



SURFACE VEHICLE RECOMMENDED PRACTICE

J3105™

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Superseding J3105

Electric Vehicle Power Transfer System Using Conductive Automated Connection Devices

RATIONALE

The original document was initially intended for on-route charging and not necessarily in a depot setting with vehicles charging adjacent to one another. The significant change in this current update is that an RFID tag has been added including the logic to ensure that the correct vehicle is paired with the correct infrastructure prior to enabling charge in close proximity. The vehicle height requirements were modified to correct an oversight. Y-cap requirements were changed to reflect a better technical solution. Sequential charging logic was added to allow for it. All timing diagrams were updated for the new subjects. A new appendix, Appendix I, is included to help clarify the additions required to support sequential charging and RFID/EVCCID pairing. A new appendix, Appendix J, is added to document the test procedure for validating the new sections of the document. Appendix I was used by the committee to verify that the system described and controls do work. A week in October was spent at the Heliox facility with more than 12 experts ranging from OEMs, charging OEMs, control OEMs, and others. Finally, miscellaneous grammar and typos were corrected.

INTRODUCTION

Conductive automated connection device (ACD) solution are attractive to heavy-duty applications where downtime resulting from charge operations need to be minimized and the operator prefers to make the connection without leaving the operator's seat. This document allows for on-route as well as depot charging of the vehicles. The systems described in this document can be used for a multiple of different vehicles including but not limited to transit buses, Class 2 to 8 trucks, drayage vehicles, yard tractors at the port, mining trucks, and automated guided vehicles (AGVs). High power levels are available from 30 kW to more than 1.2 MW.

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Documents

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1. SCOPE

This document covers the general physical, electrical, functional, testing, and performance requirements for conductive power transfer, primarily for vehicles using a conductive ACD connection capable of transferring DC power. It defines conductive power transfer methods, including the infrastructure electrical contact interface, the vehicle connection interface, the electrical characteristics of the DC supply, and the communication system. It also covers the functional and dimensional requirements for the vehicle connection interface and supply equipment interface. New editions of the documents shall be backwards compatible with the older editions. There are also sub-documents which are identified by a SAE J3105/1, SAE J3105/2, and SAE J3105/3. These will be specific requirements for a specific interface defined in the sub-document.

- SAE J3105: Main document, including most requirements.
 - SAE J3105/1: Infrastructure-Mounted Cross Rail Connection
 - SAE J3105/2: Vehicle-Mounted Pantograph Connection
 - SAE J3105/3: Enclosed Pin and Socket Connection

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of publications shall apply.

2.1.1 SAE Publications

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

SAE J1772	SAE Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler
SAE J2836/2	Use Cases for Communication Between Plug-in Vehicles and Off-Board DC Chargers
SAE J2847/2	Communication Between Plug-in Vehicles and Off-Board DC Chargers
SAE J2910	Recommended Practice for the Design and Test for Hybrid Electric and Electric Trucks and Buses for Electrical Safety
SAE J2931/1	Digital Communications for Plug-in Electric Vehicles
SAE J2931/4	Broadband PLC Communication for Plug-in Electric Vehicles
SAE J2953/1	Plug-in Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)
SAE J2953/2	Test Procedures for the Plug-in Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

2.1.2 Federal Communication Commission Publications

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpoaccess.gov/cfr/retrieve.html.

CFR 40	Code of Federal Regulations - Title 40, Part 600, Subchapter Q
CFR 47	Code of Federal Regulations - Title 47, Parts 15A, 15B, and 18C

2.1.3 IEEE Publications

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

IEEE 802.11n A set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) computer communication

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 TS 60479-2 Effects of Current on Human Beings and Livestock

IEC60068-2-6 Environmental Testing - Part 2: Tests - Test L: Dust and Sand - Edition 1.0

IEC 61300-2-6 Fiber Optic Interconnecting Devices and Passive Components - Basic Test and Measurement Procedure

2.1.5 National Fire Protection Agency Publications

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

National Electrical Code, NFPA 70, Article 625 (2020 edition)

2.1.6 UL Publications

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

UL 50 Standard for Enclosures for Electrical Equipment

UL 1439 Determination of Sharpness of Edges on Equipment

UL 2202 EV Charging System Equipment

UL 2231-1 Personnel Protection Systems for Electric Vehicle Supply Circuits: General Requirements

UL 2231-2 Personnel Protection Systems for Electric Vehicle Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems

UL 2251 Plugs, Receptacles, and Couplers for Electric Vehicles

UL 2594 Electric Vehicle Supply Equipment

2.1.7 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 7000 Graphical Symbols for Use on Equipment - Registered Symbols

ISO 15118-2 Road Vehicles - Vehicle to Grid Communication Interface - Part 2: Network and Application Protocol Requirements

ISO 17409:2020 Electrically Propelled Road Vehicles - Conductive Power Transfer- Safety Requirements

EN 50124-1:2017 Railway Applications - Insulation Coordination

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 J551-5	Performance Levels and Methods of Measurement of Magnetic and Electric Field Strength from Electric Vehicles, 150 kHz 30 MHz
SAE J1113-2	Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft) - Conducted Immunity, 15 Hz to 250 kHz - All Leads
SAE J1742	Connections for High Voltage On-Board Vehicle Electrical Wiring Harness - Test Methods and General Performance Requirements
SAE J1773	SAE Electric Vehicle Inductively Coupled Charging
SAE J1812	Function Performance Status Classification for EMC Immunity Testing
SAE J2178-1	Class B Data Communication Network Messages - Detailed Header Formats and Physical Address Assignments
SAE J2178-2	Class B Data Communication Network Messages - Part 2: Data Parameter Definitions
SAE J2178-3	Class B Data Communication Network Messages - Part 3: Frame IDs for Single-Byte Forms of Headers
SAE J2178-4	Class B Data Communication Network Messages - Message Definitions for Three Byte Headers
SAE J2836/6	Use Cases for Wireless Charging Communication for Plug-in Electric Vehicles
SAE J2847/6	Communication Between Wireless Charged Vehicles and Wireless EV Chargers
SAE J2931/6	Signaling Communication for Wirelessly Charged Electric Vehicles
SAE J2894-1	Power Quality Requirements for Plug-in Electric Vehicle Chargers
SAE J3068	Electric Vehicle Power Transfer System Using a Three-Phase Capable Coupler

2.2.2 IEC Publications

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

61000-4-3	Electromagnetic Compatibility (EMC) - Part 4-3: Testing and Measurement Techniques - Radiated, Radio-Frequency, Electromagnetic Field Immunity Test
61000-4-6	Electromagnetic Compatibility (EMC) - Part 4-6: Testing and Measurement Techniques - Immunity to Conducted Disturbances, Induced by Radiofrequency Fields
CISPR 12	Vehicles, Boats and Internal Combustion Engines - Radio Disturbance Characteristics - Limits and Methods of Measurement for the Protection of Off-Board Receivers
IEC 60417	Graphical Symbols for Use on Equipment

IEC 61851-1	Electric Vehicle Conductive Charging System - Part 1: General Requirements
IEC 61851-21	Electric Vehicle Conductive Charging System - Part 21: Electric Vehicle Requirements for Connection to an AC/DC Supply
IEC 61851-23	Electric Vehicle Conductive Charging System - Part 23: DC Electric Vehicle Charging Station
IEC 61851-23-1	DC Electric Vehicle Charging Station with an Automated Connection Device

2.2.3 UL Publications

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

UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 231	Power Outlets
UL 746	A Standard for Polymeric Materials - Short Term Property Evaluations
UL 840	Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment

2.2.4 Canadian Standards Association Publication

Available from Canadian Standards Association, 170 Rexdale Boulevard, Rexdale, Ontario, Canada M9W 1R3, www.csa.ca.

Canadian Electrical Code - Part 1, Section 86

CSA C22.2 NO. 107.1-01 (R2006), General Use Power Supplies

2.2.5 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 11451-2	Road Vehicles - Vehicle Test Methods for Electrical Disturbances from Narrowband Radiated Electromagnetic Energy - Part 2: Off-Vehicle Radiation Sources
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3. DEFINITIONS

3.1 AUTOMATIC CHARGING

Machine operates charging connection, not human.

3.2 AUTOMATIC CONNECTION DEVICE (ACD)

Active device where the physical connection between EV supply equipment and vehicle is made without user interaction providing an electromechanical interface.

3.3 CHARGER

An electrical device that converts alternating current energy to regulated direct current for replenishing the energy of a rechargeable energy storage device (i.e., battery) and may also provide energy for operating other vehicle electrical systems.

3.4 CHASSIS GROUND

The conductor used to connect the non-current carrying metal parts of the vehicle high voltage system to the equipment ground.

3.5 CONDUCTIVE

Having the ability to transmit electricity through a physical path (conductor).

3.6 CONTACT (CHARGE)

A conductive element on the infrastructure-side connection that mates with a corresponding element on the vehicle-side connection to provide an electrical path.

3.7 CONTROL PILOT

An electrical signal that is sourced by the electric vehicle supply equipment (EVSE). Control pilot is the control conductor AND is connected to the equipment ground through control circuitry on the vehicle and performs the following functions:

- a. Verifies that the vehicle is present and connected.
- b. Permits energization/de-energization of the supply.
- c. Serves as communication medium when using PLC.
- d. Aids in monitoring the presence of the equipment ground.

3.8 DC CHARGING

A method that uses dedicated direct current (DC) supply equipment to provide energy from an appropriate off-board charger to the EV.

3.9 EARTH GROUND

A large conducting body, such as the earth or an electric circuit connected to the earth, used as an arbitrary zero of potential. Refer to ISO 7000/IEC 60417.

3.10 ELECTRIC VEHICLE (EV)

A vehicle intended for highway use, powered by an electric motor that draws current from an on-vehicle energy storage device, such as a battery, which is chargeable from an off-vehicle source, such as residential or public electric service or an on-vehicle fuel-powered generator.

3.11 ELECTRIC VEHICLE CHARGING SYSTEM

The equipment required to condition and transfer energy from the constant frequency, constant voltage supply network to the direct current, variable voltage EV traction battery bus for the purpose of charging the battery, and/or operating vehicle electrical systems while connected.

3.12 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

The contacts, including the ungrounded, grounded, and equipment grounding contacts, the electric vehicle connections, attachment plugs, and all other fittings, devices, power outlets, or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle.

3.13 EQUIPMENT GROUND (GROUNDING CONDUCTOR)

A conductor used to connect the non-current carrying metal parts of the EV supply equipment to the system grounding conductor, the grounding electrode conductor, or both, at the service equipment.

3.14 EXPOSED CONDUCTIVE COMPONENT

A conductive component of electrical equipment (e.g., an electric vehicle) that may be touched, and which is not normally energized, but which may become energized in case of a fault.

3.15 EXTENSION

To straighten or spread out at full length.

3.16 HAZARDOUS LIVE COMPONENT

A live component, which under certain conditions may give a harmful electric shock, burn, and arc flash.

3.17 HUMAN MACHINE INTERFACE (HMI)

A machine that takes human inputs and translates the inputs into machine activity.

3.18 INFRASTRUCTURE-SIDE CONNECTION (ISC)

The connections made for the ACD system on the infrastructure side of the connection. The connection is made when the infrastructure-side connection mates with the vehicle-side connection.

3.19 INSULATOR

The portion of a charging system that provides for the separation, support, sealing, and protection from live parts.

3.20 LIVE COMPONENT

Any conductor or conductive component intended to be electrically energized in normal use.

3.21 PROTECTIVE EARTHING

Earthing point or points in a system or in an installation or in equipment, for purposes of electrical safety.

3.22 PROTECTIVE EARTH (PE) PROTECTIVE CONDUCTOR

PE (identification) conductor provided for purposes of safety, for example protection against electric shock.

3.23 RETRACTION

Draw back in or drawn back.

3.24 SERIAL TESTING

Serial testing is defined as intermittent product validation testing to confirm that variance in manufacturing and assembly have not affected the overall performance of the device.

3.25 TYPE TESTING

Type testing is defined as the initial evaluation of the system to conform to the given specification.

3.26 VEHICLE GROUND CLEARANCE

The vertical distance between the pavement and the lowest part of the vehicle floor pan.

3.27 VEHICLE-SIDE CONNECTION (VSC)

The connections made for the ACD system on the vehicle-side of the connection. The connection is made when the infrastructure-side connection mates with the vehicle-side connection

3.28 X, Y, AND Z DIRECTION

The X direction is the longitudinal direction and positive is toward the front of the vehicle. The Y direction is the lateral direction and the positive direction is toward the left of vehicle. The Z direction is the vertical direction and the positive direction is upward.

4. ABBREVIATIONS AND SYMBOLS (ALL)

ACD	Automatic Connection Device
CAN	Controller Area Network
CFR	United States Code of Federal Regulations
CP	Control Pilot
DC-	DC Power Negative
DC+	DC Power Positive
EMC	Electromagnetic Compatibility
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Center
EVSE	Electric Vehicle Supply Equipment
FCC	Federal Communications Commission (U.S.)
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
IMD	Isolation Monitoring Device
ISC	Infrastructure-Side Connection
LIN	Local Interconnect Network
MAC	Medium Access Control Layer
NFPA	National Fire Protection Association
OEM	Original Equipment Manufacturer
PE	Protective Earth
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PHY	Physical Layer

PLC	Power Line Carrier
RESS	Rechargeable Energy Storage System
RFID	Radio Frequency Identification
SDP	SECC Discovery Protocol
SECC	Supply Equipment Communication Controller
UL	Underwriters Laboratories
V2G	Vehicle-to-Grid Communication
VSC	Vehicle-Side Connection

5. GENERAL SYSTEM REQUIREMENTS AND INTERFACE

5.1 General ACD Charging System Requirements

An ACD charging system transfers power between the infrastructure and the vehicle. This power transfer occurs when the correct alignment is complete and the ACD moves into place to electrically connect the infrastructure and the vehicle via conductive coupling. See Figure 1 for two examples of application.

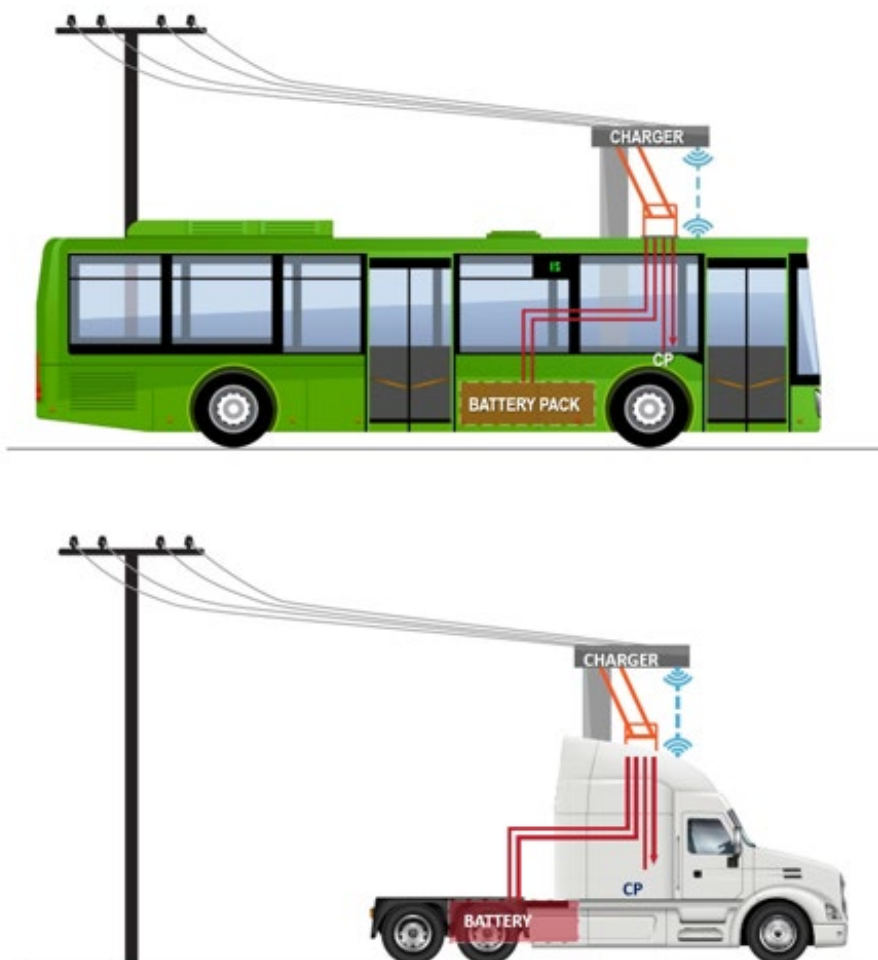


Figure 1 - Examples diagram

This document states the requirements for the power level and configuration, vehicle alignment requirements and protocol, the physical locations of the contacts, the environmental requirements, and the safety aspects.

This document will have a main document with substantially most of the requirement. There will also be sub-documents which will be identified by a SAE J3105/1, SAE J3105/2, and SAE J3105/3. These will be specific requirement for a specific interface defined in the sub-document.

- SAE J3105: Main document - including most requirements
 - SAE J3105/1: Infrastructure-mounted cross rail connection
 - SAE J3105/2: Vehicle-mounted pantograph connection
 - SAE J3105/3: Enclosed pin and socket connection

5.2 Functional/Physical Requirements

The ACD charging interface consists of four different contacts and the communications system shown in Figure 2. The contacts are called out as the high voltage positive, the high voltage negative, the protective earth, and the control pilot. A communications interface is also defined between the infrastructure and the vehicle.

The overall performance evaluation shall be conducted per Appendix F. The guidelines set forth in this appendix will allow the manufacturer or end user to accurately characterize the performance and long-term stability of their system from a mechanical, environmental, and electrical standpoint.

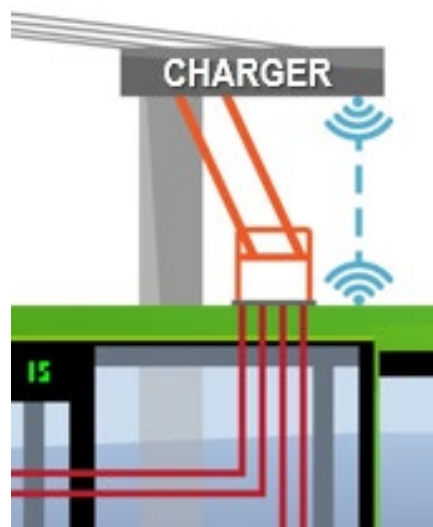


Figure 2 - Interface

5.2.1 Physical Partitions of the ACD Charging System

ACD charging technology for electric vehicles consists of three major partitions:

1. The EVSE as part of the infrastructure.
2. The conductive connections and communications.
3. The charged electric vehicle.

See Figure 3 for the architecture.

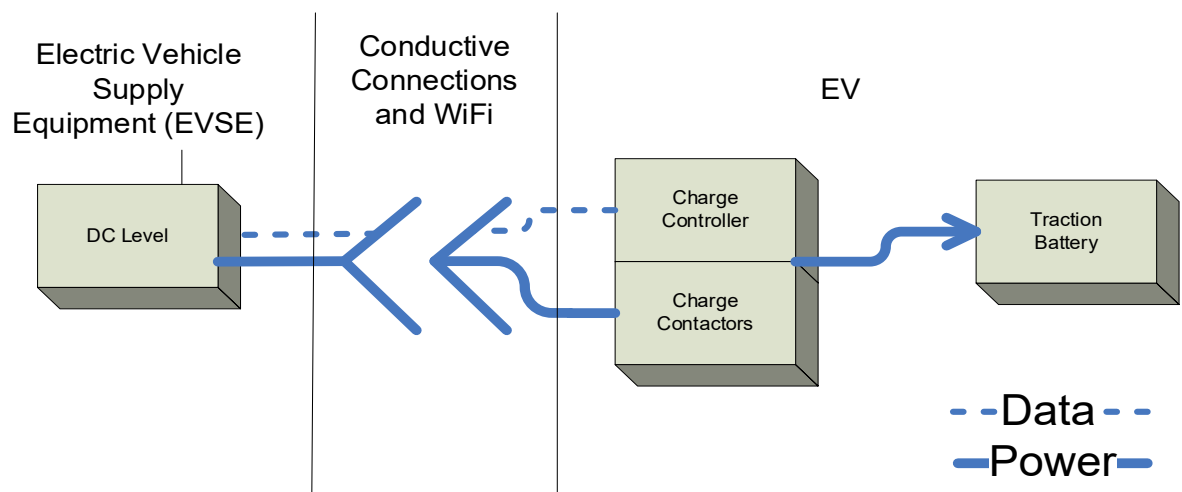


Figure 3 - DC conductive charging system architecture

The conductive connections consist of two major partitions:

- 1. The infrastructure interface is the infrastructure-side connection (ISC).
- 2. The vehicle interface is the vehicle-side connections (VSC).

The conductive connections consist of four contacts that perform the interface functions as shown in Figure 4.

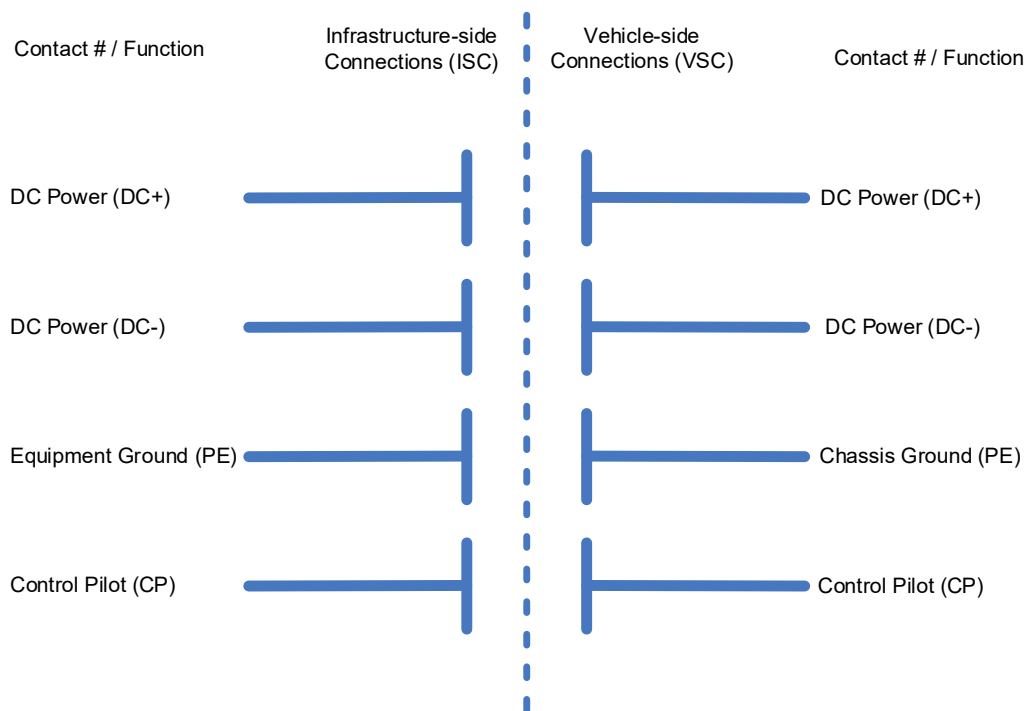


Figure 4 - DC conductive contact definition

5.2.2 Communications Link (Wireless Communications)

Communication between the EVSE and EV is necessary to enable the charging process. In a plug-in charging scenario (for example, according to SAE J1772), communication typically starts after the EV is connected to EVSE.

In case of ACD charging as described in SAE J3105/1, communication shall start before EV is connected to EVSE so that the communication link can be used to control the connecting and disconnecting procedure of the ACD connecting system. Therefore, a wireless communication link is necessary for the ACD charging system. Additionally, the communication link can also be used for the exchange information for positioning of the EV, compatibility check between EV and EVSE, etc.

The wireless communication technology for this application is IEEE 802.11n. The MAC/PHY layer implementation of the communication channel shall fulfil all requirements stated in ISO 15118-8 System Configuration.

Communications for SAE J3105/1 and SAE J3105/3 use WiFi and communications for SAE J3105/2 uses PLC.

SAE Recommended Practice SAE J2847-2 establishes requirements and specifications for communication between plug-in electric vehicle (PEV) and the DC EVSE. Where relevant, this document notes, but does not formally specify, interactions between the vehicle and vehicle operator.

This document applies to the off-board DC EVSE for conductive charging, which supplies DC current to the rechargeable energy storage system (RESS) of the electric vehicle. Communications can be on the control pilot for PLC communication or wireless network (WiFi modem). The details of powerline communications (PLC) are found in SAE J2931/4.

A typical method of DC charging is shown in Figure 5. This configuration allows DC charging with the VSC and ISC. Figure 5 is for illustration only and is not intended to constrain EVSE or EV design.

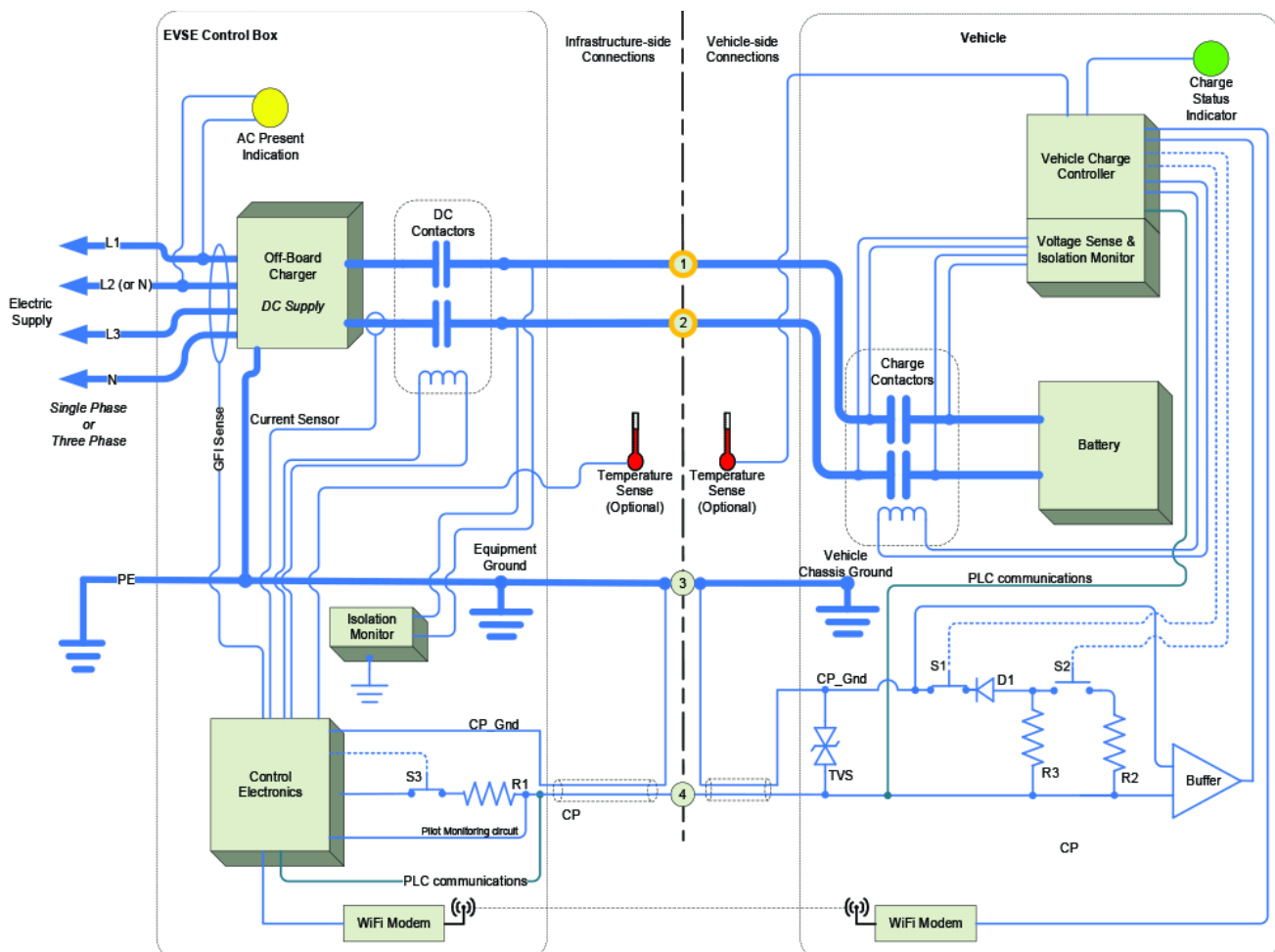


Figure 5 - DC system configuration

5.3 Electrical Ratings

The DC voltage range between DC+ and DC- ranges from 250 to 1000 VDC.

6. CHARGING REQUIREMENTS

6.1 Connection Requirements

6.1.1 ACD Extension and Retraction

The ACD shall extend only once the vehicle is properly positioned and immobilized.

Upon termination of charging session, vehicle shall remain immobilized until the ACD is completely retracted.

6.1.2 Hazard Conditions

6.1.2.1 Hazardous Conditions

The ISC and the VSC shall be designed to avoid or mitigate potentially hazardous conditions; fire, electric shock, or personnel injury.

6.1.2.2 Electrical Safety

Adopt SAE J2910.

6.1.3 Performance Requirements

The ISC shall comply with the performance requirements set forth in Appendix F.

6.1.3.1 Design Life

The manufacturer should specify the service interval and the number of cycles and the test used for a given use case. See Appendix F for details on each test.

6.1.3.2 Temperature Range

The ISC shall be designed to withstand continuous ambient temperatures in the range of -40 to +50 °C during operation when supplied with the EVSE, and continuous ambient temperatures in the range of -40 to +80 °C during shipping or storage when the components parts are assembled or supplied with the EVSE. Temperature rise test shall be conducted as per the requirements of temperature rise test of UL 2251.

6.1.3.3 Fluid Resistance

The VSC and ISC shall be unaffected by automotive lubricants, solvents, and fuels.

6.1.4 General ISC Physical Description

The VSC designs shall be of a common physical configuration that can accept common ISC physical configurations as defined for each charging method. Additionally, the physical requirements shall ensure compatibility of ISCs and VSCs manufactured by the same manufacturer at different points in time as well as different manufacturers of the mating ISCs and VSCs. See Appendix A.

6.1.5 Contact Sequencing

Contact sequencing is defined in each of the supplemental documents.

6.1.6 Unintentional Disconnect

When there is an unintentional disconnect of a power contact, then the EVSE shall shut down current flow.

6.1.7 Unintentional Power Loss to Actuator

Under accidental power loss to the ACD actuator, the EV supply equipment shall perform an emergency stop. The unit shall fully retract to its home position within 60 seconds.

6.1.8 EV Movement

The connection method must be able to maintain contact continuity with movement of the EV in the X, Y, and Z axis.

- The minimum dynamic tolerance $dY = 110$ mm for a 3.1 m vehicle height and 2 degrees kneeling (Φ_z).
- The minimum dynamic tolerance $dX = 70$ mm for back to front kneeling.
- The minimum dynamic tolerance $dZ = \pm 70$ mm due to air suspension.
- The minimum dynamic tolerance $dZ = +0/-87$ mm for 2500 mm vehicle width due to 2 degrees kneeling (Φ_z).

6.1.9 Charge ISC Optional Markings

A ISC and/or VSC manufactured to this standard may optionally visibly display the following identification on its outer surface in Arial font: "SAE J3105™." Any party providing such identification warrants that the ISC and/ or VSC complies with all mandatory requirements and agrees to indemnify and hold SAE harmless from any and all liability arising out of any failure to comply and any resulting injury or damage arising from such failure. Refer to SAE J2910 for markings.

6.1.10 Pairing

Reserved for future use.

6.1.11 Physical Dimensions

The VSC shall comply with the key physical dimensions as defined in the specific Sub-document, SAE J3105/1, SAE J3105/2, or SAE J3105/3. Refer to these documents for details.

6.1.12 Isolation

The VSC power contacts shall be electrically isolated from battery voltages when the ISC is removed from the VSC.

6.1.13 Exposure of Contacts

The ISC and the VSC shall assure the contact points are out of reach of personnel. Not readily accessible as described in NFPA 70®.

The contacts shall be mounted on high voltage insulators in order to isolate the live parts from the ground and to prevent conductivity of dust, salt, and water accumulations by time. The isolation resistance must be supervised during charging process. The isolation resistance when measured from any DC bus to the electrically conductive chassis should be at least 100 Ω/V (by itself).

6.1.14 Sharp Edges

The VSC shall be free of sharp edges and potentially injurious protrusions per UL 1439.

6.1.15 Environmental Considerations

The VSC should meet the performance requirements under weather and environmental conditions specified by the OEM.

6.2 EV Requirements

6.2.1 Vehicle Movement with Mated ISC

The EV shall be immobilized and prevent operator-intended vehicle movement when ISC is connected to the VSC.
Kneeling of the vehicle shall be possible when the ISC is connected to the VSC.

6.2.2 Charging Process Effect on Auxiliary Systems

Charging process shall not effect function of the vehicle’s auxiliary systems.

6.2.3 Alignment

6.2.3.1 Minimum Acceptable Lateral Tolerance

The minimum acceptable lateral tolerance for the EV from the reference point is 460 mm (18 inches). The reference point is commonly the curb.

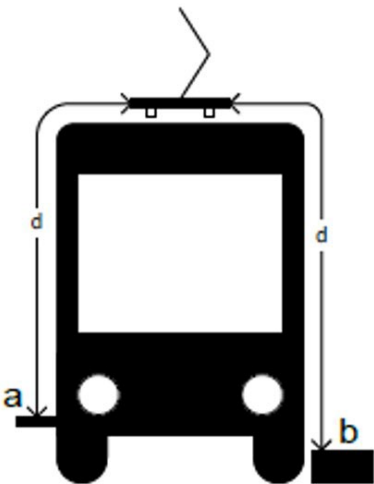
6.2.3.2 Longitudinal Reference

The longitudinal reference is defined by the centerline of the front door.

6.2.3.3 Protection by Clearance Standing Surface

The VSC shall assure the contact points are out of reach of personnel. Not readily accessible as described in NFPA 70®.

The wrap around distance and the clearance with a margin of safety, for touching in a straight line from the standing surface or instep shall be at least 3.0 m to provide protection against direct contact with live parts of an ACD as shown in Figure 6. The clearance given is the minimum value.



Key	
a	Vehicle Step
b	Standing Surface (e.g. platform)
d	> 3000 mm (118.1 inches)

Figure 6 - Minimum clearance to accessible live parts

6.2.3.4 Alignment Procedure

ACD charging of EVs adds several communication requirements to those required to support manual conductive charging. Foremost among these is the need to be able to communicate between the VSC and the ISC over a wireless connection, except for SAE J3105/2.

This also results in needing to be able to positively and securely identify the EV presently being charged by the ACD system. For communications, SAE J3105 relies on the work of SAE J2836/6, SAE J2847/6, and SAE J2931/6 to support communications needed for ACD.

6.2.3.4.1 Functions Supported by Communication

As described in other parts of this document, communications are used to support a variety of functions that are of utility to the user as well as necessary to ensure efficient and safe transfer of power while complying with applicable regulations. The sections below give a high-level description of the functions supported; details can be found in the above referenced communications standards.

6.2.3.4.2 ACD Charging Information Exchange

ACD charging information exchange allows the EV to determine the EVSE's capabilities, compatibilities, and availability. Communication supporting this functionality is independent of the charging technology.

6.2.3.4.3 Guidance and Alignment

Reserved for future use.

6.2.4 Isolation Monitoring

The vehicle isolation monitoring system shall be disconnected during charging to prevent interference with the EVSE isolation monitoring system. The vehicle shall consider various EVSE isolation monitoring technologies (AC signal injection, bus shifting, etc.) to satisfy this requirement.

6.2.5 EV Maximum Y Capacitance

The maximum total parallel Y-capacitance shall not exceed 4 μF . This implies $\leq 2 \mu\text{F}$ Y-capacitance across each DC contact and ground for an EV with Y-capacitance equally distributed between each DC contact and ground.

NOTE 1: Y-capacitance is limited to ensure limited detection time per UL 2231 for isolation faults.

NOTE 2: Y-capacitance is often added within the limits above for EMC reasons

NOTE 3: Parasitic Y-capacitance is included in the allowable limit above.

NOTE 4: The Y-capacitance measurement is defined in ISO 17409:2020, Annex A, Y-capacitance measurement.

NOTE 5: If the EV also uses another charging interface such as SAE J1772, it should also comply with the requirements in that document.

6.2.6 VSC Loss of Communications

When DC charging control communications with the EVSE is lost, the EV shall use the vehicle-initiated normal shutdown sequence; see Appendix C. After the current output achieves $\leq 1 \text{ A}$, the EV shall open charge contactors $\leq 500 \text{ ms}$. This will allow the EVSE to discharge the HV bus.

Emergency charge termination: In an emergency, the charge process shall be terminated by opening the S2, by changing CP State from C to B.

6.2.7 Vehicle Height

The maximum vehicle height from the ground is 4.4 m (14.5 feet).

NOTE: This paragraph is about the ISC clearance and not necessarily contact height compatibility.

6.3 EVSE Requirements

6.3.1 EVSE EMC Requirements

For electromagnetic compatibility (EMC) requirements, refer to FCC Title 47, Part 15 and UL 2231-2.

6.3.2 Installation Requirements

The EVSE shall meet the requirements specified in the National Electrical Code - Article 625 and Canadian Electrical Code - Part 1, Section 86.

6.3.3 General Product Standards

The EVSE shall meet and be listed to the general product requirements for isolated circuits specified in UL 2202.

NOTE: For energy storage or renewable energy, it may be required to further evaluate standard(s) not listed.

6.3.4 Personnel Protection System

The EVSE shall incorporate a listed system of personnel protection for isolated circuits as specified in UL 2231 with the exception that "nominal system voltage" is replaced with "rated system voltage."

6.3.4.1 DC Output Isolation

Contact Isolation is the resistance between each DC contact and ground including any measuring device. Total Isolation is the parallel combination of both contact Isolation values. The Total Isolation of the EVSE DC output shall be $\geq 1.25 \text{ M}\Omega$ including any measurement/monitoring devices. This implies $\geq 2.5 \text{ M}\Omega$ isolation between each DC contact and ground for an EVSE with isolation equally distributed between each DC contact and ground.

NOTE: Vehicle isolation requirements of 100 Ω/V (DC) or 500 Ω/V (AC or AC/DC) are stated in multiple documents including ECE R100, ISO 6469-3, and SAE J2344. EVSE DC output isolation requirements are stated in IEC 61851-23-1 and UL 2231. These documents state that the EVSE shall terminate charge when the isolation of the output falls below 100 Ω/V . The EVSE shall implement one of the following time management strategies of isolation monitor self-test: directly prior to supply cycle with vehicle ISC connected to the VSC or at regular intervals with a maximum period of 24 hours. Independently, the vehicle and EVSE each meet their individual requirements for isolation. When connected as a system, the resulting isolation cannot be greater than the lowest isolation of either the vehicle or EVSE. Because of EVSE tolerance and component aging, some vehicles with isolation as low as the allowable 100 Ω/V may not be able to charge.

The insulation monitoring device (IMD) shall comply with IEC 61557-8 or equivalent. The DC supply shall perform insulation monitoring between DC+ and PE and DC- and PE during the supply process and communicate the current state (invalid, valid, warning, fault) of the system periodically to the EV. The IMD of the EVSE shall have a response time less than 10 seconds with system leakage capacitance of up to 8 μF .

Prior to each supply cycle the following tests shall be performed. During these tests the DC output voltage shall not exceed the maximum voltage of the EV at ACD.

6.3.4.2 Self-Test

A self-test of the insulation monitoring function of the DC supply shall be done by applying a defined fault resistor between DC output rail and equipotential bonding (e.g., PE). At least one of the following three possibilities for time management of self-test shall be applied:

- Directly prior to supply cycle;
- At regular intervals with maximum period of 24 hours;
- After self-test has successfully been performed the station may stay in valid state for a maximum time of 24 hours and during supply session under normal conditions.

NOTE 1: The self-test is done only on the IMD itself. The rest of the EV supply equipment should not react to the isolation fault generated during the self-test.

NOTE 2: A yearly check with the IMD in which the whole chain of the isolation fault is checked should be done; e.g., a fault resistor is applied between DC and PE, the IMD registers the fault and the charge session is stopped with an emergency shutdown.

NOTE 3: The supply session should not be stopped to do a self-test.

6.3.4.3 Insulation Check Prior to Charging

An insulation check of the system by the IMD shall be performed:

EVSE connected via ACD to vehicle: system comprises station, wiring to ACD, ACD counterpart, vehicle ACD contacts, and vehicle cables.

6.3.4.4 DC Insulation Check During Charging

During the charge session, the insulation state of the system shall be monitored by the IMD of the DC EV charging station.

The insulation states of the system are defined as follows.

Invalid state: Self-test has not been carried out yet. Charging is not allowed.

Valid state: After self-test has successfully been performed, the station shall go into valid state. After each termination of energy transfer, the station shall remain in the valid state until the beginning of the next scheduled self-test.

Warning state: If the actual total physical insulation resistance between DC+/DC- to PE falls below a value calculated by $500 \Omega/V$ multiplied by the maximum voltage of the EV the DC supply shall send a warning message and store the warning.

Fault state: If self-test has failed or the actual total physical insulation resistance between DC+/DC- to PE falls below a value calculated by $100 \Omega/V$ multiplied by the maximum voltage of the EV, an optical and/or acoustical signal shall be issued by the DC supply to the user and the DC supply shall terminate the supply process. While the DC charging station is charging a vehicle, the DC charging station shall detect the fault state and indicate the invalid state ≤ 2 consecutive minutes of the insulation resistance $\leq 100 \Omega/V$.

If warning or fault state during energy transfer occurs, the station shall perform a self-test after disconnecting the ACD from the vehicle. If self-test is successfully passed, the station shall go into valid state; otherwise it shall go into invalid state and stay there until the insulation resistance remains $\leq 100 \Omega/V$.

The reaction time of the IMD shall be less than 100 seconds.

6.3.4.5 EVSE Measured Isolation Value (Optional)

The EVSE may optionally communicate the last valid measured isolation value to the EV. Refer to SAE J3105-202305.

6.3.5 Maximum Output Y-Capacitance

The maximum total parallel Y-capacitance shall not exceed 4 μF . This implies $\leq 2\mu\text{F}$ Y-capacitance across each DC contact and ground for an EVSE with Y-capacitance equally distributed between each DC contact and ground.

NOTE 1: Y-capacitance is limited to ensure limited detection time per UL 2231 for isolation faults.

NOTE 2: Y-capacitance is often added within the limits above for EMC reasons.

NOTE 3: Parasitic Y-capacitance is included in the allowable limit above.

NOTE 4: The Y-capacitance measurement is defined in ISO 17409:2020, Annex A, Y-capacitance measurement.

6.3.6 DC Output Current Measurement Accuracy and Resolution

The measured current shall be within $\pm 1\%$ of the actual current if the actual current is $>30\text{ A}$; $\pm 0.3\text{ A}$ if the actual current is $\leq 30\text{ A}$ of reading with a minimum resolution of $\pm 1.0\text{ A}$.

6.3.7 DC Output Voltage Measurement Accuracy

The measured voltage reported shall be within $\pm 1\%$ of rated voltage of the EVSE or less.

6.3.8 DC Output Current Regulation

When in current regulation mode, the EVSE shall provide direct current to the vehicle. The maximum allowable error between the actual average DC current value and the vehicle commanded current value is:

- $\pm 1.5\text{ A}$ when the commanded current value is less than or equal to 50 A .
- $\pm 3\%$ of the charger's maximum current output when the commanded current value is greater than 50 A .

6.3.9 DC Output Descending Current Slew Rate

Normal shutdown or zero current request: Slew rate shall attain a shut down in 1.0 second or less.

Malfunction or emergency shutdown: Slew rate shall attain a shut down in 30 ms or less.

6.3.10 DC Output Current Ripple

During regulation, the EVSE shall maintain a peak-to-peak current ripple as shown in Table 1.

Table 1 - Peak-to-peak ripple

Limit $I \leq 125\text{ A}^*$	Limit $I > 125\text{ A}^*$	Frequency (Hz)
1.5 A_{pp}	$1.2\% I$	<10
6.0 A_{pp}	$4.8\% I$	$<5\text{k}$
9.0 A_{pp}	$7.2\% I$	$<150\text{k}$

* Difference between positive peak top and negative peak top at full scale output I (nom).

6.3.11 DC Output Voltage - No Load Voltage Regulation

Under no load conditions (for example, during pre-charge), the actual output of the charger will be $+1\text{ V}/-20\text{ V}$ of the vehicle's request within 2 seconds . In steady state, the tolerance between requested and provided voltages is $\leq 2\%$ for the maximum rated voltage of the EVSE.

The voltage difference between the EVSE and the EV is required to be measured from the EV.

6.3.12 DC Output Voltage Transient

DC output voltage transient shall be measured at the rated power and rated voltage. Voltage transients shall be limited ± 50 V between any two power contacts.

6.3.13 DC Output Current Overshoot Time

If vehicle maximum current limit (message defined in SAE J2847/2) is exceeded by more than the amount specified in 6.3.8 for more than 400 ms, the EVSE shall shut down due to a fault condition. This is the case where the current output is no longer under the control of the vehicle, and the charging station will use its conversion circuitry to reduce current flow.

6.3.14 DC Output Inrush

The output inrush current shall not exceed 20 A.

6.3.15 DC Output Short Circuit Test

Prior to enabling its high voltage DC output, the EVSE shall check for a short circuit between the high voltage DC+ and DC- in the ISC, VSC, and vehicle cabling up to the vehicle DC charging disconnect. See Appendix C.

6.3.16 Touch Current

Touch current for EVSE, and EV while connected to EVSE for charging, shall be in accordance with the requirements of IEC 61851, clause 11.7.

6.3.17 ISC Loss of Communications

When DC charging control communications with the EV is lost, the EVSE shall use the EVSE initiated normal shutdown sequence.

6.3.18 Protection Against Uncommanded Reverse Power Flow

The EVSE shall protect itself from uncommanded reverse power flow from the EV.

6.3.19 User-Initiated Emergency Charge Termination

The EVSE shall provide a means to allow the user to terminate charging cycle in an emergency event.

6.3.20 ISC Clearance Height

Some adjustment or installation variation may be required for near tolerance vehicles, such as double decker. Road clearance must always be compliant to local regulations, which can override the below specifications.

As the initial document is driven by the transit bus industry, rooftop positioning and road clearance are aligned with this vehicle type. Other types of vehicle may use this interface and may have various rooftop positioning or infrastructure clearances.

For other infrastructure installation than on-road usage, such as indoor or in-depot type, the installation height may be adjusted based on the local needs and installation requirements.

The minimum height clearance to the ground shall be at 4500 mm (14.7 feet).

NOTE: This paragraph is about the ISC clearance and not necessarily contact height compatibility.

6.3.21 Configuration of ISC Pole - Keep Out Area

The pole or any infrastructure shall remain out of the area designated by the Figure 7. This is required to ensure all buses within the tolerance of the rail position will not violate ADA or cause an obstruction. Other types of vehicles may not need this requirement.

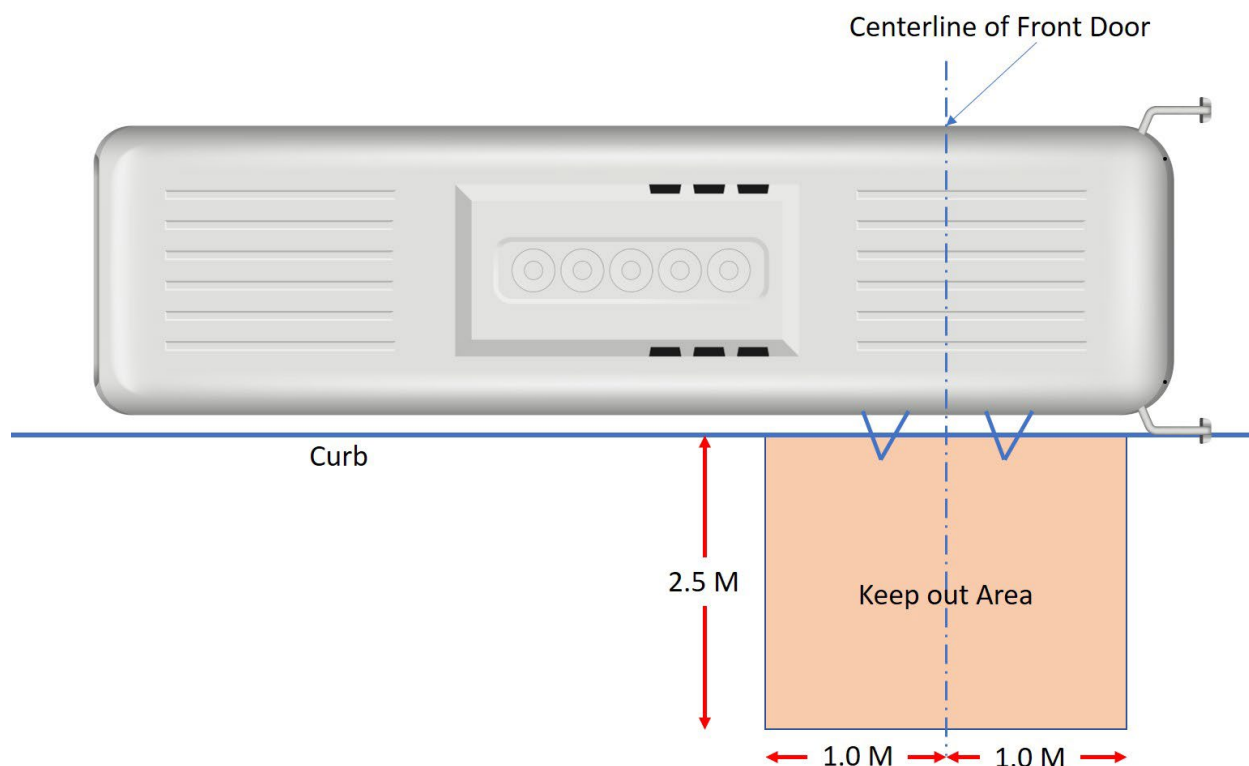


Figure 7 - ISC keep out area

6.3.22 Network an Application Protocol Requirements

The application protocol requirements for EV and EVSE for ACD according to SAE J3105/1 are described in Appendices C and D. The schema is in Appendix E.

7. NOTES

7.1 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 - CHARGING CONTROL AND INFORMATION

A.1 CONTROL PILOT

The control pilot circuit is the primary control means to ensure proper operation when connecting a EV to the EVSE. This section describes the functions and sequencing of events for this circuit based on the recommended typical implementation or equivalent circuit parameters.

A.1.1 Control Pilot Circuit

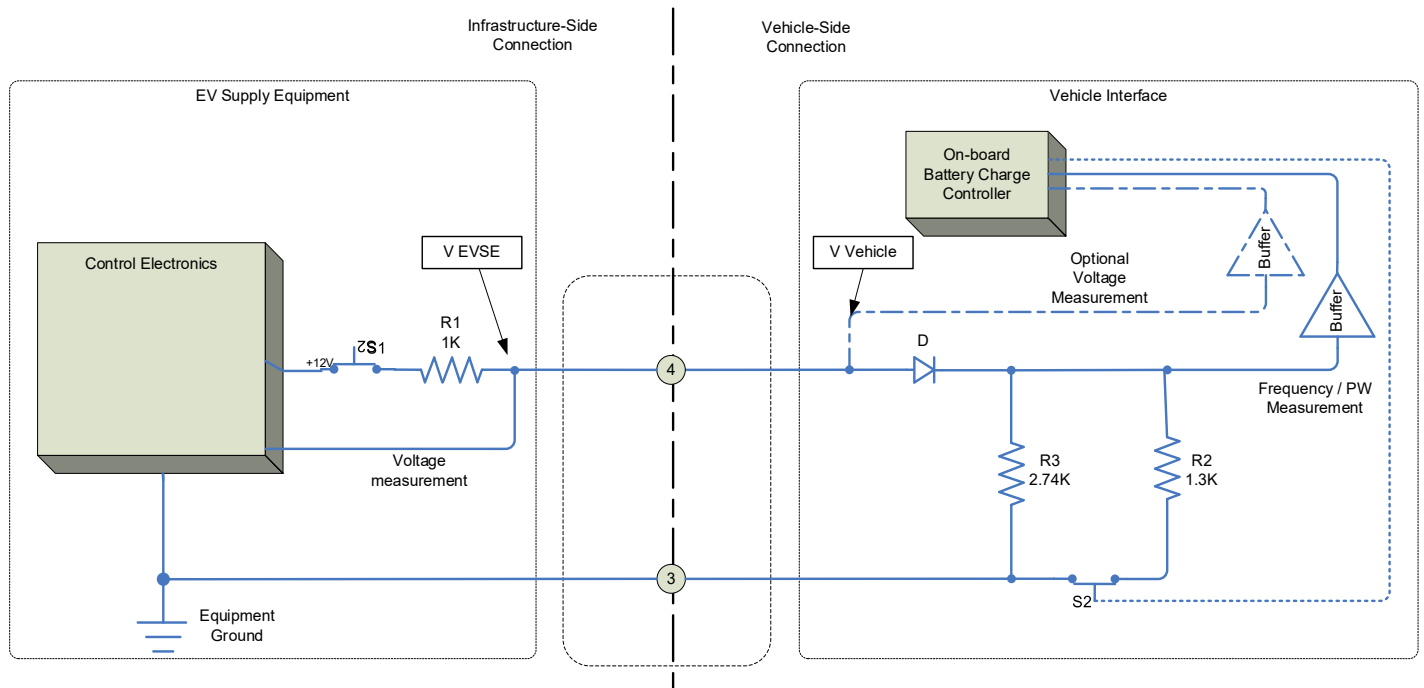


Figure A1 - Control pilot circuit

A.1.2 Vehicle States

The vehicle states are defined in Tables A1, A2, A3, and A4.

Table A1 - Definition of vehicle/EVSE states with PLC

State Designation	EVSE (VDC Nominal) ⁽⁵⁾	Vehicle (VDC Nominal) ⁽⁵⁾	Description of Vehicle/EVSE State
State A	12.0 ⁽¹⁾	0 ⁽¹⁾	Vehicle not connected
State B1	9.0 ⁽¹⁾	9.0 ⁽¹⁾	Vehicle connected/not ready to accept energy
			EVSE not ready to supply energy
State B2	9.0 ⁽²⁾⁽³⁾	9.0 ⁽²⁾⁽³⁾	Vehicle connected/not ready to accept energy
			EVSE capable to supply energy
State C	6.0 ⁽²⁾	6.0 ⁽²⁾	Vehicle connected/ready to accept energy/indoor charging area ventilation not required
			EVSE capable to supply energy
State D	3.0 ⁽²⁾	3.0 ⁽²⁾	Vehicle connected/ready to accept energy/indoor charging area ventilation required
			EVSE capable to supply energy
State E ⁽⁴⁾	0	0	EVSE disconnected from vehicle/EVSE disconnected from utility, EVSE loss of utility power or control pilot short to control pilot reference
State F	-12.0 ⁽¹⁾⁽⁶⁾	-12.0 ⁽¹⁾⁽⁶⁾	Other EVSE problem

⁽¹⁾ Static voltage.

⁽²⁾ Positive portion of 1 kHz square wave, measured after transition has fully settled.

⁽³⁾ The transition from State B1 to State B2 begins as a static DC voltage which transitions to PWM upon the EVSE detection of vehicle connected/not ready to accept energy and EVSE capable to provide energy.

⁽⁴⁾ EVSE is not required to actively generate State E.

⁽⁵⁾ Voltage measured by EVSE/Vehicle as shown in Figure 6.

⁽⁶⁾ Optional state. The EVSE may enter State F upon detecting a self-diagnosed fault that prevents the EVSE from delivering power. Once the EVSE is in State F, self-restoring (automatic restart) is not required. This option would require user intervention to reset the EVSE to restore normal operation. If the EVSE decides to self-restore while connected to an EV/PHEV, a maximum of 20 re-tries shall be allowed with a 15 minute minimum time interval between re-tries. If the EVSE does not recover within a maximum of 20 re-tries, user intervention is required to reset the EVSE to restore normal operation.

Table A2 - Control pilot state voltage range reference from mated charge connection

State	Min Voltage	Nominal Voltage	Max Voltage
A	10.5	12.0	>10.5
B	7.5	9.0	<10.5
C	2.0	4.75	<7.5
D	NA	NA	NA
E	0	1.0	<2.0
F	NA	NA	NA

NOTE: The tolerances described in table represent calculated values assuming 3% resistors in the EVSE circuitry. These values do not take into variances such as ground shift, chassis resistance, active accessory devices (air conditioning, rear defog, etc.) or other factors that may shift these values. The values do not include the EVSE cable. Vehicle manufacturers must minimize these factors in their vehicle designs.

Table A3 - EVSE control pilot circuit parameters with PLC control (see Figure A1)

Parameter ⁽¹⁾	Symbol	Units	Nominal Value	Max Value	Min Value
Generator					
Voltage high, open circuit	Voch	V	12	12.6	11.4
Voltage low, open circuit	Vocl	V	-12.00	-12.60	-11.40
Frequency	Fo	Hz	1000	1020	980
Pulse width ⁽²⁾	Pwo	μs	Per Figure 3	Nom, +5 μs	Nom, -5 μs
Rise time ⁽³⁾	Trg	μs	NA	2	NA
Fall time ⁽³⁾	Tfg	μs	NA	2	NA
Setting time ⁽⁴⁾	Tsg	μs	NA	3	NA
Output Components					
Equivalent source resistance	R1	Ω	1000	1030 ⁽⁵⁾	970 ⁽⁵⁾
Total equivalent EVSE Capacitance, w/o cable	C1	pF	NA	NA	300 ⁽⁶⁾
Total equivalent EVSE capacitance, including cable					
	C1 + Cc	pF	NA	3100	NA

⁽¹⁾ Tolerances to be maintained over the environmental conditions and useful life as specified by the manufacturer.

⁽²⁾ Measured at 50% points of complete negative-to-positive or positive-to-negative transitions.

⁽³⁾ 10 to 90% of complete negative-to-positive transition or 90 to 10% of complete positive-to-negative transition measured between the pulse generator output and R1. Note that the term "generator" is referring to the EVSE circuitry prior to and driving the 1 KΩ source resistor with a ±12 V square wave. This circuitry should have rise/fall times faster than 2 μs. Rise/fall times slower than this will begin to add noticeably to the output rise/fall times dictated by the 1 KΩ resistor and all capacitance on the pilot line.

⁽⁴⁾ To 95% of steady-state value, measured from start of transition.

⁽⁵⁾ Maximum and minimum resistor values are ±3% about nominal.

⁽⁶⁾ Guarantees rise time slow enough to remove transmission line effects from cable.

Table A4 - EV control pilot circuit parameters with PLC control (see Figure A1)

Parameter ⁽¹⁾	Symbol	Units	Nominal Value	Max Value	Min Value
Equivalent load	R2B	Ω	2740	2822 ⁽²⁾	2658 ⁽²⁾
Resistance - States B1 & B2					
Equivalent load	R2C	Ω	882	908 ⁽²⁾	856 ⁽²⁾
Resistance - State C ⁽³⁾					
Equivalent load	R2D	Ω	246	253 ⁽²⁾	239 ⁽²⁾
Resistance - State D ⁽⁴⁾					
Total equivalent capacitance	C2	pF	NA	2400	NA
Equivalent diode voltage drop ⁽⁵⁾	Vd	V	0.7	0.85	0.55

⁽¹⁾ Tolerances to be maintained over the environmental conditions and useful life as specified by the manufacturer.

⁽²⁾ Maximum and minimum resistor values are ±3% about nominal.

⁽³⁾ Vehicles not requiring ventilation for indoor charging areas.

⁽⁴⁾ Vehicles requiring ventilation for indoor charging areas.

⁽⁵⁾ Silicon small signal diode, -40 to 85 °C, forward current 3.00 to 10.0 mA.

A.1.3 Control Pilot Functions

The control pilot performs the following functions:

A.1.3.1 Verification of Vehicle Connection

The EVSE is able to determine that the ISC is connected to the VSC and properly connected to the EV by sensing resistance R3 as shown in Figure A1. The diode, D1, is present to help an EVSE determine that an EV is connected rather than other potential low impedance loads. If the EVSE does not detect diode D1 (missing or shorted), it may indicate a fault by entering State F. The EV may optionally monitor the control pilot on the anode side of diode D1 as shown in Figure A1.

A.1.3.2 EVSE Not Ready to Supply Energy

The EVSE is able to indicate to the EV that it is not ready to supply energy by not turning on the oscillator and maintaining State B1. State B1 may be used by the EVSE to maintain the current charge session during load management, fee transaction, or other events.

The EVSE may turn off the oscillator at any time while in State C or D during the current charge session. When the EVSE turns off the oscillator, the EVSE shall terminate energy transfer. The EV then opens S2, resulting in State B1.

A.1.3.3 EVSE Ready to Supply Energy

The EVSE is able to indicate to the EV that it is ready to supply energy by turning on the oscillator and providing the square wave signal according to the value derived from Figure 8. The EVSE shall not close contactors unless the oscillator is on and valid per Figure A2. In each of the states specified in Tables A1 and A2, the EVSE may supply the pilot as a DC signal or as an oscillating signal. However, normally the oscillator is only turned on in State B2, State C, or State D.

A duty cycle of 5% indicates that digital communication is needed; see 6.3.

A.1.3.4 EV Ready to Accept Energy

The EV indicates that it is ready to accept energy from the EVSE by closing switch S2, as shown in Figure A1, when the current profile on the control pilot oscillator is sensed. The EV may de-energize the EVSE at any time by opening switch S2.

A.1.3.5 Verification of Equipment Grounding Continuity

The equipment grounding conductor provides a return path for the control pilot current to ensure that the EVSE equipment ground is safely connected to the EV vehicle chassis ground during charging. Loss of this signal shall result in the automatic de-energization at the EVSE.

A.1.4 EVSE Shutdown - Control Pilot

The EVSE shall detect the loss of the control pilot (control pilot transition from State C (or D) to State A) and interrupt the DC output current to ≤ 5 A within ≤ 30 ms. See Appendix B.

A.1.5 Charge Status Indicator

The EV shall provide charge status information visible to the operator while connection is connected. The specific requirements (such as color, lamp type, styling, intensity, field of view, etc.) for the charge status indicator can be defined by the OEM.

A.1.6 Digital Data Transfer

A control pilot duty cycle of 5% indicates that digital communication is required and must be established between the EVSE and vehicle before charging. This is required for DC charging.

Digital data transfer is specified in the following SAE documents:

- SAE J2836/2: Use Cases for Communication Between Plug-in Vehicles and Off-Board DC Chargers
- SAE J2847/2: Communication Between Plug-in Vehicles and Off-Board DC 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 (EV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

A.1.7 EVSE and PEV Sequence and Response Time Specifications

See Appendix C for sequencing and response time specifications.

APPENDIX B - EVSE AND PEV MESSAGE

The message ID in the table shown below directly aligns with the request/response messages identified by yellow stars in the sequence diagrams in SAE J2847. See 5.2.2.

Table B1 - EV control pilot circuit parameters with PLC control (see Figure A1)

MSD ID	XML Message	Parameters
0A	SupportedAppProtocolReq	APPPROTOCOL
0B	SupportedAppProtocolRes	RESPONSE CODE SCHEMAID
1A	SessionSetupReq	EVCCID
1B	SessionSetupRes	RESPONSECODE EVSEID DATETIMENOW
2A	ServiceDiscoveryReq	SERVICESCOPE SERVICECATEGORY
2B	ServiceDiscoveryRes	RESPONSE CODE PAYMENTOPTIONS CHARGESERVICE SERVICELIST
XA	ServicePaymentSelectionReq	
XB	ServicePaymentSelectionRes	
YA	ContractAuthenticationReq	
VB	ContractAuthenticationRes	
3A	ChargeParameterDiscoveryReq	EVREQUESTEDENERGYTRANSFERTYPE DC_EVCHARGEPARAMETER
3B	ChargeParameterDiscoveryRes	RESPONSECODE SASCHEDULELIST DC_EVSECHARGEPARAMETER
4A	CableCheckReq	DC_EVSTATUS
4B	CableCheckRes	RESPONSECODE DC_EVSESTATUS
5A	PreChargeReq	DC_EVSTATUS EVTARGETVOLTAGE EVTARGETCURRENT
5B	PreChargeRes	RESPONSECODE DC_EVSESTATUS EVSEPRESENTVOLTAGE
6A	PowerDeliveryReq	READYTOCHARGESTATE CHARGINGPROFILE DC_EVPOWERDELIVERYPARAMETER
6B	PowerDeliveryRes	RESPONSECODE DC_EVSESTATUS

MSD ID	XML Message	Parameters
7A	CurrentDemandReq	DC_EVSTATUS EVTARGETCURRENT EVMAXIMUMVOLTAGELIMIT EVMAXIMUMCURRENTLIMIT EVMAXIMUMPOWERLIMIT <i>BULKCHARGINGCOMPLETE</i> CHARGINGCOMPLETE REMAININGTIMETOFULLSOC REMAININGTIMETOBULKSOC EVTARGETVOLTAGE
7B	CurrentDemandRes	RESPONSECODE DC_EVEVSESTATUS EVSEPRESENTVOLTAGE EVSEPRESENTCURRENT EVSECURRENTLIMITACHIEVED EVSEVOLTAGELIMITACHIEVED EVSEPOWERLIMITACHIEVED EVSEMAXIMUMVOLTAGELIMIT EVSEMAXIMUMCURRENTLIMIT EVSEMAXIMUMPOWERLIMIT
8A	PowerDeliveryReq	READYTOCHARGESTATE CHARGINGPROFILE DC_EVPOWERDELIVERYPARAMETER
8B	PowerDeliveryRes	RESPONSECODE DC_EVSESTATUS
9A	WeldingDetectionReq	DC_EVSTATUS
9B	WeldingDetectionRes	RESPONSECODE DC_EVSESTATUS EVSEPRESENTVOLTAGE
10A	SessionStopReq	(NONE)
10B	SessionStopRes	RESPONSECODE

APPENDIX C - EVSE AND PEV SEQUENCE AND RESPONSE TIME SPECIFICATIONS

C.1 BACKGROUND

The timing diagrams in this appendix were originally created for the ASSURED project in Europe prior to the release of SAE J3105:JAN2020 and have been updated to reflect this revision.

C.2 MECHANICAL INTERFACE

The mechanical interface is described in prEN 50696 CD - Annex A (normative), ACD mounted on the infrastructure.

C.3 GENERAL

The process of supplying energy to the EV by the DC supply is initiated and controlled by the messages sent by means of wireless communication as described in ISO 15118-2 and -8 and shall follow the sequences shown in Figures C1, C2, C3, and C4, for normal start up, normal shutdown, station initiated emergency shutdown and EV initiated emergency shutdown.

Legend for sequence diagrams and description:

(tx) = dedicated point in time

(tx → ty) = time period between two dedicated points in time tx and ty

<1a><1b> = reference to messages in high level communication (WLAN)



= possible time period in which described action can take place

in blue = communication signals and values described in ISO/IEC 15118-2

in orange = second variable from ISO 15118-2

in yellow = variable proposed for ISO 15118-2, 2nd edition CD

in red = not communicated value

C.3.1 Normal Start Up

Sequence diagram and description for normal start up are shown in Figure C1 and Table C1.

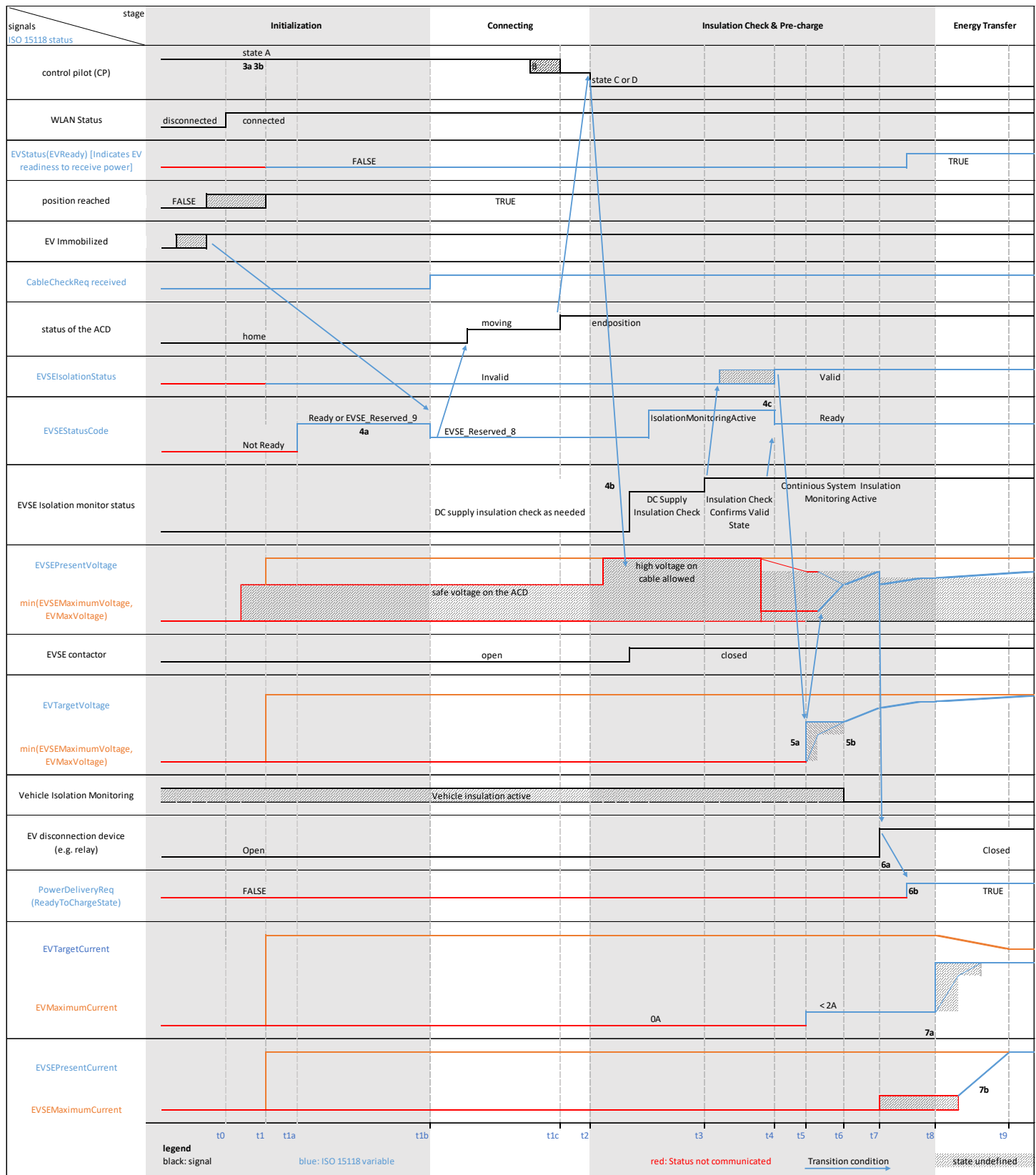


Figure C1 - Sequence diagram for normal start up

Table C1 - Sequence description for normal start up

Phase	Description
(t0)	High level communication starts and handshaking with exchange of charging parameters takes place.
(t1)	EV sends its maximum limits (amongst other parameters) for DC supply output current and voltage with <3a>. Maximum values of the DC supply are responded to the EV with <3b>. DC supply can check internal insulation as long as no voltage is applied to the ACD. If EV and EV supply equipment are not compatible, then the vehicle will not go to Ready, and will transition to step t16 in the normal shutdown sequence.
(t1a)	EVSEStatusCode set to Reserved_9 if EVSE is putting the session into standby EVSEStatusCode will be set to Ready if EVSE has given the session priority to continue.
(t1b)	EV has reached the correct position for charging. DC supply checks if DC output voltage is less than 60 V and terminates supply session if 60 V is exceeded. EV initiates connection process <4a> by sending CableCheckReq. DC supply sets its status to "EVSE_Reserved_8" until the ACD is in the working position.
(t1c)	EV supply equipment reports that the mechanical contact is secured DC supply checks if DC output voltage is less than 60 V and terminates supply session if 60 V is exceeded.
(t2)	EV changes CP state from B to C/D by closing S2 which ends connecting phase.
(t2 → 3)	EV requests cable and insulation check by <4b>. DC supply starts checking HV system insulation and continuously reports insulation state.
(t3)	DC supply determines that insulation resistance of system is above 100 Ω/V (cf. CC.4.1).
(t3 → t4)	After having successfully finished the insulation check, DC supply indicates status "valid" with subsequent message.
(t4)	EVSEStatusCode changes to "ready" with cable check response <4c>.
(t5)	Start of pre-charge phase with EV sending pre-charge request <5a>, which contains both requested DC current ≤ 2 A (maximum inrush current acc. to CC.5.2) and requested DC voltage.
(t5 → t6)	DC supply adapts DC output voltage to requested value in <5a> while limiting current to maximum value of 2 A (maximum inrush current according to CC.6.1) even if the requested current 0A.
(t6)	DC output voltages reaches requested voltage within tolerances given in 6.3.7.
(t6 → t7)	If necessary, EV adapts requested DC voltage with cyclic messages <5a> in order to limit deviation of DC output voltage from EV battery voltage to less than +1 V, -20 V. Before the EV closes any contactor the EV stops vehicle internal insulation monitoring.
(t7)	EV closes its disconnecting device after deviation of DC output voltage from EV battery voltage is less than 20 V.
(t7 → t8)	EV sends power delivery request <6a> with ReadyToChargeState "TRUE" to enable DC power supply output. EV sets EVReady status "TRUE." After disabling pre-charge circuit, if any, and switching on its power supply output, DC supply gives feedback <6b> that it is ready for energy transfer.
(t8)	EV sets DC current request with <7a> to start energy transfer phase.
(t8 → t9)	DC supply adapts its output current and voltage to the requested values. DC supply reports its present output current and output voltage, its present current limit and voltage limit, and its present status back to the EV in message <7b>. Note that EV may change its voltage request and current request even if output current has not reached the previous request.
(t9)	DC output current reaches DC current request within delay time Td. (Time span t9 - t8 = Td, if one request has been made, bold line shown this situation.)
(t9 →)	EV adapts DC current request and DC voltage request according to its charging/supply strategy with cyclic message <7a>.

C.3.2 Normal Shutdown

Sequence diagram and description for normal shutdown are shown in Figure C2 and Table C2.

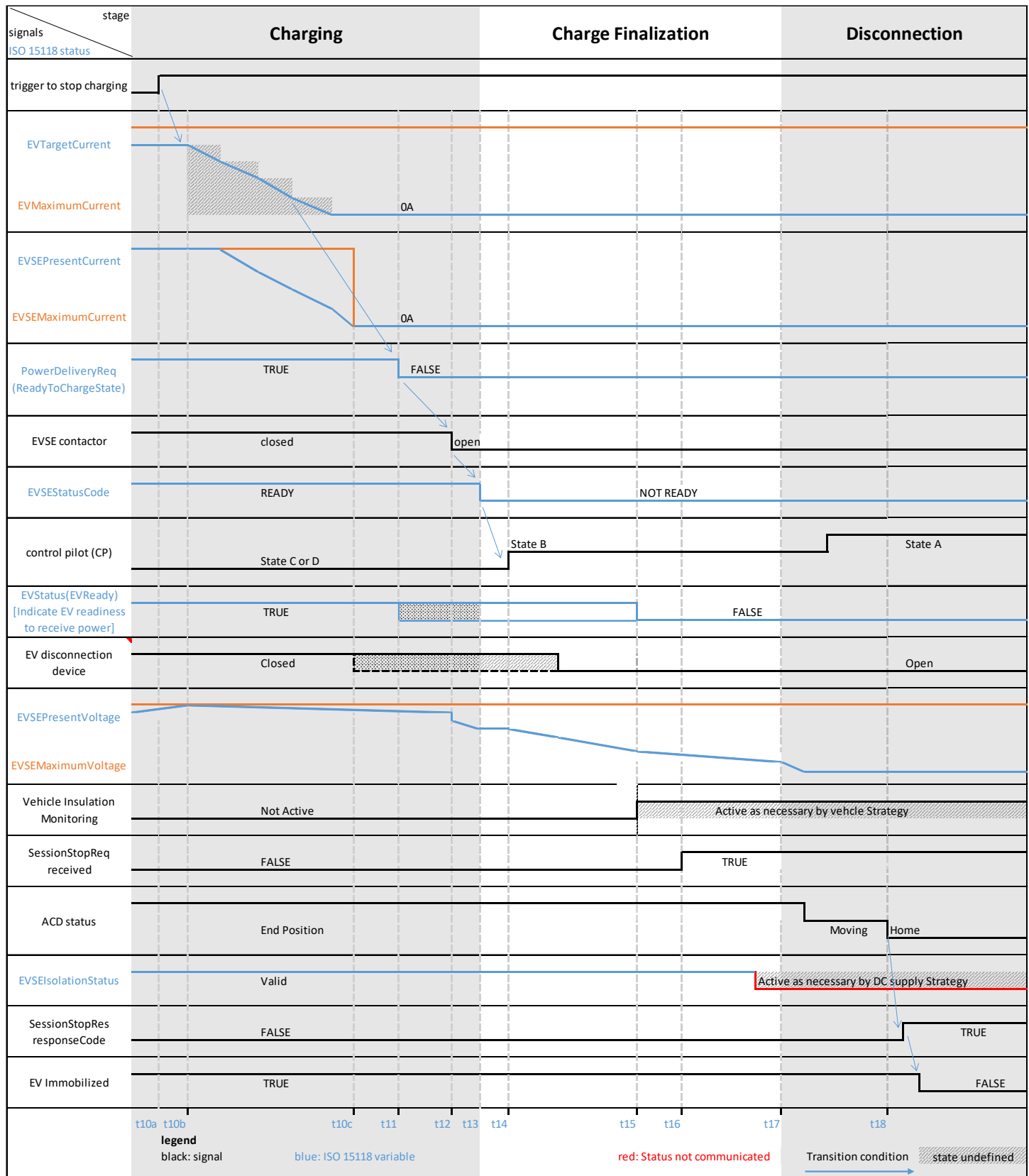


Figure C2 - Sequence diagram for normal stop



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Table C2 - Sequence description for normal stop

Phase	Description
(t10a)	The user or vehicle system indicates that charging should be stopped.
(t10b)	The EV reduces the current request to complete the energy transfer. Reduction is done based on EV charging/supply strategy.
(t10c)	EV has the option to open the EV disconnection device per V2G2-527.
(t11)	the EV requests the DC supply to disable its output power by setting PowerDeliveryReq(ReadyToChargeState) = FALSE.
(t12)	DC supply disables its output and opens contactors, if any. DC supply shall enable its circuit to actively discharge any internal capacitance on its output after receiving message with "PowerDeliveryReq(ReadyToChargeState)" set to FALSE. DC supply shall not cause any current flow on EV input during discharge.
(t13)	DC supply reports EVSEStatusCode "not ready" within 2 seconds after the DC supply has disabled its output.
(t14)	EV changes CP state to B after receiving message PowerDeliveryRes() with EVSEStatusCode "not ready" or after timeout to ensure that DC supply has discharged its output at latest by t14 (in case message was lost).
(t14')	EV can optionally perform its welded contactor check and indicating this to the DC supply.
(t15)	Earliest time for EV isolation monitoring active.
(t16)	The SessionStopReq is received.
(t17)	The DC output voltage is checked to be below 60 VDC.
(t17 → t18)	State A is observed.
(t18)	The EV shall be mobilized only when the ACD is confirmed to be in the home position by a sessionStopRes with responseCode = Ok.

C.3.3 DC Supply Initiated Emergency Shutdown

An emergency shutdown of the output current to less than 5 A within 1 second with a current descending rate of 200 A/s or more shall be applied by the DC supply. DC supply shall indicate supply initiated emergency shutdown by turning off CP.

NOTE: DC supply initiated emergency shut can be triggered by several causes or faults.

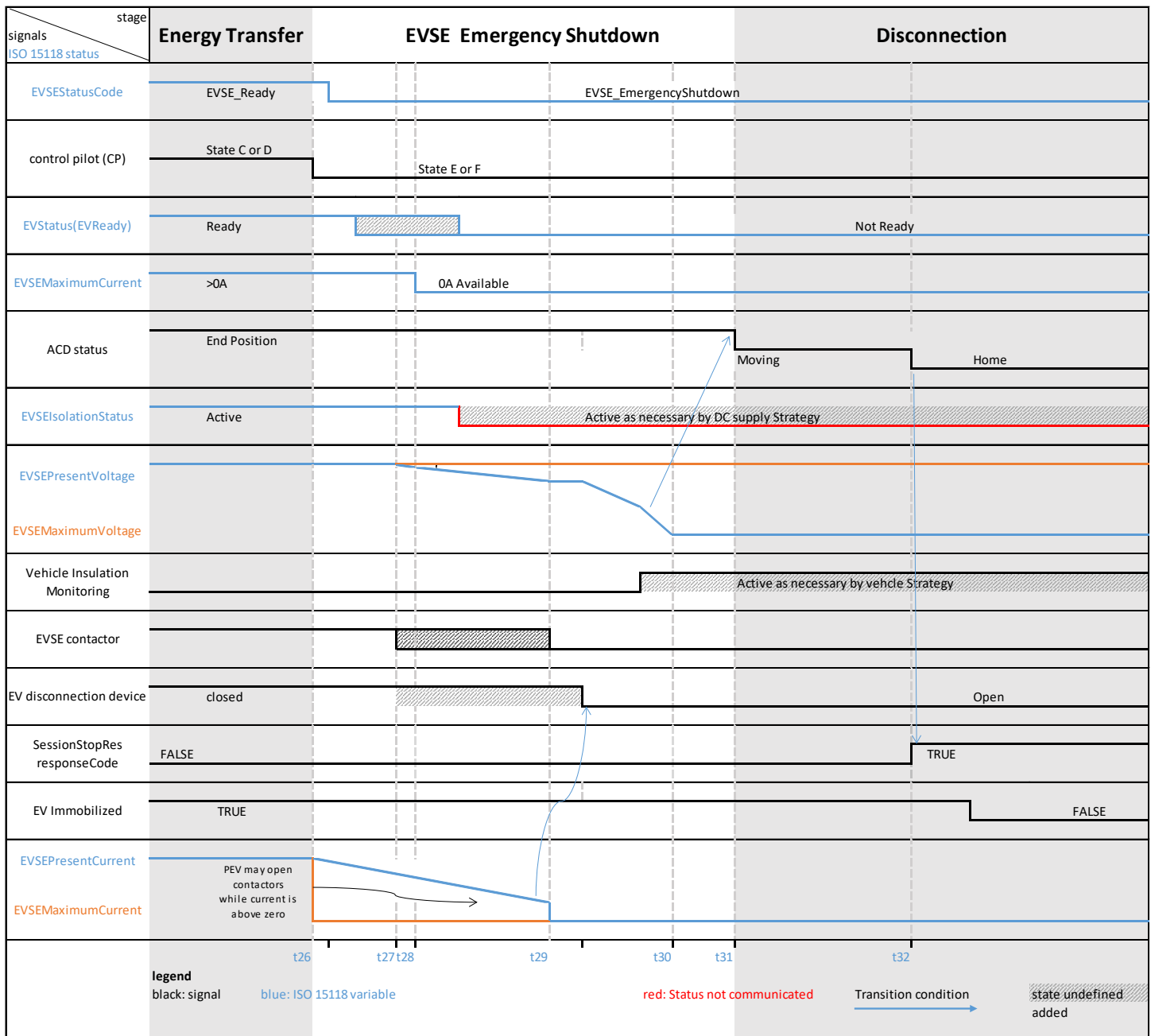


Figure C3 - Sequence diagram for DC supply initiated emergency stop

Table C3 - Sequence description for DC supply initiated emergency stop

Phase	Description
(t26)	EV supply equipment experiences an emergency (isolation fault, emergency button press, etc.) and sets the control pilot signal to state E or state F. The EV supply equipment reduces its maximum current limit and start reducing its current.
(t27)	The EV reacts by disabling S2 and may open its contactor from this time.
(t29)	The EV supply equipment has reduced its current to <5 A and has opened its contactors. The EV has opened its contactors as well.
(t30)	The EV supply equipment reduced its voltage below 60 V.
(t31)	The EV supply equipment starts disconnecting the ACD.
(t32)	The EVSE changes the control pilot signal to State A once the emergency fault has been reset.

C.3.4 EV-Initiated Emergency Shutdown

EV triggers emergency shutdown by opening S2 and changing CP state from C/D to B. DC supply shall acknowledge emergency shutdown request from the EV by performing emergency shutdown.

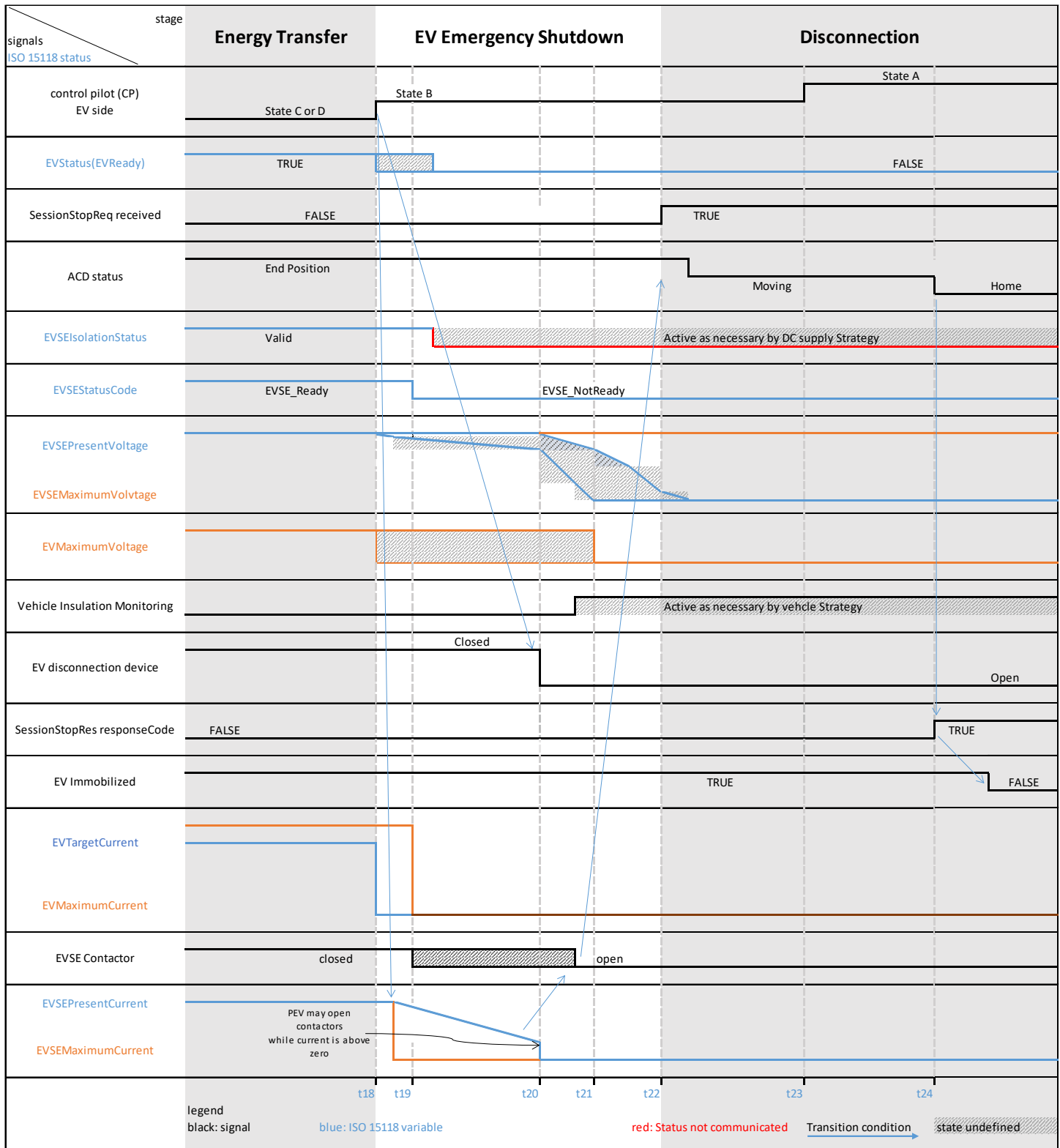


Figure C4 - Sequence diagram for EV-initiated emergency stop



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Table C4 - Sequence description for EV-initiated emergency stop

Phase	Description
(t18)	The EVCC opens S2 switch on the CP-PE circuit and State B is reached.
(t19)	The EVSEStatusCode changes from “ready” to “not ready” and the EV maximum current limit value changes to 0 A.
(t20)	The current shall be reduced to <5 A by the EVSE (within 70 ms for an emergency shutdown and within 1 second for a normal shutdown). The maximum time for EV disconnection device to open its relays. The output current drops to <5 A the instant the EV disconnection device opens.
(t21)	The DC output voltage drops to <60 V.
(t22)	The SessionStopReq received.
(t23)	The ACD disconnects and State A is reached.
(t24)	The ACD has reached Home position indicated by a SessionStopRes with responseCode = Ok.

The WiFi antenna 3 dB beam width is 9 degrees. At the ideal position the vehicle shall start V2G communication (SupportedAppProtocolReq) when the signal strength is higher than -75 dBm.

C.4 TLS/CERTIFICATES

TLS shall not be used.

C.5 SESSION SETUP

A vehicle ID shall be sent for reference during interoperability testing with the following definition:

Two alphanumeric characters representing the OEM and six last digits of VIN; e.g., AB123456.

Table C5 - OEM IDs

OEM	ID
BYD	BY
Gillig	GI
Irizar	IR
IVECO	IV
New Flyer	NF
Nova Bus	NB
Proterra	PR
Solaris	SO
URBASER	UR
VDL	VD
Volvo	VO

C.6 MISALIGNMENT

When a misalignment is observed by the charger, the charger shall respond with CableCheckRes where the responseCode = failed and abort the charging session.

After aborting the charging session, the charger shall prepare itself for a new charging session. The charger shall not enter a locked state by the failed charging session.

Condition to detect misalignment:

- ACD is in the end position, i.e., completely extended.
- Control pilot status is State A.

C.7 CABLE CHECK

During cable check the minimum of the maximum voltages of the vehicle and charger shall not be exceeded.

C.8 VOLTAGE DURING CABLE CHECK UNTIL PRECHARGE

During the period between CableCheck and PreCharge, the voltage of the charger shall be between zero and the minimum of the maximum voltages of the vehicle and charger.

$(V > 0 \text{ V})$ and $[V < \min(\text{EVSEMaxVoltage}, \text{EVMaxVoltage})]$.

C.9 PRECHARGE

During PreCharge, the charger shall supply the requested voltage, regardless of what the current setpoint is. The charger shall limit the current to maximum 2 A.

APPENDIX D - NETWORK AND APPLICATION PROTOCOL REQUIREMENTS

ISO 15118-2 DIS 2012 is applicable, except as follows:

Addition:

OppCharge Core Specification, *Technical description of the OppCharge interface*, Volvo Buses AB, December 2016 (https://www.oppcharge.org/dok/OppCharge_Core_Specification.pdf).

For detailed information, refer to OppCharge web site: <https://www.oppcharge.org/>.

IEEE/Std 802.11™-2012, IEEE Standard for Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — specific requirements: Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

The original requirements are quoted *in italics and in the color blue*. Deviations or restrictions to original requirements are specified under a new modified requirement number. A new number is attached to the original number in a schema ["original number"_n]. For example: [V2G2-OC-000_1], where [V2G-000] is the original requirement number.

If any mandatory parameter specified by ISO 15118-2 is not used for connection communication, a default value is set, "0" for integer type, an empty string "" for string type. In case of other data types, the default value is given at the value definition.

If the usage of an element in the message is specified as "don't care," it is not forbidden to send the information in this element, but this information may not be used by the receiver and the sender cannot expect the receiver to act on the sent information. It is comparable to an optional element, but to state out the difference to the standard "don't care" is used instead and can also be applied to elements that are mandatory in ISO 15118-2.

D.1 NETWORK AND APPLICATION PROTOCOL REQUIREMENTS

These sections of ISO 15118-2 apply or not as noted below:

7. BASIC REQUIREMENTS FOR V2G COMMUNICATION

7.1 General Information

This clause of ISO 15118-2 is applicable.

7.2 Service Primitive Concept of OSI Layered Architecture

This clause of ISO 15118-2 is applicable.

7.3 Security Concept

This clause of ISO 15118-2 is NOT applicable.

Restriction:

In the first version of connection communication standard TLS, certificate-based authentication and contracts are not supported.

Communication takes place via WLAN. The WLAN connection is secured by WPA2.

7.4 V2G Communication States

This clause of ISO 15118-2 is applicable.

7.5 Data Link Layer

This clause of ISO 15118-2 is not applicable. Instead of wired communication connection wireless communication is compliant to IEEE/Std 802.11TM-2012

7.6 Network Layer

This clause of ISO 15118-2 is applicable.

7.7 Transport Layer

This clause of ISO 15118-2 is applicable, except as follows:

Restriction:

Subclause 7.7.3 and its subclauses are not applicable.

7.8 V2G Transfer Protocol

This clause of ISO 15118-2 is applicable.

7.9 Presentation Layer

This clause of ISO 15118-2 is applicable.

7.10 Application Layer

This clause of ISO 15118-2 is applicable.

D.2 APPLICATION AND NETWORK REQUIREMENTS

These sections of ISO 15118-2 apply or not as noted below:

8. APPLICATION LAYER MESSAGES

8.1 General Information and Definitions

This clause of ISO 15118-2 is applicable.

8.2 Protocol Handshake Definition

This clause of ISO 15118-2 is applicable, except as follows:

Original requirement:

[V2G2-166] The EVCC shall initiate the handshake sending a supportedAppProtocolReq message as depicted in Table D1 to the SECC. This request message provides a list of charging protocols supported by the EVCC.

Note: ProtocolNamespace: "urn:sae:j3105:B:2022:MsgDef" protocol supports two additional functionality 1) RFID identification for pairing the correct ISC with the EV. 2) Sequential charging.

Addition:

[V2G2-OC-166_1] If the EVCC does not receive an SDP response from EVSE in 15 seconds, EVCC shall increment the EVCC.numfailedpairings by 1 and try for another WiFi connection.