of the vehicle identification number (VIN), which designates the manufacturer of the vehicle and is assigned to a vehicle manufacturer to allow identification of that manufacturer. Defined by ISO 3780.

4. TECHNICAL REQUIREMENTS

This section defines requirements, designated by “shall” statements, that are expected to be exactly followed by the organization responsible for their implementation. This would be the vehicle manufacturer for the case of PEV requirements and the EVSE manufacturer for the case of EVSE requirements.

Section [4.1](#) describes an EVSE-PEV system concept which serves to define SAE Type V2G-AC, which is the focus of this standard. There are no specified “shall” requirements in this section. This is only an informational section. Please note that the term “inverter” refers to a distributed system of hardware and software components within the PEV that perform the inverter functions as defined by IEEE 1547-2018.

Section [4.2](#) defines the concept of “system type” to consist of a PEV with an onboard inverter system function operating as a distributed energy resource (DER) and an EVSE operating as a DER Managing entity (DME). Two system types (A1, B1) are defined based on the physical connection between PEV and EVSE and the protocol used for communication between DME and DER. Other system types may be added in subsequent revisions. Most requirements in this standard are applicable to all system types. A defined system type is needed when certain requirements must be differentiated based on system type.

Section [4.3](#) defines the concept of an inverter system model (ISM) and the assignment of a globally unique, 32-character, inverter system model number (ISMN) by the vehicle manufacturer. Because the inverter function is not entirely contained in one removable component produced by a supplier, the vehicle manufacturer must establish a configuration management system to uniquely define the hardware and software components of the vehicle that comprise, what the vehicle manufacturer considers to constitute, the core inverter system function.

Section [4.4](#) defines the process by which the vehicle manufacturer certifies the ISM as conforming to the requirements of this standard. It also defines procedures for the vehicle manufacturer to follow to address changes to hardware or software and the need to create a new ISMN and perform a full certification or an incremental delta certification.

Section [4.5](#) requires the EVSE manufacturer to certify the EVSE to the requirements of SAE J3072. This is in addition to other standards that apply to the EVSE for charging vehicles. This standard describes certain information exchanges between the PEV and EVSE in [4.6](#) and [4.7](#) from the perspective of the PEV receiving information from the EVSE and providing information to the EVSE. Each EVSE model shall be independently tested to certify that it conforms to these requirements.

Section [4.6](#) defines specific PEV and EVSE communications required at coupling to program the vehicle for operation as a distributed energy resource (DER) at that specific location for that session. The outcome of the described required process is that the PEV shall have the correct Nameplate Information, Configuration Information, and Management Information as defined by IEEE 1547-2018 Clause 10. [Appendix B](#) provides additional narrative regarding specific parameters called out in this section and should be used as a reference. This was done to keep the “shall” requirements clearly stated in [4.6](#) and not mixed with descriptive rationale and other discussion more appropriate for [Appendix B](#).

Section [4.7](#) defines requirements for engagement of the PEV with a designated DER managing entity (DME) during a session. The EVSE is designated as the exclusive DME for providing the PEV with authorization to discharge and for managing all required functions defined by IEEE 1547-2018. The PEV shall also implement the coordinated charge/discharge management function for which active power commands may be provided by other DME. The PEV shall implement the dynamic calibration function for correcting voltage measured at the point of connection (PoC) to voltage at the point of common coupling (PCC).

Section [4.8](#) requires the inverter system function of the PEV to meet the requirements of IEEE 1547-2018, as tested in accordance with IEEE 1547.1-2020. The requirements in [4.6](#) and [4.7](#) are based on these same standards.

Section [4.9](#) requires the vehicle manufacturer to ensure that automotive industry standards and practices used to design, produce, and test other safety-critical, electronic equipment are followed for the PEV inverter system model. This section also calls out some other specific design and test 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 and 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). The PEV is considered to be a complete distributed energy resource (DER) which connects to the local electric power system at the vehicle charging inlet. The EVSE is considered to be a DER managing entity (DME).

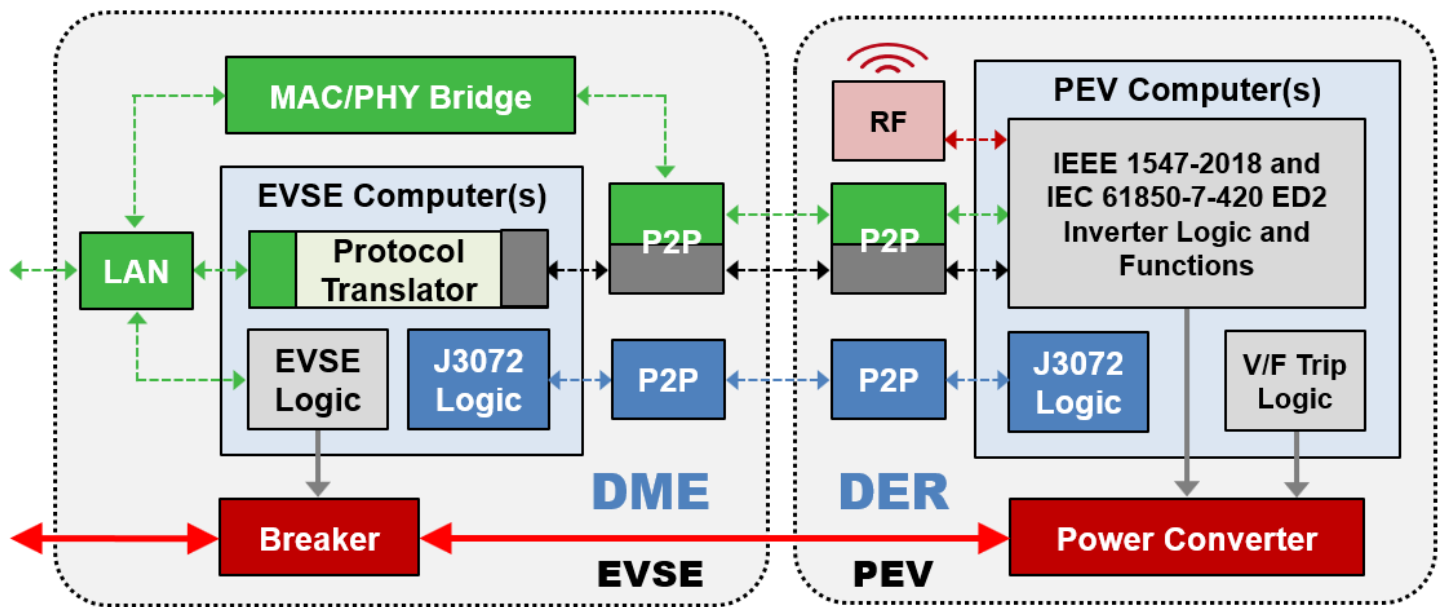


Figure 1 - System concept example

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.

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 61850-7-420 ED2 defines the logic and the associated information model for many smart inverter functions. Inverters are expected to follow this information model for those functions which are selected for implementation. IEC 61850-7-420 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 61850-7-420 ED2 inverter functions designates the logic associated with implementing these functions. IEEE 1547-2018 requires the implementation of many of the functions described by IEC 61850-7-420 ED2. This standard requires the implementation of SAE J2836/3 Use Case U6 which is identified as the coordinated charge/discharge operational function DTCD in IEC 61850-7-420 ED2.

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, understanding how the PEV could engage with an EMS to perform a V2G application is important. [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, this approach could be used to communicate directly with a home EMS. IEEE 2030.5 supports many IEC 61850-7-420 ED2 functions and all of those identified in SAE 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 61850-7-420 ED2 purposes. However, there are many other reasons why a PEV would provide a telematics link.

The SAE J3072 point-to-point messaging between the EVSE and the PEV, which are defined by this standard, must be differentiated from the higher level V2G engagement between an EMS and the PEV smart inverter; however, 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 **shall** operate as a distributed energy resource and the connected EVSE **shall** operate as a DER managing entity. 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. For each system type the communication protocol to be used **shall** be defined.

4.2.1 System Type A1 (SAE J1772 AC L2 IEEE 2030.5-2018)

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.

4.2.2 System Type B1 (SAE J3068 LIN-CP)

The EVSE and PEV conform to the requirements of SAE J3068. The PEV **shall** provide an SAE J3068 AC6 receptacle with or without DC8 combo contacts and may transfer single or three phase AC power. Information which is defined by this standard to be directly exchanged between the EVSE and PEV will be transferred using LIN-CP as defined in SAE J3068.

4.3 Inverter System Models

The vehicle manufacturer (VM) is expected to perform conformance testing to SAE 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 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

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 and 2 **shall** be the system type as defined in [4.2](#) (e.g., A1, B1, ...).

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

Characters 4 through 6 **shall** be a three-character World Identification Number (WMI) 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 model in which it is installed).

The VM **shall** use the last 26 characters (7 through 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 from the Unicode Basic Latin code table encoded in UTF-8 ([Universal Character Set Transformation Format 8-bit](#)).
- Include at least ten non-blank characters and not more than 26 characters.
- Be unique and not depend on characters one through three of the inverter system model number for uniqueness.

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 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; Part A might be a vehicle management computer, Part B might be the VMC software, and 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 the part is interchangeable at the top assembly level. This can be tracked using a revision level, but the top assembly is not changed. The top assembly is “xxxG01,” which might look something like 299A4000G01 in an actual drawing system. In the fourth column, the change to Part E2 creates a new top assembly because the part 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 inverter. This example also assumes 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, four-quadrant inverter, 5 kW, series 301. The VM is only required to 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

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

There **shall** be a certification plan which will ensure conformance to the requirements of SAE J3072 for a specific inverter system model.

An authorized agency **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 authorized agency **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

[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.

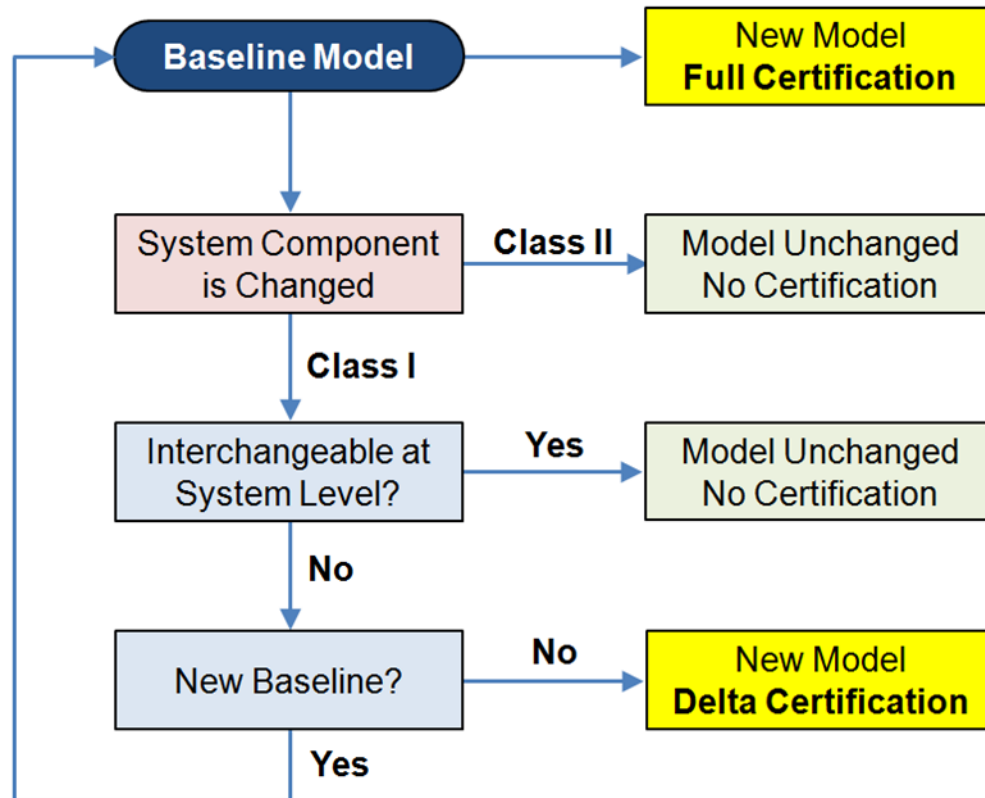


Figure 3 - Certification and changes

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 parts of the full certification test need to be repeated to certify the new model (Delta Certification). The VM must assess whether the magnitude of the change is appropriate for using a delta certification 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 an approved “Test EVSE” which **shall** be either an actual EVSE or an EVSE simulator which conforms to the requirements of SAE J3072 and other required standards. 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 (4.5), Tier 2 (4.6), and Tier 3 ampacity control test (4.7.1).

4.4.2.2 System Type B1

For system types based on SAE J3068 AC EVSE and PEV, the EVSE and PEV **shall** conform to SAE J3068 requirements for AC charging including SAE J1772 interoperability requirements.

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.

4.5 Certification of EVSE to SAE J3072

The EVSE **shall** be tested and certified to the requirements of SAE J3072 or to an EVSE standard which calls out conformance to SAE J3072, as well as other required and applicable standards such as United Laboratory (UL) or Protocol. The authorized entity **shall** issue a certificate of conformance to SAE J3072 or other EVSE standard for each authorized EVSE model.

The EVSE, as an independent device, will need to meet many other requirements. [Appendix G](#) provides guidelines for a System Type A1 EVSE.

4.6 Define PEV Configuration and Management Information at Connection to EVSE

The PEV **shall** internally store Nameplate Information (IEEE 1547-2018 10.3) for each element described within IEEE 1547-2018 Table 28. The values for this information in the PEV **shall** only be entered or changed at manufacture or after service by an authorized manufacturer representative. An image of PEV Nameplate Information, as may be presented by the PEV, could disclose different values based on processes defined by this standard.

At coupling, the EVSE **shall** present certain information to the PEV that represents the limitations of the EVSE at the interconnection site. The PEV **shall** then define Configuration Information (IEEE 1547-2018 10.4) for each element described by IEEE 1547-2018 Table 28 and other information, as required by this standard. PEV values **shall** be set following procedures of this section.

The EVSE **shall** evaluate the updated PEV Configuration Information to ensure that the values are appropriate for use at the location.

After definition of PEV Configuration Information has been coordinated between the EVSE and PEV, the EVSE **shall** provide Management Information (IEEE 1547-2018 10.6) to the PEV for only those functions for which the local site does not use the default settings defined by IEEE 1547-2018.

The PEV **shall** not discharge until it has been authorized by the EVSE to do so at the completion of these processes. The EVSE **shall** not issue such authorization, or continue such authorization, if the EVSE determines before or during a session that the PEV is not properly configured to operate as a DER at this location at this time.

4.6.1 Connection of PEV to EVSE

The vehicle operator connects the PEV to the EVSE by inserting the EVSE cable plug into the vehicle charging receptacle. This will initiate the normal sequencing logic for AC charging. This basic EVSE and PEV interoperability for charging is not a specific requirement of this standard, but this 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 as a DER Managing Entity and PEV as a DER. This P2P link **shall** remain active throughout the session. If for any reason this link is lost, the PEV **shall** cease to discharge. Specific SAE J3072 protocol requirements and examples **shall** be developed for the PEV and EVSE for each system type and **shall** be included in a standalone specification or in other approved standards. The PEV and EVSE **shall** be tested and certified for conformance to the protocol requirements.

4.6.2.1 System Type A1

System Type A1 **shall** conform to the IEEE 2030.5-2018 Smart Energy Profile for P2P communication between the EVSE and the PEV. 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 an IEEE 2030.5 host server for the PEV IEEE 2030.5 client for the P2P link. Examples of IEEE 2030.5 objects to be used by the EVSE and PEV for the P2P communication are provided in [Appendix C](#).

4.6.2.2 System Type B1

System Type B1 **shall** perform P2P communication between the EVSE and the PEV via LIN-CP signals defined specifically for this purpose in SAE J3068. A PEV with a bidirectional inverter conforming to IEEE 1547-2003 **shall** exclusively use signals specifically intended for SAE J3072 compliance. A PEV with a four-quadrant inverter **shall** use the SunSpec information models described in SAE J3068 communicated via the SunSpec-LIN-CP tunnel defined in SAE J3068 except where noted in that standard.