SURFACE VEHICLE STANDARD

J3072™   **JUN2024**

Interconnection Requirements for Onboard, Grid Support Inverter Systems

RATIONALE

The California Public Utility Commission directed its utilities to work with industry and standards development organizations (SDO) to develop standards to support V2G-AC. SAE J3072 was identified by CPUC as a standard to be considered for the EV. As part of this utility-led activity, UL is working on an EVSE standard, "UL 1741 Supplement SC," that aligns with an EV certified to SAE J3072 to support V2G-AC. This standard is expected to be published in 2024. SunSpec published the "IEEE 2030.5 V2G-AC Profile Implementation Guide for SAE J3072" in June 2022. Certain changes have been made to this version to correct for errors and omissions identified during the development of these documents.

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1. SCOPE

SAE J3072 establishes requirements for a grid support inverter system function that 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 1547-2018 and IEEE 1547.1-2020 or later versions.

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 that 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 an 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 database 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 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 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 Source
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
SAE J3068/1	Identification of Vehicles and Supply Equipment for Conductive AC Charging
SAE J3068/2	Control of Bidirectional Power for AC Conductive Charging
SAE J3400	NACS Electric Vehicle 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 1547.1-2020	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, Tel: 800-313-3774, www.epri.com.

Common Functions for Smart Inverters, Version 4; 2016. 3002008217

2.1.4   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 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

IEC 62196-2   Plugs, Socket-Outlets, Vehicle Connectors and Vehicle Inlets - Conductive Charging of Electric Vehicles

2.1.5   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 15118   Road Vehicles - Vehicle to Grid Communication Interface

ISO 15118-20: 2022   Road Vehicles - Vehicle to Grid Communication Interface - Part 20: 2nd Generation Network Layer and Application Layer Requirements

ISO 3780:2009   Road Vehicles - World Manufacturer Identifier (WMI) Code

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

2.1.6   SunSpec Alliance Publications

Available from SunSpec Alliance, 500 E. Hamilton Ave # 1022, Cambell, CA 95008, Tel: 408-217-9110, https://sunspec.org.

IEEE 2030.5 V2G-AC Profile Implementation Guide for SAE J3072

2.1.7   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 1741 SB   Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources: Supplement SB

UL 1741 SC   Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources: Supplement SC (Bidirectional Electric Vehicle Supply Equipment (BEVSE) / Interconnection Systems Equipment (ISE) for EVs with Bidirectional Onboard Inverters)

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

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   NFPA Publications

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

NFPA 70   National Electrical Code® (NEC®)

2.2.3   UL Publications

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

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 that 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 as 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 than 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 EPS, a home that 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 that 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 that 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-amps 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 3780:2009.

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 that 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). System types 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 PEV to be connected to an EVSE that has been certified as conforming to UL 1741 Supplement SC.

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 PEV with an onboard inverter system interconnecting to the EPS by way of a conductive coupling to 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 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).
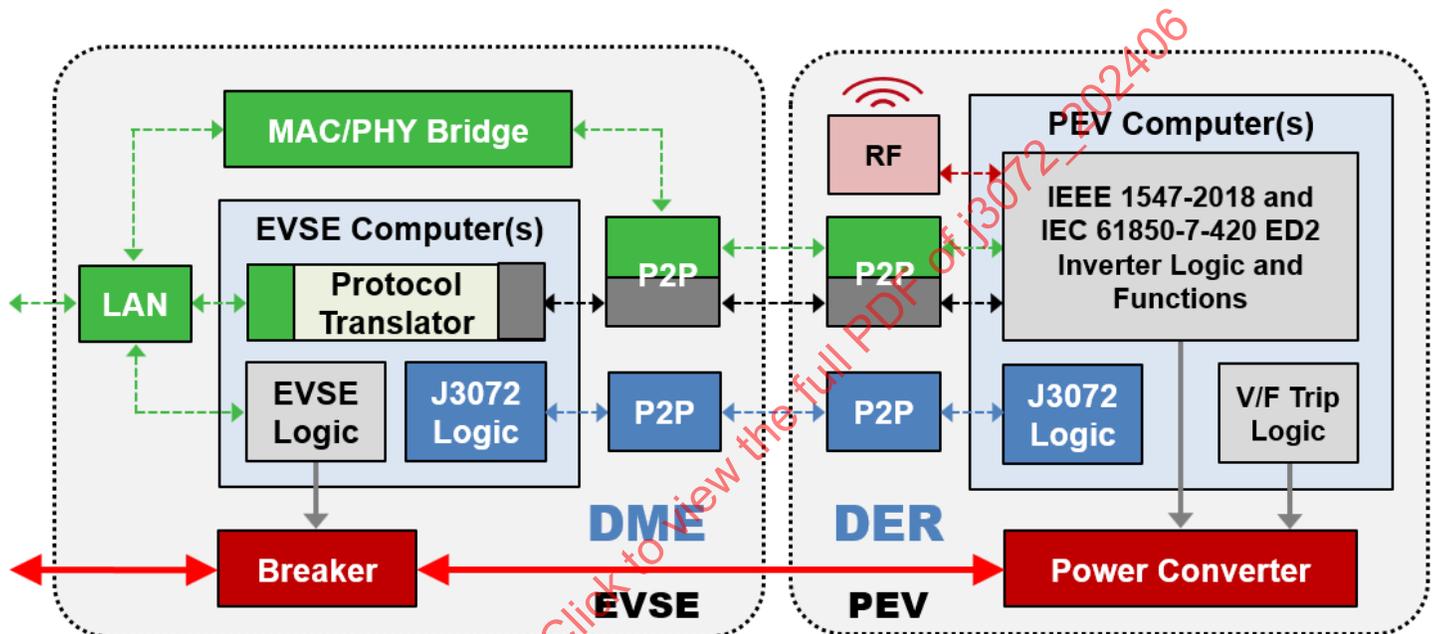
Figure 1 - System concept example

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, Wi-Fi, 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 that 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 that are selected for implementation. IEC 61850-7-420 does not mandate which functions must be implemented. SAE J2836/3 recommends specific functions that 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 that 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 Wi-Fi 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 that 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. A "System Type" shall be assigned to the PEV onboard inverter system based on the charging receptacle installed on the PEV and the complete communication protocol stack from the physical layer through the application layer. Each System Type shall be designated by a two-character code, which shall be included in the Inverter System Model Number (ISMN) as defined in 4.3.3. and Table 1. If a PEV supports more than one protocol stack, it would include an ISMN for each System Type, and the one that corresponds to the established EVSE-PEV communication would be exchanged with the EVSE.

4.2.1   Legacy System Types

Two System Types (A1, B1) were established in prior versions of this standard that are valid configurations but are being replaced by a new system type code model. System Type A1 will be replaced by C1 and System Type B1 will be replaced by System Type D2 for new models. For historical reference, A1 and B1 are retained.

4.2.1.1   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 that 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.

4.2.1.2   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 that 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.

4.2.2   New System Type Designations

The maximum voltage and maximum power *are* digitally negotiated between the EVSE and PEV prior to establishing a bidirectional charging session according to the applicable standards for the type of digital communications in use (see 4.6). In case of separate AC and DC pins, only AC pins *shall* be used for power transfer under this standard. In case of shared AC and DC pins, power transfer *shall* be limited to AC under this standard.

4.2.2.1   System Type C[*] - PWM-CP + PLC-CP, IEEE 2030.5

PWM-CP communications *shall* be established between the EVSE and PEV according to SAE J1772. PLC-CP digital communications *shall* be established between the EVSE and PEV according to SAE J2931/4. Additional requirements pertaining to nominal and 5% duty cycle *shall* be fulfilled according to SAE J3400.

Additional requirements between the EVSE and PEV for IEEE 2030.5 *shall* be fulfilled as defined in SunSpec IEEE 2030.5 V2G-AC Profile Implementation Guide for SAE J3072.

4.2.2.1.1   System Type C1 - PEV Utilizing SAE J1772 C1 (IEC 62196-2 Type 1) with or without Combo (CCS1)

The requirements of System Type C[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J1772 C1 or SAE J1772 C1 Combo.

4.2.2.1.2   System Type C2 - PEV Utilizing SAE J3068 AC6 (IEC 62196-2 Type 2) with or without DC8 (CCS2)

The requirements of System Type C[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J3068 AC6 or SAE J3068 AC6 + DC8.

4.2.2.1.3   System Type C3 - PEV Utilizing SAE J3400 (NACS)

The requirements of System Type C[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J3400.

4.2.2.2   System Type D[*] - LIN-CP, SunSpec Modbus

LIN-CP communications *shall* be established between the EVSE and PEV according to SAE J3068.

Additional requirements between the EVSE and PEV for LIN-CP and SunSpec Modbus *shall* be fulfilled as defined in SAE J3068/1 and SAE J3068/2.

4.2.2.2.1   System Type D1 - PEV Utilizing SAE J1772 C1 (IEC 62196-2 Type 1) with or without Combo (CCS1)

The requirements of System Type D[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J1772 C1 or SAE J1772 C1 Combo.

4.2.2.2.2   System Type D2 - PEV Utilizing SAE J3068 AC6 (IEC 62196-2 Type 2) with or without DC8 (CCS2)

The requirements of System Type D[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J3068 AC6 or SAE J3068 AC6 + DC8.

4.2.2.2.3   System Type D3 - PEV Utilizing SAE J3400 (NACS)

The requirements of System Type D[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J3400.

4.2.2.3   System Type E[*] - PWM-CP + PLC-CP, ISO 15118

PWM-CP communications *shall* be established between the EVSE and PEV according to SAE J1772. PLC-CP digital communications *shall* be established between the EVSE and PEV according to SAE J2931/4. Additional requirements pertaining to nominal and 5% duty cycle *shall* be fulfilled according to SAE J3400.

Additional requirements between the EVSE and PEV for ISO 15118 series *shall* be fulfilled to meet the communication requirements of this document and IEEE 1547.

NOTE: ISO 15118-20:2022 does not describe the necessary configuration and parameters necessary to fulfill the requirements of this document.

4.2.2.3.1   System Type E1 - PEV Utilizing SAE J1772 C1 (IEC 62196-2 Type 1) with or without Combo (CCS1)

The requirements of System Type E[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J1772 C1 or SAE J1772 C1 Combo.

4.2.2.3.2   System Type E2 - PEV Utilizing SAE J3068 AC6 (IEC 62196-2 Type 2) with or without DC8 (CCS2)

The requirements of System Type E[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J3068 AC6 or SAE J3068 AC6 + DC8.

4.2.2.3.3   System Type E3 - PEV Utilizing SAE J3400 (NACS)

The requirements of System Type E[*] *shall* be fulfilled utilizing a PEV inlet conforming to SAE J3400.

4.2.3   Authorized System Types

As of the effective date of this standard, System Types C[*] and D[*] are authorized for use in all equipment and System Types A1 and B1 continue to be authorized for use in legacy equipment. System Type E[*] is not authorized for use except for technical demonstrations.

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 that 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 that 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 stand-alone 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 database 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. This character shall always be set to a value of "4" because conformance to IEEE 1547-2018 or later is required by this standard.

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 the 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 that 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 that comes directly from the VM configuration management system or may elect to use a "more user-friendly" notation that 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 that 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 that 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 that 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 that is not performed by a licensed dealer.

4.4   Certification of Inverter System Model to SAE J3072

The Vehicle Manufacturer (VM) *shall* prepare a certification plan that will ensure conformance to the requirements of SAE J3072 for a specific inverter system model which is installed onboard the vehicle.

The VM and/or another 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 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 that 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.
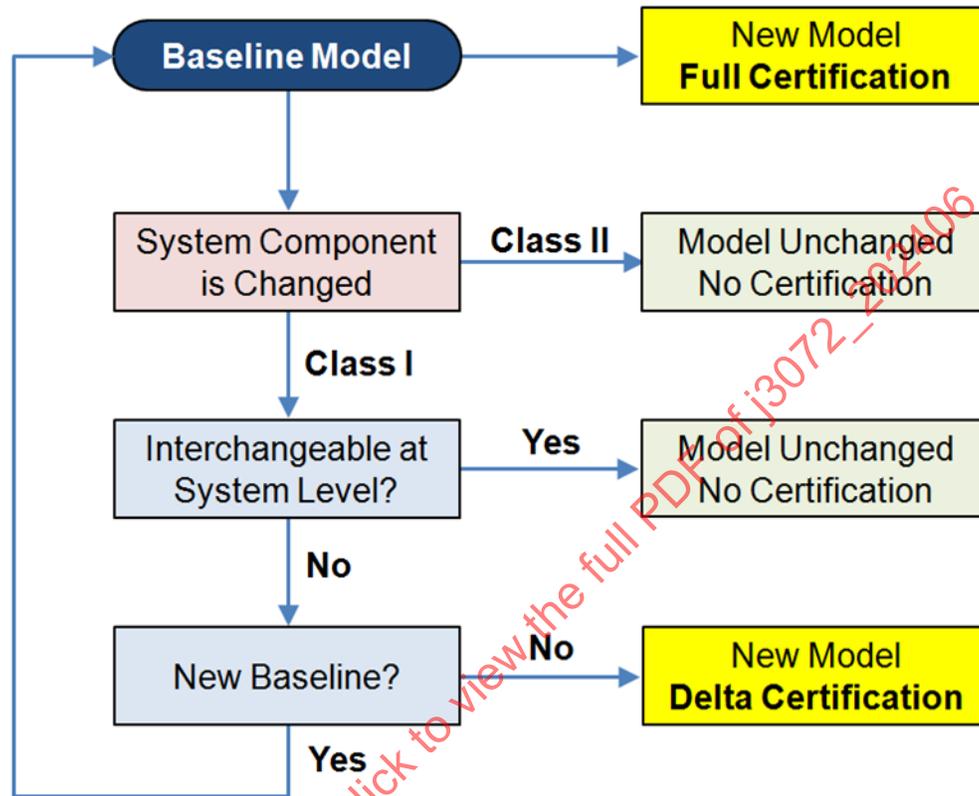
Figure 3 - Certification and changes

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) that 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 that conforms to the requirements of SAE J3072 and other required standards (see 4.5). However, any testing that 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 (refer to 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 on board 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 that 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 any user on board 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   PEV Connects with a Certified EVSE

A PEV with a grid support inverter system function, which has been certified to this standard, is expected to operate properly when interconnected with an EVSE that has been listed as conforming to the requirements of UL 1741 Supplement SC (Bidirectional Electric Vehicle Supply Equipment (BEVSE) / Interconnection Systems Equipment (ISE)).

It is expected that the Authority Having Jurisdiction (AHJ) over approval of interconnection of an SAE Type V2G-AC DER system at a site will require use of such a UL 1741 Supplement SC BEVSE/ISE model at the site.

Certification testing of the PEV inverter function to SAE J3072 shall use such a certified EVSE or test equipment that emulates such an 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 those functions which are enabled at the time authorization to discharge is provided by the EVSE to the PEV.

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 stand-alone 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.

4.6.2.3   System Type C[*]

System Type C[*] requirements are further defined in 4.2.2.1 and its subsections.

4.6.2.4   System Type D[*]

System Type D[*] requirements are further defined in 4.2.2.2 and its subsections.

4.6.2.5   System Type E[*]

System Type E[*] requirements are further defined in 4.2.2.3 and its subsections.

4.6.3   Initial Transfer of EVSE Parameters to PEV

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.

Table 2 - EVSE parameters for PEV

61850 Term	IEEE 1547 Parameter
WMaxEVSE	Active power setting in watts at unity power factor
ChaWMaxEVSE	Maximum active power charge setting in watts
IvarMaxEVSE	Maximum injected reactive power setting in vars
AvarMaxEVSE	Maximum absorbed reactive power setting in vars
VRefEVSE	Nominal AC voltage setting in rms volts
VRefOfsEVSE	VRef offset in rms volts (note special SAE J3072 use)
VMaxEVSE	Maximum AC voltage setting in rms volts
VMinEVSE	Minimum AC voltage setting in rms volts
UpdateTimeEVSE	UTC time stamp

4.6.4   Initial Transfer of PEV Configuration Information to EVSE

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 table is based on IEEE 1547-2018 Table 28 Nameplate Information, except the 61850 term shown is generally that used for Configuration Information (settings). The 61850 term for Nameplate Information often ends with "Rtg," such as WMaxRtg. The second column designates whether Nameplate (N) or Configuration (C) Information should be used by the EVSE. Some Nameplate Information is discussed in this section and in Appendix B, but the values cannot be changed by the PEV as a result of connection to the EVSE. The values of Nameplate Information are set at manufacture and not as a result of exchanging information with the EVSE. The four parameters designated with an asterisk are not explicitly listed in IEEE 1547-2018 Table 28. The 61850 Term generally corresponds to IEC 61850-7-420 ED2 data object names for Configuration Information. The expected use of the EVSE parameters by the PEV to prepare the parameters in this table is described below.

Table 3 - PEV nameplate and configuration information

61850 Term	N/C	IEEE 1547 Parameter
WMax	C	Active power setting in watts at unity power factor
WOvPF	C	Active power setting in watts at specified over-excited power factor
OvPF	C	Specified over-excited power factor
WUnPF	C	Active power setting in watts at specified under-excited power factor
UnPF	C	Specified under-excited power factor
VAMax	C	Maximum apparent power setting in voltamperes
IEEE1547Cat1	N	Normal operating performance category (A/B)
IEEE1547Cat2	N	Abnormal operating performance category (I, II, III)
IvarMax	C	Maximum injected reactive power setting in vars
AvarMax	C	Maximum absorbed reactive power setting in vars
ChaWMax	C	Maximum active power charge setting in watts
ChaVAMax	C	Maximum apparent power charge setting in voltamperes
VRef	C	Nominal AC voltage setting in rms volts
VMax	C	Maximum AC voltage setting in rms volts
VMin	C	Minimum AC voltage setting in rms volts
Modes	N	Indication of support for each control mode function
SuscRtg	N	Reactive susceptance that remains connected to the area EPS
Manufacturer	N	Vehicle manufacturer
Model	N	Inverter system model number
SerialNumber	N	Vehicle serial number (VIN)
Version	N	Version
VRefOfs	C	*VRef Offset in rms volts (note special SAE J3072 use)
J3072Cert	N	*SAE J3072 certified
J3072Date	N	*SAE J3072 certification date
WHRtg	N	Useable Watt-Hours for the battery
UpdateTime	C	*UTC time stamp

4.6.4.1 VRef (Reference Voltage)

The PEV **shall** set the value of VRef to the value of VRefEVSE if VRefEVSE is within the range for the system type.

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

- The PEV *shall* not discharge during the session.

- WMax, AvarMax, and IvarMax *shall* be set to a value of zero.

- VRef *shall* be set to a default value for the system type.

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

4.6.4.2   VRefOfs (Reference Voltage Offset)

The PEV *shall* set the value of VRefOfs to the value of VRefOfsEVSE.

If the PEV considers the value to not be valid, it *shall* set VRefOfs to a value of zero Vrms.

4.6.4.3   VMax (Maximum AC Voltage)

The PEV *shall* set the value of VMax to the value of VMaxEVSE.

4.6.4.4   VMin (Minimum AC Voltage)

The PEV *shall* set the value of VMin to the value of VMinEVSE.

4.6.4.5   WMax (Maximum Discharging Power)

The PEV *shall* set the value for WMax to the lower of:

- The value of WMaxRtg.

- The value of WMaxEVSE.

- 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 VRef.

The value of WMax *shall* be set to zero if the values for VRef and VRefEVSE do not agree.

4.6.4.6   VAMax (Maximum Apparent Power Discharging)

The PEV *shall* set the value for VAMax to the lower of:

- The value of WMaxRtg in voltamperes.

- The value of WMaxEVSE in voltamperes.

- 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 VRef.

The value of VAMax *shall* be set to zero if the values for VRef and VRefEVSE do not agree.

4.6.4.7   IvarMax (Maximum Reactive Power Supplying)

IvarMax *shall* be set to the lower of:

- The value of IvarMaxRtg.

- The value of IvarMaxEVSE.

The value of IvarMax *shall* be set to zero if the values for VRef and VRefEVSE do not agree.

4.6.4.8   AvarMax (Maximum Reactive Power Absorbing)

AvarMax *shall* be set to the lower of:

- The value of AvarMaxRtg.

- The value of AvarMaxEVSE.

The value of AvarMax *shall* be set to zero if the values for VRef and VRefEVSE do not agree.

4.6.4.9   ChaWMax (Maximum Charging Power)

The PEV *shall* set the value for ChaWMax to the lower of:

- The value of ChaWMaxRtg.

- The value of ChaWMaxEVSE.

- 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 VRef.

4.6.4.10   ChaVAMax (Maximum Apparent Power Charging)

The PEV *shall* set the value for ChaVAMax to the lower of

- The value of ChaWMaxRtg in voltamperes.

- The value of ChaWMaxEVSE in voltamperes.

- 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 VRef.

The value of ChaVAMax *shall* be set to zero if the values for VRef and VRefEVSE do not agree.

4.6.4.11   WOvPF, OvPF, WUnPF, UnPF

IEEE 1547-2018 5.2 defines the minimum reactive power capability for injection and absorption. In Quadrant I, this minimum is 44% of VAMax for power above 20% of WMax. The power flow vector, which intercepts the VAMax arc at 44% of VAMax, has a power factor OvPF of 0.898 with an active power WOvPF of 0.898 X WMax. The inverter can operate at any active power up to WOvPF and be capable of injecting up to the required minimum reactive power. But at active power levels between WOvPF and WMax, the inverter may need to reduce active power to meet reactive power requirements. In Quadrant IV for Category B, the minimum VAR is also 44% and UnPF is also 0.898.

4.6.4.12   Abnormal and Normal Operating Performance Categories (Nameplate Information)

The normal category **shall** be set to B at manufacture. The abnormal category **shall** be set to III at manufacture. For a bidirectional inverter, the categories shall both be set to zero at manufacture. See B.3.7 and B.3.8 for an explanation of these category designations. Design and test of the inverter to these designated categories is defined by 4.8. This paragraph only defines the requirement to display the designated values as Nameplate Information as shown in Table 3.

4.6.4.13   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 **shall** correspond to the actual installed inverter system model in the PEV.

4.6.4.14   SuscRtg

Reactive susceptance that remains connected to the Area EPS. This value is defined by the inverter OEM and is a PEV Nameplate Information value and set at manufacture.

4.6.4.15   Modes (Functions)

Each communication protocol provides a means to designate which functions are implemented and available. This is Nameplate Information. An available function may not be activated by a DME.

4.6.5   EVSE Evaluates PEV Configuration Information

The EVSE **shall** evaluate the Configuration Information received from the PEV as part of the authorization to discharge process. If any of the conditions below are not met, the EVSE **shall** not authorize the PEV to discharge.

4.6.5.1   WMax (Maximum Discharging Power)

The value of WMax **shall** not exceed the lower of:

- The value of WMaxEVSE.

- The value of the product of VRef 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   ChaWMax (Maximum Charging Power)

The value of ChaWMax **shall** not exceed the lower of:

- The value of ChaWMaxEVSE.

- The value of the product of VRef and the current limit which is defined by the EVSE setting for the SAE J1772 Control PWM Signal (if available for the system type).

4.6.5.3   IvarMax (Maximum Reactive Power Supplying)

The value of IvarMax **shall** not exceed the lower of:

- The value of IvarMaxEVSE.

- The value of VAMax.

- The value of the product of VRef 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   AvarMax (Maximum Reactive Power Absorbing)

The value of AvarMax *shall* not exceed the lower of:

- The value of AvarMaxEVSE.

- The value of VAMax

- The value of the product of VRef and the current limit which is defined by the EVSE setting for the SAE J1772 Control PWM Signal (if available for the system type).

4.6.5.5   VRef (Reference Voltage)

The value of VRef *shall* be equal to the value of VRefEVSE.

4.6.5.6   VRefOfs (Reference Voltage Offset)

The value of VRefOfs *shall* be equal to the value of VRefOfsEVSE.

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 the inverter system model number has been approved is outside the scope of this standard.

4.6.6   EVSE Transfers Management Information to PEV

IEEE 1547-2018 10.6 defines Management Information, which is used to update functional and mode settings for the DER. This information is defined by the utility for the specific EVSE location and must be transferred from the EVSE to the PEV at connection. In the tables in the subsections of this paragraph, the default setting applies to creation of the required information by the EVSE and does not authorize the PEV to use the value if the EVSE fails to provide the required information.

4.6.6.1   Constant Power Factor Function

This is one of four voltage and reactive power control functions defined by IEEE 1547-2018 5.3. The other three functions are voltage-reactive power function, active power-reactive power function, and constant reactive power function. Only one of these four functions *shall* be active at the same time, except during changes as defined by IEEE 1547-2018 4.6.3 "Execution of Mode or Parameter Changes."

This function is defined by IEEE 1547-2018 5.3.2 and explained in EPRI Common Functions for Smart Inverters as the Fixed Power Factor Function. This *shall* be the default function used with a power factor setting of 1.0.

When PEV default settings shown in Table 4 are not the values to be used for the EVSE location, the EVSE *shall* provide the proper values for these parameters to the PEV.

If this function is not designated by the EVSE to be enabled at the time of authorization for discharge, it shall not be executed during this phase. During operation, the EVSE *shall* be capable of enabling or disabling this function, changing the power factor setting, or changing the excitation.

Table 4 - Constant power factor function parameters

61850 Term	IEEE 1547 Parameter	Range	Default Setting
DFPF.FctEna	Constant Power Factor Function Enable	Off/On	On
DFPF.PFGnTgtSpt	Constant Power Factor Setting	0.0 to 1.0	1.0
DFPF.PFGnExtSet	Constant Power Factor Excitation	Over-Excited Under-Excited	Over-Excited

4.6.6.2   Voltage-Reactive Power Function

This is one of four voltage and reactive power control functions defined by IEEE 1547-2018 5.3. The other three functions are constant power factor function, active power-reactive power function, and constant reactive power function. Only one of these four functions shall be active at the same time, except during changes as defined by IEEE 1547-2018 4.6.3 "Execution of Mode or Parameter Changes."

This voltage and reactive power control function is defined by IEEE 1547-2018 5.3.3. EPRI Common Functions for Smart Inverters describes this as the volt-VAR function.

If PEV default settings shown in Table 5 are not the values to be used for the EVSE location, the EVSE *shall* provide the proper values for these parameters to the PEV.

If this function is not designated by the EVSE to be enabled at the time of authorization for discharge, it shall not be transferred during this phase. During operation, the EVSE *shall* be capable of enabling or disabling this function

Table 5 - Voltage-reactive power function parameters

61850 Term	IEEE 1547 Parameter	Default Setting
DVVR.FctEna	Volt-Reactive Power Function Enable	Off
DVVR.Ident	VVarCrv ID Number	1
DVVR.VVarCrv	Volt-Reactive Power V/Q Curve Points	V1 = 0.92*VRef; Q1= 0.44*VAMax INJ V2=0.98*VRef; Q2=0 V3=1.02*VRef; Q3=0 V4=1.08*VRef; Q4=0.44*VAMax ABS
DVVR.OplTmsMax	Open Loop Response Time	5 seconds

4.6.6.3   Active Power-Reactive Power Function

This is one of four voltage and reactive power control functions defined by IEEE 1547-2018 5.3. The other three functions are constant power factor function, voltage-reactive power function, and constant reactive power function. Only one of these four functions shall be active at the same time, except during changes as defined by IEEE 1547-2018 4.6.3 "Execution of Mode or Parameter Changes."

This voltage and reactive power control function is defined by IEEE 1547-2018 5.3.4. EPRI Common Functions for Smart Inverters describes this as the watt-VAR function.

If PEV default settings shown in Table 6 are not the values to be used for the EVSE location, the EVSE *shall* provide the proper values for these parameters to the PEV.

If this function is not designated by the EVSE to be enabled at the time of authorization for discharge, it shall not be transferred during this phase. During operation, the EVSE *shall* be capable of enabling or disabling this function.

Table 6 - Active power-reactive power function parameters

61850 Term	IEEE 1547 Parameter	Default Setting
DWVR.FctEna	Active Power-Reactive Power Function Enable	Off
DWVR.WVArCrv	Active Power-Reactive Power P/Q Curve Points	P1=0.2*WMax; Q1=0 P2=0.5*WMax; Q2=0 P3=WMax; Q3=0.44*VAMax ABS P'1=-0.2ChaWMax; Q'1=0 P'2=-0.5*ChaWMax; Q'2=0 P'3=-ChaWMax; Q'3=0.44*ChaVAMax INJ

4.6.6.4   Constant Reactive Power Function

This is one of four voltage and reactive power control functions defined by IEEE 1547-2018 5.3. The other three functions are constant power factor function, voltage-reactive power function, and active power-reactive power function. Only one of these four functions shall be active at the same time, except during changes as defined by IEEE 1547-2018 4.6.3 "Execution of Mode or Parameter Changes."

This voltage and reactive power control function is defined by IEEE 1547-2018 5.3.5. If PEV default settings shown in Table 7 are not the values to be used for the EVSE location, the EVSE *shall* provide the proper values for these parameters to the PEV.

If this function is not designated by the EVSE to be enabled at the time of authorization for discharge, it shall not be transferred during this phase. During operation, the EVSE *shall* be capable of enabling or disabling this function or changing the reactive power setting.

Table 7 - Constant reactive power function parameters

61850 Term	IEEE 1547 Parameter	Range	Default Setting
DVAR.FctEna	Constant Reactive Power Function Enable	Off/On	Off
DVAR.VArTgtSpt	Constant Reactive Power Setting	-AvarMax to IvarMax	0.0

4.6.6.5   Voltage-Active Power Function

This voltage and active power control function is defined by IEEE 1547-2018 5.4. EPRI Common Functions for Smart Inverters describes this as the volt-watt function. When PEV default settings shown in Table 8 are not the values to be used for the EVSE location, the EVSE *shall* provide the proper values for these parameters to the PEV.

If this function is not designated by the EVSE to be enabled at the time of authorization for discharge, it shall not be transferred during this phase. During operation, the EVSE *shall* be capable of enabling or disabling this function.

Table 8 - Voltage-active power function parameters

61850 Term	IEEE 1547 Parameter	Default Setting
DVWC.FctEna	Voltage-Active Power Function Enable	Off
DVWC.VWCrv	Voltage-Active Power V/P Curve Points	V1=1.06*VRef; P1=WMax V2=1.1*VRef; P2= ChaWMax
DVWC.OplTmsMax	Open Loop Response Time	10 seconds

4.6.6.6   Voltage Trip and Ride-Through

IEEE 1547-2018 6.4.1 defines mandatory high and low voltage tripping requirements. Two overvoltage trip functions, OV1 and OV2, and two undervoltage trip functions, UV1 and UV2, are defined. The PEV *shall* meet Category III settings as defined by IEEE 1547-2018 Table 13 and its Figure H.9 (based on amendment 1). IEEE 1547-2018 6.4.2 defines voltage disturbance ride-through requirements which are defined by IEEE 1547-2018 Table 16 and its Figure H.9. EPRI Common Functions for Smart Inverters describes these functions as the low/high voltage ride-through function.

When PEV default settings shown in Table 9 are not used for the EVSE location, the EVSE *shall* provide the HV and LV trip and ride-through trip parameters for the PEV. These are based on Category III.

Table 9 - Voltage trip functions

IEC 61850 Function	IEEE 1547 Shall Trip Functions	Voltage (x VRef)		Clearing Times (seconds)	
		Range	Default	Range	Default
DHVT:TmVCrv	OV2	1.20	1.20	0.16	0.16
	OV1	1.10-1.20	1.10	1.0-13.0	13.0
DLVTTmVCrv	UN1	0.0-0.88	0.88	2.0-50.0	21.0
	UN2	0.0-0.50	0.50	0.16-21.0	2.0

4.6.6.7   Frequency Trip and Ride-Through

IEEE 1547-2018 6.5.1 defines mandatory high and low frequency tripping requirements. Two over-frequency trip functions, OF1 and OF2, and two under-frequency trip functions, UF1 and UF2, are defined. The PEV *shall* meet settings as defined by IEEE 1547-2018 Table 18 and its Figure H.10. IEEE 1547-2018 6.5.2 defines frequency disturbance ride-through requirements, which are defined by IEEE 1547-2018 Table 19 and its Figure H.10. EPRI Common Functions for Smart Inverters describes these functions as the low/high frequency ride-through function. When PEV default settings shown in Table 10 are not used for the EVSE location, the EVSE *shall* provide the proper values for these parameters for the PEV. These are based on Category III.

Table 10 - Frequency trip functions

IEC 61850 Function	IEEE 1547 Shall Trip Functions	Frequency (Hz)		Clearing Times (seconds)	
		Range	Default	Range	Default
DHFT:TmFCrv	OF2	61.8-66.0	62.0	0.16-1000	0.16
	OF1	61.0-66.0	61.2	180-1000	300
DLFT:TmFCrv	UF1	50.0-59.0	58.5	180-1000	300
	UF2	50.0-57.0	56.5	0.16-1000	0.16

4.6.6.8   Frequency-Droop (Frequency Power) Capability and Operation

IEEE 1547-2018 6.5.2.7 defines frequency-droop capability and operation. EPRI Common Functions for Smart Inverters describes this as the frequency-watt function. When PEV default settings shown in Table 11 are not used for the EVSE location, the EVSE *shall* provide the proper values for these parameters to the PEV. These are based on Category III.

Table 11 - Frequency-droop parameters

61850 Term	IEEE 1547 Parameter	Range	Default Setting
DHFW.FctEna	High Frequency Droop F/W Function Enable	On	On
DLFW.FctEna	Low Frequency Droop F/W Function Enable	On	On
DHFW.HzStr	Over-frequency Droop dbOF	0.017-1.0	0.036
DLFW.HzStr	Under-frequency Droop dbUF	0.017-1.0	0.036
DHFW.WGra	Over-frequency Droop kOF	0.02-0.05	0.05
DLFW.WGra	Under-frequency Droop kUF	0.02-0.05	0.05
DHFW.OplTmsMax	Open Loop Response Time HF	0.2-10 seconds	5 seconds
DLFW.OplTmsMax	Open Loop Response Time LF	0.2-10 seconds	5 seconds

4.6.6.9   Enter Service

IEEE 1547-2018 4.10 defines enter service parameters. The EVSE **shall** provide the parameters shown in Table 12 to the PEV if values other than the default settings need to be provided. Otherwise, the PEV **shall** use the default values. The EVSE **shall** maintain permit service at "off" until the EVSE is ready to authorize the PEV to discharge.

Table 12 - Enter service parameters

61850 Term	IEEE 1547 Parameter	Range	Default Setting
DCTE.RtnSrvAuth	Permit Service	Off/On	Off
DCTE.VHiLim	ES Voltage High	1.05*VRef to 1.06*VRef	≤1.05*VRef
DCTE.VLoLim	ES Voltage Low	0.88*VRef to 0.95*VRef	≥0.917*VRef
DCTE.HzHiLim	ES Frequency High	60.1 to 61.0 Hz	≤60.1 Hz
DCTE.HzLoLim	ES Frequency Low	59.0 to 59.9 Hz	≥59.5 Hz
DCTE.RtnDlTmms	ES Delay	0-600 seconds	300
DCTE.RtnDlTmms	ES Randomized Delay	1-1000 seconds	300
DCTE.RtnRmpTmms	ES Ramp Rate	1-1000 seconds	300

4.6.6.10   Limit Maximum Active Power

IEEE 1547-2018 4.6.2 defines the capability to limit active power. EPRI Common Functions for Smart Inverters describes this as the limit DER power output function. The EVSE **shall** provide the parameters shown in Table 13 to the PEV if values other than the default settings need to be provided. Otherwise, the PEV **shall** use the default values.

If this function is not designated by the EVSE to be enabled at the time of authorization for discharge, it shall not be transferred during this phase. During operation, the EVSE **shall** be capable of enabling or disabling this function or changing the limit setting.

Table 13 - Limit maximum active power parameters

61850 Term	IEEE 1547 Parameter	Range	Default Setting
DWMX.FctEna	Limit Active Power Enable	Off/On	Off
DWMX.WLimSpt	Maximum Active Power Setting	0-100%	100%

4.6.6.11   Summary of Transfer of Management Information

Table 14 lists the Management Information for each of the smart inverter functions defined by IEEE 1547-2018. It shows the SAE J3072 paragraph number, the IEC 61850 function designation, the IEEE 1547-2018 function names, and the static Management Information provided at the time of connection. Only those functions that are expected to be enabled at the time of authorization to discharge by the EVSE are transferred and enabled. Management information can be provided during operation, as discussed in 4.7.

Table 14 - Management information

SAE J3072	61850 Function	IEEE 1547-2018 Function	Management Information
4.6.6.1	DFPF	Constant Power Factor	
4.6.6.2	DVVR	Voltage-Reactive Power	Volt-VAR Curve, DVVR:OplTmsMax
4.6.6.3	DWVR	Active Power-Reactive Power	Watt-VAR Curve
4.6.6.4	DVAR	Constant Reactive Power	
4.6.6.5	DVWC	Voltage-Active Power	Watt-VAR Curve, DVWC.OplTmsMax
4.6.6.6	DHVT	High Voltage Trip	OV1, OV2
4.6.6.6	DLVT	Low Voltage Trip	UV1, UV2
4.6.6.7	DHFT	High Frequency Trip	OF1, OF2
4.6.6.7	DLFT	Low Frequency Trip	UF1, UF2
4.6.6.8	DHFW	High Frequency Droop	dbOF, kOF, olrtOF
4.6.6.8	DLFW	Low Frequency Droop	dbUF, kUF, olrtUF
4.6.6.9	DCTE	Enter Service Parameters	VHiLim, VLoLim, HzHiLim, HzLoLim, RtnDlTmms, RtnDlTmms, RtnRmpTmms
4.6.6.10	DWMX	Limit Active Power	

4.7 Control of Inverter During Session

4.7.1 DER Managing Entity

IEEE 1547-2018 defines DER managing entity (DME) as "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 other." There can be more than one authorized DME for a specific DER, in which case the DER must have well-defined prioritization logic to arbitrate potentially conflicting commands.

For V2G-AC, the EVSE *shall* be a DER managing entity and it *shall* be the sole authorized DME for the purposes of meeting SAE J3072 requirements of 4.6. For those functions listed in Table 15, the EVSE *shall* be the only authorized DME. The PEV *shall* not accept messages for any of these functions from any other source. If another DME wants the PEV to change, for example, from DFPF to DVVR function, the EVSE must be designed to accept the command from the other DME and relay the command to the PEV using the SAE J3072 P2P link. The EVSE is representing the combined EVSE and PEV upstream, but it acts as the sole authorized DME with the PEV.

The Notes on Table 15 show that only one of the four functions DFPF, DVVR, DWVR, and DVAR can be activated, except as governed by IEEE 1547-2018 4.6.3 "Execution of Mode or Parameter Changes." While Table 15 shows the enable parameter and setting parameter associated with certain functions, for curve functions the management information transfer would also include the curve data as described in the tables in 4.6.6. Management Information for a new Voltage-Reactive Power (DVVR) curve would replace any existing DVVR curve after the transition. There is no requirement for the PEV to disengage as a DER to accept new Management Information.

Table 15 - Functions under sole control by EVSE

61850 Term	Purpose	Enable	Setting(s)	Notes
DFPF	Constant PF	DFPF.FctEna	DFPF.PFGnTgt DFPF:PFExtSet	w/o DVVR, DWVR, DVAR
DVVR	Volt-VAR Curve	DVVR.FctEna		w/o DFPF, DWVR, DVAR
DWVR	Watt-VAR Curve	DWVR.FctEna		w/o DFPF,DVVR, DVAR
DVAR	Constant VAR	DVAR.FctEna	DVAR.VArTgt	w/o DFPF, DVVR, DWVR
DVWC	Volt-Watt Curve	DVWC.FctEna		
DHFW	HFreq-Watt Curve	DHFW.FctEna		
DLFW	LFreq-Watt Curve	DLFW.FctEna		
DWMX	Limit Active Power	DWMX.FctEna	DWMX.WLimSpt	
DCTE	Permit Service	Always Active	DCTE.RtnSrvAuth	

For DER functions other than those defined in 4.6 and Table 15, the EVSE may provide network access or information for an authorized DME. The PEV could directly engage a facility DER energy management system (FDEMS) by way of a MAC/PHY bridge provided within the EVSE. The PEV could engage using the bridge and Internet access to a remote V2G aggregator. The PEV could be authorized to use telematics.

4.7.2   Authorization to Discharge

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 DCTE permit service authorization from the EVSE is TRUE.

The PEV *shall* check the EVSE permit service authorization at least every second and stop discharging if not 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 EVSE circuit breaker or by other positive means as appropriate.

All of the functions activated by transfer of management information in 4.6.6 are intended to be enabled when authorization is received. During operation, the EVSE can provide management information to activate or disable specific functions.

4.7.3   Monitoring Information

The PEV *shall* be capable of providing monitoring information to the DME and *shall* include the minimum information contained in Table 16. The information *shall* be the latest value that has been measured within the required response time for the application.

Table 16 - Monitoring information

61850 Term	IEEE 1547 Parameter	Units
MMXU.TotW	Active Power	Watts
MMXU.TotVAr	Reactive Power	VARS
By Phase	Voltage	Volts rms
MMXU.Hz	Frequency	Hertz
----	Operational State	---
----	Connection Status	---
----	Alarm Status	---
DSTO:SocUsePct	State of Charge	Percent
----	Time of Reference	UTC

4.7.4   Coordinated Charge/Discharge Management Function

IEEE 1547-2018 does not define any function by which a DME can command the rate of charging or discharging of an energy storage system (ESS). However, this is a primary purpose of an ESS, but not one that is relevant to IEEE 1547-2018, which is written from the perspective of an energy generator. These active power control functions will be designed into an ESS, but they are not certified as part of IEEE 1547.1-2020 certification testing.

SAE J2836/3 defines Use Case U6, Basic Distributed Energy Resource. EPRI later adopted this SAE U6 and described it as the "Energy Storage: Coordinated Charge/Discharge Management Function" in its Common Functions for Smart Inverters. IEC 61850-7-420 ED2 also adopted this same function, which is identified as DTCD, Coordinated Charge/Discharge operational function. IEEE 2030.5 fully supports communication required between a V2G-AC PEV and an authorized DME to execute this function.

The vehicle manufacturer *shall* fully implement SAE U6 and verify and validate the proper operation of this function for command update rates as fast as every second. This implementation *shall* be included in the SAE J3072 or Protocol PEV and EVSE certification testing. The PEV *shall* not accept discharge-related Management Information from another DME until the EVSE has approved discharge.

The PEV *shall* provide a means for the vehicle operator to designate a target "time charge is needed" and an associated "target SOC." This could be by explicit data entry at the PEV at the time of parking at the charge station or other means, such as a calculated default value. But at the time of connection of the PEV to the EVSE, the PEV *shall* present a target SOC and Time Charge is Needed to the DME. This *shall* be done even if no active power function is enabled. And all the additional monitoring information shown in Table 17 *shall* be measured or calculated by the PEV throughout a session even if no active power function has been activated.

Table 17 - Additional monitoring information

61850 Term (Class)	SAE/EPRI Term	Units	Source
DTCD:DateTgt (TSG)	Time Charge is Needed	UTC	INPUT/CALC
DTCD:SocUseTgt (ING)	Target State of Charge	Percent	INPUT/CALC
DTCD: WhReq (MV)	Energy Request	Watt-Hours	CALC
DTCD:DurMin (ING)	Minimum Charging Duration	Seconds	CALC
DTCD:ChaDurMax (ING)	Duration Maximum Charge Rate	Seconds	CALC
DTCD:DschDurMax (ING)	Duration Maximum Discharge Rate	Seconds	CALC
DTCD:SocDate (TSG)	Time of Reference	UTC	CALC

There are other EPRI and IEC 61850 functions for control of active power. IEC 61850-90-7 defined a basic function INV4, which provides the command structure used by SAE U6. SAE U6 uses the INV4 function control structure with all the additional information in Table 17 provided to the DME. This standard now requires the same information for IEC INV4 (IEC DWGC) and SAE U6 (IEC DTCD). The command structure for SAE U6 and IEC INV4 are shown in Table 18.

The difference between a driver activating SAE U6 versus IEC INV4, if the VM offers that option, is that for the case of SAE U6, the PEV is expected to automatically disengage as a DER from the DME as required to meet its charging objectives. In the case of IEC INV4, the PEV could allow its battery to be fully depleted as commanded by the DME. The coordination is optional for the DME for either SAE U6 or IEC INV4, but the PEV response without coordination between PEV and DME could be different.

Table 18 - Active power function engagement

61850 Term	Purpose	Enable	Session Setup	Active Command
DTCD	SAE U6	DTCD.FctEna	DTCD:DateTgt DTCD:SocUseTgt	DTCD.ReqW
DWGC	IEC INV4	DWGC.FctEna	DTCD:DateTgt DTCD:SocUseTgt	DWGC.ReqW

4.7.5   Dynamic Calibration Function

The PEV *shall* implement the dynamic calibration function as defined by Appendix H. If VRefOfs is set to a value of zero, the PEV *shall* use its point of connection (PoC) to the EVSE as the reference point of applicability (RPA). If VRefOfs is set to a nonzero value, the RPA *shall* be the designated point of common coupling (PCC) and the PEV *shall* use the dynamic calibration function to calculate the rms voltage at the PCC using measured rms voltage at the PoC. If the Authority Having Jurisdiction over the interconnection does not authorize the use of this function (see Appendix H) to estimate voltage at the PCC from measured voltage at the PoC, and use of PCC as the RPA is required, the EVSE shall not authorize discharge.

4.8   Utility Interaction

The grid support inverter system *shall* meet the requirements of IEEE 1547-2018 and Amendment 1 (January 2020) with any clarifications, exceptions, or modifications described in Appendix D. For the purpose of IEEE 1547-2018 Clause 5, the inverter system *shall* be Category B, and for the purpose of IEEE 1547-2018 Clause 6, the inverter system *shall* be Category III (see B.3.7 and B.3.8). The inverter system *shall* be tested in accordance with IEEE 1547.1-2020 with any clarifications, exceptions, or modifications described in Appendix E.

The interoperability tests defined by IEEE 1547.1-2020 Clause 6 for the PEV onboard inverter system model *shall* be conducted using a UL 1741 Supplement SC BEVSE/ISE, or equivalent test equipment, using the protocol stack for the defined system type.

4.9   Standards and Practices

The vehicle manufacturer *shall* ensure that standards and practices followed by the automotive industry to design, produce, and test safety-critical electronic equipment, such as powertrain system controls and anti-skid system controls, are followed for hardware, software, and firmware used to implement the functions of the onboard inverter system.

4.9.1   Access Covers

Any vehicle access covers for fuses and other potentially serviceable items are at the discretion of the vehicle OEM and may vary on a vehicle model and vary across products. There is no requirement for these to be hinged and may not comply with UL 508.

4.9.2   Bonding Conductor Test

Per the requirements detailed in SAE J2578.

4.9.3   Dielectric Voltage-Withstand Test

SAE J2344 includes the requirements for this and refers to SAE J2578 Appendix B for guidance in establishing test voltages and conducting the test.

4.9.4   Electrical Shock- Voltage and Stored Energy

Vehicles comply to FMVSS305 and SAE J1766 for HV isolation monitoring and isolation.

4.9.5   Equipment Grounding

Vehicles use SAE J1772, which refers to UL 2202 for sizing the ground wire between the onboard charger and charging inlet for AC charging and increases as specified when a vehicle includes DC charging for the maximum current rating. The AC ground is from the charging inlet to the onboard charger, and if the vehicle includes DC charging, this ground is instead connected to a central ground point on the vehicle near the 12 V battery ground. Each HV component on the vehicle also includes a grounding/bonding strap from its enclosure to vehicle chassis. The HV positive and negative circuits, however, are isolated from vehicle chassis to meet FMVSS305 and SAE J1766.

4.9.6   Isolation Monitoring System and DC Ground Fault Detection/Interrupter

Vehicle HV systems **shall** be designed per SAE J1766, which is the basis for FMVSS305. Since the HV battery is electrically isolated from the vehicle chassis, continuous monitoring between the HV battery negative circuit and vehicle chassis along with the HV battery positive circuit and vehicle chassis is to be within the SAE and FMVSS requirements for the DC system. When the vehicle charges, for AC EVSEs, they conform to UL and SAE J1772 requirements for leakage monitoring and control using a GFCI or CCID approach. When the vehicle charges for DC charging, the vehicle's Isolation Monitoring Device (IMD) is disabled so the DC EVSE can accomplish this. Since the vehicle DC circuits are connected directly to the DC circuits in the DC EVSE during charging, only one device can monitor isolation as to not include conflicts. DC charging isolation engagement and disengagement is described in SAE J1772, and the EVSE uses the identical values as the vehicle uses when not connected to the DC EVSE.

4.9.7   Overcurrent Protection - Output AC Power Circuit Overcurrent Protection

Vehicle onboard inverters **shall** either be electronically current limited or **shall** employ additional fusing to prevent output overcurrent.

4.9.8   Overcurrent Protection - Battery Circuits

Vehicles use HV fast-acting fuses in the battery circuit for fusing protection.

4.9.9   Output Power Characteristics - Harmonic Distortion

Except when discharging, vehicles **shall** comply with SAE J2894/1 and SAE J2894/2 for grid power quality requirements and are tested to SAE J2953/1 and SAE J2953/2.

4.9.10   Protection of Users and Service Personnel

Protection against direct contact is identified in SAE J1766 and specifies the use of barriers and protection using the jointed test finger described in ISO 20653 is inserted into any gaps or openings in the physical protection barrier(s) with a test force of 10 N + 10%.

5.   NOTES

5.1   Revision Indicator

A change bar (I) 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 SAE HYBRID - EV COMMITTEE

APPENDIX A - ABBREVIATIONS

For this document, the following abbreviations apply:

A	Amperes
AC	Alternating Current
BMS	Battery Management System
CAN	Controller Area Network Data Bus
CP	Control Pilot (SAE J1772)
DC	Direct Current
DER	Distributed Energy Resources
DG	Distributed Generation
DME	DER Managing Entity
EMI	Electromagnetic Interference
EMS	Energy Management System
EPRI	Electric Power Research Institute
EPS	Electric Power Systems
EVSE	Electric Vehicle Supply Equipment
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	Power Line Carrier
PoC	Point of Connection
PV	Photovoltaic (Solar)
PWM	Pulse Width Modulation
rms	Root Mean Square
RPA	Reference Point of Applicability
SEP	Smart Energy Profile (IEEE 2030.5-2018)
SGIP	Smart Grid Interoperability Panel
SOC	State of Charge
TCIN	Time Charge Is Needed
TSOC	Target State of Charge
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 Identifier Code

APPENDIX B - INFORMATION DEFINITIONS

This appendix defines some of the information that is exchanged between the PEV and EVSE, which are referenced in this document. Figure B1 illustrates certain IEC 61850 terms used with a four-quadrant inverter in a PEV. The horizontal axis designates active (real) power flow (P) in watts. Positive active power (P+) along the x-axis is termed discharging, generation, injection, or production, and negative power flow (P-) is termed charging, absorption, or consumption. The vertical y-axis designates reactive power flow (Q) in volt-amperes reactive (which is watts in SI units). Positive reactive power flow (Q+) is considered to inject or supply VAR and be over-excited. Negative reactive power flow (Q-) is considered to absorb VAR and be under-excited.
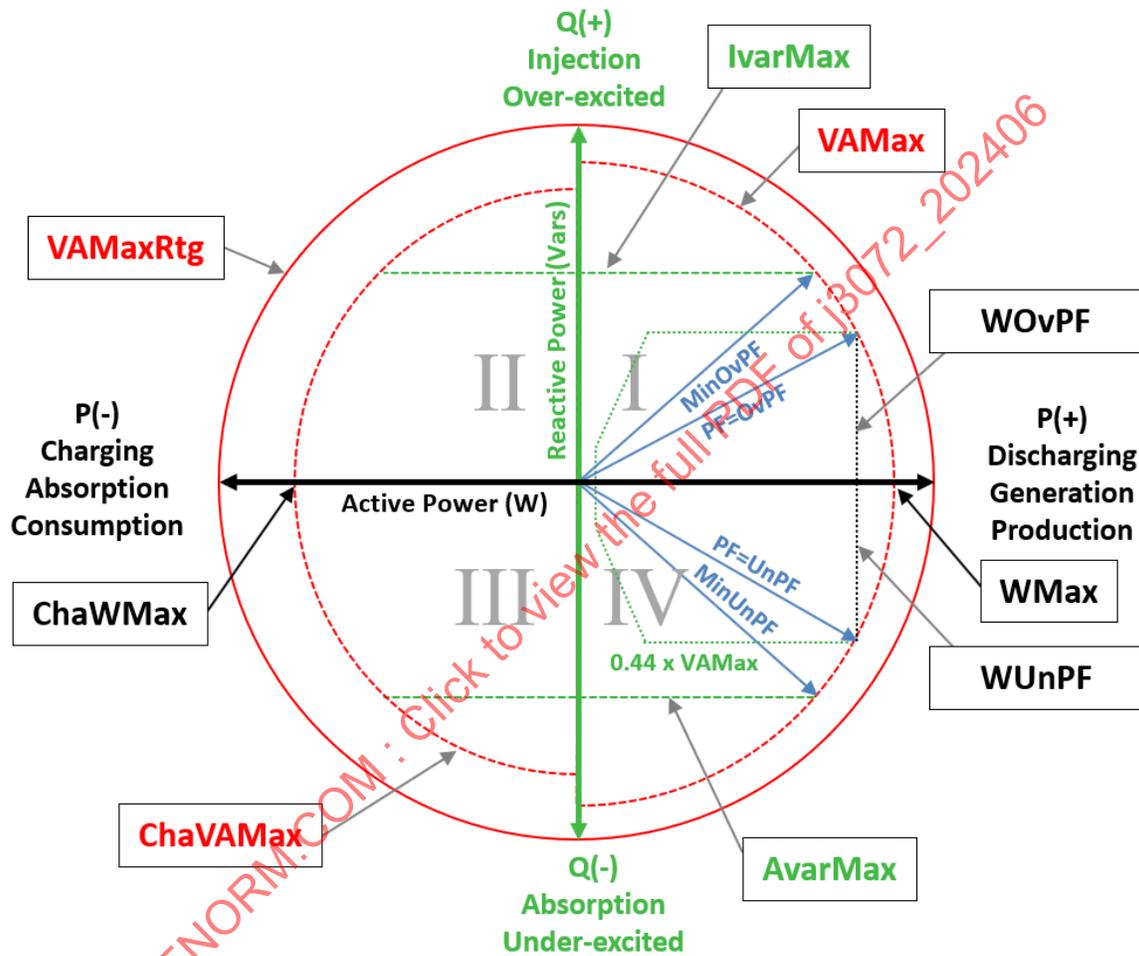
Figure B1 - Power vector quadrant diagram

The solid red circle designates the maximum volt-ampere rating (which is also watts in SI units) of the inverter (VAMaxRtg). Because of site limitations, battery considerations, or other factors, the inverter may be set to operate at a lower volt-ampere setting. In this illustration, the inverter operates at a setting of VAMax while discharging, as shown by the red dashed semicircle in Quadrant I and Quadrant IV. In this example, the inverter operates at a reduced capacity of ChaVAMax while charging as shown by the dashed arc in Quadrant II and Quadrant III. The inverter could be symmetric or have more capability when charging.

While an inverter may be capable of injecting VAR at VAMax at an active power of zero watts, there may be reasons for the inverter to limit the maximum VAR below the VAMax. The diagram shows a defined injection/supply limit of IvarMax with a corresponding minimum power factor of MinOvPF and a defined absorption limit of AvarMax with a corresponding minimum power factor of MinUnPF. While it may be possible for an inverter to absorb and supply VAR while charging, this is NOT REQUIRED by IEEE 1547-2018. When charging, a PEV inverter would normally be expected to maintain the power factor at unity in accordance with SAE J2894/1; however, with agreement with the utility, the PEV may be authorized to absorb or inject VAR during charging.

IEEE 1547-2018 5.2 defines the minimum required reactive power capability for injection and absorption. In Quadrant I, this minimum is 44% of VAMax for active power above 20% of WMax. The power flow vector that intercepts the VAMax arc at 44% of VAMax has a power factor OvPF of 0.898 with an active power WOvPF of 0.898 X WMax. The inverter can operate at any active power up to WOvPF and be capable of injecting up to the required minimum reactive power. But at active power levels between WOvPF and WMax, the inverter would need to reduce active power to meet minimum reactive power requirements. For a symmetric category B system shown in Quadrant IV, the power vector is defined by the same power factor UnPF of 0.898 with an active power WUnPF of 0.898 X WMax.

B.1   PEV INVERTER RATING INFORMATION

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

Figure B2 shows profiles for an inverter engaging in charging and discharging of the PEV battery, where the primary constraint is the peak 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.
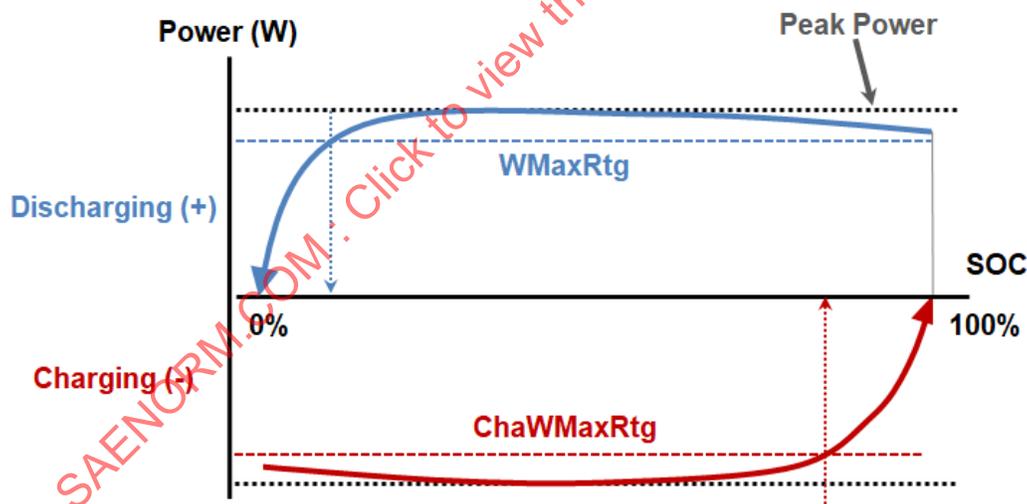
Figure B2 - Battery charging and discharging profiles

For a DER, the flat power level for charging or discharging that can be used by the inverter over a broad range of battery SOC must be defined. For the case of charging, ChaWMaxRtg (rated maximum charging 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 ChaWMaxRtg intersects the charging profile. A similar approach would be used for discharging to define the value for WMaxRtg (rated maximum discharging power). Even though an inverter and its battery may be capable of higher power flow at a specific SOC, the DER must establish flat ratings across a broad operating range.

The EV information below is presented in the order of active power (P+/P-), reactive power (Q+/Q-), and apparent power (QI-QIV, QII-QIII).

B.1.1   WMaxRtg (Rated Maximum Discharging Power)

Units: Watts (W)

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.1.2   ChaWMaxRtg (Rated Maximum Charging Power)

Units: Watts (W)

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.1.3   IvarMaxRtg (Rated Maximum Reactive Power Supplying)

Units: Volt-amperes reactive (VAR)

This parameter is set to the volt-amperes reactive rating of the inverter when supplying reactive power as a four-quadrant inverter. For a bidirectional inverter, a value of zero is used.

B.1.4   AvarMaxRtg (Rated Maximum Reactive Power Absorbing)

Units: Volt-amperes reactive (VAR)

This parameter is set to the volt-amperes reactive rating of the inverter when absorbing reactive power as a four-quadrant inverter. For a bidirectional inverter, a value of zero is used.

B.1.5   VAMaxRtg (Rated Maximum Apparent Power)

Units: Volt-amperes (VA)

This parameter is set to the value of WMaxRtg.

B.1.6   ChaVAMaxRtg (Rated Maximum Apparent Power while Charging)

Units: Volt-amperes (VA)

This parameter is set to the value of ChaWMaxRtg.

B.2   EVSE INFORMATION

The upper limit for the value of each EVSE parameter would 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 would 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.

The EVSE information below is presented in the order of active power (P+/P-), reactive power (Q+/Q-), and then voltage types.

B.2.1   WMaxEVSE (EVSE Maximum Discharging Power)

Units: Watts (W)

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

The upper limit for this parameter is defined as the product of the VRefEVSE 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.

B.2.2   ChaWMaxEVSE (EVSE Maximum Charging Power)

Units: Watts (W)

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

The upper limit for this parameter is defined as the product of the VRefEVSE rms 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.

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   IvarMaxEVSE (EVSE Maximum Reactive Power Injecting)

Units: Volt-amperes reactive (VAR)

This is the maximum reactive power that the PEV is authorized to inject through the EVSE.

The upper limit for this parameter is defined as the product of the VRefEVSE 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.

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

B.2.4   AvarMaxEVSE (EVSE Maximum Reactive Power Absorbing)

Units: Volt-amperes reactive (VAR)

This is the maximum reactive power that the PEV is authorized to absorb through the EVSE.

The upper limit for this parameter is defined as the product of the VRefEVSE 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.

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

B.2.5   VRefEVSE (EVSE Reference Voltage)

Units: Volts rms (Vrms)

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.2.6   VRefOfsEVSE (EVSE Reference Voltage Offset)

Units: Volts rms (Vrms)

This parameter is uniquely used for SAE J3072. If the EVSE provides a value of zero this indicates that the PEV is expected to use the point of connection (PoC) for the reference point of applicability (RPA) in IEEE 1547-2018. When the PEV is expected to use the point of common coupling (PCC) as the RPA, a positive value is provided that is based on the difference in the rms voltage measured at the PoC and the PCC when the PEV is discharging at 20 rms amperes. This is discussed in Appendix H.

B.2.7   VMaxEVSE (EVSE Maximum Voltage)

Units: Volts rms (Vrms)

The maximum voltage should be based on ANSI C84.1 Range A for service voltage, which would be set to 105% of the reference voltage. For a VRefEVSE of 240 Vrms, VMaxEVSE would be 252 Vrms.

B.2.8   VMinEVSE (EVSE Minimum Voltage)

Units: Volts rms (Vrms)

The minimum voltage should be based on ANSI C84.1 Range A for service voltage, which would be set to 95% of the reference voltage. For a VRefEVSE of 240 Vrms, VMinEVSE would be 228 Vrms.

B.2.9   UpdateTimeEVSE

Units: UTC

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

B.3   PEV CONFIGURATION INFORMATION

This is the IEEE 1547-2018 10.4 Configuration Information, which the PEV presents after it has connected with the EVSE and has corrected PEV ratings to be compatible with EVSE site constraints in accordance with 4.6.4. This is the "as configured" PEV information. The PEV is the source of all of this information. The information is listed in the order of Table 3.

B.3.1   WMax (Active Power Rating at Unity Power Factor)

Units: Watts (W)

This is the maximum energy transfer rate during discharging that the PEV can supply.

B.3.2   WOvPF (Active Power Rating in Watts at Specified Over-Excited Power Factor)

Units: Watts (W)

Value = 0.898 X WMax for 4Q inverter (and WMax for bidirectional inverter).

B.3.3   OvPF (Specified Over-Excited Power Factor)

Units: None

Value = 0.898 for 4Q inverter (and 1.0 for bidirectional inverter).

B.3.4   WUnPF (Active Power Rating in Watts at Specified Under-Excited Power Factor)

Units: Watts (W)

Value = 0.898 X WMax for 4Q inverter (and WMax for bidirectional inverter).

B.3.5   UnPF (Specified Under-Excited Power Factor)

Units: None

Value = 0.898 for 4Q inverter (and 1.0 for bidirectional Inverter).

B.3.6   VAMax (Maximum Apparent Power Rating)

Units: Volt-amperes (VA)

Value = WMax expressed in volt-amperes, not watts.

B.3.7   IEEE1547Cat1 (Normal Operating Performance Category)

Units: None

Value = B

IEEE 1547-2018 Clause 5 defines requirements for "reactive power capability and voltage/power control requirements." Requirements are defined for two categories of normal operating performance: Category A and Category B. The minimum reactive power injection and absorption capability are more demanding for Category B, and this is appropriate for a storage DER. Category B also requires implementation and test of two reactive/active power control functions that are not required (optional) for Category B. One of these, the volt-Watt function, is very useful for a storage DER. The other required watt-VAR function is of less interest to some utilities, but it is designated as mandatory for Category B, although it does not have to be enabled at the location. The requirement to design and test the inverter to Category B is stated in 4.8 and the requirement to display the value as Nameplate Information is stated in 4.6.4.12.

B.3.8   IEEE1547Cat2 (Abnormal Operating Performance Category)

Units: None

Value = III

IEEE 1547-2018 Clause 6 defines requirements for "response to Area EPS abnormal conditions." Requirements are defined for three categories of abnormal operating performance: Category I, II, and III. For each category, different default settings and allowable ranges are defined for "shall trip" and for "voltage ride-through" requirements for abnormal voltages. The higher the category, the longer the range of the required ride-through capability. At a specific location, the higher category inverter design could be set to operate to a lower ride-through setting. The requirement to design and test the inverter to Category III is stated in 4.8 and the requirement to display the value as Nameplate Information is stated in 4.6.4.12.

B.3.9   IvarMax (Reactive Power Injected Maximum Rating)

Units: Volt-amperes reactive (VAR)

This is the maximum reactive power that a PEV is allowed to supply in QI.

B.3.10   AvarMax (Reactive Power Absorbed Maximum Rating)

Units: Volt-amperes reactive (VAR)

This is the maximum reactive power that a PEV is allowed to absorb in QIV.

B.3.11   ChaWMax (Active Power Charge Maximum Setting)

Units: Watts (W)

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

B.3.12   ChaVAMax (Maximum Apparent Power Charge Rating)

Units: Volt-amperes (VA)

Value = ChaWMax expressed in volt-amperes, not watts.

B.3.13 VRef (Reference Voltage)

Units: Volts rms (Vrms)

This is the nominal voltage that 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 61850-7-420 ED2 smart inverter functions. Table 28 in IEEE 1547-2018 defines "AC voltage nominal rating," which is described as "Nominal AC voltage rating in RMS volts." This document uses the term VRef for this purpose and does not define a VNom parameter.

The PEV sets VRef to the value of VRefEVSE if VRefEVSE is within the valid range for the system type.

Otherwise, the PEV IS NOT AUTHORIZED TO DISCHARGE and a default value would be used based on the system type to protect other calculations conducted by the inverter. 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 VRef.

- For System Type A1, if the value for VRefEVSE is lower than 208 VAC or greater than 240 VAC, the PEV sets a default value of 200 VAC for VRef.

- For System Type B1, the energizing contactor is not allowed to close without verifying VRefEVSE is within the range allowed by the PEV. A default value of 100 VAC would be used.

- For System Type C[*], System Type D[*], and System Type E[*], the energizing contactor is not allowed to close without verifying VRefEVSE is within the range allowed by the PEV. A default value of 100 VAC would be used.

B.3.14 VRefOfs (Reference Voltage Offset)

Units: Volts rms (Vrms)

This parameter is uniquely used for SAE J3072. See Appendix H.

The PEV sets VRefOfs to the value of VRefOfsEVSE.

B.3.15 VMax (Maximum AC Voltage Rating in Volts rms)

Units: Volts rms (Vrms)

The PEV sets VMax to the value of VMaxEVSE.

B.3.16 VMin (Minimum AC Voltage Rating in Volts rms)

Units: Volts rms (Vrms)

The PEV sets VMin to the value of VMinEVSE.

B.3.17 Modes (Indication of Support for Each Control Function Function)

Units: None

Each communication protocol has a means to designate supported functions. Each of the functions required to be implemented in 4.6.6 and 4.7.4 is supported. IEC 61850 functions include: DFPF, DVVR, DWVR, DVAR, DVWC, DHVT, DLVT, DHFT, DLFT, DHFW, DLFW, DCTE, DWMX, DTCD, and DWGC.

B.3.18 SuscRtg (Reactive Susceptance that Remains Connected to the Area EPS)

Units: Siemens

This is a characteristic of inverter design and interconnection at PoC.

B.3.19   Model (Inverter System Model Number)

Units: String 32 characters

The inverter system model number is a string of 32 characters that is defined in 4.3.3.

The VM provides 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 ensure that the inverter system model number corresponds to the actual installed inverter system model in the PEV.

B.3.20   SAE J3072 Certified

Units: TRUE/FALSE

The value is set to TRUE if the VM has certified the inverter system model to this standard.

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

B.3.21   SAE J3072 Certification Date

Units: UTC

This is the date of the SAE J3072 certificate.

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

B.3.22   Updated Time

Units: UTC

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

APPENDIX C - USING IEEE 2030.5-2018

NOTICE: The intent of this appendix is entirely replaced by the "IEEE 2030.5 V2G-AC Profile Implementation Guide for SAE J3072," which was created by the SunSpec Alliance. This appendix was used by the SunSpec Alliance team while preparing their profile document. Most of the content of this appendix is correct, but there are some errors that were recognized but not followed by the SunSpec team. Because this appendix has served its purpose and the SunSpec Alliance documents now govern, this appendix, which was created for the March 2021 version of this standard, is only retained for historical purposes.

This appendix *shall* be followed for those system types that use IEEE 2030.5-2018 to exchange information between the EVSE and PEV, which is required by this standard (i.e., the SAE J3072 information).

This appendix is not intended to be a comprehensive guide to communication protocols and the use of IEEE 2030.5. 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 IEEE 2030.5. This appendix only defines certain aspects of the use of IEEE 2030.5, which are unique to how specific aspects of the IEEE 2030.5 model are used to exchange SAE J3072 information. The EVSE and PEV shall use the exact IEEE 2030.5 resource objects and attributes defined in this appendix for information exchange.

Figure C1 shows an EVSE and PEV configuration that uses the IEEE 2030.5 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 local area network (LAN) by bridging IEEE 2030.5 Internet messages at the MAC/PHY layers in the EVSE. These are two separate IEEE 2030.5 communication channels with different purposes.
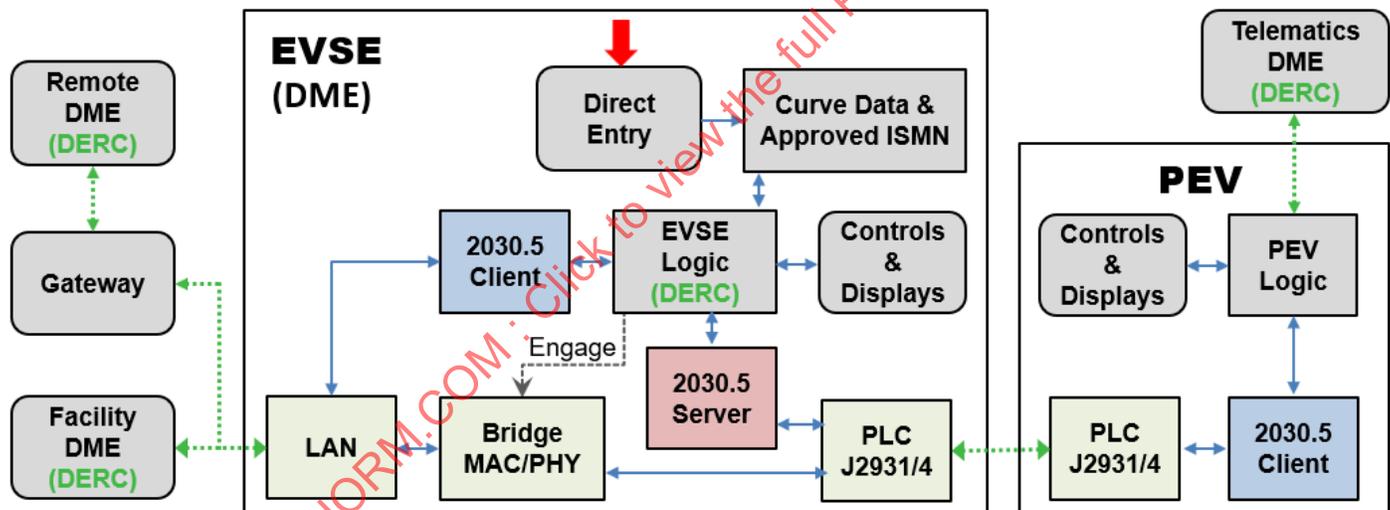
Figure C1 - EVSE as IEEE 2030.5 server for SAE J3072 communications

In the example, the bridge is used for the PEV to communicate with a facility DER managing entity (DME) that will act as a controller for a V2G application. SAE J2847/3 discusses the use of IEEE 2030.5 for these engagements. When the bridge is active, the PEV IEEE 2030.5 client can place its resources on an IEEE 2030.5 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 IEEE 2030.5 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 IEEE 2030.5 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 IEEE 2030.5 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 four IEEE 2030.5 resource objects are specifically required to perform the SAE J3072 information transfer between the EVSE and PEV: one from the EVSE and three from the PEV for the purposes of SAE J3072 4.6.3 and 4.6.4. These will be discussed in detail because interoperability between any EVSE and PEV model depend on the meaning and use to be very clear. Other IEEE 2030.5 resources, such as those needed to establish the communications and to comply with the IEEE 2030.5 protocol standard, may also be needed, but these will be governed by the IEEE 2030.5 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 IEEE 2030.5 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 IEEE 2030.5 WADL

Resource	Sample URI	GET	PUT	POST	DEL	GETResponse
		HTTP Method				
EVSE Resources						
DERSettings	URI: /edev/{id1}/der/{id2}/derg	M	E	E	E	DERSettings
PEV Resources DERCapability						
	URI: /edev/{id1}/der/{id2}/dercap	M	M	E	E	DERCapability
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 IEEE 2030.5 DERSettings Resource Object to provide its SAE J3072 4.6.3 information to the PEV. This is the only DER resource needed, although it may be required by the IEEE 2030.5 protocol to include others that 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.

Table C2 shows the minimum information described in SAE J3072 4.6.3 that *shall* be provided by the EVSE to the PEV. The EVSE *shall* respond with the appropriate XML data package to an HTTP GET request from the PEV for the DERSettings object. Only the items listed in Table C2 are required to be provided in the XML package to the PEV, although it is acceptable to transmit the entire content of the DERSettings object.

Table C2 - EVSE DERSettings object

61850 Term	DERSettings: Attribute: Type
WMaxEVSE	setMaxW: ActivePower
ChaWMaxEVSE	setMaxChargeRateW: ActivePower
IvarMaxEVSE	setMaxVar: ReactivePower
AvarMaxEVSE	setMaxVarNeg: ReactivePower
VRefEVSE	setVNom: Voltagerms
VRefOfsEVSE	setMaxV: Voltagerms
VMaxEVSE	setVRefOfs: Voltagerms
VMinEVSE	setMinV: Voltagerms
UpdateTimeEVSE	updatedTime: TimeType

The PEV hosts three IEEE 2030.5 resource objects on the EVSE server for the purpose of SAE J3072 4.6.4 information transfer. One is DERSettings, which is shown in Table C3; the other is DeviceInformation, which is shown in Table C4. The last is DERCapability, which is shown in Table C5. 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.

Table C3 shows each attribute of the IEEE 2030.5-2018 DERSettings object and its data type. All items required by SAE J3072 are designated by an "X" in the second column. Those not specifically designated are not directly called out in SAE J3072 or by reference to Table 28 of IEEE 1547-2018 (see Table 3 of SAE J3072). These can be provided by the PEV. The third column shows the associated 61850 data object term.

Table C3 - PEV DERSettings object

DERSettings: Attribute: Type	SAE J3072	61850 Term
modesEnabled: DERControlType	X	Functions
setESDelay: Uint32	X	DCTE.RtnSrvRmpTim
setESHighFreq: Uint16	X	DCTE:HzHiLim
setESHighVolt: Int16	X	DCTE.VhiLim
setESLowFreq: Uint16	X	DCTE.HzLoLim
setESLowVolt: Int16	X	DCTE.VloLim
setESRampTms: Uint32	X	DCTE.xxxx
setESRandomDelay: Uint32	X	DCTE.RtnSrvDlyTim
setGradW: Uint16	X	xxx
setMaxA: Currentrms		Amax
setMaxAh: AmpereHour		AhrMax
setMaxChargeRateVA: ApparentPower	X	ChaVAMax
setMaxChargeRateW: ActivePower	X	ChaWMax
setMaxDischargeRateVA: ApparentPower	X	VAMax
setMaxDischargeRateW: ActivePower	X	WMax
setMaxV: Voltagerms	X	VMax
setMaxVA: ApparentPower	X	VAMax
setMaxVar: ReactivePower	X	IvarMax
setMaxVarNeg: ReactivePower	X	AvarMax
setMaxW: ActivePower	X	WMax
setMaxWh: WattHour		WhrMax
setMinPFOverExcited: PowerFactor		MinOvPF
setMinPFUnderExcited: PowerFactor		MinUnPF
setMinV: Voltagerms	X	Vmin
setSoftGradW: Uint16	X	xxxx
setVNom: Voltagerms	X	Vnom
setVRef: Voltagerms	X	VRef
setVRefOfs: Voltagerms	X	VRefOfs
updatedTime: TimeType	X	UpdatedTime

Table C4 shows each attribute of the IEEE 2030.5-2018 DeviceInformation Object and its data type. The second column defines the purpose of the attribute. Those attributes that are specifically required by IEEE 2030.5 are designated by an "R." Those designated by "J3072" are specifically required by SAE J3072. Those designated by "1547" are required by IEEE 1547-2018 Table 28. Other attributes of DeviceInformation defined by IEEE 2030.5-2018 that are not specifically listed in this table can be optionally provided by the PEV. The third column provides the 61850 term for the attribute. The fourth column shows the SAE J3072 parameter associated with the 61850 term.