AUTOMOTIVE INDUSTRY STANDARD

Electric Vehicle Conductive DC Charging System

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UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF ROAD TRANSPORT & HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT & HIGHWAYS)
GOVERNMENT OF INDIA

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Status chart of the standard to be used by the purchaser for updating the record

Sr. No.	Corrigenda.	Amendment	Revision	Date	Remark	Misc.
General remarks :						

INTRODUCTION

The Government of India felt the need for a permanent agency to expedite the publication of standards and development of test facilities in parallel when the work of preparation of standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the standard and commissioning of test facilities. To this end, the erstwhile Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order no. RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CMVR TSC). After approval, The Automotive Research Association of India, (ARAI), Pune, being the secretariat of the AIS Committee, has published this standard. For better dissemination of this information, ARAI may publish this standard on their website.

Under National Electric Mobility Mission Plan (NEMMP) - FAME scheme introduced by Department of Heavy Industry, Govt. of India envisages Faster Adaption and Manufacturing of Electric (EV) and Hybrid Electric Vehicles (HEV) in the country. This will need infrastructure support in terms of AC and DC charging stations.

This standard prescribes the specifications for performance and safety for DC charging Stations for EV and HEV application for Indian conditions.

While preparing this standard considerable assistance has been derived from following regulations.

IEC 61851-1	Electric vehicle conductive charging system - Part 1: General Requirements
IEC 61851-21	Electric vehicle requirements for conductive connection to an AC /DC supply
IEC 61851-23	General requirements for the control communication between a DC EV charging station and an EV.
IEC 61851-24	Requirements for digital communication between DC EV charging station and electric vehicle for control of DC charging

The Panel and the Automotive Industry Standards Committee (AISC) responsible for preparation of this standard are given in Annex-I and Annex-J respectively.

Electric Vehicle Conductive DC Charging System

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1.0 SCOPE

This standard gives the requirements for DC electric vehicle (EV) charging stations, herein also referred to as "DC charger", for conductive connection to the vehicle, with an AC or DC input voltage up to 1000 V AC and up to 1500 V DC (as per IS 12360/IEC 60038). This standard includes information on EV for conductive connection, but limited to the necessary content for describing the power and signaling interface. This part covers DC output voltages up to 1500 V. Typical diagrams and variation of DC charging systems are shown in Annex D. This standard does not cover all safety aspects related to maintenance. This part specifies the DC charging systems A, B and C as defined in Annexes A, B and C. Typical configuration of DC EV charging system is shown in Annex E. This standard provides the general requirements for the control communication between a DC EV charging station and an EV. The requirements for digital communication between DC EV charging station and electric vehicle for control of DC charging are defined in this standard.

This standard also applies to digital communication between a DC EV charging station and an electric road vehicle (EV) for control of DC charging, with an AC or DC input voltage up to 1000 V AC and up to 1500 V DC for the conductive charging procedure. The EV charging mode is external DC.

Annexes F, G, and H give descriptions of digital communications for control of DC charging specific to DC EV charging systems A, B and C as defined in this standard.

2.0 REFERENCES

The following referenced documents in addition to reference documents in clause 2 of AIS-138 (Part 1), Electric vehicle conductive AC charging system are indispensable for the application of this standard.

IEC 61851-1: 2014-03	Electric vehicle conductive charging system – Electric vehicle conductive charging system – Part 23: DC electric vehicle charging station
IEC 60364-5-54:2011	Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors
IEC/TS 60479-1: 2005	Effects of current on human beings and livestock - Part 1: General aspects
IEC 60950-1: 2005	Information technology equipment - Safety - Part 1: General requirements Amendment 1:2009, Amendment 2:2013

IEC 61140	Protection against electric shock – Common aspects for installation and equipment
IEC 61439-1: 2011	Low voltage switchgear and control gear assemblies – Part 1: General rules
IEC 61557-8	Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part8: Insulation monitoring devices for IT systems
IEC 61558-1: 2005	Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests
IEC 61851-1: 2010	Electric vehicle conductive charging system – Part 1: General requirements
IEC 61851-24: 2014	Electric vehicle conductive charging system – Part 24: Digital communication between a DC EV charging station and an electric vehicle for control of DC charging
IEC 62052-11	Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 11: Metering equipment
IEC 62053-21	Electricity metering equipment (AC) – Particular requirements – Part 21: Static meters for active energy (classes 1 and 2)
IEC 62196-3	Plugs, socket-outlets, and vehicle couplers – Conductive charging of electric vehicles – Part 3: Dimensional compatibility and interchangeability requirements for DC and AC / DC pin and tube-type contact vehicle couplers
ISO/IEC 15118-1	Road vehicles – Vehicle to grid communication interface – Part 1: General information and use-case definition
ISO/IEC 15118-2	Road Vehicles – Vehicle to grid communication interface – Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements
ISO/IEC 15118-3	Road Vehicles – Vehicle to grid communication interface – Part 3: Physical layer and data link layer requirements

ISO 11898-1	Rad vehicles – Controller area network (CAN) – Part 1: Data link layer and physical signaling
ISO 11898-1: 2003	Road vehicles – Controller area network (CAN) – Part 1: Data link layer and physical signaling
ISO 11898-2: 2003	Road vehicles – Controller area network (CAN) – Part 2: High-speed medium access unit
DIN SPEC 70121	Electro-mobility – Digital communication between a DC EV charging station and an electric vehicle for control of DC charging in the Combined Charging System

3.0 TERMS AND DEFINITIONS

For the purposes of this document, the terms and definitions given in AIS-138 (Part 1) and IEC 61668-1, as well as the following apply.

Definitions applying to isolating transformers, safety isolating transformers, switch mode power supplies and their construction are included in IEC 61558-1.

3.1 **Basic insulation**

Insulation of hazardous-live-parts which provides basic protection.

3.2 **Cable assembly**

Piece of equipment used to establish the connection between the EV and socket outlet.

NOTE 1 It may be either fixed or be included in the vehicle or the EVSE, or detachable.

NOTE 2 It includes the flexible cable and the connector and/or plug that are required for proper connection.

NOTE 3 See Figure 1 for description of case C. (case C as specified in AIS- 138 Part 1).

NOTE 4 A detachable cable assembly is not considered as a part of the fixed installation.

3.3 **Charger**

Power converter that performs the necessary functions for charging a battery.

3.3.1 **Class I charger**

Charger with basic insulation as provision for basic protection and protective bonding as provision for fault protection.

NOTE Protective bonding consists of connection of all exposed conductive parts to the charger earth terminal.

3.3.2 **Class II charger**

Charger with

- Basic insulation as provision for basic protection, and
- Supplementary insulation as provision for fault protection or in which
- Basic and fault protection are provided by reinforced insulation

3.3.3 **Off-board charger**

Charger connected to the premises wiring of the AC supply network (mains) and designed to operate entirely off the vehicle. In this case, direct current electrical power is delivered to the vehicle.

3.3.3.1 **Dedicated off-board charger**

Off-board charger designed to be used only by a specific type of EV, which may have control charging functions and/or communication.

3.3.4 **On-board charger**

Charger mounted on the vehicle and designed to operate only on the vehicle.

3.4 **Charging**

All functions necessary to condition standard voltage and frequency AC supply current to a regulated voltage/current level to assure proper charging of the EV traction battery and/or supply of energy to the EV traction battery bus, for operating on-board electrical equipment in a controlled manner to assure proper energy transfer.

3.5 **Connection**

Single conductive path.

3.6 **Control pilot**

The control conductor in the cable assembly connecting the in-cable control box or the fixed part of the EVSE and the EV earth through the control circuitry on the vehicle. It may be used to perform several functions.

3.7 **Earth terminal**

Accessible connection point for all exposed conductive parts electrically bound together.

3.8 **Electric vehicle**

EV / Electric road vehicle (ISO)

Any vehicle propelled by an electric motor drawing current from a rechargeable storage battery or from other portable energy storage devices (rechargeable, using energy from a source off the vehicle such as a residential or public electric service), which is manufactured primarily for use on public streets, roads or highways.

3.8.1 **Class I EV**

An EV with basic insulation as provision for basic protection and protective bonding as provision for fault protection.

NOTE- This consists of connection of all exposed conductive parts to the EV earth terminal.

3.8.2 **Class II EV**

EV in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

3.9 **EV supply equipment**

EVSE Conductors, including the phase, neutral and protective earth conductors, the EV couplers, attachment plugs, and all other accessories, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the EV and allowing communication between them if required.

3.9.1 **AC EV charging station**

All equipment for delivering AC current to EVs, installed in an enclosure(s) and with special control functions.

3.9.2 **DC EV charging station**

All equipment for delivering DC current to EVs, installed in an enclosure(s), with special control functions and communication and located off the vehicle.

NOTE: DC charging includes pulse mode charging.

3.9.3 **Exposed conductive part**

Conductive part of equipment, which can be touched and which is not normally live, but which can become live when basic insulation fails.

3.9.4 **Direct contact**

Contact of persons with live parts.

3.9.5 **Indirect contact**

Contact of persons with exposed conductive parts made live by an insulation failure.

3.10 **Live part**

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

3.10.1 **Hazardous live part**

Live part, which under certain conditions, can result in an electric shock.

3.11 **In-cable control box**

A device incorporated in the cable assembly, which performs control functions and safety functions.

NOTE: The in-cable control box is located in a detachable cable assembly or plug that is not part of the fixed installation.

3.12 **Plug and socket-outlet**

Means of enabling the manual connection of a flexible cable to fixed wiring.

NOTE: It consists of two parts: a socket-outlet and a plug.

3.12.1 **Plug**

Part of a plug and socket-outlet integral with or intended to be attached to the flexible cable connected to the socket-outlet.

3.12.2 **Socket-outlet**

Part of a plug and socket-outlet intended to be installed with the fixed wiring.

3.13 **Power indicator**

Resistor value identifying supply rating recognition by the vehicle.

3.14 **Retaining device**

Mechanical arrangement which holds a plug or connector in position when it is in proper engagement, and prevents unintentional withdrawal of the plug or connector.

NOTE: The retaining device can be electrically or mechanically operated.

3.15 **Vehicle coupler**

Means of enabling the manual connection of a flexible cable to an EV for the purpose of charging the traction batteries.

NOTE: It consists of two parts: a vehicle connector and a vehicle inlet.

3.15.1 **Vehicle connector**

Part of a vehicle coupler integral with, or intended to be attached to, the flexible cable connected to the AC supply network (mains).

3.15.2 **Vehicle inlet**

Part of a vehicle coupler incorporated in, or fixed to, the EV or intended to be fixed to it.

3.16 **Function**

Any means, electronic or mechanical, that insure that the conditions related to the safety or the transmission of data required for the mode of operation are respected.

3.17 **Pilot function**

Any means, electronic or mechanical, that insures the conditions related to the safety or the transmission of data required for the mode of operation.

3.18 **Proximity function**

A means, electrical or mechanical, in a coupler to indicate the presence of the vehicle connector to the vehicle.

3.19 **Standardized socket-outlet**

Socket-outlet which meets the requirements of any IEC and/or national standard.

3.20 **Residual current device (RCD)**

Mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions.

NOTE 1: A residual current device can be a combination of various separate elements designed to detect and evaluate the residual current and to make and break current.

3.21 **Pulse mode charging**

Charging of storage batteries using modulated direct current.

3.22 **Standard interface**

Interface that is defined by any of the following standards IEC 60309-1, IEC 60309-2, or IEC 60884-1 and/or national standard having an equivalent scope, and is not fitted with any supplementary pilot or auxiliary contacts.

3.23 **Basic interface**

Interface as defined by the IEC 62196-1 and for which a functional description is given in 8.4.

3.24 **Universal interface**

Interface as defined by the IEC 62196-1 and for which a functional description is given in 8.5.

3.25 **Plug in hybrid electric road vehicle (PHEV)**

Any electrical vehicle that can charge the rechargeable electrical energy storage device from an external electric source and also derives part of its energy from another source.

3.26 **Cord extension set**

Assembly consisting of a flexible cable or cord fitted with both a plug and a connector of a standard interface type.

3.27 **Adaptor**

A portable accessory constructed as an integral unit incorporating both a plug portion and one socket-outlet.

NOTE: The socket-outlet may accept different configurations and ratings.

3.28 **Indoor use**

Equipment designed to be exclusively used in a weather protected location.

3.29 **Outdoor use**

Equipment designed to be allowed to be used in non-weather protected locations.

3.30 **Signal**

Data element that is communicated between a DC EV charging station and an EV using any means other than digital communication.

3.31 **Digital communication**

Digitally encoded information exchanged between a DC EV charging station and an EV, as well as the method by which it is exchanged.

3.32 **Parameter**

Single piece of information relevant to charging control and that is exchanged between a DC EV charging station and an EV using a form of digital communication.

3.33 **DC EV charging system**

System composed of a DC charger, cable assembly and the equipment on EV that is required to fulfil the charging function including digital communication for charging control.

3.34 **Isolated DC EV charging station**

DC EV charging station with DC circuit on output side which is electrically separated by at least basic insulation from AC circuit on power system side.

3.35 **Non-isolated DC EV charging station**

DC EV charging station with DC circuit on output side which is not electrically separated by at least basic insulation from the supply system.

3.36 **Regulated DC EV charging station**

DC EV charging stations that supplies vehicle battery with a charging current or charging voltage in accordance with the request from vehicle.

3.37 **DC charging control function (DCCCF)**

Function embedded in a DC EV charging station which controls DC power output following VCCF direction.

3.38 **Vehicle charging control function (VCCF)**

Function in a vehicle which controls the charging parameters of off-board DC EV charging station.

3.39 **CCC Controlled current charging**

Energy transfer method that the DC EV charging station regulates charging current according to the current value requested by the vehicle.

3.40 **CVC Controlled voltage charging**

Energy transfer method that the DC EV charging station regulates charging voltage according to the voltage value requested by the vehicle.

3.41 **Control circuit**

Circuit for signal and digital communication with vehicle, and for the management of charging control process.

3.42 **Primary circuit**

A circuit that is directly connected to the AC mains supply, and includes the primary windings of transformers, other loading devices and the means of connection to the AC mains supply.

3.43 **Secondary circuit**

Circuit that has no direct connection to a primary circuit and derives its power from a transformer, converter or equivalent isolation device.

3.44 Insulation

All the materials and parts used to insulate conductive elements of a device, or a set of properties which characterize the ability of the insulation to provide its function.

[SOURCE: IEC 60050-151:2001, 151.15.41 and IEC 60050-151:2001, 151.15.42]

3.45 **Isolation**

Function intended to make dead for reasons of safety all or a discrete section of the electrical installation by separating the electrical installation or section from every source of electric energy.

[SOURCE: IEC 60050-826:2004, 826.17.01].

3.46 **Maximum voltage limit**

Upper limit value of charging voltage that is notified by the vehicle to the DC EV charging station, and is used for overvoltage protection of vehicle battery.

3.47 **Protective conductor** (PE)

Conductor provided for purposes of safety, for example protection against electric shock [SOURCE: IEC 60050-195:1998, 195.02.09].

3.48 **Charging state**

Physical status of DC EV charging system.

3.49 **Emergency shutdown**

Shutdown of DC EV charging station that results in the termination of charging, caused by a failure detected by the DC EV charging station or the vehicle.

4.0 GENERAL REQUIREMENTS

The EV shall be connected to the EVSE so that in normal conditions of use, the conductive energy transfer function operates safely.

In general, this principle is achieved by fulfilling the relevant requirements specified in this standard, and compliance is checked by carrying out all relevant tests.

**Periodic compliance of EVSE is to be ensured by authorized agencies.

5.0 RATING OF THE SUPPLY AC VOLTAGE

6.0 GENERAL SYSTEM REQUIREMENT AND INTERFACE

6.1 **General description**

One method for EV charging is to connect the AC supply network (mains) to an on-board charger. An alternative method for charging an EV is to use an off-board charger for delivering direct current. For charging in a short period of time, special charging facilities operating at high power levels could be utilized.

6.2 EV charging mode

EV charging mode of this standard is external DC.

DC charging in this part means the connection of the EV to the supply network utilizing a DC EV charging station (e.g. off-board charger) where the control pilot function extends to the DC EV charging station.

Pluggable DC EV charging stations, which are intended to be connected to the AC supply network (mains) using standard plugs and socket outlets, shall be compatible with residual current device with characteristics of type A. The pluggable DC EV charging station shall be provided with an RCD, and may be equipped with an over current protection device.

Further requirements for pluggable DC EV charging stations are under consideration.

6.3 Types of EV connection

6.3.1 General description

The connection of EVs using cables shall be carried out in case of C connection as specified in AIS-138 Part 1.

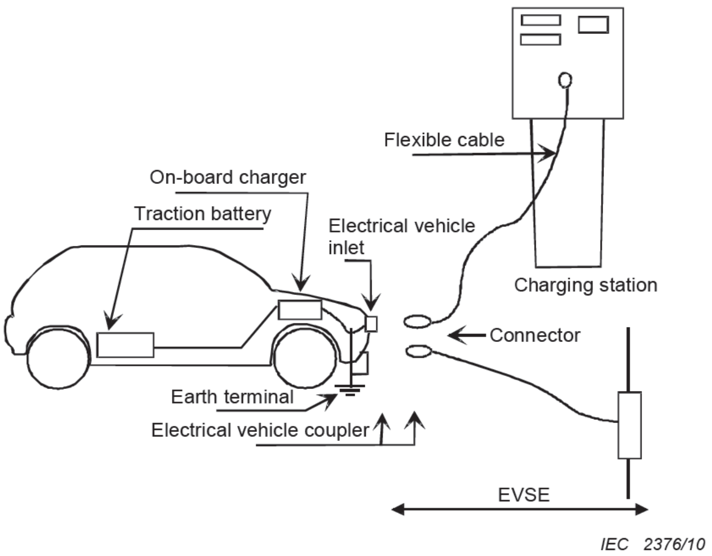


Figure 1 – Case "C" connection (as specified in AIS 138 Part 1)

Connection of an EV to DC supply utilizing supply cable and connector permanently attached to the supply equipment.

6.3.2 Cord extension set

A cord extension set or second cable assembly shall not be used in addition to the cable assembly for the connection of the EV to the EVSE. The vehicle manual shall clearly indicate this. A cable assembly shall be so constructed so that it cannot be used as a cord extension set.

6.3.3 Adaptors

Adaptors shall not be used to connect a vehicle connector to a vehicle inlet.

6.4 Functions provided in DC charging

The DC EV charging station shall supply a DC current or voltage to the vehicle battery in accordance with a VCCF request.

6.4.1 Charging functions

These functions shall be provided by DC charging system as given below:

- Verification that the vehicle is properly connected;
- Protective conductor continuity checking (6.4.3.2);
- Energization of the system (6.4.3.3);
- De-energization of the system (6.4.3.4);
- DC supply for EV (6.4.3.5);
- Measuring current and voltage (6.4.3.6);
- Retaining / releasing coupler (6.4.3.7);
- Locking of the coupler (6.4.3.8);
- Compatibility assessment (6.4.3.9);
- Insulation test before charging (6.4.3.10);
- Protection against overvoltage at the battery (6.4.3.11);
- Verification of vehicle connector voltage (6.4.3.12);
- Control circuit supply integrity (6.4.3.13);
- Short circuit test before charging (6.4.3.14);
- User initiated shutdown (6.4.3.15);
- Overload protection for parallel conductors (conditional function) (6.4.3.16);
- Protection against temporary overvoltage (6.4.3.17).
- Emergency shutdown (6.4.3.18).

6.4.2 Optional functions

These functions, if provided, should be provided by DC charging system as optional as given below:

- Determination of ventilation requirements of the charging area;
- Detection/adjustment of the real time available load current of the supply equipment;
- Selection of charging current;
- Wake up of DC EV charging station by EV (6.4.4.1);
- Indicating means to notify users of locked status of vehicle coupler.

Other additional functions may be provided.

NOTE 1 Un-intentional live disconnect avoidance functions may be incorporated in the latching function interlock system.

NOTE 2 Primary protections against overvoltage and overcurrent of vehicle battery is the responsibility of the vehicle.

6.4.3 Details of functions for DC charging

6.4.3.1 Verification that the vehicle is properly connected

The EVSE shall be able to determine that the connector is properly inserted in the vehicle inlet and properly connected to the EVSE.

Vehicle movement by its own propulsion system shall be impossible as long as the vehicle is physically connected to the EVSE as required in ISO 6469-2.

6.4.3.2 Protective conductor continuity checking

For isolated systems, protective conductor continuity between the DC EV charging station and the vehicle shall be monitored. For the rated voltage of DC 60 V or higher, the DC EV charging station shall perform an emergency shutdown (see 6.4.3.18) within 10 s after a loss of electrical continuity of the protective conductor between DC EV charging station and EV(emergency shutdown).

For non-isolated systems, in case of loss of earthing conductor continuity, the non-isolated DC EV charging station shall be disconnected from AC supply network (mains). Earthing conductor continuity between the DC EV charging station and the vehicle shall be monitored.

For the rated voltage of DC 60 V or higher, the DC EV charging station shall perform an emergency shutdown within 5 s after a loss of electrical continuity of the protective conductor between DC EV charging station and EV.

NOTE: The isolated DC EV charging station can be disconnected from AC mains when PE continuity is lost.

6.4.3.3 Energization of the system

Energization of the system shall not be performed until the pilot function between EVSE and EV has been established correctly.

Energization may also be subject to other conditions being fulfilled.

6.4.3.4 De-energization of the system

If the pilot function is interrupted, the power supply to the cable assembly shall be interrupted but the control circuit may remain energized.

In the case of failure in control circuit of DC EV charging station, such as short-circuit, earth leakage, CPU failure or excess temperature, the DC EV charging station shall terminate the supply of charging current, and disconnect the supply of control circuit. In addition, the conductor, in which earth fault or over current is detected, shall be disconnected from its supply.

Requirement for disconnection of EV is defined in 7.2.3.2.

6.4.3.5 **DC supply for EV**

The DC EV charging station shall supply DC voltage and current to the vehicle battery in accordance with VCCF's controlling.

For regulated systems, the DC EV charging station shall supply regulated DC voltage or current (not simultaneously, but as requested by the vehicle during charging) to the vehicle battery in accordance with VCCF's controlling. Requirements for charging performance of regulated DC current / voltage are given in 12.2.1.1, 12.2.1.2 and 12.2.1.3 and 12.2.1.4.

In either case mentioned above, the maximum ratings of the DC EV charging station shall not be exceeded.

The vehicle can change the requested current and/or requested voltage.

6.4.3.6 **Measuring current and voltage**

The DC EV charging station shall measure the output current and output voltage. The accuracy of output measurement is defined for each system in Annexes A, B and C.

6.4.3.7 **Retaining/releasing coupler**

A means shall be provided to retain and release the vehicle coupler. Such means may be mechanical, electrical interlock, or combination of interlock and latch.

6.4.3.8 **Locking of the coupler**

A vehicle connector used for DC charging shall be locked on a vehicle inlet if the voltage is higher than 60V DC. The vehicle connector shall not be unlocked (if the locking mechanism is engaged) when hazardous voltage is detected through charging process including after the end of charging. In case of charging system malfunction, a means for safe disconnection may be provided.

NOTE: The actuation portion of the locking function can be in either the vehicle connector or the vehicle inlet. It is configuration dependent.

The DC EV charging station shall have the following functions in case the locking is done by the DC EV charging station:

- Electrical or mechanical locking function to retain the locked status, and
- Function to detect the disconnection of the electrical circuits for the locking function.

NOTE 1: The locking function for each system is defined in Annexes A, B and C.

NOTE 2: An example of lock function and disconnection detection circuit is shown in Annex A.

For the tests of mechanical strength, refer to IEC 62196-3.

6.4.3.9 **Compatibility assessment**

Compatibility of EV and DC EV charging station shall be checked with the information exchanged at the initialization phase as specified in 13.5.1.

6.4.3.10 **Insulation test before charging**

The DC EV charging station shall confirm the insulation resistance between its DC output circuit and protective conductor to the vehicle chassis, including the charging station enclosure, before the EV contactors are allowed to close.

If the required value is not met, the DC EV charging station shall send the signal to the vehicle that the charging is not allowed.

Conformance is determined by measuring the insulation resistance as follows:

Any relays in the DC output circuit of the DC EV charging station shall be closed during the test.

The required value of insulation resistance R shall be as shown in Formula (1):

$$R \geq 100\ \Omega/V \times U \quad (1)$$

Where,

U is rated output voltage of the DC EV charging station.

6.4.3.11 **Protection against overvoltage at the battery**

The DC EV charging station shall perform an emergency shutdown and disconnect its supply to prevent overvoltage at the battery, if output voltage exceeds maximum voltage limit sent by the vehicle. In case of vehicle failure, disconnection from AC mains may not be necessary.

Specific requirement for detection and shutdown are defined in Annexes A, B and C.

The vehicle can change the maximum voltage limit during charging process. Compliance is checked according to the following test.

The DC EV charging station is connected to a DC voltage source or artificial load.

The voltage of the DC voltage source or artificial load should be within the operating range of the charging station.

The DC EV charging station is set to charge the DC voltage source at a current of more than 10 % of the maximum rated current of DC EV charging station.

A maximum voltage limit command lower than the voltage of the voltage source shall be sent to the DC EV charging station.

Both the time between when the command is sent and the beginning of charging current reduction and the rate of reduction shall be measured.

The voltage of the voltage source, the way the command voltage limit is sent and the value of the voltage limit can be chosen freely to comply with this test.

NOTE: The selection of charging current can be made by the system or the user.

6.4.3.12 **Verification of vehicle connector voltage**

This clause is only applicable for charging stations which are responsible for locking of vehicle connector, such as system A and system B.

The DC EV charging station shall not energize the charging cable when the vehicle connector is unlocked. The voltage at which the vehicle connector unlocks shall be lower than 60 V.

6.4.3.13 **Control circuit supply integrity**

If an earth fault, short circuit or over current is detected in output circuit of DC EV charging station, the power circuit shall be disconnected from its supply, but the power supply for control circuit shall not be interrupted unless the power circuit interruption is due to a loss of AC supply network (mains).

6.4.3.14 **Short circuit test before charging**

With the EV connected to the DC EV charging station and before the EV contactor is closed, the DC EV charging station shall have a means to check for a short circuit between DC output circuit positive and negative for the cable and vehicle coupler.

Compliance test specifications are defined in Annexes A, B and C

6.4.3.15 **User initiated shutdown**

The DC EV charging station shall have a means to allow the user to shut down the charging process.

6.4.3.16 **Overload protection for parallel conductors (conditional function)**

If more than one conductor or wire and/or vehicle connector contact is used in parallel for DC current supply to the vehicle, the DC EV charging station shall have a mean to ensure, that none of the conductors or wires will be overloaded.

NOTE: For example, the currents on the different paths can be monitored or more than one power source can be used.

6.4.3.17 **Protection against temporary overvoltage**

For stations serving a maximum output voltage up to 500 V, no voltage higher than 550 V shall occur for more than 5 s at the output between DC+ and PE or between DC- and PE.

For stations serving a maximum output voltage above 500 V and up to 1000 V, no voltage higher than 110 % of DC output voltage shall occur for more than 5 s at the output between DC+ and PE or between DC-and PE. See Figure 2.

For voltage above 1000 V: under consideration.

The DC EV charging station shall terminate the supply of charging current and disconnect the DC power circuit from its supply within 5 s, to remove the source of overvoltage (see 5.3.3.2.3 in IEC 60664-1:2007). This shall also apply in case of a first earth fault within the isolated output part of the DC EV charging station.

For Un, as the minimum DC charger output voltage, the DC EV charging station shall limit the voltage between DC+/- and PE at:

(2 Un+ 1 000) × 1,41 V or;

(Un+ 1 200) × 1,41 V, whichever is less.

NOTE: The voltage can be limited by reducing the overvoltage category or by adding a surge protection device with sufficient clamping voltage.

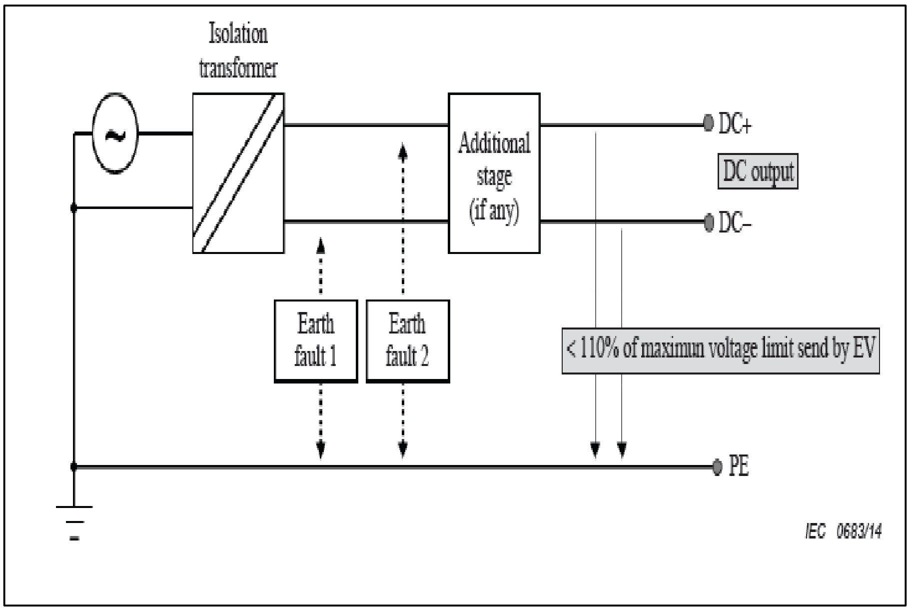


Figure 2
Protection against temporary overvoltage

6.4.3.1 **Emergency shutdown**

When the DC EV charging station detects an abnormality in the station and/or the vehicle, the safety shall be ensured by the emergency shutdown as follows.

Stop charging by:

a) Controlled expedited interruption of charging current or voltage to the vehicle, where DC current descends with a controlled slope, and appropriate signaling to the vehicle, or

b) Uncontrolled abrupt termination of charging under specific fault conditions, where there is no control of current, and the vehicle may not be informed in time.

NOTE: The DC EV charging station can achieve this requirement by exchange of information with the vehicle (see 13.4 and Annex A, B or C).

Under specific conditions, the following disconnection, for example, is required according to the risk assessment of the abnormality in the station or the vehicle:

- Disconnection of the supply to the conductor in which an earth leakage is detected;
- Disconnection of the conductor in which an over current is detected;
- Disconnection of the DC power circuit from the supply if an insulation failure is detected.

General procedure of shutdown in the charging control process is given in 13.5.3.

6.4.4 **Detail of optional function**

6.4.4.1 **Determination of ventilation requirements during charging**

If additional ventilation is required during charging, charging shall only be allowed if such ventilation is provided.

6.4.4.2 **Wake up of DC EV charging station by EV**

The charging station may support a standby mode to minimize power consumption. In this case, the station shall be able to be woken up by the EV.

6.4.4.3 **Detection/adjustment of the real time available load current of EVSE**

Means shall be provided to ensure that the charging rate shall not exceed the real time available load current of the EVSE and its power supply.

6.4.4.4 **Selection of charging rate**

A manual or automatic means shall be provided to ensure that the charging rate does not exceed the rated capacity of the AC supply network (mains), vehicle or battery capabilities.

6.4.5 **Details of pilot function**

For DC charging, control pilot function is mandatory. The control pilot function shall be capable of performing at least the mandatory functions described in 6.4.3.1, 6.4.3.2, 6.4.3.3 and 6.4.3.4, and may also be capable of contributing to optional functions described in 6.4.4.

6.5 **Serial data communication**

Serial data information exchange shall be provided to allow the vehicle to control the off-board charger, except in the case of dedicated off-board chargers.

6.6 **Classification**

DC EV charging stations and systems may be classified as follows.

6.6.1 **Category**

6.6.1.1 **According to system structure**

- Isolated DC EV charging station, according to the type of insulation between input and output:
  a) Basic insulation
  b) Reinforced insulation
  c) Double insulation
- Non-isolated DC EV charging station.

6.6.1.2 **According to system control**

- Regulated DC EV charging station:
  a) controlled current charging
  b) controlled voltage charging
  c) Combination of a) and b)
- Non-regulated DC EV charging station.

6.6.1.3 **According to power receiving**

- DC EV charging station connected to AC mains;
- DC EV charging station connected to DC mains.

6.6.1.4 **According to environmental conditions**

- Outdoor use.
- Indoor use.

NOTE: DC EV charging stations classified for outdoor use can be used for indoor use, provided ventilation requirements are satisfied.

6.6.1.5 **According to the system used**

- System A (see Annex A)
- System B (see Annex B)
- System C (see Annex C)

6.6.2 **Rating**

According to DC output voltage:

- Up to and including 60 V
- Over 60 V up to and including 1500 V

7.0 PROTECTION AGAINST ELECTRIC SHOCK

7.1 **General requirements**

Hazardous live parts shall not be accessible.

Exposed conductive parts shall not become a hazardous live part under normal conditions (operation as intended use and in the absence of a fault), and under single-fault conditions.

Protection against electric shock is provided by the application of appropriate measures for protection both in normal service and in case of a fault.

- For systems or equipment on board the vehicle, the requirements are defined in ISO 6469-3;
- For systems or equipment external to the vehicle, the requirements are defined in Clause 411 of IEC 60364-4-41:2005.

Protection in normal service (Provisions for basic protection), is defined in Annexes A and B of IEC 60364-4-41:2005. Measures for fault protections are defined in Clauses 411, 412 and 413; additional protection is defined in 415 of IEC 60364-4-41:2005.

7.2 **Protection against direct contact**

7.2.1 **General**

Protection against direct contact shall consist of one or more provisions that under normal conditions prevent contact with hazardous-live parts. For systems or equipment's on board the vehicle, the requirements are defined in ISO 6469-3.

Protective bonding shall consist of connection of all exposed conductive parts to the EV earth terminal.

7.2.2 **Accessibility of live parts**

When connected to the supply network, the EVSE shall not have any accessible hazardous live part, even after removal of parts that can be removed without a tool.

Compliance is checked by inspection and according to the requirements of IEC 60529(IPXXB).

NOTE: Extra low voltage (ELV) auxiliary circuits which are galvanically connected to the vehicle body are accessible. Particular attention is drawn to the requirements for ELV circuit isolation when the traction battery is being charged using a non-isolated charger.

7.2.3 **Stored energy – discharge of capacitors**

7.2.3.1 **Disconnection of EV**

One second after having disconnected the EV from the supply, the voltage between accessible conductive parts or any accessible conductive part and protective conductor shall be less than or equal to 60 V DC, and the stored energy available shall be less than 20 J (see IEC 60950-1).

If the voltage is greater than 42.4 V peak (30 V rms) or 60 V DC, or the energy is 20 J or more, a warning label shall be attached in an appropriate position.

EV inlet, when unconnected, is according to ISO 6469-3.

Compliance is checked by inspection and by test.

7.2.3.2 **Disconnection of DC EV charging station**

Conditions for the disconnections of the DC EV charging station from the supply mains are identical to those required for the disconnection of the EV as indicated in 7.2.3.1.

7.3 **Fault protection**

Protection against indirect contact shall consist of one or more recognized provision(s).

According to IEC 60364-4-41:2005 recognized individual provisions for fault protection are:

- Supplementary or reinforced insulation;
- Protective equi-potential bonding;
- Protective screening;
- Automatic disconnection of supply;
- Simple separation.

7.4 **Supplementary measures**

Not applicable except for the mobile DC EV charging station.

To avoid indirect contact in case of failure of the basic and/or fault protection or carelessness by users, additional protection against electric shock shall be required.

An RCD (I<30 mA) shall be provided as a part of the EV conductive supply equipment for earthed systems. The RCD shall have a performance at least equal to Type A and be inconformity with standard IEC 60364-4-41.

NOTE: In some countries, other systems of personnel protection are required.

Where power supply circuits that are galvanically separated from mains and are galvanically isolated from earth, electrical isolation between the isolated circuits and earth, and between the isolated circuits and exposed conductive parts of vehicle and EVSE shall be monitored.

When a fault condition related to the electrical isolation is detected, the power supply circuits shall be automatically de-energized or disconnected by the EVSE.

7.5 **Protective measures for DC EV charging stations**

The types of DC EV charging stations covered by these requirements, including all accessible conductive parts on the equipment shall have the following protective measures as described in IEC 61140.

protective measures by automatic disconnection of supply by connecting all exposed conductive-parts to a protective conductor during battery charging, unless protective measure by reinforced or double insulation or protective measure by electrical separation is used for the DC EV charging stations.

7.5.1 **Requirements of the isolated DC EV charging station**

Requirements for the isolated DC EV charging station for protection against electric shock are defined for each system in A.3.1, B.2 or C.4.1.

In addition, if the DC EV charging station has multiple DC outputs designed for simultaneous operation, each output circuit shall be isolated from each other by basic insulation or reinforced insulation.

NOTE 1: Requirements for multiple simultaneous outputs, which are non-isolated from each other, are under consideration.

For multiple outputs, see IEC 60364-7-722 (To be published).

7.5.2 **Requirements of the non-isolated DC EV charging station**

Reserved

7.5.3 **Protective conductor dimension cross-sectional area**

Protective conductor shall be of sufficient cross-sectional area to satisfy the requirements of IEC 60364-5-54.

7.6 **Additional requirements**

The DC EV charging station shall be compatible with RCD Type A in the installation, i.e. AC supply network (mains).

Class II chargers may have a lead- through protective conductor for earthing the EV chassis.

8.0 CONNECTION BETWEEN THE POWER SUPPLY AND THE EV

8.1 **General**

The physical conductive electrical interface requirements between the vehicle and the DC EV charging station are as defined in IEC 62196-3.

For non-isolated systems: Reserved

8.2 **Contact sequencing**

For all DC interfaces, the contact sequence during the connection process shall be:

- Protective Earth (if any)
- DC power contacts
- Isolation monitor contacts:

NOTE 1: if provided, isolation monitor contacts shall mate before or simultaneously with the control pilot contact.

- Proximity detection or connection switch contact

NOTE 2: if provided, proximity detection or connection switch contacts shall mate before or simultaneously with the control pilot contact.

- Control pilot contact

During disconnection the order shall be reversed.

8.2.1 **Configuration EE and FF combined interface**

A combined interface extends the use of a basic interface for AC and DC charging. DC charging can be achieved by providing additional DC power contacts to supply DC energy to the electric vehicle.

The basic portion of the combined vehicle inlet can be used with a basic connector for AC charging only or a combined vehicle connector for DC charging.

Combined couplers shall only be used for DC charging with the "DC electric vehicle charging station of System C" described in IEC 61851-23:2014, Annex C.

General requirements and ratings for all contacts are given in IEC 62196-1:2014, Table 5.

If the AC or DC ratings of a mating connector and inlet differ, the coupler (mating pair) shall be used at the lower rating of either the vehicle connector or vehicle inlet of the mating accessory. Ratings and requirements for the use of the combined interface with AC are defined in IEC 62196-2:2011.

Electric vehicles with a combined vehicle inlet shall withstand AC voltage at the power contacts of the basic portion.

NOTE. This requirement will be withdrawn when an equivalent update is included in ISO 17409.

Table : Compatibility of mating accessories at vehicle

		Vehicle connector								
		Type 1	Type 2	Type 3	Configuration AA	Configuration BB	Configuration EE	Configuration FF	Universal, high power a.c.	Universal, high power d.c.
Vehicle inlet	Type 1	Yes	-	-	-	-	-	-	-	-
	Type 2	-	Yes	-	-	-	-	-	-	-
	Type 3	-	-	Yes	-	-	-	-	-	-
	Configuration AA	-	-	-	Yes	-	-	-	-	-
	Configuration BB	-	-	-	-	Yes	-	-	-	-
	Configuration EE	Yes	-	-	-	-	Yes	-	-	-
	Configuration FF	-	Yes	-	-	-	-	Yes	-	-
	Universal, high power a.c.	-	-	-	-	-	-	-	Yes	-
	Universal, high power d.c.	-	-	-	-	-	-	-	-	Yes

NOTE 1 For Type 1, Type 2 and Type 3 refer to the corresponding standard sheets in IEC 62196-2:2011.

NOTE 2 For Configurations AA, BB, EE, and FF, refer to the corresponding standards sheets.

NOTE 3 For Universal high power a.c. and Universal high power d.c., refer to IEC 62196-1:2014.

8.3 **Functional description of a universal interface**

The universal vehicle inlet shall be intermateable with either the high power AC connector or the high power DC connector.

The basic vehicle connector may be intermateable with the universal vehicle inlet if the two are designed to prevent mismatching and designed to be fail-safe.

A means shall be used on the vehicle inlet and the vehicle connectors to ensure that the DC power connector cannot be mated with the AC vehicle inlet and vice versa.

9.0 Specific requirements for vehicle coupler

9.1 **General requirements**

The construction and performance requirements of vehicle coupler are specified in IEC 62196-1.

The requirements for the DC interfaces are specified in IEC 62196-3.

9.2 **Operating temperature**

Operating temperature is defined in accordance with IEC 60309-1, IEC 60309-2 and IEC 60884-1 (as examples A1 and B1 in 6.3) or IEC 62196-1 (cases A2 and B2 in 6.3).

9.3 **Service life of vehicle coupler**

The construction and performance requirements of vehicle coupler are specified in IEC 62196-1.

9.4 **Breaking capacity**

For DC charging, the vehicle couplers are rated "not for current interruption." A disconnection shall not take place under load.

In the case of disconnection under DC load due to a fault, no hazardous condition shall occur.

Avoidance of breaking under load can be achieved by a specific means on the vehicle connector or a system with interlock.

In addition to locking mechanism defined in 6.4.3.8, in case of unintended disconnection of the vehicle coupler, the output current of the DC EV charging station shall be turned off within a defined time to contain a possible arc within the vehicle coupler housing. This turn-off time shall comply with the value specified in Annexes A, B and C, using a speed of separation of the vehicle connector of (0.8± 0.1) m/s according to IEC 60309-1.

Disconnection of vehicle coupler can be detected when one of the following occurs:

– Loss of digital communication;

– Interruption of interlock circuit(s), e.g. control pilot, proximity circuit, to mitigate electrical arcing and shock hazards.

The system specific requirement for breaking capacity and system redundancy are defined in Annexes A, B and C.

9.5 **IP degrees**

IP degrees for accessories are treated in 11.3.

9.6 **Insertion and extraction force**

The force required for connecting and disconnecting operations for the connector and inlet is in accordance with 16.15 of IEC 62196-1 (latching device being deactivated).

The force required for connecting and disconnecting operations for the plug and socket is in accordance with 16.15 of IEC 62196-1.

For cases A1 and B1 refer to the relevant standards.

9.7 **Latching of the retaining device**

Latching or retaining if required may be a function of the complete system or the connector.

10.0 Charging cable assembly requirements

10.1 **Electrical rating**

The rated voltage and current of each conductor shall correspond to the rated voltage and current of the DC output of the DC EV charging station.

10.2 Electrical characteristics

The voltage and current ratings of the cable shall be compatible with those of the charger.

The cable may be fitted with an earth-connected metal shielding. The cable insulation shall be wear resistant and maintain flexibility over the full temperature range.

NOTE 1 : IEC 60245-6 cable has been proposed as an adequate standard that defines cable properties.

10.3 Dielectric withstand characteristics

Dielectric withstand characteristics shall be as indicated for the EVSE in 11.4.

10.4 Mechanical characteristics

The mechanical characteristics of the cable should be equivalent or superior to those of IEC 60245-6 cable, as well as for fire resistance, chemical withstand, UV resistance.

The anchorage force of the cable in the connector or plug shall be greater than the retaining device force, if used.

10.5 Functional characteristics

The maximum cord length may be specified by some national codes.

11.0 EVSE REQUIREMENTS

11.1 General test requirements

- All tests in this standard are type tests.
- Unless otherwise specified, type tests shall be carried out on a single specimen as delivered and configured in accordance with the manufacturer's instructions.
- The tests in 11.12 may be conducted on separate samples at the discretion of the manufacturer. Unless otherwise specified, all other tests shall be carried out in the order of the clauses and sub clauses in this part.
- The tests shall be carried out with the specimen, or any movable part of it, placed in the most unfavorable position which may occur in normal use.
- Unless otherwise specified, the tests shall be carried out in a draught-free location and at an ambient temperature of 20 °C ±5 °C.
- The characteristics of the test voltages in 11.4 shall comply with IEC 61180-1.

Additional specific requirements for the:

- AC charging station (EVSE) are specified in IEC 61851-22,
- DC charging stations (EVSE) are specified in IEC 61851-23.

NOTE: Standard Interface requirements are covered in their appropriate standards as defined in 9.1. National codes and regulations should be taken into account.

11.2 **Classification**

EVSE shall be classified according to exposure to environmental conditions:

- Outdoor use
- Indoor use.

NOTE: EVSEs classified for outdoor use can be used for indoor use, provided ventilation requirements are satisfied.

11.3 **IP degrees for basic and universal interfaces**

11.3.1 **IP degrees for ingress of objects**

Compliance is checked by test in accordance with IEC 60529.

The minimum IP degrees for ingress of object and liquids shall be:

Indoor use:

- Vehicle inlet mated with connector: IP21,
- Plug mated with socket outlet: IP21,
- Connector for case C when not mated, indoor: IP21.

Outdoor use:

- Vehicle inlet mated with connector: IP44,
- Plug mated with socket outlet: IP44.

All cable assemblies shall meet outdoor requirements.

- EV inlet in "road" position: IP55.
- Connector when not mated: IP24,
- Socket-outlet when not mated: IP24.

NOTE 1: IPX4 may be obtained by the combination of the socket-outlet or connector and the lid or cap, EVSE enclosure, or EV enclosure.

NOTE 2: EV inlet protection may be obtained by the combination of the inlet and vehicle design.

11.3.2 **Protection against electric shock**

- Vehicle inlet mated with connector: IPXXD;
- Plug mated with socket outlet: IPXXD;
- Connector intended for mode 1 use, not mated: IPXXD (1);
- Connector intended for mode 2 and mode 3 use, not mated:

IPXXB:

- Socket-outlet not mated: IPXXD (2).

Energy transfer from vehicle to grid:

- Vehicle inlet not mated: IPXXD (3);
- Plug not mated: IPXXD (3).

Compliance is checked with the accessory in the installed position.

Equivalent protection to IPXXD may also be obtained with IPXXB accessories if an isolating function is used according to IEC 60364-5-53.

Equivalent protection to IPXXD may also be obtained with IPXXB accessories if an isolating function is used on the vehicle according to requirements described in 7.2.3.1 and 7.10.1 of ISO 6469-3.

11.4 **Dielectric withstand characteristics**

11.4.1 **Dielectric withstand voltage**

The dielectric withstand voltage at power frequency (50 Hz or 60 Hz) shall be applied for

1 min as follows:

a) For class I chargers

Un + 1200 V r.m.s. in common mode (all circuits in relation to the exposed conductive parts) and differential mode (between each electrically independent circuit and all other exposed conductive parts or circuits) as specified in 5.3.3.2.3 of IEC 60664-1.

NOTE: Un is the nominal line to neutral voltage of the neutral-earthed supply system.

b) For class II chargers

2 x (Un+1200 V) r.m.s. in common mode (all circuits in relation to the exposed conductive parts) and differential mode (between each electrically independent circuit and all other

Exposed conductive parts or circuits) as specified in 5.3.3.2.3 of IEC 60664-1.

For both class 1 and class 2 AC supply equipment, if the insulation between the mains and the extra low voltage circuit is double or reinforced insulation, 2 ´ (Un+1200 V) r.m.s. shall be applied to the insulation.

Equivalent values of the DC voltage can be used instead of the AC peak values.

For this test, all the electrical equipment shall be connected, except those items of apparatus which, according to the relevant specifications, are designed for a lower test voltage; current consuming apparatus (e.g. windings, measuring instruments, voltage surge suppression devices) in which the application of the test voltage would cause the flow of a current, shall be disconnected. Such apparatus shall be disconnected at one of their terminals unless they are not designed to withstand the full test voltage, in which case all terminals may be disconnected.

For test voltage tolerances and the selection of test equipment, see IEC 61180-1.

11.4.2 **Impulse dielectric withstand (1.2/50 µs)**

The dielectric withstand of the power circuits at impulse shall be checked using values as indicated in Table F.1 of IEC 60664-1:2007, category III for fixed DC EV charging stations and category II for detachable DC EV charging stations. Lower overvoltage category can apply if appropriate overvoltage reduction specified in IEC 60664-1 is provided.

The test shall be carried out in accordance with the requirements of IEC 61180-1.

11.5 **Suppression of overvoltage category**

The isolated DC EV charging station shall reduce overvoltage to the EV to the rated impulse voltage of 2500 V.

Primary circuit of DC charging station in outdoor is overvoltage category (OVC) III according to Part 1.

NOTE: The overvoltage reduction can be achieved by combination of one or more attenuation means in accordance with 4.3.3.6 of IEC 60664-1:2007.

11.6 **Insulation resistance**

The insulation resistance with a 500 V DC voltage applied between all inputs/outputs connected together (power source included) and the accessible parts shall be:

- for a class I station: R > 1 MW;
- for a class II station: R > 7 MW.

The measurement of insulation resistance shall be carried out after applying the test voltage during 1 min and immediately after the damp heat test.

Insulation resistance according to 11.6 does not include components bridging insulation according to 1.5.6 and 1.5.7 of IEC 60950-1:2005, Amendment 1:2009, Amendment 2:2013.

NOTE: The test is made without an insulation monitoring system.

11.7 **Clearances and creepage distances**

Clearance and creepage distances shall be in accordance with IEC 60664-1.

The minimum pollution degrees shall be as specified below:

- Outdoor use: pollution degree 3,
- Indoor use: pollution degree 2, except industrial areas: pollution degree 3.

The pollution degree of the micro environment for the DC EV charging station may be influenced by installation in an enclosure.

NOTE: The macro environment for indoor use only is assumed to be a pollution degree of at least 2 for mild conditions.

11.8 Leakage-touch-current

This sub-clause defines the measurement of current through networks simulating the impedance of the human body (touch current).

11.8.1 Touch-current limit

The touch current between any AC supply network poles and the accessible metal parts connected with each other and with a metal foil covering insulated external parts shall not exceed the values indicated in Table 2 of Part 1.

The test shall be made when the DC electric vehicle charging station is functioning with a resistive load at rated output power.

For Class I DC EV charging station, 11.8.6 is applicable, if the test touch current exceeds 3.5 mA.

Circuitry which is connected through a fixed resistance or referenced to protective conductor (for example, EV connection check) should be disconnected before this test.

11.8.2 Test configuration

Test configurations for measurement of leakage current are given in 5.4.1 of IEC 60990:1999.

11.8.3 Application of measuring network

The measuring network is defined in Figure 3. In Figure 3, terminal B of the measuring network is connected to the earthed (neutral) conductor of the supply. Terminal A of the measuring network is connected to each conductive or unearthed accessible surface in turn.

All accessible conductive or unearthed surfaces are to be tested for touch currents. The measuring network of Figure 3 is from Figure 4 of IEC 60990:1999.

For an accessible non-conductive part, the test is made to metal foil having dimensions of 100 mm by 200 mm in contact with the part.

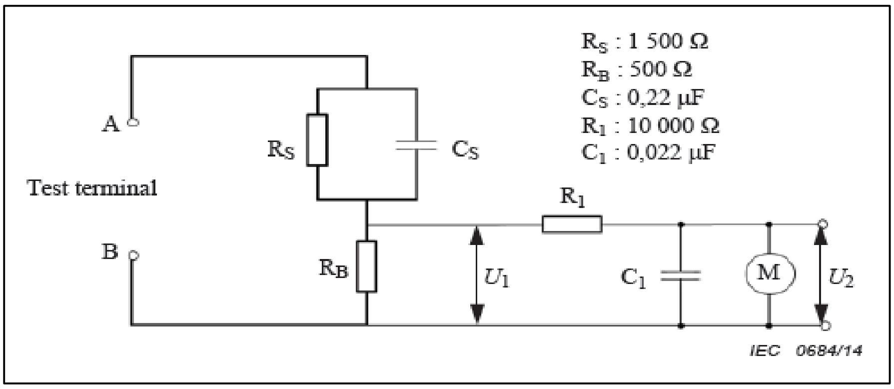


Figure 3
Measuring network of touch current weighted for perception or reaction

11.8.4 **Test condition**

The touch current shall be measured after the damp heat test, with the DC EV charging station connected to AC supply network (mains) in accordance with Clause 6 of IEC 60990:1999. The supply voltage shall be 1.1 times the nominal rated voltage. Measurements shall be made with each of the applicable fault conditions specified in 6.2.2 of IEC 60990:1999.

11.8.5 **Test measurements**

The r.m.s. value of the voltage, U2, shall be measured using the measuring instrument M in Figure 3. Formula (2) shall be used to calculate the touch current:

TOUCH CURRENT b(A) = U2 / 500 (2)

None of the values measured in accordance with 11.8.4 shall exceed the relevant limits specified in 11.8.1.

11.8.6 **Protection measures for the touch current exceeding 3.5 mA**

For Class I DC EV charging station, if the test touch current exceeds 3.5 mA r.m.s, any of the following requirements shall be met. The touch current shall be measured under the fault condition with earthing conductor closed.

a) The protective conductor shall have a cross-sectional area of at least 10 mm2 Cu or16 mm2 Al, through its total run.

b) Where the protective conductor has a cross-sectional area of less than 10 mm^2 Cu or 16 mm^2 Al, a second protective conductor of at least the same cross-sectional area shall be provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm^2 Cu or 16 mm^2 Al.

NOTE: This can require that the DC EV charging station has a separate terminal for a second protective conductor.

c) Automatic disconnection of the supply in case of loss of continuity of the protective conductor.

A caution symbol shall be placed on the outside of the DC EV charging station, visible to the user.

The minimum size of the protective earthing conductor shall comply with the local safety regulations, and shall be indicated in the installation manual.

11.9 Climatic environmental tests

11.9.1 **General**

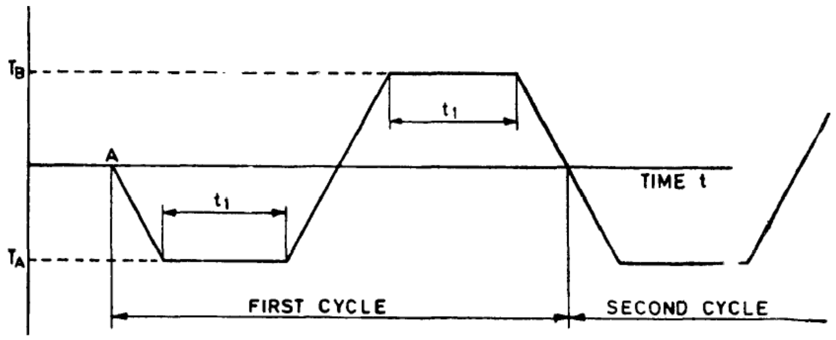
During the following tests, the EVSE - DC shall function at its nominal voltage with maximum output power and current. After each test, the original requirements shall still be met.

11.9.2 **Ambient air temperature**

The EVSE - DC shall be designed to operate within the temperature range 0 °C to +55 °C.

These tests shall be carried out in accordance with the Nb test (change of temperature with specified rate of change) of IEC 60068-2-14/ IS 9000 (Part 14) - sec 2.

Test Cycle



Test Parameters

Parameter	**Value**	**Unit**
Low temp T_A	0	°C
High temp T_B	+55	°C
Rate of Temp (Max)	1	°C/min
Time t1	1	h
No of cycles	2	--

EVSE Condition

Power ON with output loading for maximum power and current.

EVSE Monitoring

Periodic measurements of output power and current during the test.

Compliance/ Acceptance Criteria

- Output power and current values to be within specified band
- Safety checks
  - To ensure protection against short circuit.
  - To check the insulation resistance.

11.9.3 **Dry heat**

The test shall be in accordance with IEC 60068-2-2 Bc or Bd test (dry heat)/ IS 9000 (Part 3) - sec 5.

Test Parameters

Parameter	Value	Unit
Temperature	55	°C
Relative humidity	<50	%
Rate of Temp (Max)	1	°C/min
Duration	16	h

EVSE Condition

Power ON with output loading for maximum power and current.

EVSE Monitoring

Periodic measurements of output power and current during the test.

Compliance/ Acceptance Criteria

- Output power and current values to be within specified band.
- Safety checks.
  - To ensure protection against short circuit.
  - To check the insulation resistance.

11.9.4 **Ambient humidity**

The EVSE -DC shall be designed to operate with a relative humidity rate between 5 % and 95 %.

Damp heat cycle test

The test shall be carried out in accordance with IEC 60068-2-30/ IS 9000(Part 5 /Sec 2), test Db, at 55°c for six cycles.

Test Parameters

Parameter	Value	Unit
Temperature	55	°C
Relative humidity	95	%
Rate of Temp (Max)	1	°C/min
Duration	12 + 12	hours
No of cycles	6	

EVSE Condition

Power ON with output loading for maximum power and current.

EVSE Monitoring

Periodic measurements of output power and current during the test.

Compliance/ Acceptance Criteria

- Immediately after damp heat within 1 min, Insulation Resistance test to be performed.
- Output power and current values to be within specified band.

Safety checks to ensure protection against short circuit.

11.9.5 **Cold test**

The test shall be carried out in accordance with IEC 60068-2-1 test Ab/ IS 9000(Part 2) - sec 3.

Test Parameters

Parameter	Value	Unit
Temperature	0	°C
Rate of Temp (Max)	1	°C/min
Duration	16	hours

EVSE Condition

Power ON with output loading for maximum power and current.

EVSE Monitoring

Periodic measurements of output power and current during the test.

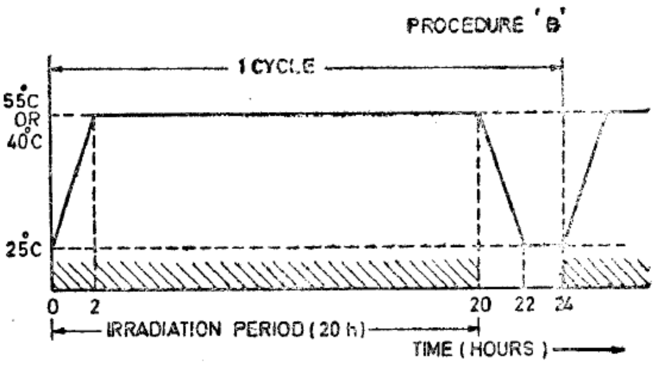
Compliance/ Acceptance Criteria

- Output power and current values to be within specified band.
- Safety checks
  - To ensure protection against short circuit.
  - To check the insulation resistance.

11.9.6 **Solar radiation**

The test shall be carried out in accordance with IEC 60068-2-5, test Sa, procedure B/ IS 9000(Part 17) procedure B.

Test Cycle



Test Parameters

Parameter	Value	Unit
Temperature low	25	°C
Temperature high	55	°C
Irradiation Duration	20	hours
Darkness duration	4	hours
No of cycles	10	

EVSE Condition

Power ON with output loading for maximum power and current.

EVSE Monitoring

Measurements of output power and current during the test at extreme pressure conditions.

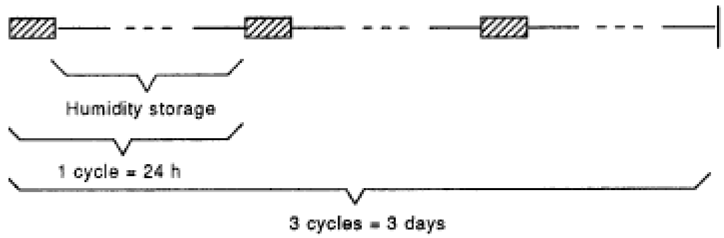
Compliance/ Acceptance Criteria

- Output power and current values to be within specified band.
- Safety checks.
  - To ensure protection against short circuit.
  - To check the insulation resistance.

11.9.7 **Saline mist**

The tests shall be carried out in accordance with IEC 60068-2-52, Kb test-severity.

Test Cycle



Test Parameters

Parameter	Value	Unit
Salt mist chamber temp.	15 - 35	°C
Spray Duration	2	h
Humidity chamber temp.	40 +/- 2	°C
Humidity	93	%
Humidity storage period	20 - 22	h
No of cycles	3	

EVSE Condition

Power ON with output loading for maximum power and current.

EVSE Monitoring

Measurements of output power and current during the test at extreme pressure conditions.

Compliance/ Acceptance Criteria

- Insulation Resistance test to be performed immediately within 1 min after damp heat.
- Output power and current values to be within specified band.
- Safety checks to ensure protection against short circuit.

11.10 **Permissible surface temperature**

The maximum permissible surface temperature of the EVSE that is hand-grasped for lifting, carrying and holding for the means of operation, at the maximum rated current and at ambient temperature of 40 °C, shall be:

- 50 °C for metal parts;
- 60 °C for non-metallic parts.

For parts which may be touched but not grasped, maximum permissible surface temperature under the same conditions shall be:

- 60 °C for metal parts;
- 85 °C for non-metallic parts.

11.11 **Environmental conditions**

The EVSE shall be designed to resist the effect of normal automotive solvents and fluids, vibration and shock, material flammability standards and other conditions appropriate to the application.

11.12 **Mechanical Environmental tests**

11.12.1 **General**

After the following tests, no degradation of performance is permitted.

Compliance is checked by verification after the test that

1) The IP degree is not affected;
2) The operation of the doors and locking points is not impaired;
3) The electrical clearances have remained satisfactory for the duration of the tests, and
4) For a charging station having a metallic enclosure, no contact between live parts and the enclosure has occurred, caused by permanent or temporary distortion.

For a charging station having an enclosure of insulating material, if the conditions above are satisfied, then damage such as small dents or small degrees of surface cracking or flaking are disregarded, provided that there are no associated cracks detrimental to the serviceability of the charging station.

11.12.2 **Mechanical impact**

The EVSE – DC body shall not be damaged by mechanical impact.

Compliance is checked according to the test procedure described in IEC 60068-2-75 (severity) / IS 9000(Part 7/Sec 7) - impact energy value 20 J (5 kg at 0.4 m).

11.12.3 **Stability**

The EVSE - DC shall be installed as intended by the manufacturer's installation instructions. A force of 500 N shall be applied for 5 min in the horizontal direction to the top of the EVSE - DC in each of the four directions or in the worst possible horizontal direction. There shall be neither deterioration of the Electric vehicle charging neither station nor deformation at its summit greater than

50 mm during the load application;

10 mm alter the load application

11.12.4 **IP TESTING**

The testing shall be carried out in accordance with IS/IEC 60529

Atmospheric conditions for water or dust tests

Parameter	Value	Unit	Reference
Temperature	15 to 35	°C	As given in the test standard
Relative humidity	25 to 75	%	
Air pressure	86 to 106	kPa	

For EVSE-DC IP for Outdoor applications: IP 54

Test means and main test conditions for the tests for protection against dust.

Dust chamber (Test device to verify protection against dust): As per test standard.

Talcum powder: As per test standard.

Category 2 Enclosures: Enclosures where no pressure difference relative to the surrounding air is present.

The enclosure under test is supported in its normal operating position inside the test chamber, but not connected to a vacuum pump. Any drain-hole normally open shall be left open for the duration of the test.

Duration of Test: 8 h.

Acceptance: The protection is satisfactory if, on inspection, talcum powder has not accumulated in a quantity or location such that has with any other kind of dust; it could interfere with the correct operation of the equipment or impair safety.

Test means and main test conditions for the tests for protection against water

Test Means	Water flow	Duration	Test conditions
Oscillating tube, as per test std., Spray ± 180 deg from vertical distance, max. 200 mm vertical or Spray nozzle, as per std. Spray ± 180 deg from vertical	0,07 l/min +/- 5 % multiplied by number of holes 10 I/min ± 5 %	10 min 1 min/m^2 at least 5 min	As per test standard As per test standard

For EVSE –DC IP for Indoor applications: IP 23

Test means and main test conditions for the tests for protection against dust.

Test means: The object probe (rigid sphere without handle or guard with 12.5 mm diameter) is pushed against any openings of the enclosure with the force 30 N ± 10 %.

Duration of Test: 8 h.

Acceptance: The protection is satisfactory if, the full diameter of the object probe does not pass through any opening.

Test means and main test conditions for the tests for protection against water.

Test Means	Water flow	Duration	Test conditions
Oscillating tube, as per test std., Spray ± 60 deg from vertical distance, max. 200 mm vertical or Spray nozzle, as per std. Spray ± 60 deg from vertical	0.07 l/min ± 5 % multiplied by number of holes 10 I/min ± 5 %	10 min 1 min/m^2 at least 5 min	As per test standard As per test standard

11.12.5 Electromagnetic environmental tests.

11.12.5.1 **Immunity to EM disturbances**

General

The electric vehicle charging station shall not become dangerous or unsafe as a result of the application of the tests defined in this standard.

A functional description and a definition of performance criteria during, or as a consequence of, the EMC testing shall be provided by the manufacturer and noted in the test report based on the following criteria.

Performance criterion A: The apparatus shall continue to operate as intended. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the apparatus is used as intended. In some cases, the performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer then either of these may be derived from the product description and documentation (including leaflets and advertising) and what the user may reasonably expect from the apparatus if used as intended.

Performance criterion B: The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the apparatus is used as intended. In some cases, the performance level may be replaced by a permissible loss of performance. During the test, however, degradation of performance is allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer then either of these may be derived from the product description and documentation (including leaflets and advertising) and what the user may reasonably expect from the apparatus if used as intended.

Performance criterion C: Temporary loss of function is allowed, provided the loss of function can be restored by operation of the controls.

In any case, safety functions and metering shall be maintained (level A).

11.12.5.2 Immunity to electrostatic discharges

The EVSE – DC shall withstand electrostatic discharges.

Minimal requirement (IEC 61000-4-2) / IS 14700 (Part 4/See 2): 8 kV (in air discharge) or 4 kV (contact discharge).

Performance criterion: B.

Compliance is checked according to IEC 61000-4-2/ IS 14700 (Part 4/See 2). In the standard, the contact discharge method is mandatory. Tests shall be carried out with the EVSE - DC connected to a resistive load at its rated output power.

Immunity to low-frequency conducted disturbances

Tests shall be carried out with the EVSE - DC connected to a resistive load at its rated output power.

a) Supply voltage harmonics

The EVSE – DC, powered by the AC supply network (mains), shall withstand the voltage harmonics of the main supply, in the frequency range 50 Hz - 2 kHz, generally caused by other non-linear loads connected to the AC supply network.

Minimum requirement: compatibility levels of IEC 61000-2-2 multiplied by a factor of 1.7.

Performance criteria: A for charging functions.

Compliance is checked by simulating the above conditions (IEC 61000-4-1/ IS 14700 (Part 4/sec1)).

b) Supply voltage dips and interruptions

The EVSE - DC, powered by the AC supply network (mains), shall withstand the voltage dips and interruptions of the AC supply, generally caused by faults on the AC supply network.

Minimum requirement: voltage reduction of 30 % of nominal voltage for 10 ms.

Performance criterion: B for charging functions.

Minimum requirement: voltage reduction of 50% for 100 ms.

Performance criterion: B for charging functions.

Minimum requirement: voltage reduction >95% for 5 s.

Performance criterion: B for charging functions.

Compliance is checked by simulating the above conditions (see IEC 61000-4-11/ IS 14700 (Part 4/ sec 11)).

c) Immunity to voltage unbalance

The EVSE - DC, powered by a three-phase AC supply (mains), shall withstand voltage unbalance of the AC supply.

Minimum requirement: under consideration.

Performance criteria: under consideration.

d) DC component

The EVSE - DC, powered by the AC supply network (mains), shall withstand the DC components, generally caused by asymmetrical loads.

Minimal requirement: under consideration.

Performance criteria: under consideration.

Immunity to high-frequency conducted disturbances

Tests shall be carried out with the EVSE – DC connected to a resistive load at its rated output power.

a) Fast transient bursts

The EVSE - DC, powered by the AC supply network (mains), shall withstand common-mode conducted disturbances to levels given in IEC 61000-4-4/ IS 14700 (Part 4/Set 4), generally caused by the switching of small inductive loads, relay contacts bouncing, or switching of high-voltage switchgear.

Minimal requirement (IEC 61000-4-4/ IS 14700 (Part 4/Set 4): 2 kV, for a time greater than 1 min and a repetition rate of the impulses of 5 kHz.

Performance criterion: B for charging functions.

Compliance is checked by tests according to IEC 61000-4-4/ IS 14700 (Part 4/Set 4).

The tests shall be made on all power cables and on 1/0 signal and control cables, if any, normally connected to EVSE - DC during the charge. For 1/0 signal and control cables the voltage level is divided by two.

b) Voltage surges

The EVSE - DC, powered by the AC supply network (mains), shall withstand the voltage surges, generally caused by switching phenomena in the power AC supply network, faults or lightning strokes (indirect strokes).

Minimal requirement: 1, 2/50 uS surges, 2 kV in common mode, 1 kV in differential mode.

Performance criteria: C for charging functions.

Compliance is checked by tests according to IEC 61000-4-5.

The tests shall be made on all power cables. Tests shall be carried out with the EVSE - DC connected to a resistive load at rated output power.

Immunity to radiated electromagnetic disturbances

The EVSE - DC shall withstand radiated electromagnetic disturbances.

Minimal requirement (IEC 61000-4-3): 3 V/m in the frequency range 80 MHz to 1000 MHz.

Performance criterion: A.

Minimal requirement (IEC 61000-4-3): 10 V/m in the frequency range 80 MHz to 1000 MHz.

Performance criterion: B.

Compliance is checked by tests according to IEC 61000-4-3.

Tests shall be carried out with the EVSE - DC connected to a resistive load at rated output power.

11.12.5.3 **Emitted EM disturbances**

Low-frequency conducted disturbances

Input current distortion of the EVSE – DC shall not be excessive.

The harmonic limits for the input current of the EVSE - DC, with no load connected, shall be in accordance with IEC 61000-3-2.

Compliance is checked according to IEC 61000-3-2.

High frequency conducted disturbances

a) AC input terminal

Conducted disturbances emitted at the input of the EVSE - DC, with a resistive load at its rated output power, shall be less than the amplitude of the level defined in Table 1.

Table 1 :
Limit levels of conducted Interference AC supply Network

Frequency Range (MHz)	Limits dB (uV)	
	Quasi –Peak	Average
0,15 to 0,50	66 to 56	56 to 46
0,50 to 5	56	46
5 to 30	60	50

Compliance is checked according to CISPR 22.

b) Signal I/0 and control terminals

Conducted disturbances emitted at signal I/0 and control terminals, if any, shall be less than the amplitude of the level defined in Table 2, using a quasi-peak detector.

Table 2 :
Conducted Interference signal I/O and control

Frequency Range (MHz)	Limits dB (uV)	
	Quasi –Peak	Average
0,15 to 0,50	40 to 30	30 to 20
0,5 to 30	30	20

NOTE 1 - The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.

Compliance is checked according to CISPR 22.

Radiated electromagnetic disturbances

a) Magnetic field (150 kHz- 30 MHz)
Under consideration.

b) Electrical field (30 MHz- 1000 MHz)

Radiated disturbances by the EVSE-DC at 10 m, operating with a resistive load at its rated output power, shall not exceed the limits given in Table 3, using a quasi-peak detector.

Table 3 :
Limit Levels of radiated emissions – enclosure at a measuring distance of 10m

Frequency range (MHz)	Radiated Interference (dBuV/m)
30 to 230	30
230 to 1000	37

NOTE 1 - The lower limit shall apply at the transition frequency.

NOTE 2 -Additional provisions may be required for cases where interference occurs.

Compliance is checked according to CISPR 22.

11. 13 **Electromagnetic compatibility tests**

The EMC requirements for DC EV charging stations are defined in IEC 61851-21-2.2.

11.13.1 **Metering**

If electric metering is provided, it shall comply with IEC 62052-11 and IEC 62053-21.

NOTE 1 National regulation for electric metering may be applied.

NOTE 2 Usage can be determined by other means e.g. measurement of time period used for charging.

11.14 **Latching of the retaining device**

An interlock may rely on the retaining device to avoid disconnection under load if this function is not provided by the connector.

11.15 **Service**

The socket-outlet should be designed so that a certified technician could remove, service and replace it if is necessary.

11.16 **Marking and instructions**

11.16.1 **Connection instructions**

Instructions for the connection of the electric vehicle to the EVSE - DC shall be provided with the vehicle, with the user's manual and on the EVSE – DC.

11.16.2 **Legibility**

The markings required by this standard shall be legible with corrected vision, durable and visible during use.

Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

After all the tests of this standard, the marking shall be easily legible; it shall not be easily possible to remove marking plates and they shall show no curling.

11.16.3 **Marking of EVSE - DC**

The station shall bear the following markings in a clear manner:

- Name or initials of manufacturer;
- Equipment reference;
- Serial number;
- Date of manufacture; rated voltage in V; rated frequency in Hz; rated current in A; number of phases;
- IP degrees;
- "Indoor Use Only", *or* the equivalent, if intended for indoor use only;
- Class of EV depending on Load Capacity

For a Class II station, the symbol shall clearly appear in the markings;

Some minimal additional information can possibly appear on the station itself (phone number, address of contractor).

Compliance is checked by inspection and tests.

11.17 **Telecommunication network**

Tests on any telecommunication network or telecommunication port on the EVSE, if present, shall comply with IEC 60950-1.

12 SPECIFIC REQUIREMENTS FOR DC EV CHARGING STATION

12.1 **General**

12.1.1 Emergency switching

An emergency disconnection device may be installed to isolate the AC supply network (mains) from the DC electric vehicle charging station in case of risk of electric shock, fire or explosion.

The disconnection device may be provided with a means to prevent accidental operation.

12.1.2 **IP degrees for ingress of objects**

The minimum IP degrees shall be as specified below:

– Indoor : IP21,

– Outdoor : IP44.

Compliance is checked with the accessory such as cable assembly and vehicle connector in the installed position.

NOTE For the DC EV charging station of stationary type, the test conditions can be defined in accordance with installation conditions.

12.1.3 **Storage means of the cable assembly and vehicle connector**

For DC EV charging stations, a storage means shall be provided for the cable assembly and vehicle connector when not in use.

The storage means provided for the vehicle connector shall be located at a height between 0.4 m and 1.5 m above ground level.

12.1.4 **Stability**

The DC electric vehicle charging station shall be installed as intended by the manufacturer's installation instructions. A force of 500 N shall be applied for 5 min in the horizontal direction to the top of the DC electric vehicle charging station in each of the four directions or in the worst possible horizontal direction. There shall be neither deterioration of the DC electric vehicle charging station nor deformation at its summit greater than:

– 50 mm during the load application;

– 10 mm after the load application.

12.1.5 **Protection against uncontrolled reverse power flow from vehicle**

The DC EV charging station shall be equipped with a protective device against the uncontrolled reverse power flow from vehicle. Uncontrolled power flow does not include instantaneous reverse power flow, which may occur with closing of contactors within the tolerances and duration specified in Annexes A, B and C.

12.2 **Specific requirements for isolated systems**

12.2.1 DC output

12.2.1.1 Rated outputs and maximum output power

The DC EV charging station may limit its maximum current under the given condition independent of the rated and demanded power. The DC EV charging station shall be able to deliver DC power in the voltage range [V_{min},V_{max}] and the regulated current range [I_{min}, I_{max}] within the limit of its maximum rated power[P_{max}] at the ambient temperature –5 °C to 40 °C below 1000 m above sea level. The DC EV charging station shall not exceed its maximum rated power, even if the maximum power requested by the EV is beyond the rated maximum power of DC charger. Outside this operating range the DC charger is allowed to de-rate the power or the current.

NOTE National or industrial codes and regulations may require different operating temperature ranges.

12.2.1.2 Output voltage and current tolerance

12.2.1.2.1 Output current regulation in CCC

The tolerance between the output current of the DC EV charging station compared to the required value sent by the electric vehicle shall be ± 2,5 A for the requirement below 50 A and ± 5 % of the required value for 50 A or more.

12.2.1.2.2 Output voltage regulation in CVC

The tolerance between the output voltages of the DC EV charging station compared to the required value sent by the electric vehicle in steady state operation shall not be greater than2 % for the maximum rated voltage of the DC EV charging station.

12.2.1.3 **Control delay of charging current in CCC**

The DC EV charging station shall control the output current within 1 s after the request from vehicle, with a current control accuracy specified in 12.2.1.2.1, and with a changing rate dI_{min} of 20 A/s or more.

If the vehicle requests a target current I_N, which shows deviation lower than or equal to 20 A compared to the base current value I0, the output current of DC EV charging station shall be within the tolerance limits given in 12.2.1.2.1 within a delay time of 1 s.

If the vehicle requests any target current I_N, which shows deviation higher than 20 A compared to the base current value I0, the output current of DC EV charging station shall be within the tolerance limits given in 12.2.1.2.1 within a delay time T_d as defined in Formula (3),and as shown in Figure 4.

$$T_d \le \frac{|I_N - I_0|}{dI_{min}} \quad \text{for} \quad |I_N - I_0| \ge 20A$$

Where

T_d is the control delay of charging current;

I_N is the value for the target current;

I_0 is the value for the base current, i.e. output current at the time of new request; dI_{min} is the minimum current change rate.

$I_N - I_0$ gives the absolute value of the difference between I_N and I_0.

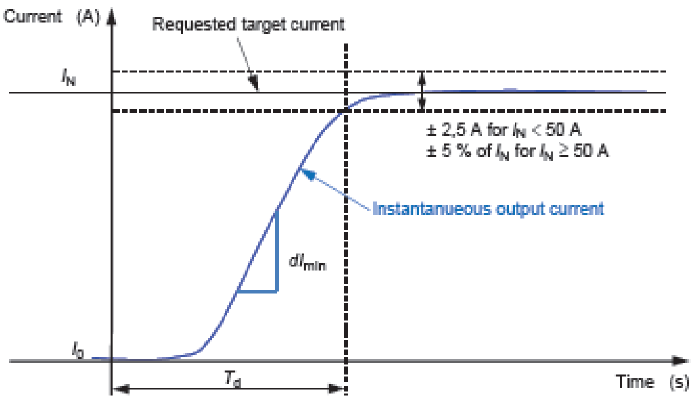


Figure 4
Step response for constant value control

12.2.1.4 **Descending rate of charging current**

The DC EV charging station shall be able to reduce current with the descending rate of 100 A/s or more in normal operation.

For emergency shutdown and for fulfilling general requirements in 9.4, even much higher descending rates are necessary. For detailed values refer to Annexes A, B and C.

12.2.1.5 **Periodic and random deviation (current ripple)**

Current ripple of DC EV charging station during current regulation shall not exceed the limit as defined in Table 4. Measurement shall be made at maximum rated power and maximum rated current or in the worst case where the output voltage and output current correspond theoretically to the maximum current ripple. The current ripple is not included in the tolerance defined in 12.2.1.2.1.

The measurement principle shown in Figure 5 shall be used.

Table 4
Current ripple limit of DC EV charging station

Limit [a]	Frequency
1,5 A	below 10 Hz
6 A	below 5 000 Hz
9 A	below 150 kHz

[a] difference between positive peak top and negative peak top at full scale output

R_1: Variable resistance

C_1: Value set to prevent internal dissipation of ripple current in DC EV charging station; (5600 µF or more)

I_1: DC current (measuring current)

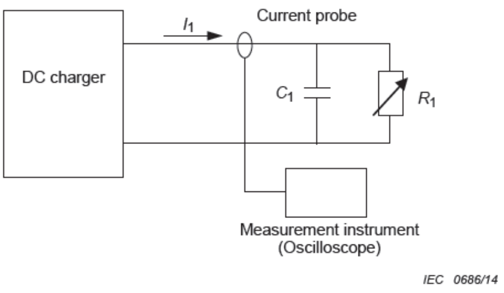


Figure 5
Current ripple measurement equipment with capacitor

12.2.1.6 Periodic and random deviation (voltage ripple in CVC)

For CVC, the maximum voltage deviation during pre-charge state and during charging of the vehicle/traction battery shall not exceed ±5 % of the requested voltage. The maximum voltage ripple in normal operation shall not exceed ±5 V. The maximum voltage slew rate in normal operation shall not exceed ±20 V/ms. For explanation of terms, see Figure 6.

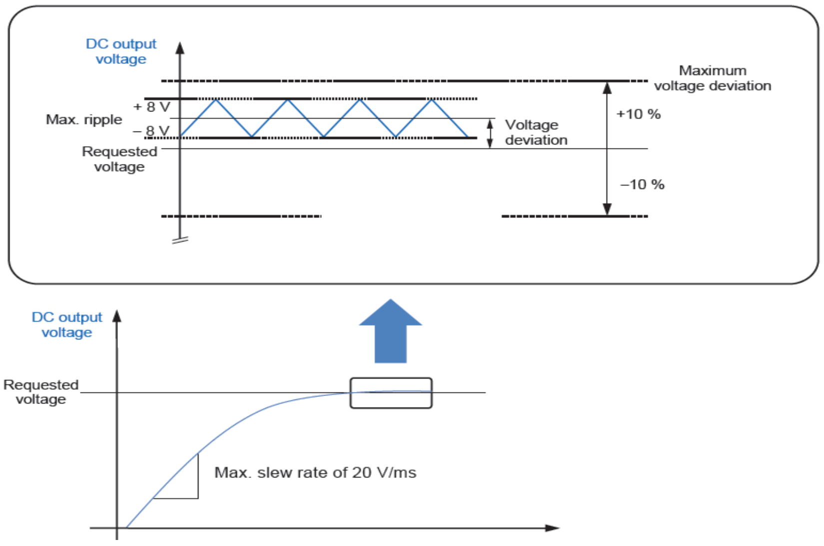


Figure 6
Maximum ratings for voltage dynamics

12.2.1.7 Load dump

Worst case of load dump is a reduction of output current from 100 % nominal value to 0 %, e.g. caused by disconnecting the vehicle battery while other loads in the EV stay connected. In any case of load dump, voltage overshoot shall not exceed the limit specified for each system in Annexes A, B or C.

Maximum slew rate of output voltage in case of load dump shall not exceed 250 V/ms.

12.2.2 Effective earth continuity between the enclosure and the external protective circuit.

Exposed conductive part of DC EV charging station shall be connected to the terminal for the external protective conductor. The test shall be conducted in accordance with 10.5.2 in IEC 61439-1:2011 unless otherwise specified by national regulations.

12.3 Specific requirement for non-isolated systems.

Reserved.

13.0 COMMUNICATION BETWEEN EV AND DC EV CHARGING STATION

13.1 General

This clause provides the general requirements for the control communication function and the system between EV and DC EV charging station. The specific requirements of digital communication of charging control between off-board DC charging system and electric road vehicle are defined in this document

EVs are equipped with propulsion batteries with different technologies and voltages.

Accordingly, the charging process shall be managed by the vehicle in order to ensure the charging of different types of on-board energy storage systems.

EVs are equipped with VCCF for charging process management. The general-purpose DC EV charging stations shall have a means allowing the vehicles to control the charging parameters of DC EV charging station.

13.2 System configuration

The communication between the DC EV charging station and the vehicle can be established via basic communication and high level communications.

Key steps in the charging control process, such as start of charging and normal/emergency shutdown, shall be managed through the basic communication with signal exchange via the control pilot lines in DC EV charging system.

In addition to the basic communication, the DC EV charging station shall be equipped with digital communication means in order to exchange the control parameters for DC charging between the DC EV charging station and the vehicle through the high level communication.

The following digital communication means are used by the systems defined in Annexes A,B and C:

a) Control area network (CAN) over dedicated digital communication circuit according to ISO 11898-1, or

b) Power line communication (PLC) over control pilot circuit.

13.3 **Basic communication**

13.3.1 Interface

Typical interfaces of control pilot function on DC EV charging systems are specified in Annexes A, B and C. Each system shall carry out control pilot function through the control pilot conductors and terminals specified in IEC 62196-3.

13.3.2 **Charging state**

Table 5 defines the charging state of DC EV charging station. The charging states show physical status of DC EV charging system. The DC EV charging station and the vehicle can exchange their charging state through the signal communication and the digital communication.

Table 5
Charging state of DC EV charging station

State		Vehicle Connected	Vehicle Connector	Charging Possible	Description
DC-A	Not Connected	No	Open	No	Vehicle Unconnected
DC-B1	Initialization	Yes	Open	No	Vehicle Connected/not ready to accept energy/communication not established/ connector unlocked/vehicle contactor open
DC-B2		Yes	Open	No	Vehicle Connected/not ready to accept energy/communication established/ connector unlocked/vehicle contactor open
DC-B3		Yes	Open	No	Vehicle Connected/not ready to accept energy/communication established/ connector unlocked/vehicle contactor open/ other supplemental processes not completed
DC-C	Energy Transfer	Yes	Close	Yes	Vehicle Connected/ ready to accept energy/ indoor charging area ventilation not required/ communication established/ connector locked/ vehicle contactor close/ other supplemental processes completed
DC-D		Yes	Close	Yes	Vehicle Connected/ ready to accept energy/ indoor charging area ventilation required/ communication established/ connector locked/ vehicle contactor close/ other supplemental processes completed
DC-B'1	Shutdown	Yes	Close	Yes	Vehicle Connected/ Charging finished / communication maintained / connector locked / vehicle contactor close

DC – B’2	Shutdown	Yes	Open	No	Vehicle Connected / Charging finished/ communication maintained / connector locked/ vehicle contactor open / other supplemental processes completed
DC-B’3	Shutdown	Yes	Open	No	Vehicle Connected/ Charging finished / communication maintained / connector unlocked / vehicle contactor open
DC-B’4	Shutdown	Yes	Open	No	Vehicle Connected / charging finished / communication finished / connector unlocked / vehicle contactor open
DC-E	Error	Yes	Open	No	DC Charger disconnected from vehicle / DC Charger disconnected from utility, DC Charger loss of utility power or control pilot short to control pilot reference.
DC-F	Malfunction	Yes	Open	No	Other DC charger problem
NOTE: The control pilot functions as specified in Table 13 can be achieved using PWM pilot control as described in Part 1 or any other system that provides the same results.					

13.4 **Digital communication architecture**

In this standard, two digital communication architectures are used:

- one, based on CAN using a dedicated data communication circuit; CAN protocol is given in ISO 11898-1; refer to Annex E and Annex F for specific implementation details; and
- the other, based on Homeplug Green PHY™ over the control pilot line; refer to Annex G for specific implementation details.

NOTE 1 Homeplug Green PHY ™ is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of this product.

13.5 **Charging control process and state**

The digital communication of DC charging control covered by this standard is as shown in Figure 7. This standard does not cover the control protocol internal to the DC EV charging station, nor the vehicle, such as power control protocol for AC/DC inverter of DC EV charging station and battery management control in the vehicle.

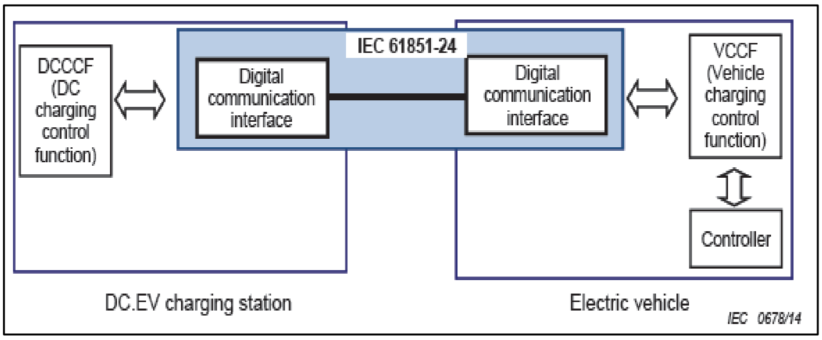


Figure 7
Digital communication between a DC EV charging station and an electric vehicle for control of DC charging

13.5.1 **General**

Charging control process of general-purpose DC EV charging stations shall consist of the following three stages:

- Process before the start of charging (initialization);
- Process during charging (energy transfer);
- Process of shutdown (shutdown).

The DC EV charging station and the vehicle shall synchronize control process with each other. The following signals and information shall be used for the synchronization:

- Signals through the pilot wire circuit;
- Parameters through the digital communication circuit;
- Measurement values such as voltage and current level of the DC charging circuit.

The DC EV charging station and the vehicle shall preserve specified time constraints and control timings for ensuring smooth charging control and operation. Charging control process as system action level is shown in Table 6. General sequence diagrams are specified in Annex F, Annex G, and Annex H. Digital communication parameters, formats, and other communication requirements are specified in IEC 61851-24.

Table 6

Charging control process of DC EV charging station at system action level

Charging control stage (process)		State	High level action
	Handshaking	DC-A	Vehicle unconnected
		DC-B1	Connector plugged in
		DC-B1	Wake up of DCCCF and VCCF

Initialization		DC-B1	Communication data initialization
		DC-B1→DC-B2	Communication established, parameters exchanged, and compatibility checked
	Charge preparation	DC-B2→DC-B3	Connector locked
		DC-B3	Insulation test for DC power line
		DC-B3	Pre-charge (depending on the system architecture)
Energy transfer		DC-C or DC-D	Vehicle side contactors closed
		DC-C or DC-D	Charging by current demand (for CCC)
		DC-C or DC-D	Charging by voltage demand (for CVC)
		DC-C or DC-D→ DC-B'1	Current suppression
		DC-C or DC-D	Renegotiate parameter limits (option)
Shutdown		DC-B'1	Zero current confirmed
		DC-B'1→DC-B'2	Welding detection (by vehicle, option)
		DC-B'2	Vehicle side contactors open
		DC-B'2	DC. power line voltage verification
		DC-B'3	Connector unlocked
		DC-B'4	End of charge at communication level
		DC-A	Connector unplugged
* The order of actions does not refer to the procedure of charging control process.			

13.5.2 Description of the process before the start of charging (initialization)

In this process, the vehicle and the DC EV charging station exchange their operational limitations and relevant parameters for charging control. Messages, such as the voltage limit of vehicle battery, maximum charging current, etc. are also transferred to each other. Circuit voltage shall be measured for checking whether the batteries and the DC EV charging station are connected before the start of charging and whether the batteries and the DC EV charging station are disconnected after the end of charging. The DC EV charging station shall not proceed with the next stage of charging process unless it verifies the compatibility with the vehicle. After compatibility check, the DC EV charging station shall conduct the insulation test between the DC power lines and the enclosures, including vehicle chassis. The vehicle connector shall be locked before the insulation test.

13.5.3 Description of the process during charging (energy transfer)

In this process, the vehicle continues to send a setting value of charging current or voltage to the DC EV charging station throughout the charging process. Either of the following two algorithms shall be taken.

a) CCC

- The vehicle battery can be charged using CCC with the vehicle as master and the DC EV charging station as slave.
- The DC EV charging station shall receive the charging current value the vehicle requested (command value), throughout the charging control process.
- The DC EV charging station shall set the command value as control target, and regulate the DC charging current.
- The command value from the vehicle shall be notified to the DC EV charging station at regular intervals according to the system requirements.
- The DC EV charging station shall regulate the DC charging current responding to the change of command value of the vehicle.

b) CVC

- The vehicle battery can be charged using CVC with the vehicle as master and the DC EV charging station as slave.
- The DC EV charging station shall receive the charging voltage value the vehicle requested (command value) throughout the charging process.
- The DC EV charging station shall set the command value as control target, and regulate the DC charging voltage.
- The command value from the vehicle shall be notified to the DC EV charging station at regular intervals according to the system requirements.
- The DC EV charging station shall regulate the DC charging voltage responding to the change of command value of the vehicle.

13.5.4 Description of process of shutdown

Normal shutdown shall occur when the vehicle battery capacity reaches a certain limit, or when the charging process is stopped by the user with a normal stop means. Emergency shutdown shall occur under a fault condition (see 6.4.3.18). After completion of charging session, the shutdown phase allows the vehicle and the DC EV charging station to return to the conditions so that the user can safely handle the charging cable and the vehicle connector. When the end of charging is notified by the vehicle, the DC EV charging station shall reduce the charge current to zero. The vehicle side contactors open at near zero current. After the inlet voltage reaches at the safety level, the vehicle connector can be unlocked by the DCEV charging station or the vehicle, and the user can remove the vehicle connector from the inlet (see 6.4.3.12). Minimum requirement on the safety voltage is specified in 7.2.3.1.

13.5.5 Exchanged information for DC charging control

This clause describes information which shall be exchanged between a DC EV charging station and a vehicle during the charging process according to IEC 61851-23. The information in Table 7 is common to all systems described in Annexes F, G and H. Each information listed in Table 7 is defined as a parameter in each annex. Each system may need additional parameters, and these parameters are defined in each annex.

Table 7
Exchanged information for DC charging control

No.	Information	Description	Relevant requirement in IEC 61851-23:— (unless specified as IEC 61851-1)
a-1	Current request for the controlled current charging (CCC) system	Exchange of current value requested by EV	6.4.3.5 DC supply
a-2	Voltage request for the controlled voltage charging (CVC) system	Exchange of current value requested by EV	6.4.3.5 DC supply
a-3	Maximum rated voltage of DC EV charging station	Exchange of maximum rated voltage value of DC EV charging station	6.4.3.5 DC supply - 6.4.3.9 Compatibility assessment - 6.4.3.11 Protection against overvoltage at the battery

a-4	Maximum rated current of DC EV charging station	Exchange of maximum rated voltage value of DC EV charging station	- 6.4.3.5 DC supply for EV - 6.4.3.9 Compatibility assessment
b-1	Communication protocol	Exchange of software version of a charging system	6.4.3.9 Compatibility assessment
b-2	Maximum voltage limit of EV	Exchange of maximum voltage limit value of vehicle.	6.4.3.9 Compatibility assessment
b-3	EV minimum current limit, only for the controlled voltage charging(CVC) system	Under consideration	6.4.3.9 Compatibility assessment
c	Insulation test result	Exchange of the result of insulation test before charging - If insulation test fails, a signal is sent that charging is not allowed.	6.4.3.10 Insulation test before charging
d	Short circuit test before charging	Exchange of information on short circuit test before charging	6.4.3.14 Short circuit test before charging
e	Charging stopped by user	Exchange of information on charge stop command by the user of DC EV charging station	6.4.3.15 User initiated shutdown
f	EVSE real time available load current (optional)	Exchange of EVSE real time available load current for demand management.	6.4.4.3 (of IEC 61851-1) Detection/adjustment of the real time available

		Required for system providing that function.	load current of EVSE
g	Loss of digital communication	Detection of loss of digital communication - If a receiver does not get information expected to receive within time out period, it is considered as loss of digital communication.	9.4 Breaking capacity
h-1	Zero current confirmed	Notification of zero current confirmed - Station informs EV that low current condition has been met (to allow connector unlocking)	13.5 Charging control process and state
h-2	Welding detection	Exchange of information on the whole process of welding detection	13.5 Charging control process and state

Annexes

The annexes of AIS 138 Part-1 apply with the following new annexes.

ANNEX A

DC EV charging station of system A (Normative)

A.1 GENERAL

This annex provides the specific requirements for the DC EV charging stations of system A (hereinafter referred to as "system A station" or "station"), in addition to the general requirements as defined in the body text of this standard. System A is a regulated DC charging system using a dedicated CAN communication circuit for digital communication between a DC EV charging station and an EV for control of DC charging. The vehicle coupler of configuration A as specified in IEC 62196-3 is applicable to system AA. The specific requirements for digital communication and details of the communication actions and parameters of system A are defined in Annex A of IEC 61851-24:—.

The rated voltage of DC output for system A station is limited to 500 V DC

This system is suitable for the passenger vehicles and light trucks.

This annex defines the system with an AC input, but does not prohibit DC input. This annex includes information on the circuits on vehicle side.

More detailed information on system A is defined in JIS/TSD0007.

A.2 SCHEMATIC AND INTERFACE CIRCUIT DIAGRAM

The schematic block diagram of system A is given in Figure A.1. The interface circuit between the station and the vehicle for charging control is shown in Figure A.2. CAN-bus circuit is provided for digital communication with the vehicle. The definition and description of symbols and terms in Figure A.1 and Figure A.2 are given in Table A.1. The values of the parameters for the interface circuit are given in Table A.2.

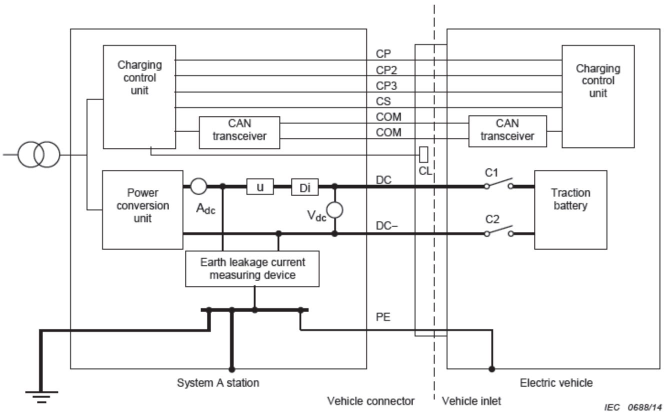


Figure A.1
Overall schematic of system A station and EV

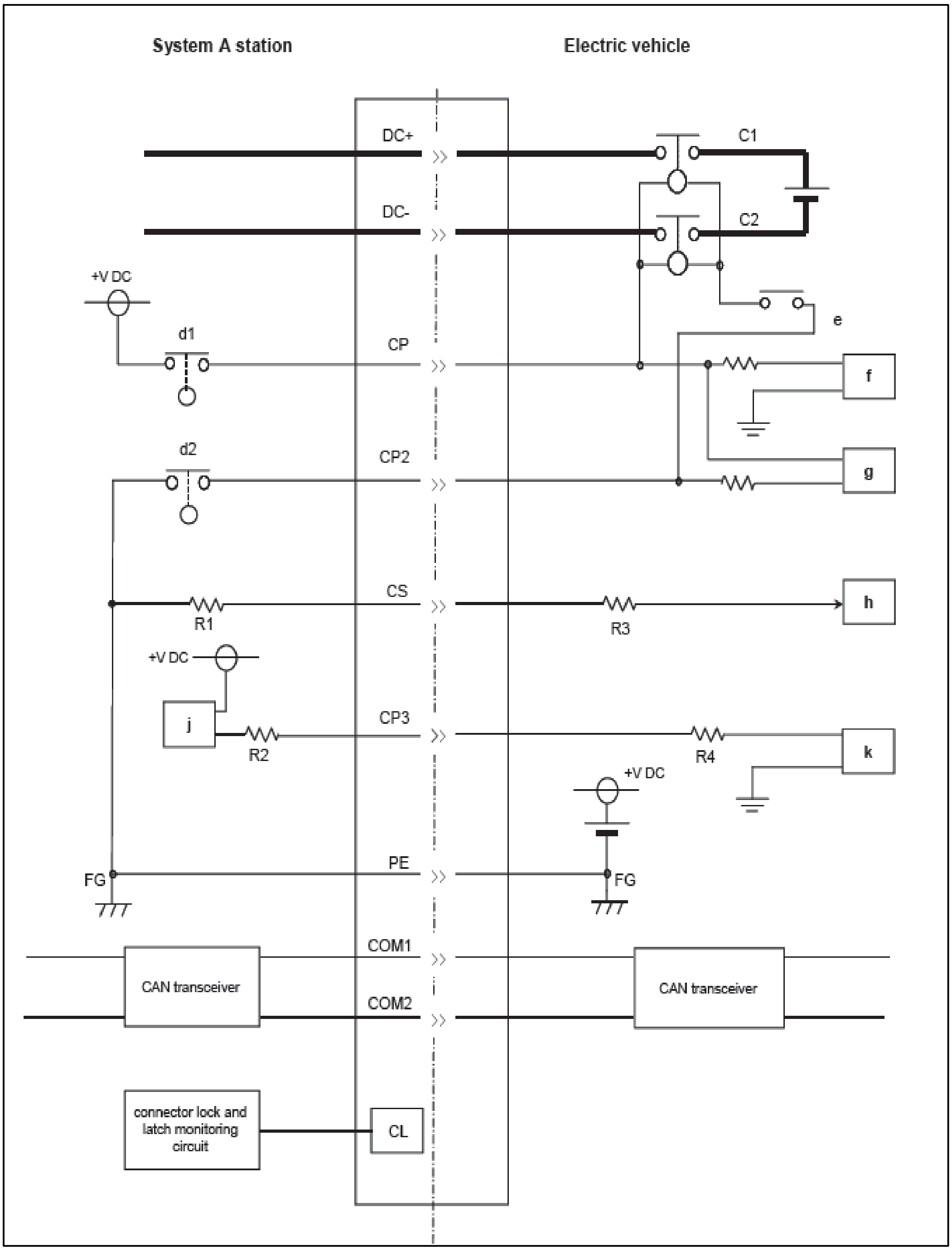


Figure A.2
Interface circuit for charging control of system A station

Table A.1
Definition of symbols in Figure A.1 and Figure A.2

	Symbols	Definitions	Requirements
System A station	Di	Reverse-current-prevention device (e.g. diode: cathode on the vehicle sid , anode on the station side)	A.3.3
	d1	Switch on CP for controlling the charging start/stop signals from the station to the vehicle	A.3.5, Clause A.4
	d2	Switch on CP for controlling the charging start/stop signals from the station to the vehicle	A.3.5, Clause A.4
	j	Signal sensing device to detect vehicle ready/not ready to accept energy	A.3.6
	Vdc	Voltage measurement device	A.3.2, Clause A.4
	Adc	Current measurement device	Clause A.4
	u	Short-circuit protection device (e.g. current limiting fuse)	A.3.3
	R1	Resistor	Table A.2
	R2	Resistor	Table A.2
	+V DC	DC power supply to EV contactors	Table A.2
Electric vehicle	C1,C2	Disconnection switch for DC power lines (EV contactors)	A.3.5, A.3.7, Clause A.4
	e	Relay for turning on EV contactors	Clause A.4
	f	Signal sensing device to detect the status of d1	Clause A.4
	g	Signal sensing device to detect the status of d2	Clause A.4
	h	Signal sensing device to detect connection / disconnection of vehicle coupler	Clause A.4
	k	Switch to give the go ahead / stop to charge	Clause A.4
	R3	Resistor	Table A.2
	R4	Resistor	Table A.2
Terminal and wire	DC+	DC power supply (positive)	A.3.7, Clause A.4
	DC-	DC power supply (negative)	A.3.7, Clause A.4
	CP	Control pilot which indicates the start/stop status of station	Clause A. 2, A.3.5,Clause A.4

	CP2	Control pilot which indicates the start/stop status of station	Clause A. 2, A.3.5, Clause A.4
	CS	Pilot wire which indicates the status of vehicle coupler connection	Table A.2
	CP3	Control pilot which confirms that the vehicle is ready for charging	Clause A. 2, A.3.6, Clause A.4
	COM1 COM2	Signal line pair for digital communication	Clause A.4, Annex A of IEC 61851-24:—
	PE	Protective conductor between the station and EV for detecting the first DC earth fault	A.3.1
Vehicle connector	CL	Connector latching and locking mechanism	A.3.4

Table A.2
Parameters and values for interface circuit in Figure A.2

System A station					
Terminal/ Wire	Parameters	Minimum value	Typical value	Maximum value	Unit
CP	+V DC	10.8	12.0	13.2	V
CS	Resistor R1	190	200	210	Ω
CP3	Resistor R2	950	1000	1050	Ω
CP	Load current of switch d1	2		2000	mA
CP2	Load current of switch d2	2		2000	mA
Electric vehicle					
CP	Load current (when d1 closing)	10		2000	mA
CP2	Load current (when d1 and d2 closing)	10		2000	mA
CS	Resistor R3	950	1000	1050	Ω
	+V DC	8	12	16	V
CP3	Resistor R4	190	200	210	Ω

A.3 SPECIFIC SAFETY REQUIREMENTS

A.3.1 Fault protection in the secondary circuit

A.3.1.1 General

For fault protection in the secondary circuit, system A station shall have the following measures:

a) Reinforced isolating transformer;
b) Earth leakage current measurement using a grounding resistor between the DC power lines DC+/DC- and earth (enclosure and chassis);
c) Automatic disconnection of supply to DC power circuit at the first DC earth fault;
d) Charging cable consisting of line conductors that are individually insulated.

When PE forms part of a charging cable, the cross-sectional area of PE shall be determined by the formula in 543.1.2 of IEC 60364-5-54:2011.

Table A.3 shows the principle of fault protection, in which case 1 is applicable to system A.

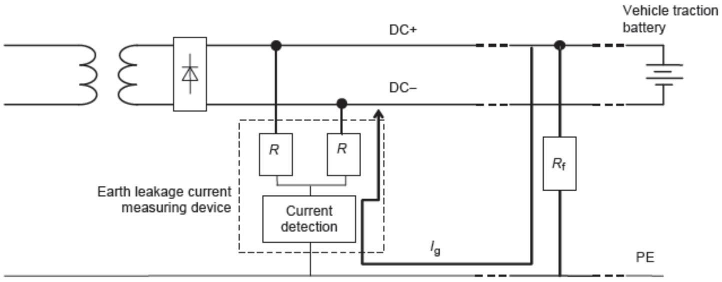
Table A.3
Principle of fault protection

	Power supply in case of the first fault	Protection measure in case of the first fault	Protection against the secondary fault
Case 1	Not required	Automatic shutdown	Prohibition of operation at the first fault
Case 2	Required	– Detection and notice of the first fault using an insulation monitoring device – Recommendation for elimination of the first fault with the shortest practicable delay	– PE equivalent to TN ground required –Visible warning for system operator at the detection of symmetric fault

A.3.1.2 Automatic disconnection and earth fault monitoring

System A station shall measure the earth leakage current between the secondary circuit and its enclosure, or between the secondary circuit and the vehicle chassis. When an earth fault is detected during charging, the station shall reduce the DC output current to less than 5 A. Then, the switch d1 shall be open in order to prevent the vehicle to close EV contactor. The line-to-line voltage of DC output Vdc shall be reduced to less than 60 V. The automatic disconnection process shall be accomplished within 5 s from the detection of earth fault. Fault current detection principle and performance requirements are defined in Figure A.3 and Table A.4.

A method to detect a DC fault current is required for the first earth fault. System A station shall detect an earth fault current caused by the first failure in the secondary circuit as specified in Table A.4.



R_f = insulation resistance between DC+/DC- and vehicle or enclosure the first fault

R= grounding resistor to detect and limit the first fault current

I_g= earth leakage current at the first earth fault

Figure A.3
Failure detection principle by detection of DC leakage current

Table A.4
Requirements for earth fault monitoring

Item	Detection performance
Maximum detection time[a]	Less than 1 s
Nuisance trip prevention	Minimum response time shall be more than 0,2 s with continuous threshold monitoring
Sensitivity [b]	Sensitivity of earth leakage current measuring device and grounding resistor of ‘R’ shall be designed so that the body current of human at the first earth fault is within DC-2 zone in Figure 22 of IEC/TS 60479-1:2005.

Example

Set-up condition 1: When the body current Ih exceeds DC-2 zone calculated by Formula (A.1), a measurement device is designed to detect the deterioration of insulation resistance Rf as the first earth fault by measuring earth leakage current shown in Formula (A.2).

$$I_h = V_{dc} \times (R + R_f)/(R \times R_f) \qquad (A.1)$$

Where

Ih is the body current

Vdc is the line to line voltage of DC output circuit

R is a grounding resistor

Rf is an insulation resistance

$$I_g = V_{dc} / (R + 2 \times R_f) \qquad (A.2)$$

Where

Ig is the measuring current

Set-up condition 2: The measurement device is designed to detect the body current within DC-2 zone, except the set-up condition 1.

a The detection time does not include shutdown time of DC output current.

b The actual body current may differ from the measured leakage current Ig, which should be taken into account when designing the station.

A.3.2 Voltage measurement of DC power line for vehicle connector unlock

According to 6.4.3.8, the vehicle connector shall not be unlocked when hazardous voltage is detected. To unlock the vehicle connector, the voltage of DC power line shall be measured at Vdc in Figure A.1, and be confirmed to be within safe levels, i.e. 10 V or less.

A.3.3 Prevention of the hazard due to vehicle battery short-circuit

Over current protection device, such as current-limiting fuse u, shall be provided in the output circuit of system A station in order to prevent the hazard due to short-circuit current of vehicle battery caused by the reverse connection of charging cable by mistake, i.e. when DC+/DC- on vehicle or station side are connected to DC-/DC+ of vehicle connector terminal by faulty maintenance. The over current protection device shall have a current rating of 250 A or less and be a quick-break type.

A.3.4 Lock and latch monitoring for vehicle connector

The vehicle connector shall have a means of mechanical latching, electrical locking, and lock and latch monitoring.

In case of failure of mechanical latching or electrical locking of the vehicle connector, the station shall not energize the DC power lines connected to the vehicle connector. If the failure is detected during charging, the station shall reduce the DC output current to less than 5 A within 2 s. Then, the switch d1 shall open.

The vehicle connector shall have a means to provide system A station with information on anomaly detection in monitoring of latch and electrical locking. Figure A.4 shows an example of a detection means in vehicle connector and system A station.

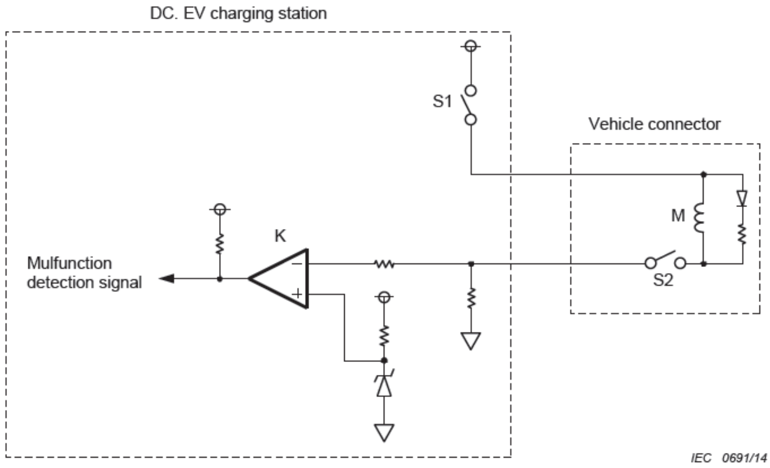


Figure A.4
Example of vehicle connector latch and lock monitoring circuit

K comparator

S1 switch

S2 switch, interlocked with locking and latching

M solenoid

A.3.5 **Protection of EV contactor**

In order to prevent the welding of EV contactor, switches d1 and d2 shall not open at current exceeding 5 A

A.3.6 **Emergency shutdown at control pilot disconnection**

If a control pilot is disconnected during charging, system A station shall decrease output current to 5 A or less within 30 ms. Detection may be made using CP, CP2 or CP3 as defined by the manufacturer.

A.3.7 **Turn on inrush current for vehicle circuit**

Inrush current on DC power line of system A station shall not exceed 20 A at vehicle connector.

A.3.8 **Protection against overvoltage at the battery**

System A station shall reduce the DC output current to less than 5 A of rated current within3 s to prevent overvoltage at the battery, if output voltage exceeds maximum voltage limit sent by the vehicle.

A.3.9 **Load dump**

In any case of load dump, voltage overshoot of DC output of the station shall not exceed 600 V.

A.4 CHARGING PROCESS AND COMMUNICATION BETWEEN THE DC EV CHARGING STATION AND THE VEHICLE FOR CHARGING CONTROL

A.4.1 Communication measures

Communication between the station and the vehicle is carried out through the control pilots CP, CP2 and CP3, proximity circuit CS, and the digital communication circuits COM1 andCOM2. CP and CP2 transmit signals such as "ready to charge" and "end of charge" from the station to the vehicle. CP3 is used to transmit instructions to start charging or shutdown, from the vehicle to the station. Numerical parameters in Annex A of IEC 61851-24:— such as output rating of station and maximum voltage of battery are exchanged through COM1 andCOM2.

A.4.2 Charging control process

A.4.2.1 State transition diagram and sequence diagram

The charging process of system A shall conform to the state transition diagram as shown in Figure A.5. Figure A.6 gives the charging control sequence under normal conditions.

A.4.2.2 Start of charging

When the charging process is initiated by system A station, d1 shall be closed. The switch d2 shall be open until the end of insulation test in A.4.2.3.

A.4.2.3 Insulation test before charging

The insulation test shall not start until the vehicle provides system A station with a permission signal through CP3, and permission parameters by digital communication as shown in Annex A of IEC 61851-24:— Before the insulation test, system A station shall inform the vehicle through digital communication that the vehicle connector is locked.

The insulation test shall be performed in accordance with 6.4.3.10 and as per the following procedure.

a) Before the test, the station shall measure Vdc of DC power line and confirm that the EV contactors open. The voltage of DC power line, measured at Vdc, shall be less than 10 V.

   If the measured voltage exceeds 10 V, the charging process shall be shut down (see Figure A.5).

b) The voltage U that is applied to the DC power line shall be the maximum output voltage of the station.

c) After the test, it shall be confirmed that the voltage at Vdc is less than 20 V. Then, the station shall inform the vehicle of the termination of test with closing d2 switch.

During the insulation test, the earth fault shall be monitored in accordance with A.3.1.2.

A.4.2.4 **Energy transfer**

System A shall continuously monitor the charging current value requested by the vehicle. The charging current shall be changed responding to the vehicle requested value, in accordance with CCC requirements in 12.2.1.2.1 and 12.2.1.3. The characteristics of charging current control shall meet Table A.5 and Figure A.8.

A.4.2.5 **Shutdown**

In order to terminate the charging safely, system A station shall comply with the following procedure.

a) The station shall notify the vehicle of start of shutdown process by digital communication.

b) The station shall reduce the output current to 5 A or less.

c) In normal conditions, switches d1 and d2 shall not be open until the welding detection of EV contactor by vehicle is finished.

d) After d1 and d2 open, and before the vehicle connector unlocks, it shall be confirmed that the voltage at V_{dc} is less than 10 V.

A.4.3 **Measuring current and voltage**

The accuracy of output measurement of system A shall be within the following values:

- Current: ± (1.5% of actual current + 1 A);
- Voltage: ±5 V.

A.5 RESPONSE TO VEHICLE COMMAND ON CHARGE CURRENT

System A station shall supply DC current to the vehicle using CCC with the vehicle as the master and DC charger as the slave. Recommended specification for the charge current request from the vehicle and the response performance of system A station are given in Table A.5 and Figure A.7 for the vehicle, and in Table A.6 and Figure A.8 for system A station.

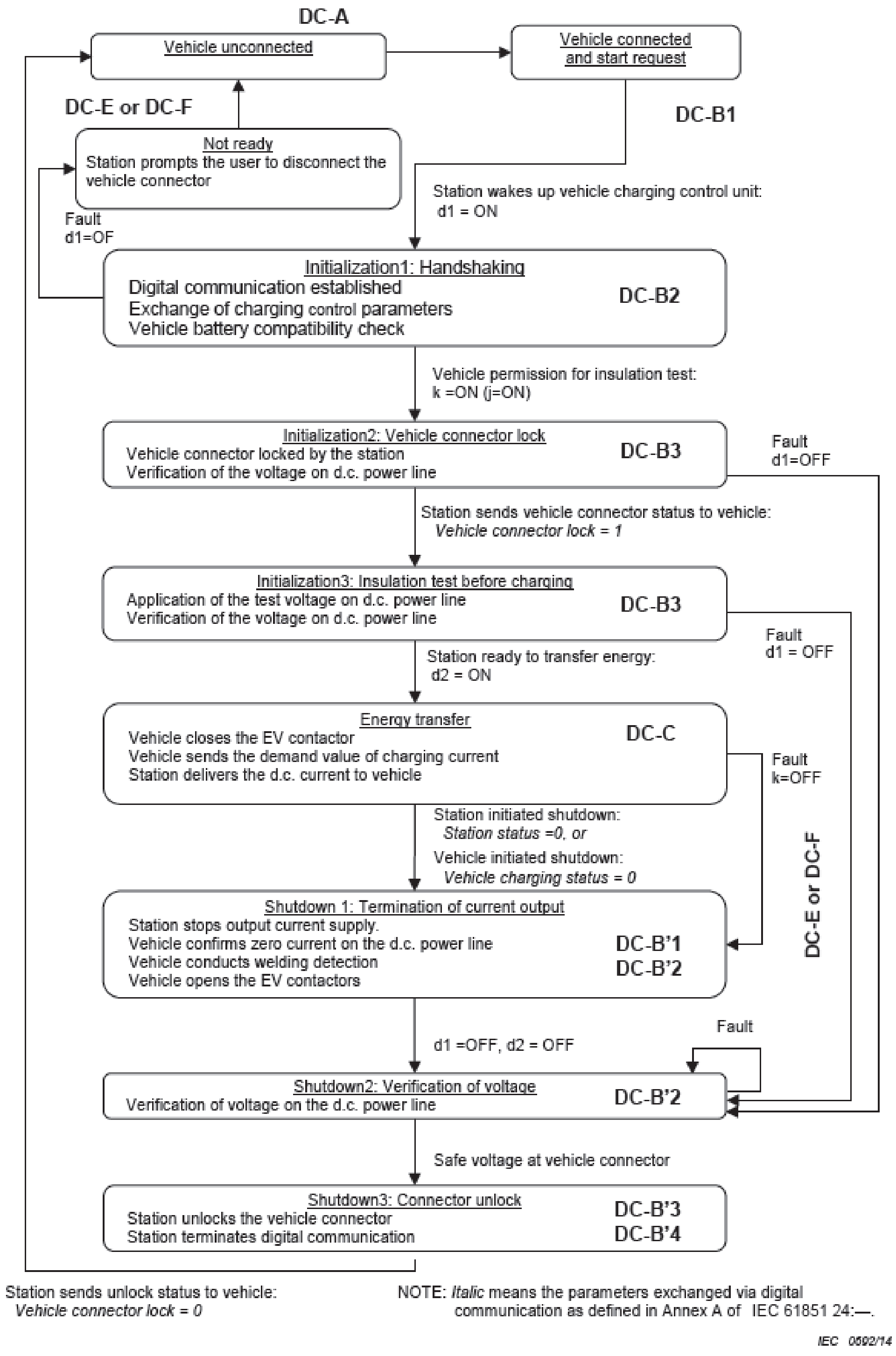


Figure A.5

State transition diagram of charging process for system A

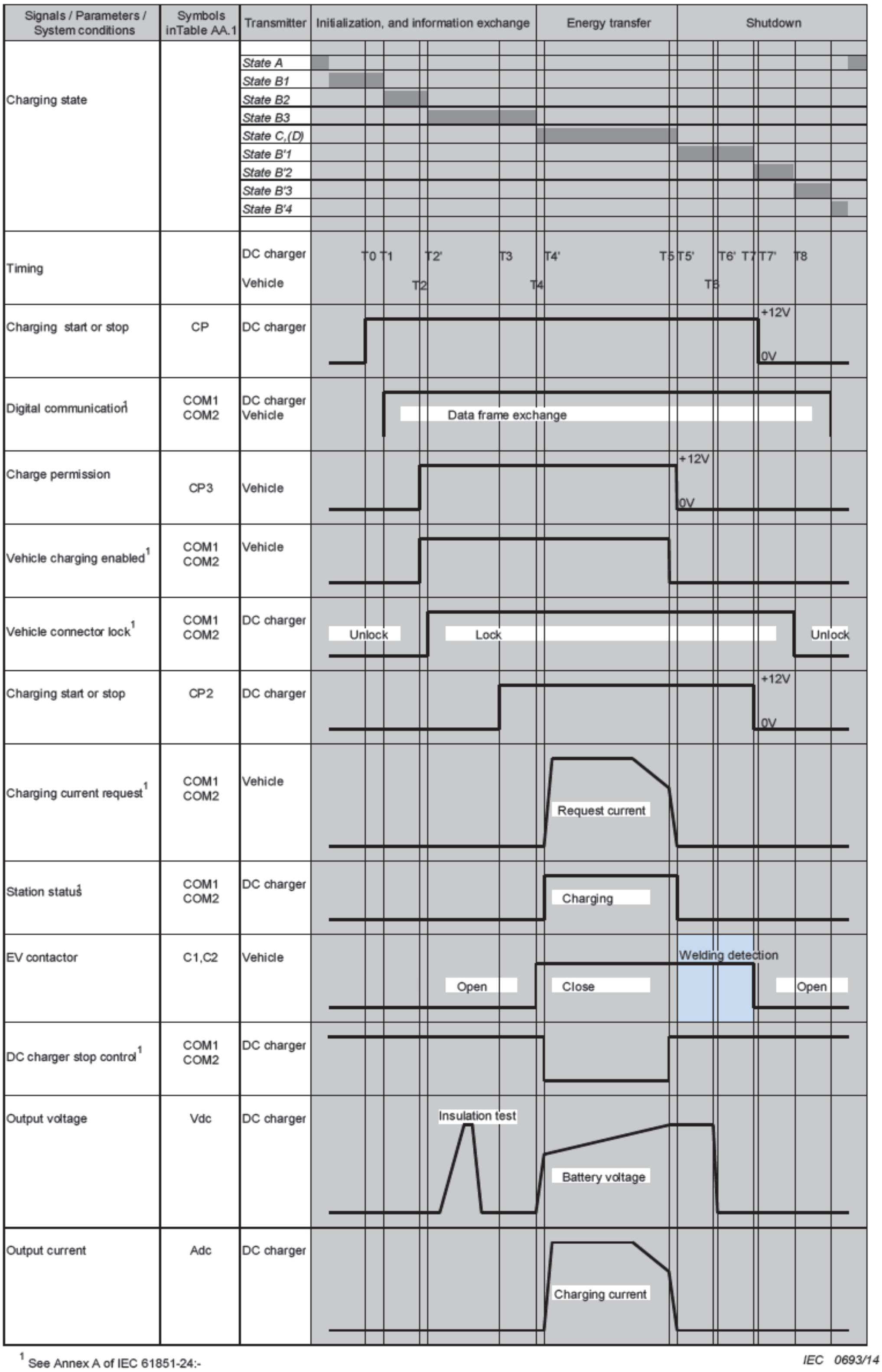


Figure A.6

Sequence diagram of system A

Table A.5

Recommended specification of charging current requested by the vehicle

Item	**Symbol**	**Condition**	**Specification**		
			Minimum	Maximum	Unit
Charging current request range	I_{req}		0	Available output current (IEC 61851-24:AnnexA)	A
Rate of demand value Change	ΔI_{req1}		–20	20	A/s
Descending speed at the time of shutdown	ΔI_{req2}	Normal shutdown	NA	200	A/s

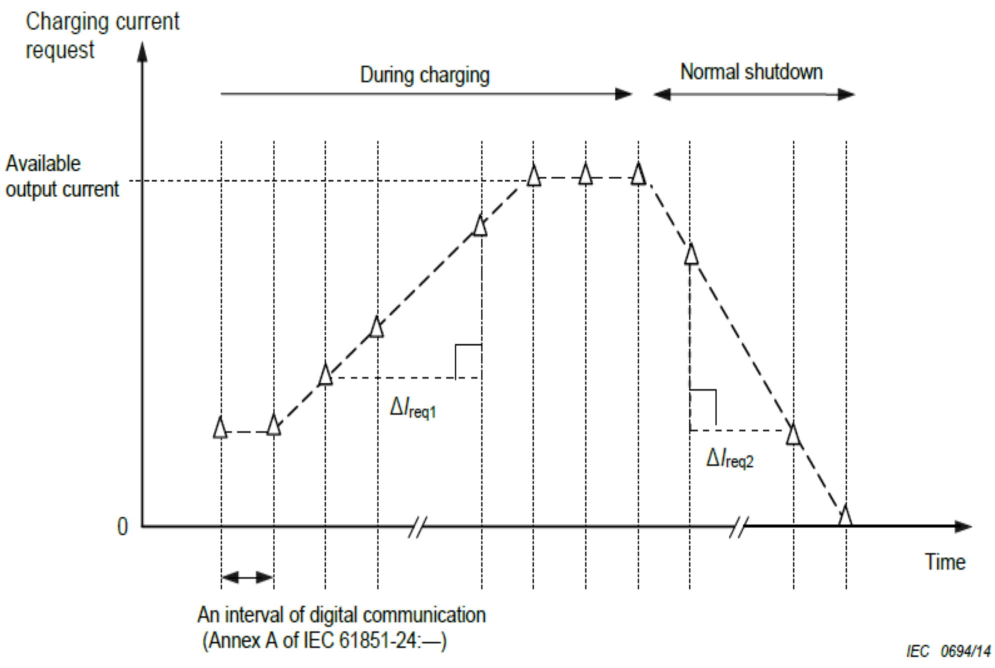


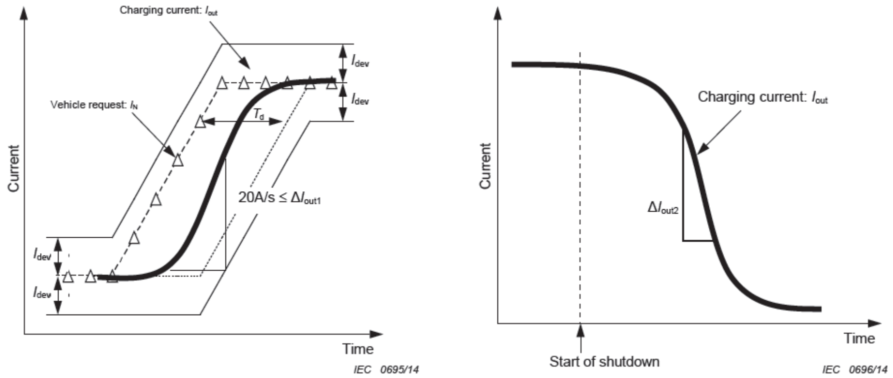
Figure A.7

Charging current value requested by the vehicle

Table A.6

Requirements for the output response performance of DC EV charging station

Item	Symbol	Condition	Specification		
			Minimum	**Maximum**	**Unit**
Output accuracy	Idev	Charging current request: 0 A to 50 A	I – 2,5 A	I + 2,5 A	A
		Charging current request: 50 A to 200 A	I × 95 %	I × 105 %	
Control delay to vehicle request	Td		-	1.0	s
Output response Speed	ΔIout1	At charging	20	-	A/s
Output current descending speed	ΔIout2	Normal shutdown	100	200	
		Emergency shutdown	200 [a]	-	
[a]In case of disconnection of CP, CP2 or CP3 during charging, faster termination of charging current is required. See A.3.6.					



a) Energy transfer b) Shutdown

Figure AA.8
Output response performance of DC EV charging station

ANNEX B
DC EV charging station of system B (Normative)

B.1 GENERAL

This annex shows the specification of the DC EV charging station of system B using dedicated DC vehicle coupler of configuration BB as specified in IEC 62196-3.

B.2 BASIC SOLUTION TO DC CHARGING SECURITY SYSTEM

Figure B.1 shows the basic solution of DC charging system for charging DC, including DC charger control unit, resistors R1, R2, R3, R4 and R5, switch S, AC supply circuit contactor K0, isolating transformer T, AC/DC inverter, DC supply circuit contactors K1 and K2, low voltage auxiliary supply circuit contactors K3 and K4, charging circuit contactors K5 andK6, reverse-current-prevention device including diode K7 and R6, electrical interlock, and vehicle control unit. Vehicle control unit can be integrated in the BMS (battery management system). Resistors R2 and R3 are installed on the vehicle connector and resistance R4 is installed in the vehicle inlet. Switch S is the inner switch of vehicle connector, and it will close when the vehicle connector and vehicle inlet are properly connected. During the whole charging process, DC charger control unit should detect and control the states of K1, K2, K3and K4, while the vehicle control unit detects and controls K5 and K6. During the charging procedure, if the IMD (insulation monitoring device) detects that the insulation resistance drops below the setting value, the setting value shall be no less than a value calculated by 100 Ω/V multiplied by the maximum output voltage rating of the DC EV charging station.

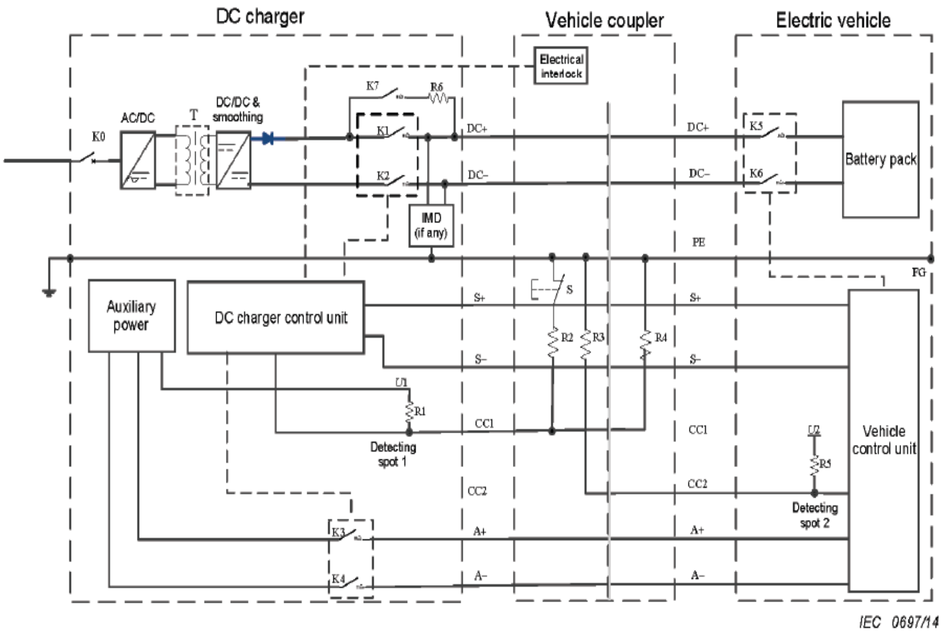


Figure B.1
Schematic diagram for basic solution for DC charging system

B.3 THE OPERATION AND CONTROL PROCEDURE OF CHARGING PROCESS

B.3.1 Measurement accuracy of current and voltage

The accuracy of output measurement of system B shall be within the following values:
– Voltage measurement: ± 0.5%
– Current measurement:
• ±2 % of the actual current if the actual current is above (>) 50 A;
• ±1 A if the actual current is less than or equal to (≤) 50 A.

B.3.2 Proximity function

When the vehicle connector is inserted into the vehicle inlet, the proximity function will be active. Namely once the voltage of detecting point 2 changes from 12 V to 6 V, the vehicle confirms the presence of the vehicle connector.

B.3.3 Confirmation of connection state of vehicle interface (state 3).

When the operator initiates the charging configuration for the DC EV charging station, the DC charger control unit can determine whether the vehicle connector is properly connected to the vehicle inlet by the voltage measurement of detecting point 1. For example, if the voltage of detecting point 1 is 4 V, it can be determined that the vehicle interface is properly connected.

When the operator completes the human-machine interaction setup and the DC EV charging station is properly connected, the DC charger control unit retains electrical interlock.

The releasing of electrical interlock cannot be achieved unless the following three conditions are fully met:

– charging terminates (there is no charging current output);
– K1 – K6 are all disconnected;
– unlock command is received from operator.

B.3.4 DC charger self-detection is finished (state 4)

After the vehicle interface is properly connected, if the DC charger self-detection (including insulation monitoring) is finished, close K3 and K4 to initiate low voltage auxiliary supply circuit. Meanwhile "Charger identification broadcast message" is sent periodically. After the energy is transferred to the low voltage supply power circuit by DC charger, the EV vehicle control unit determines whether the vehicle interface is properly connected by the voltage measurement of detecting point 2. If the voltage of detecting point 2 is 6 V, then the vehicle control unit begins to send "vehicle control unit (or battery management system) identification broadcast message" periodically. The signal can be considered as one of the trigger conditions of non-driving state.

B.3.5 **Charger ready (state 5)**

After handshaking and configuration for the vehicle control unit and the DC charger control unit is finished by communication, the vehicle control unit closes K5 and K6 to energize charging supply output circuit; and the DC charger control unit closes K1 and K2 to energize the DC power supply circuit.

B.3.6 **Charging stage (state 5)**

During the whole charging process, the vehicle control unit controls the charging process by sending the battery charge level requirements to the DC charger control unit. The DC charger control unit adjusts the charging voltage and current to ensure normal operation of charging procedure according to the battery charge level requirements. In addition, the vehicle control unit and the DC charger control unit send charging status to each other

B.3.7 **Terminate charging in normal condition**

The vehicle control unit determines when to stop charging according to the charged status of the battery system or whether there is a message of "Terminate Charger Request/Response" from the DC EV charging station. When one of the above charging termination conditions is met, the vehicle control unit starts to send "Vehicle control unit (or battery management system) Terminate Charger Request/Response" periodically, and makes the charger stop charging before K1, K2, K5 and K6 are opened. After communication is closed, K3 and K4 shall be opened, then release the electrical interlock. Finally the vehicle coupler could be disconnected and the whole charging process is finished.

B.3.8 **Safety protection under failure mode**

B.3.8.1 **Safety protection under general failures**

During the charging process, when there are general failures, the DC charger control unit automatically stops charging (shutdown charging current output), then contactors K1, K2, K5, K6, K3 and K4 are opened by the DC charger control unit and the vehicle control unit before the operators release the electrical interlock through the DC charger setup, pull out the vehicle connector or carry out the error checks. These general failures include but are not limited to the following conditions.

– The vehicle fails to continue charging. At this time, the vehicle control unit sends a "stop charging request" to the DC charger control unit periodically; the DC charger fails to continue charging. At this time, the DC charger control unit sends a "stop charging request" to the vehicle control unit; communication disconnects between the DC charger control unit and the vehicle control unit (state 6).

B.3.8.2 **Protection against overvoltage at the battery**

The system B station shall reduce the DC output current to less than 5 A within 2 s, to prevent overvoltage at the battery, if the output voltage exceeds the maximum voltage limit of the battery system for 1 s.

B.3.8.3 **Requirements for load dump**

In any case of load dump, the voltage overshoot shall not exceed 110 % of the maximum voltage limit requested by the vehicle.

Table B.1 provides the definitions of charging states.

Recommended parameters of DC charging security system are shown in Table B.2.

Table B.1
Definitions of charging states

Charging state	Vehicle coupler state	S	DC charger Self-detection finished	Handshake and Configuration finished	Comm state	Charging or not	U1 V	U2 V	Note
State 1	Disconnection	OPEN	-	-	-	NO	12	-	NO communication
State 2	Disconnection	OPEN	-	-	-	NO	6	-	NO communication
State 3	Connection	CLOSED	NO	-	-	NO	4	-	Self-detection is not finished and NO communication
State 4	Connection	CLOSED	YES	NO	YES	NO	4	6	K3 and K4 closed, communication going on.
State 5	Connection	CLOSED	YES	YES	YES	YES	4	6	K5, K6, K1, K2 closed
State 6	Connection	CLOSED	YES	YES	NO	NO	4	6	Communication disconnect, start to protection
State 7	Connection	OPEN	YES	YES	-	NO	6	6	If this state holds for a solid time (200 ms), DC charger control equipment start to adopt protection

State 8	Disconnection	OPEN	YES	YES	-	NO	12	12	VCE and DC charger control equipment adopt different protection solutions
NOTE Charging state is detected by the voltage of point 1 (U1) and point 2 (U2).									

Table B.2
Recommended parameters of DC charging security system

Object	Parameters[a]	Symbol	Unit	Nominal	Max	Min
Requirements of DC charger control unit	Equivalent resistance R1	R1	Ω	1 000	1 030	970
	Pull-up voltage	U1	V	12	12.6	11.4
	Voltage 1	U1a	V	12	12.8	11.2
		U1b	V	6	6.8	5.2
		U1c	V	4	4.8	3.2
Requirements of vehicle connector	Equivalent resistance R2	R2	Ω	1000	1030	970

	Equivalent resistance R3	R3	Ω	1000	1030	970
Requirements of EV	Equivalent resistance R5	R5	Ω	1000	1030	970
	Pull-up voltage	U2	V	12	12.6	11.4
	Voltage 2	U2a	V	12	12.8	11.2
		U2b	V	6	6.8	5.2
a The accuracy shall be maintained under applicable environmental conditions and service life.						

B.4 Sequence diagram of charging process

The sequence diagram of charging process is shown in Figure B.2.

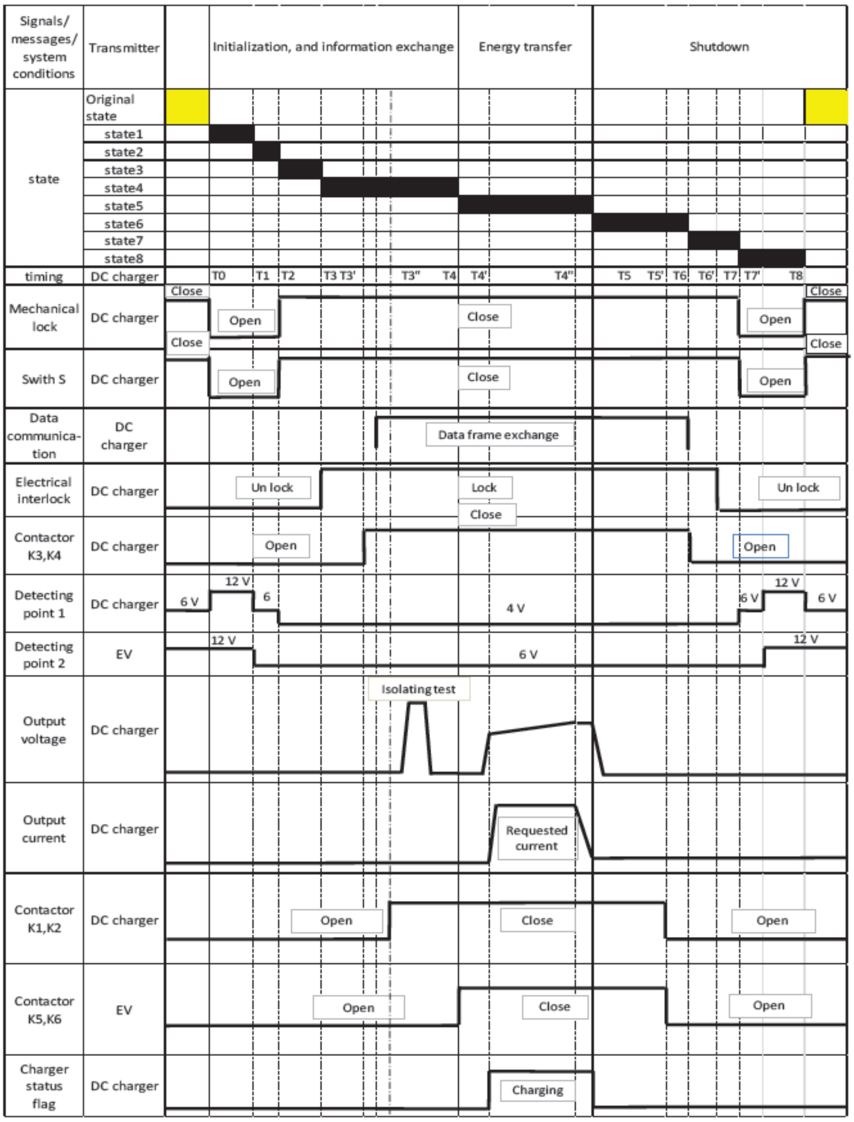


Figure B.2
Sequence diagram of charging process

B.5 Interlock operation flow charts of vehicle coupler's insertion and withdrawal

Figures B.3 and B.4 show the flow charts of interlock operation of vehicle couplers.

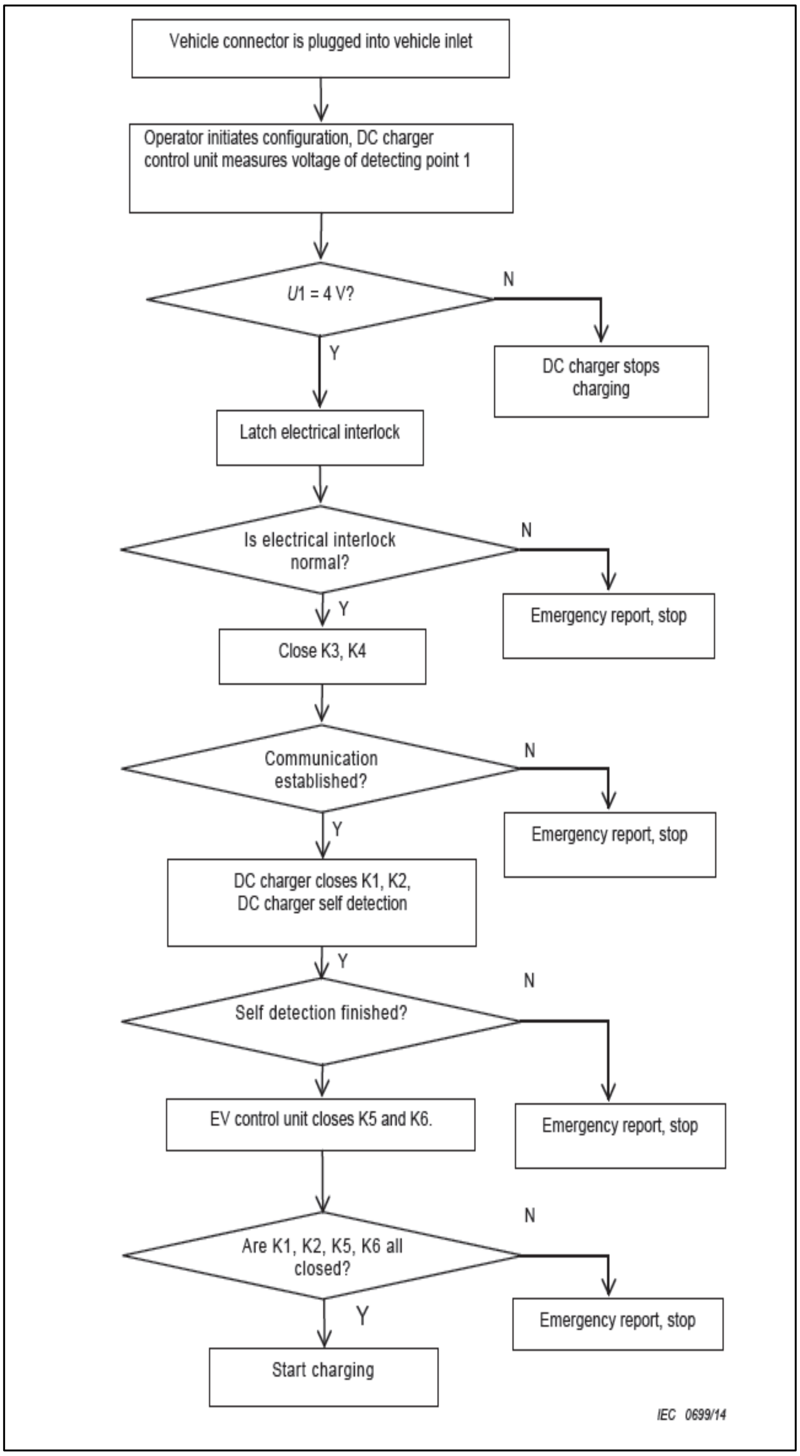


Figure B.3
Operation flow chart of start charging

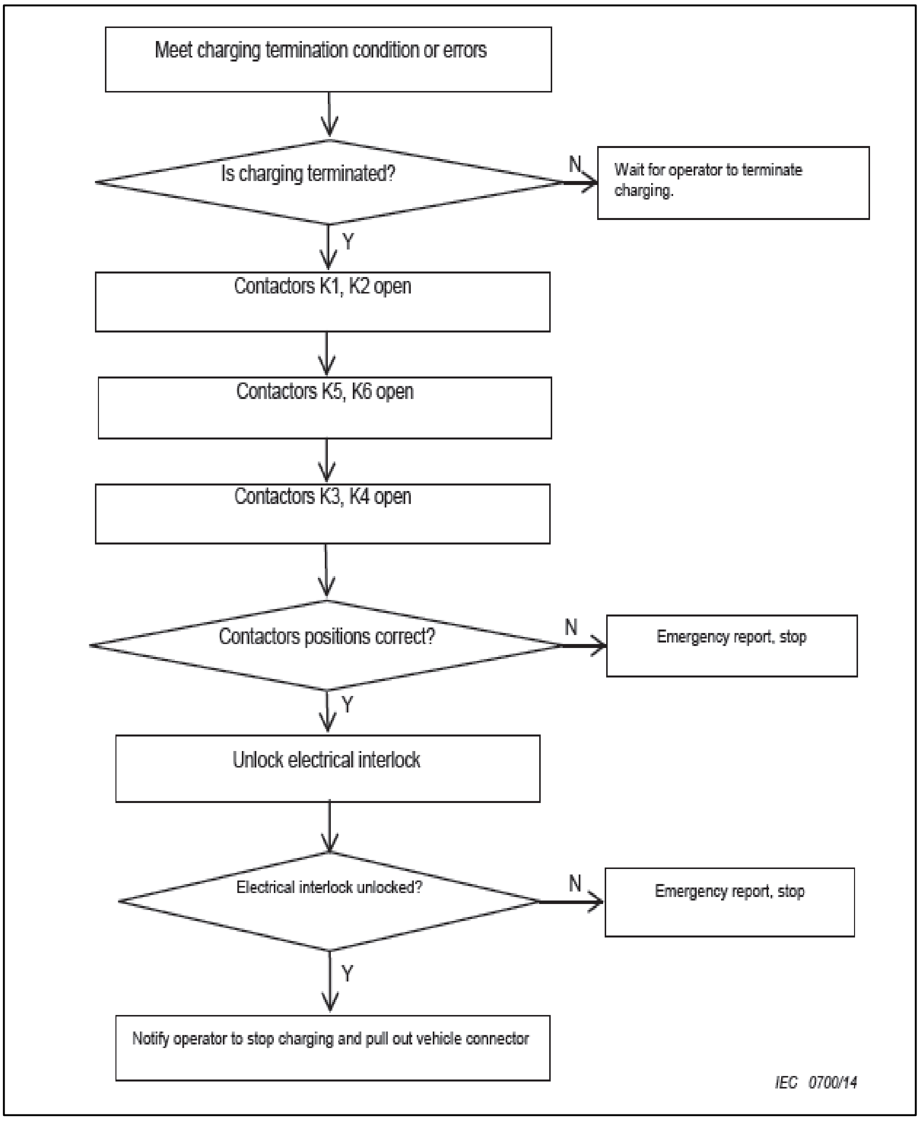


Figure B.4

Operation flow chart of stop charging

ANNEX C

DC EV charging station of system C (Combined charging system)
(Normative)

C.1 General

This annex provides specific requirements for DC EV charging stations for use with the combined charging system (system C). The combined charging system is a DC charging system. The rated DC output voltage of the combined charging system is limited to 1000 VDC The rated DC output voltage of a specific charging station configuration shall be limited to the maximum system output voltage per Table C.1.

Table C.1

DC couplers and maximum system output voltage for combined charging system

Nr.	DC couplers for combined charging system	Maximum system output voltage
a)	Configuration CC according to IEC 62196-3-1[3]	500 V DC
b)	Configuration DD according to IEC 62196-3-1	500 V DC
c)	Configuration EE according to IEC 62196-3:—	500 V DC
d)	Configuration FF according to IEC 62196-3:—	1 000 V DC

C.2 Communication

C.2.1 The general definitions and functions of the Proximity (PP) and Pilot (CP)

Signals /contacts are according to IEC 61851-1 (including detailed resistor definitions in Clause B.5) and SAE J1772™ with specific resistor values for configurations DD and FF given in Table C.2. A CP duty cycle of 5% shall be used according Annex A of IEC 61851-1:2010.

Table C.2

Definition of proximity resistor for configurations DD and FF

Proximity resistor (R6 acc. IEC 61851-1)	Maximum current for AC charging	DC connector
1500 Ω	Not applicable	Configuration FF
680 Ω	20 A	Configuration DD
220 Ω	32 A	Configuration DD
100 Ω	63 A	Configuration DD

C.2.2 Charge control communications between the DC supply and the EV are specified in IEC 61851-24:—.

The physical layer for charge control communications shall comply with ISO/IEC 15118-3:—.

Equivalent requirements for the physical layer of communications are in SAE J2931/4.

C.3 UNDER CONSIDERATION.

Communication is achieved by PLC on CP and PE/ground contacts. Contact assignments of the different connectors are in IEC 62196-3:—. Charge control communications shall comply with DIN SPEC 70121. Charge control communications shall also comply with ISO/IEC 15118-2:—. Equivalent requirements for charge control communications are in SAE J2836/2™, SAE J2847/2 and SAE J2931/1.

C.3.1 **General**

The process of supplying energy to the EV by the DC supply is initiated and controlled by the messages sent over PLC and shall follow the sequences shown in Figures C.1 to C.4, 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 (PLC)

Possible time period, in which described action can take place

In blue: communication signals and values described in ISO/IEC 15118-2:—

C.3.2 Normal start up

Sequence diagram and description for normal start up are shown in Figure C.1 and Table C.3.

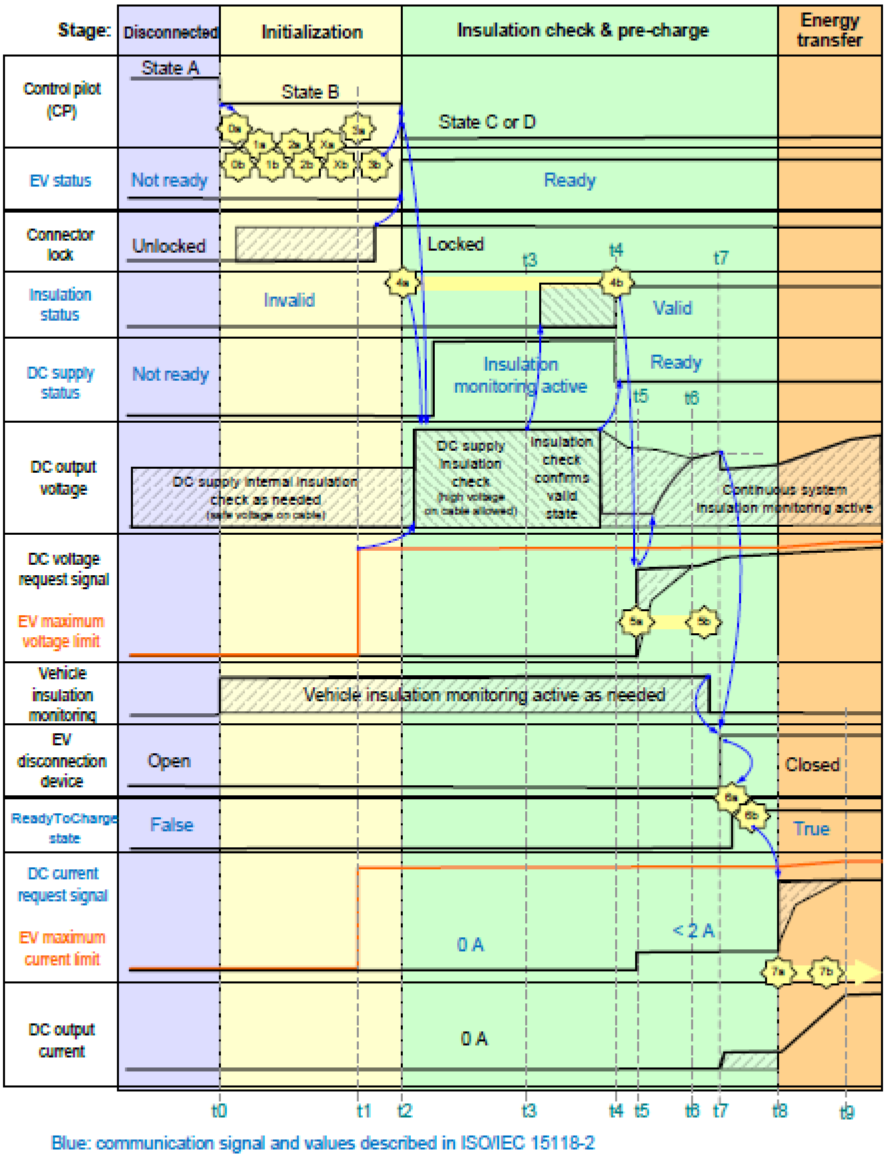


Figure C.1

Sequence diagram for normal start up

Table C.3

Sequence description for normal start up

Description	
(t0)	– Vehicle connector is plugged into vehicle inlet which changes CP state from A to B.
(t0→t1)	– High level communication (PLC) starts and handshaking with exchange of charging parameter stakes place. – DC supply checks if DC output voltage is less than 60 V and terminates supply session if 60 V is exceeded.
(t1)	– EV sends its maximum limits (amongst other parameters) for DC supply output current and voltage with <3a>.
(t1 → t2)	– EV locks vehicle connector in its inlet. – 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 connector. – If EV and DC supply are not compatible, then the vehicle will not go to Ready, and will transition to step t16 in the normal shutdown sequence.
(t2)	– EV changes CP state from B to C/D by closing S2 and sets EV status “Ready”, which ends initialization phase.
(t2 → t3)	– EV requests cable and insulation check by <4a> after connector lock has been confirmed. – DC supply starts checking HV system insulation and continuously reports insulation state by <4b>.
(t3)	– DC supply determines that insulation resistance of system is above 100 kΩ (cf. C.4.1).
(t3→ t4)	– After having successfully finished the insulation check, DC supply indicates status ”Valid” with subsequent message <4b>
(t4)	– DC supply status changes to “Ready” with Cable Check Response <4b>
(t5)	– Start of pre-charge phase with EV sending Pre-Charge Request <5a>, which contains both requested DC current <2A (maximum inrush current according to C.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 C.6.1)
(t6)	– DC output voltage reaches requested voltage within tolerances given in 12.2.1.2.

(t6 → t7)	– EV stops vehicle internal insulation monitoring, if any and necessary. – 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 20 V (cf. Note in C.5.1).
(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 Ready To Charge State “True” to enable DCpower supply output. – 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 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 defined in 12.2.1.3. (time span t9 – t8 = Td, if one request has been made, bold line shows this situation)
(t9→)	– EV adapts DC current request and DC voltage request according to its charging/supply strategy with cyclic message <7a>.

C.3.3 Normal shutdown

Sequence diagram and description for normal shutdown are shown in Figure C.2 and Table C.4.

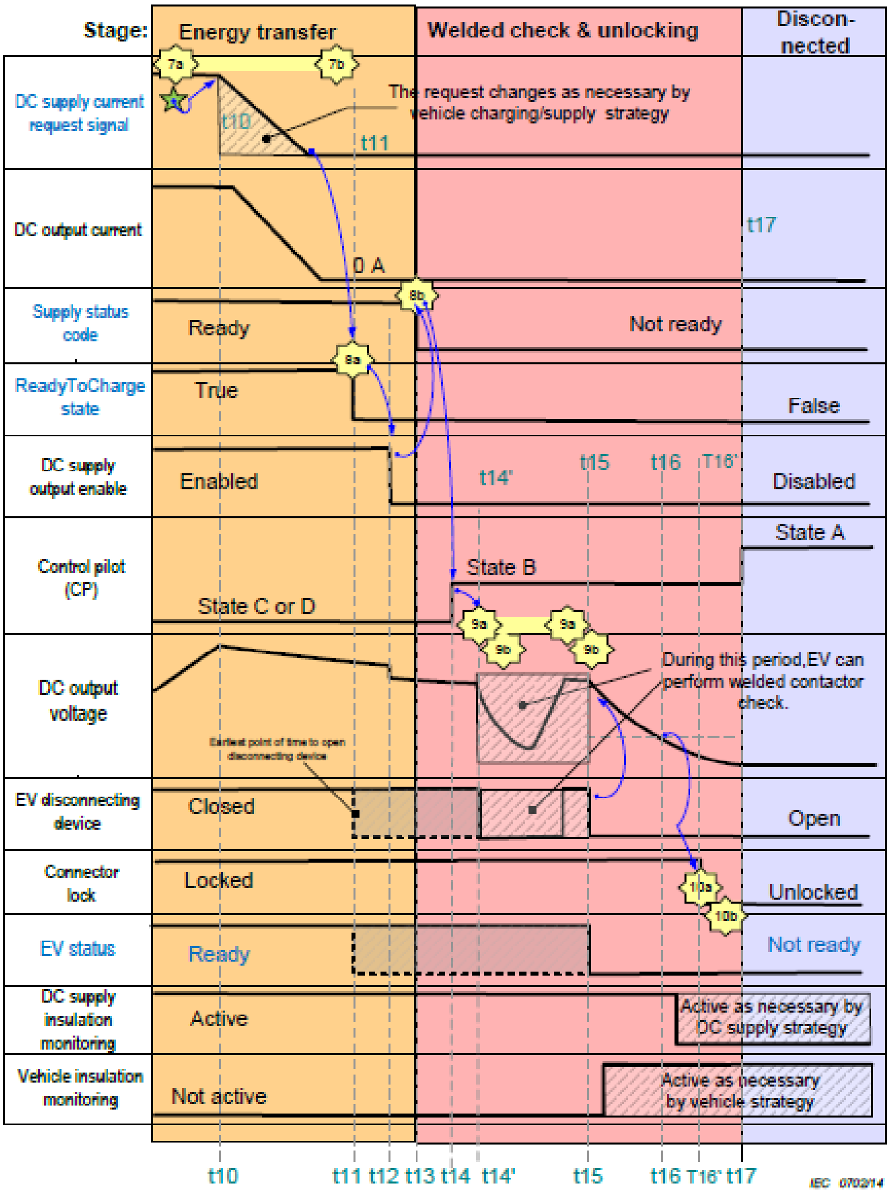


Figure C.2

Sequence diagram and description for normal shutdown

Table C.4
Sequence description for normal shutdown

Description	
(t10)	The EV reduces the current request to complete the energy transfer. Reduction is done on EV charging/supply strategy.
(t10 → t11)	DC supply shall follow current request with a time delay acc. to 12.2.1.3 and it shall reduce the output current to less than 1 A before disabling its output.
(t11)	The EV requests the DC supply to disable its output by sending message <8a> power delivery request With Ready To Charge State set to False.
(t11 → t12)	EV may open its disconnection device after current is below 1 A.
(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 <8a>with ”Read To Charge State” set to false. – DC supply shall not cause any current flow on EV input during discharge.
(t13)	DC supply reports status code ”Not Ready” with message <8b> to indicate it has disabled its output within 2 s.
(t14)	EV changes CP state to B after receiving message <8b> or after timeout to ensure that DC.. supply has discharged its output at latest by t14 (in case message <8a> was lost)
(t14')	EV can optionally perform its welded contactor check and indicate this to the DC supply with message<9a>.
(t14' → t15)	The vehicle may send multiple <9a> requests in order to read the DC supply output voltage measured by the DC supply in the response message <9b>
(t15)	Latest point in time for EV going into “Not Ready” status and opening its disconnecting device
(t15 → t16)	EV can start EV isolation monitoring, if any.
(t16)	EV unlocks the connector after DC output has dropped below 60 V.

(t16 →t16')	DC supply continues insulation monitoring dependent on DC supply strategy.
(t16')	– Session Stop Request with message <10a> terminates digital communication (PLC). – DC supply shall maintain state B2 (5 %) until 2 s to5 s after Session Stop Request was received and then change to B1 (100 %). NOTE If the EV wants to restart supply again, it locks the connector, asserts "EV Ready", after which it initialization phase starts from t1. The communications session may have to re-start from t0 if the modems have shutdown.
(t17)	Disconnecting of vehicle connector changes CP state from B to A.

C.3.4 DC supply initiated emergency shutdown

An emergency shutdown of the output current to less than 5 A within 1s 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 oscillator.

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

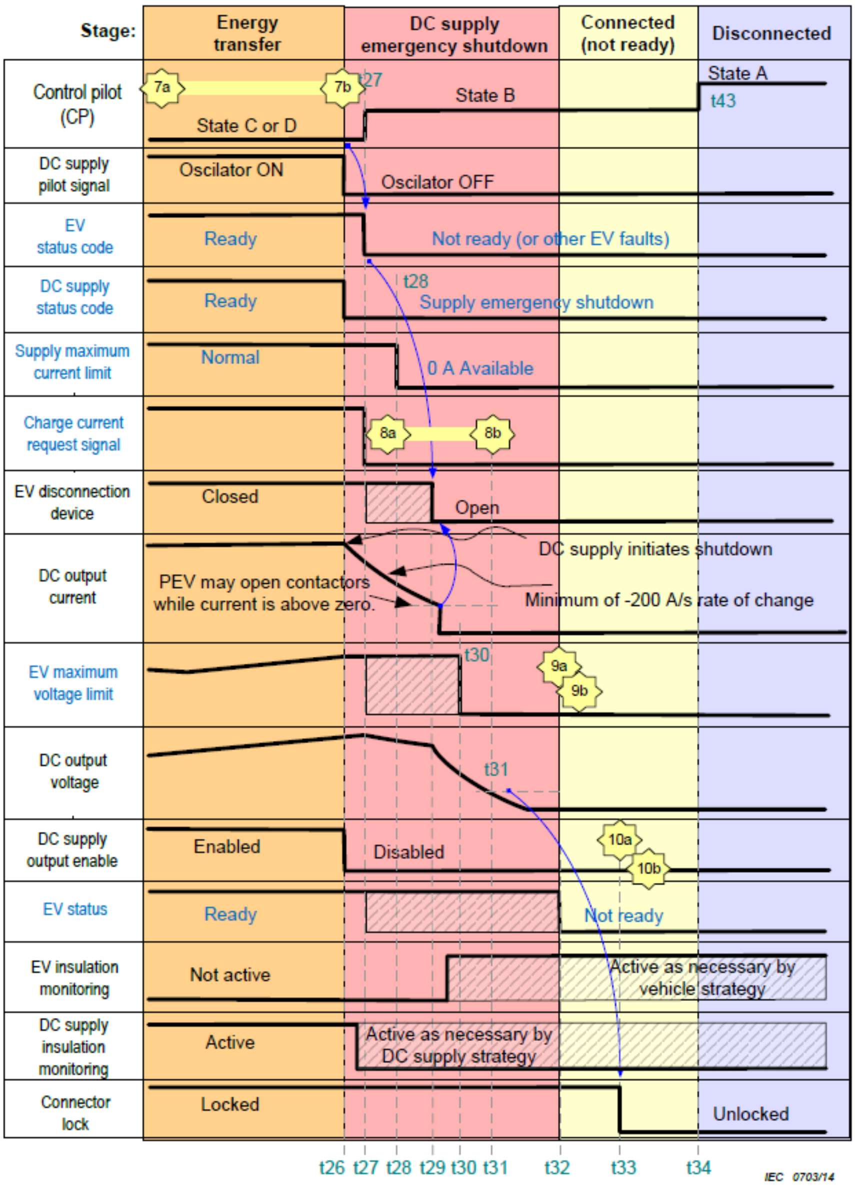


Figure C.3

Sequence diagram for DC supply initiated emergency shutdown

C.3.5 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 according to C.3.3.

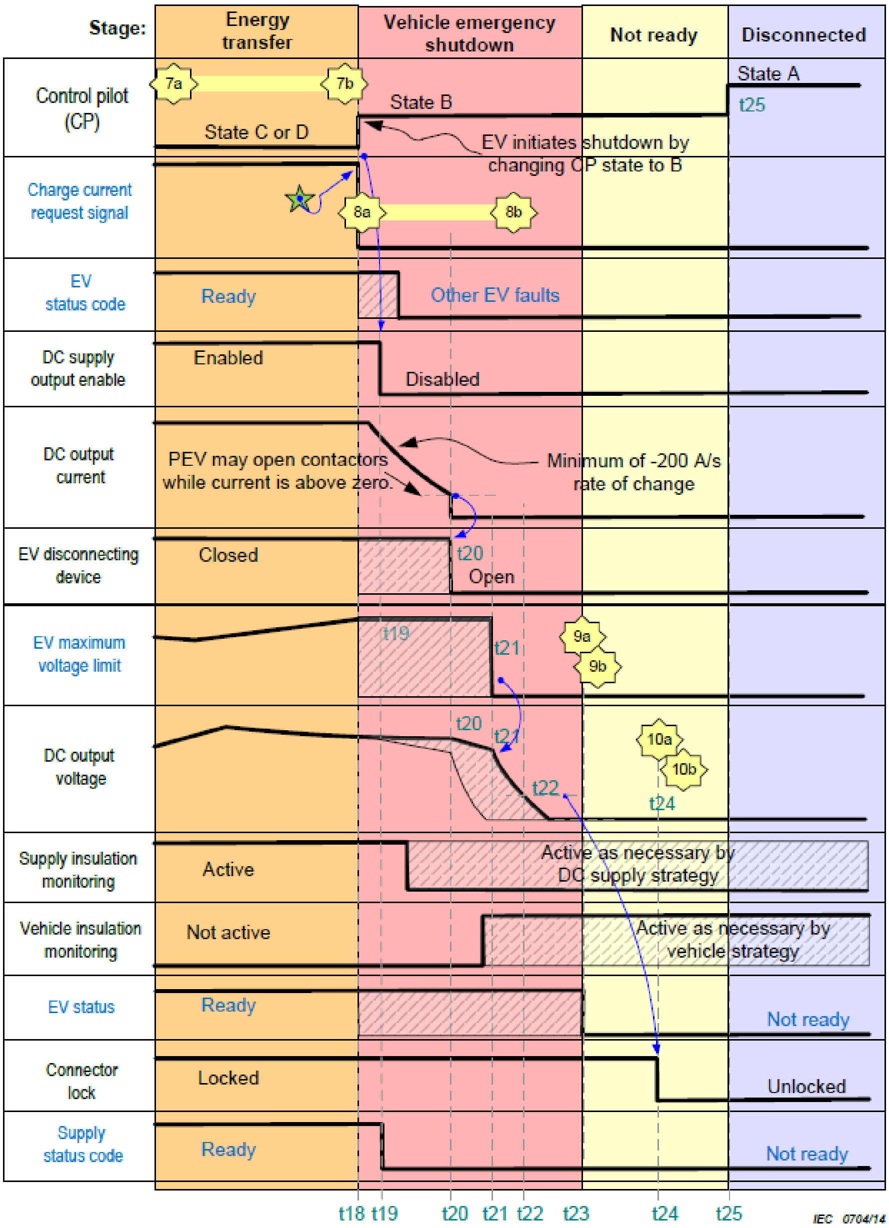


Figure C.4

Sequence diagram for EV initiated emergency shutdown.

C.4 SAFETY MEASURES

C.4.1 IT (isolated terra) system requirements

The secondary circuit (output side) of the DC supply shall be designed as an IT system and protection measures in accordance with 411 of IEC 60364-4-41:2005 shall be applied.

In case of using an insulation monitoring device (IMD), it 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.

Prior to each supply cycle the following tests shall be performed. During these tests the DC output voltage shall not exceed 500 V at vehicle connector.

a) 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:

1) Directly prior to supply cycle with vehicle connector plugged into vehicle inlet;

2) At regular intervals with maximum period of 1 h;

3) After self test has successfully been performed the station may stay in Valid state for a maximum time of 1 h and during supply session under normal conditions.

NOTE: The purpose is to check whether the whole system is being monitored, verifying the fault limit of the insulation resistance is not the purpose.

b) An insulation check of the system according to 6.4.3.10, e.g. by IMD shall be performed:

1) Vehicle connector not plugged into vehicle inlet: system comprises station, cable and vehicle connector, or

2) Vehicle connector plugged into vehicle inlet: system comprises station, charging cable, vehicle connector, vehicle inlet and vehicle cables

The insulation states of the system are defined as follows.

a) **Invalid state:** Self test has not been carried out yet. Charging is not allowed.

b) **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 go back into Invalid state.

c) **Warning state:** If the actual total physical insulation resistance between DC+/DC- to PE falls below a value calculated by 500 Ω/V multiplied by the maximum output voltage rating of the DC EV charging station (without negative tolerance) the DC supply shall send a Warning message and store the Warning.

d) **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 Ω/V multiplied by the maximum output voltage rating of the DC EV charging station (without negative tolerance) 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 ≤ 100 Ω/V.

If Warning or Fault state during energy transfer occurs, the station shall perform a self test after disconnecting the vehicle connector 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 serviced.

NOTE : The EV takes responsibility for time coordination of its IMD, if any. Prior to closing its EV-DC- relays (cf. time t8 in Figure CC1. the EV either turns off its IMD or it is guaranteed that no interference with the station's IMD occurs.

In case the DC supply does not use an IMD, the requirements of IEC 60364-4-41:2005, 411.6 and Table 41.1 shall be fulfilled. The following state shall be transmitted from the DC supply to the EV.

e) No IMD state: In case of no IMD inside DC supply.

C.4.2 **Temperature monitoring**

Temperature monitoring of the vehicle connector is required and shall be done by the DC supply to avoid overheating of vehicle connector. This function serves to protect during an abnormal condition and not intended to operate during normal conditions.

The station shall shutdown when the lower of the following 2 limits is exceeded:

– The vehicle connector contact temperature limit is exceeded; or

– The vehicle connector cable temperature rating is exceeded.

For vehicle connectors designed to operate with contact temperature greater than 120 °C, the DC EV charging station shall shutdown when the vehicle connector contact temperature reaches or exceeds 120 °C.

C.4.3 **Combined coupler lock function**

For all types of DC connectors according to Table C.1, the vehicle inlet shall provide a locking function to mitigate unintentional disconnecting of the vehicle connector from the vehicle inlet during energy supply.

NOTE: Additionally the locking function can include a means to diagnose the lock operation. Requirement is stated in ISO 17409.

C.4.4 **CP lost shutdown (for all connectors of configuration C)**

Fast emergency shutdown of the output current to less than 5 A within 30 ms shall be applied by the DC supply.

Shutdown is initiated by direct change of pilot from state C to state A due to interruption of the CP line. If an interruption of the pilot occurs the station shall latch the fault, which will prevent the station from going into ready mode until the station is serviced.

De-energization of the system shall be done within 100 ms according to Table A.7 in Part 1.

C.4.5 **PP lost shutdown (additionally with using connector configurations C and E)**

Fast emergency shutdown of the output current by the DC supply within 30 ms shall be applied. Shutdown is initiated by the EVSE and vehicle detecting the Proximity Circuit transitioning from no Proximity Circuit fault detected, S3 closed, to any other state. According to SAE J1772™ a +5 V PP voltage inside EV is applied (see Figure C.5).

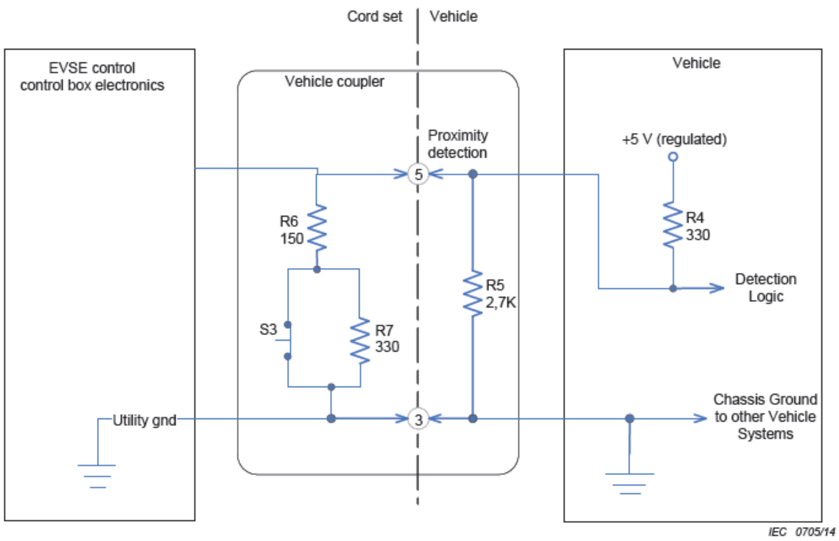


Figure C.5
Special components for configurations C and E coupler C

C.4.6 **Voltage check at initialization**

At beginning of supply session, with CP state A or B, the DC supply shall check if voltage on the cable is less than 60 V and shall terminate supply session if 60 V is exceeded.

C.4.7 **DC EV charging station maximum output Y capacitanc*e***

The maximum total parallel Y capacitance shall not exceed 1 μF. This implies Y capacitance ≤500 nF across each DC rail and ground for a DC EV charging station with Y capacitance equally distributed between each DC rail and ground.

C.5 ADDITIONAL FUNCTIONS

C.5.1 **Pre-charging**

Pre-charging for voltage matching shall be done by DC EV charging station according to the requirements given in 12.2.1.6.

NOTE When EV closes its relays, voltage difference between output of DC EV charging station and battery voltage of EV is lower than 20 V.

C.5.2 **Wake up of DC supply by EV**

The DC supply may support a standby mode to minimize power consumption as described as optional function in 6.4.4.2. In this case it is mandatory for the DC supply to wake up and resume energy supply according to the following method.

– If the vehicle attached to the DC supply has not changed the control pilot from state B2 to C2 or D2 for more than 2 min, the station may go to sleep.

The control pilot signal B1 shall be supplied continuously by the DC supply to enable a wakeup of the station triggered by the EV changing into state C1 or D1.

C.5.3 **Provision for manual unlocking of vehicle connector**

A means may be provided by the EV to manually unlock the vehicle connector even in case the voltage at the output stays higher than 60 V after the termination of the energy supply.

NOTE C.5.4 and C.5.5 are applicable.

C.5.4 **Configuration C connector latch position switch (S3) activation**

Latch position switch (S3) of the configuration C connector shall not be able to be actuated when the vehicle connector is locked to the vehicle inlet.

Standard sheet 3-III of IEC 62196-3:— provides location requirements of the vehicle inlet lock feature to be used to meet this requirement.

C.5.5 **Configuration C connector latch and latch position switch (S3) verification**

A supply cycle shall only be allowed once the DC EV charging station checks for the existence of the configuration C connector latch and the function of the latch position switch (S3) prior to connecting the vehicle connector to the vehicle inlet.

C.6 SPECIFIC REQUIREMENTS

C.6.1 **Turn on inrush current (DC side)**

Any inrush current on DC side in both directions when closing of EV disconnection device and station contactors, if any, shall not exceed 2 A. DC supply shall be responsible for limiting the inrush current, e.g. by applying a pre-charging circuit as shown in Figure C.3.

NOTE Higher current values for short time under 1 ms can appear for charging and discharging of cable capacitance.

C.6.2 **Protection against overvoltage of battery**

The DC supply shall trigger a DC supply initiated emergency shutdown according to C.4.3 in order to prevent overvoltage at the battery, if output voltage exceeds maximum voltage limit sent by the vehicle for 400 ms. (See 6.4.3.11).

C.6.3 **Requirements for load dump**

Worst case of load dump is a reduction of output current from 100 % nominal value to 0 %, e.g. caused by disconnecting the vehicle battery while other loads in the EV stay connected.

In any case of load dump, voltage overshoot shall not exceed 110 % of the maximum voltage limit requested by the vehicle (See 12.2.1.7).

Maximum slew rate of output voltage in case of load dump shall not exceed 250 V/ms.

C.6.4 **DC output current regulation.**

When in current regulation mode, the DC charger 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:

- ±150 mA when the commanded current value is less than or equal to 5 A;
- ±1.5 A when the commanded current value is greater than 5 A but less than or equal to 50A;
- ±3 % of the DC charger's maximum current output when the commanded current value is greater than 50 A.

C.6.5 **Measuring current and voltage**

The accuracy of output measurement of system C shall be within the following values:

– Voltage: ± 10 V,

– Current: ≤ 50 A.

The measured current reported shall be within ±1.5% of reading, but not better than ± 0.5 A.

C.7 Schematics and description

Schematics of combined charging system for DC supply is given in Figure C.6, as well the definition and description of symbols and terms in Table C.5.

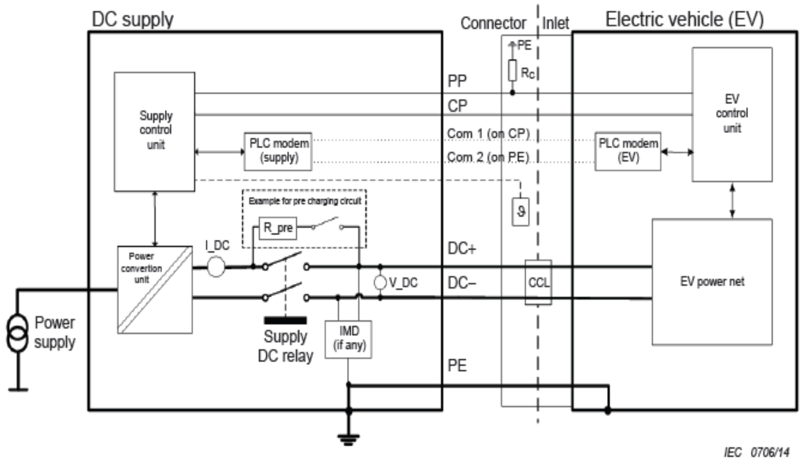


Figure C.6

System schematics of combined DC charging system

PP line from vehicle connector to DC supply is mandatory for configurations C and E and optional for configurations D and FF couplers.

NOTE 1 The supply DC relay can be substituted by a diode.

NOTE 2 Temperature monitoring can be with or without connection to the DC supply control unit.

NOTE 3 Diagram shows functional description of interface. Contact assignment of vehicle coupler is done in IEC 62196-3.

NOTE 4 Special components for configurations C and E, see Figure C.2.

Table C.5

Definition and description of symbols / terms

DC supply		Electric Vehicle (EV)		Interface Circuit	
Symbols/ terms	Definitions	Symbols/ terms	Definitions	Symbols / terms	Definitions
V_DC	Voltage measure-ment at output of DC supply	PLC modem (EV)	EV communica-tion interface between PLC and internal EV communica-tion	PE	Protective conductor
I_DC	Current measure-ment (on DC+ or DC- or both)	EV control unit	Unit for communica-ting from EV to the DC supply and verifying safety procedure	DC+	DC power supply (positive)
Power conversion unit	Galvanical-ly isolated power stage for converting mains power supply into regulated DC power for EV supplying	EV power net	Subsystem within the EV related to be supplied with energy from the DC supply.	DC-	DC power supply (negative)

Supply DC relay	All-line-relay to connect and disconnect DC output of DC supply to power conversion unit [a]			Com1	(Positive) line for PLC [c]
PLC modem (supply)	Supply communica-tion interface between PLC and internal supply communica-tion			Com2	(Negative) line for PLC
Supply control unit	Unit for control of supply process within DC supply and communica-ting with EV			PP (proximi-ty)	General functions according to IEC 61851-1 with definition of values in table C.2 for configurati-ons D and FF and SAE J1772TM with +5 V PP voltage inside EV for DC supply with configurati-ons C and E.

R_pre	Resistor for pre-charging circuit [b]			CP (control pilot)	Function acc. to IEC 61851-1 Also used for emergency shutdown of DC supply by EV going into state B or interruption of control pilot for CP lost shutdown.
IMD	Insulation monitoring device			RC	Proximity-resistor used for coding of cable current capability in case of AC supply acc. values in IEC 61851-1.
				CCL (correct contact & locking)	Feedback of correct contact and locking of DC vehicle connector
				ϑ	Temperature monitoring of vehicle connector by DC supply

[a] The supply DC-relay may be substituted by a diode.

[b] Switch and resistor are recommended for implementation of mandatory pre-charging function.

[c] Refer to Table C.1 for different connectors.

ANNEX D
Typical DC Charging Systems
(Informative)

This annex shows typical diagrams and variation of DC EV charging systems. Examples of typical isolated system, non-isolated system, simplified isolated system and DC mains system are shown in Figures D.1, D.2, D.3 and D.4. Table D.1 provides an example for categories of DC supply system to electric vehicles

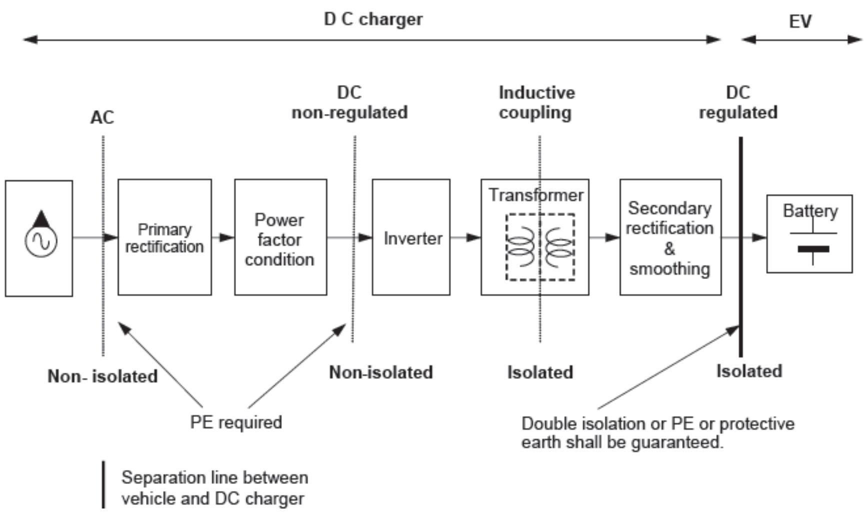


Figure D.1

Example of typical isolated system

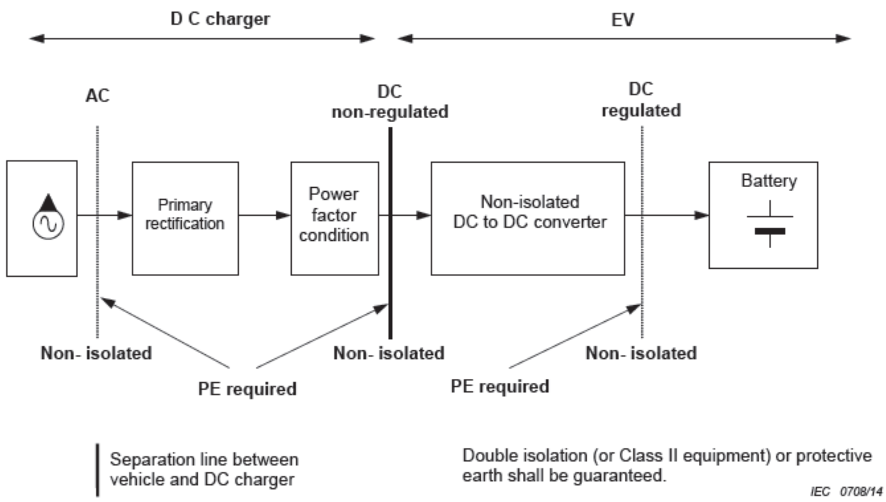


Figure D.2

Example of typical non-isolated system

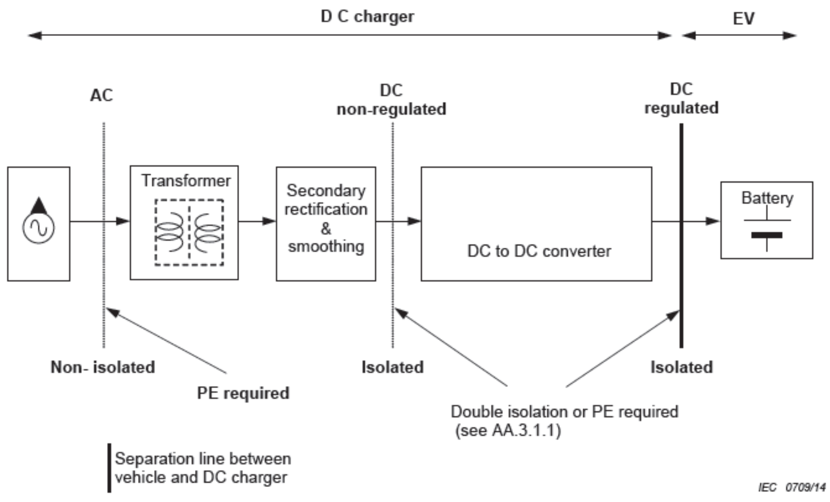


Figure D.3
Example of simplified isolated system

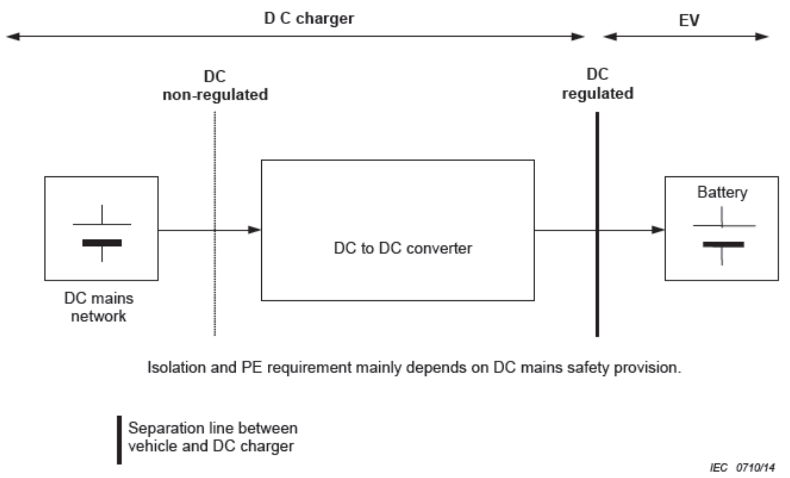


Figure D.4
Example of DC mains system

Table D.1
Example for categories of DC supply system to electric vehicles

Parameters	Categories
1. Isolation	A DC supply system can be: a) isolated, or b) non-isolated, with one or more than one charging stations connected to the AC source.
2. Regulation	A DC supply system can be: a) regulated, or b) non-regulated. When non-regulated, a full equipotential bonding (functional earth) wire is required.

3. Voltage (Vdc)	A DC supply system can operate at a maximum voltage level of: a) <60 V (e.g. light electric vehicles like scooters); b) 60 V to 600 V (e.g. passenger cars); c) 600 V to 1 000 V (e.g. passenger cars and heavy duty vehicles); d) >1 000 V (e.g. heavy duty vehicles – buses and trucks).
4. Current	A DC supply system can supply a maximum current output of, e.g. a) <80 A b) 80 A to 200 A c) 200 A to 300 A
5. Charge control communication	The EV and/or the DC supply system can: a) communicate by digital messages and analog signals, or b) communicate only by analog signals, using: – dedicated communication contacts, or – over power lines.
6. Interface interoperability	A DC supply system may be: a) dedicated to one or more EVs, or b) interoperable with any EV (non-dedicated, can be used by any consumer).
7. Operator	A DC supply system may be: a) Dedicated to one or more EVs, or b) Interoperable with any EV (non-dedicated, can be used by any consumer).
8. Regulating method	A DC supply system may be used in: a) CCC mode for opportunity charging / bulk charging to 80 % SOC, as a non-continuous load (<3 h); b) CVC mode for full charge / cell balancing to 100 % SOC, as a continuous load(>3 h); c) both modes.

The EV and/or the DC supply system can

a) Communicate by digital messages and analog signals, or

b) Communicate only by analog signals, using:

- Dedicated communication contacts, or
- Over power lines.

Typical voltage ranges for isolated DC EV charging stations are as shown in Table D.2.

Table D.2
Typical voltage ranges for isolated DC EV charging stations

	Voltage range	Example of application
1	40 V to 500 V	Electric scooters, Passenger vehicles
2	400 V to 800 V	Electric buses
NOTE: Full current control would be maintained between these above defined voltage ranges. Specific current supply conditions may exist below these voltage ranges.		

ANNEX E
Typical Configuration of DC Charging System
(Informative)

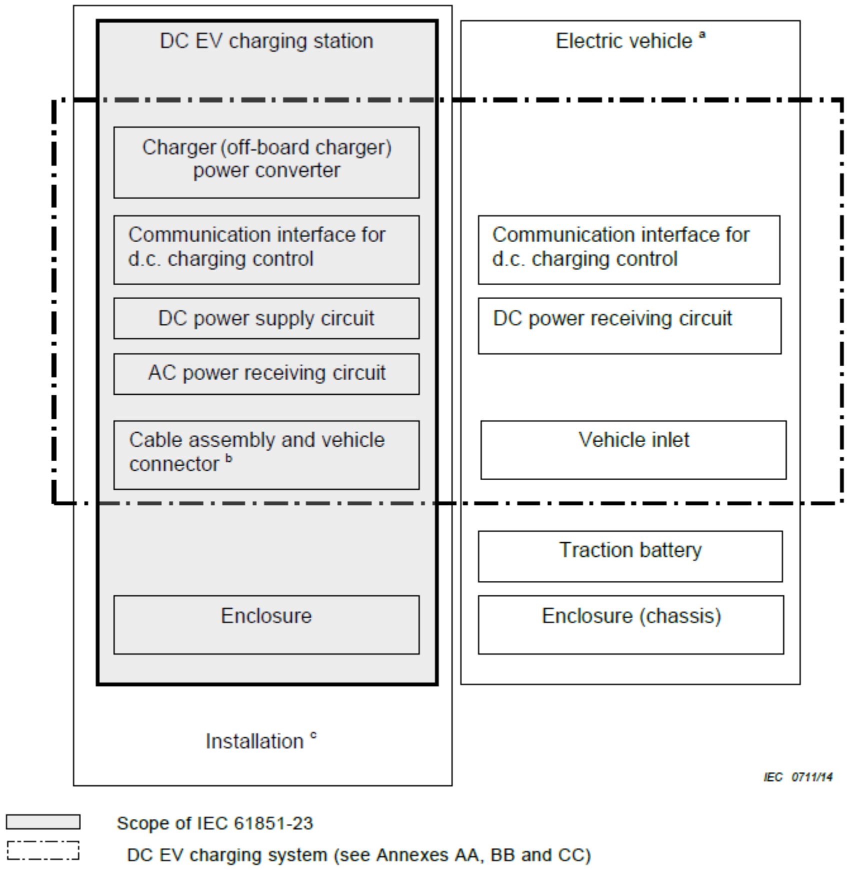


Figure E.1
Typical configuration of DC charging system.

[a] Including information on element of EV for conductive connection.

[b] Detailed requirements for DC vehicle couplers are defined in IEC 62196-3. Requirements for cable assemblies are specified in IEC 62196-1.

[c] Installation (see IEC 60364-7-722) is also applicable for mobile chargers.

ANNEX F

Digital communication for control of DC EV charging system A (normative)

F.1 General

This annex shows the specification of digital communication for control of the DC EV charging station of system A (in this annex, referred to as "system A station" or "station") as specified in Annex AA of IEC 61851-23:—. More detailed information on system A is defined in JIS/TSD0007.

F.2 Digital communication actions during charging control process

The communication actions and parameters according to the charging control process as defined in Table 103 of IEC 61851-23:— are shown in Table F.1.

Table F.1

Communication actions and parameters during DC charging control process between system A station and vehicle (1 of 2)

Charging control stage		State	High level action at system level *	Digital communic-ation action	Parameter	
					From DC EV charging station	From vehicle
Initialization	Handshaking	DC-A	Vehicle unconnected	None	N/A	N/A
		DC-B1	Connector plugged in	None	N/A	N/A
		DC-B1	Wake up of DCCCF and VCCF	None	N/A	(default CAN)
		DC-B1	Communication data initializat-ion	Preparat-ion for digital communic-ation	(default CAN)	(default CAN)

		DC-B1→ DC-B2	Communic-ation established, parameters exchanged, and compatibil-ity checked	Exchange of charging control parameters	– Control protocol number – Available output voltage – Available output current – Battery incompatibility	– Control protocol number – Rated capacity of battery – Maximum battery voltage – Maximum charging time – Target battery voltage – Vehicle charging enabled
	Charge Preparation	DC-B2 →DC-B3	Connector locked	Notification of connector locked status	Vehicle connector lock	None
		DC-B3	Insulation test for DC power line	None	Charging system malfunction	None
		DC-B3	Pre-charge (depending on the system architecture)	N/A	N/A	N/A
En rgy transfer Preparation		DC-C or DC-D	Vehicle side contactors closed	Notification of vehicle main contactor closed status	None	None
		DC-C or DC-D	Charging by current demand (for CCC)	Notification of request value of charging current (or voltage)	– Station status – Output voltage – Output current – Remaining charging time – Station malfunction – Charging system	– Charging current request – Charging system fault – Vehicle shift lever position

				malfunction	
	DC-C or DC-D	Charging by voltage demand (for CVC)	N/A	N/A	N/A
	DC-C,(D) →DC-B’1	Current suppression	Request of energy transfer shut-off	– Station status – Charging stop control – Output voltage – Output current	Vehicle charging enabled
Shutdown	DC-B’1	Zero current confirmed	Notification of energy transfe shut-off	– Station status – Charging system malfunction	
	DC-B’1→ DC-B’2	Welding detection (by vehicle)		None	None
	DC-B’2	Vehicle side contactors open	None	None	None
	DC-B’2	DC power line voltage verification	Notification of present voltage	Output oltage	None
	DC-B’3	Connector unlocked	Notification of connector unlocked status	Vehicle connector lock	None
	DC-B’4	End of charge at communication level	Terminate the digital communication	None	None
	DC-A	Connector unplugged		N/A	N/A
*The order of actions does not refer to the procedure of charging control process.					

F.3 Digital communication of DC charging control

The parameters for digital communication of DC charging control shall be exchanged according to the sequence diagram as shown in Figure F.1.

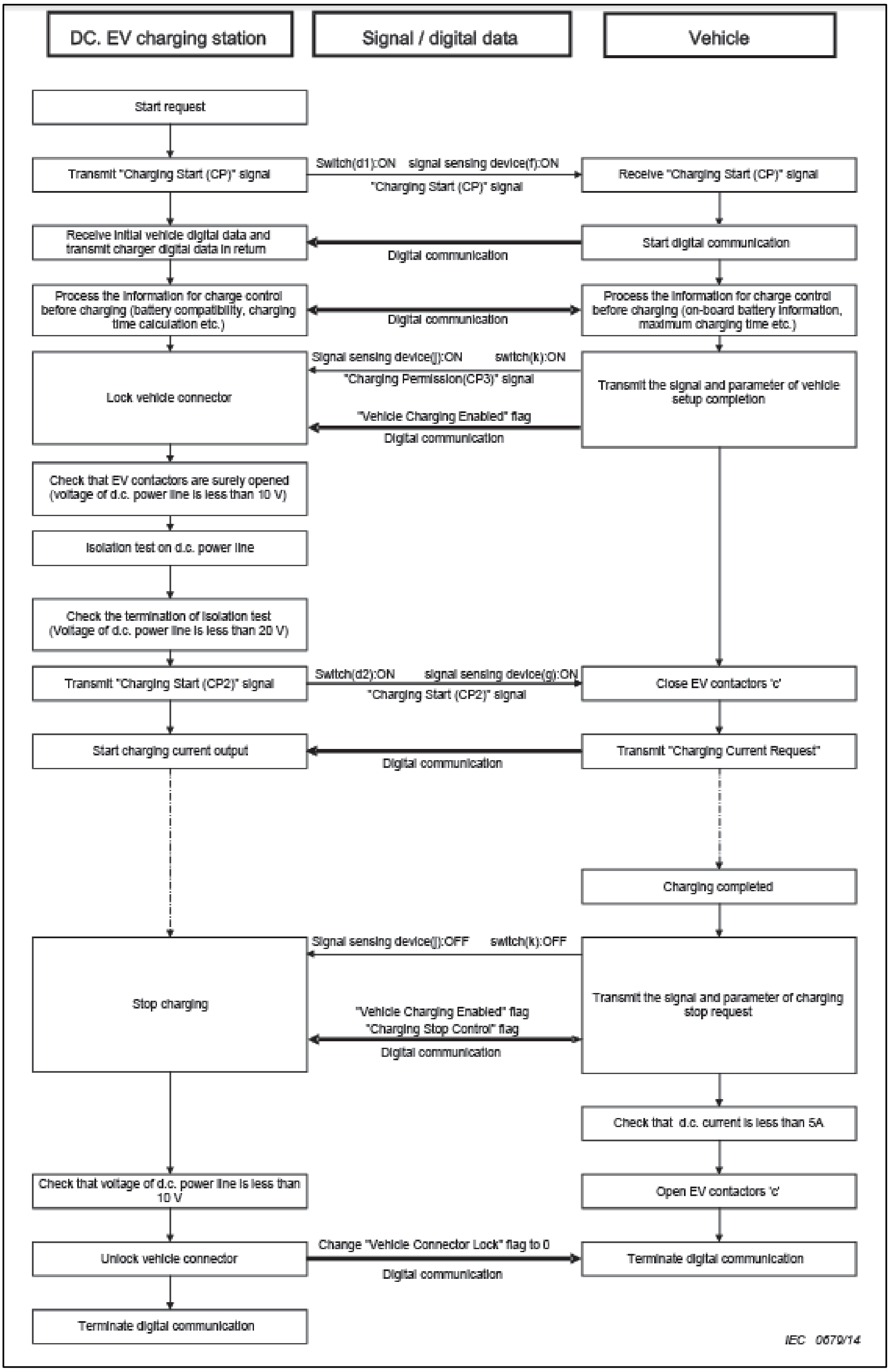


Figure F.1
Sequence diagram of DC charging control communication for system A

F.4 Parameter definition

The definition of parameters during DC charging control process are shown in Table F.2.

Table F.2 – Exchanged parameter during DC charging control process between system A station and vehicle (1 of 4)

Item in Table 1	Parameter	Content	CAN ID ID.byte(bit)	Source	Destination	Data update rate	Unit	Status flag	Resolution (range)
b-2	Maximum battery voltage	The maximum voltage value at the vehicle inlet terminals, at which the station stops charging to protect the vehicle battery	H'100.4, H'100.5	EV	System A station	100 ms	V	-	1 V/bit
	Rated capacity of battery	Rated capacity of battery	H'101.5, H'101.6	EV	System A station	100 ms	kWh	-	0,11 kWh/bit
	Constant of charging rate indication	Fixed value for charging rate indication, which is the maximum charging rate (100 %) of vehicle battery	H'100.6	EV	System A station	100 ms	%		1 % bit,100 % (fixed)
	Maximum charging time (set by 10 s)	Maximum charging time permitted by EV, set by 10 s	H'101.1	EV	System A station	100 ms	s	-	10 s/bit (0 to 2 540 s)
	Maximum charging time (set by minute)	Maximum charging time permitted by EV, set by minute	H'101.2	EV	System A station		min		1 min/bit (0 to 255 min)
	Estimated charging time	Estimated remaining time before the end of charging calculated by EV	H'101.3	EV	System A station	100 ms	min	-	1 min/bit (0 to 254 min)
b-1	Control protocol number	Software version of control protocol to which EV corresponds	H'102.0	EV	System A station	100 ms		-	1/bit (0 to 255)
	Target battery voltage	Targeted charging voltage at the vehicle inlet terminals	H'102.1, H'102.2	EV	System A station	100 ms	V	-	1 V/bit (0 to 600 V)
a-1	Charging-current-request	Current value requested by EV during charging	H'102.3	EV	System A station	100 ms	A	-	1 A/bit (0 to 255 A)
	Charging rate	Charging rate of vehicle battery	H'102.6	EV	System A station	100 ms	%		1 %/bit (0 % to 100 %)
g	Vehicle charging enabled	Status flag indicating charge permission status of EV	H'102.5(0)	EV	System A station	–	–	0: disabled, 1: enabled	
	Vehicle shift lever position	Status flag indicating the shift lever position	H'102.5(1)	EV	System A station	–	–	0: "Parking" position, 1: other position	
	Charging system fault	Status flag indicating a malfunction caused by EV or the station, and detected by EV	H'102.5(2)	EV	System A station	–	–	0: normal, 1: fault	
	Vehicle status	Status flag indicating the EV contactor status	H'102.5(3)	EV	System A station	–	–	0: EV contactor closed or during welding detection, 1: EV contactor open or welding detection finished	
	Normal stop request before charging	Status flag indicating the request of EV to stop charging control	H'102.5(4)	EV	System A station	–	–	0: no request, 1: request to stop	
	Battery overvoltage	Status flag indicating whether or not the vehicle battery voltage exceeds the maximum limit specified by EV	H'102.4(0)	EV	System A station	–	–	0:normal, 1: fault	
	Battery undervoltage	Status flag indicating whether or not the vehicle battery voltage is less than the lower limit specified by EV	H'102.4(1)	EV	System A station	–	–	0:normal, 1:fault	
	Battery current deviation error	Status flag indicating whether or not the output current deviates from EV requested current	H'102.4(2)	EV	System A station	–	–	0:normal, 1: fault	
	High battery temperature	Status flag indicating whether or not the temperature of vehicle battery exceeds the maximum limit	H'102.4(3)	EV	System A station	–	–	0:normal, 1:fault	
	Battery voltage deviation error	Status flag indicating whether or not the vehicle battery voltage deviates from the output voltage measured by the station	H'102.4(4)	EV	System A station	–	–	0:normal, 1: fault	
h-2	EV contactor welding detection support identifier	Identifier indicating whether or not the station deals with EV contactor welding detection	H'108.0	System A station	EV	100 ms		0:not supporting vehicle welding detection, 1 or more: supporting vehicle welding detection	
a-3	Available output voltage	Maximum output voltage value at the vehicle connector terminals	H'108.1, H'108.2	System A station	EV	100 ms	V	-	1 V/bit (0 to 600 V)
a-4	Available output current	Maximum output current value of the station	H'108.3	System A station	EV	100 ms	A	-	1 A/bit (0 to 255 A)
b-2	Threshold voltage	Threshold voltage to stop the charging process in order to protect vehicle battery	H'108.4, H'108.5	System A station	EV	100 ms	V		1 V/bit (0 to 600 V)
b-1	Control protocol number	Software version number of control protocol or charging sequences that the station deals with	H'109.0	System A station	EV	100 ms			1 / bit (0 to 255)
	Output voltage	Supply voltage value of the output circuit in the station	H'109.1, H'109.2	System A station	EV	100 ms	V	-	1 V/bit (0 to 600 V)

Item in Table 1	Parameter	Content	CAN ID ID.byte(bit)	Source	Destination	Data update rate	Unit	Status flag	Resolution
	Output current	Supply current value of the output circuit in the station	H'109.3	System A station	EV	100 ms	A	-	1A/bit (0 to 255 A)
	Remaining charging time (counted by 10 s)	Remaining time before the end of charging (counted by 10 s)	H'109.6	System A station	EV	100 ms	s		10 s/bit (0 to 2540 s)
	Remaining charging time (counted by min)	Remaining time before the end of charging (counted by min)	H'109.7	System A station	EV	100 ms	min		1 min/bit (0 to 255 min)
c h-1	Station status	Status flag indicating the energy transfer from the station	H'109.5(0)	System A station	EV	100 ms	-	0: standby, 1: charging	
	Station malfunction	Status flag indicating whether or not there is a malfunction caused by the station	H'109.5(1)	System A station	EV	100 ms	-	0: normal, 1: fault	
	Vehicle connector lock	Status flag indicating the electromagnetic lock status of vehicle connector	H'109.5(2)	System A station	EV	100 ms	-	0: unlocked, 1: locked	
	Battery incompatibility	Status flag indicating the compatibility of vehicle battery with the output voltage of station	H'109.5(3)	System A station	EV	100 ms	-	0:compatible, 1: incompatible	
d	Charging system malfunction	Status flag indicating whether or not there is a problem with EV, such as improper connection	H'109.5(4)	System A station	EV	100 ms	-	0: normal, 1: malfunction	
e	Charger stop control	Status flag indicating whether or not the station proceeds with shutdown process	H'109.5(5)	System A station	EV	100 ms	-	0: operating, 1: shutdown or stop charging	

F.5 Physical/data link layer

F.5.1 Specifications

The physical/data link layer specifications are shown in Table F.3.

Table F.3 – The physical/data link layer specifications for system A

Communication system	Communication protocol	ISO 11898-1 and ISO 11898-2 The extension bit (12 − 29 bit) is not used.
	Transmission rate (kbps)	500
	Cycle	100 ms ± 10 %

F.5.2 Communication circuit

The CAN communication circuit is established to exchange parameters, i.e. voltage, current,
status flags, and fault flags, which are necessary for the charging control.
– Terminating resistor

1:1 communication is assumed. The vehicle and the DC EV charging station shall be equipped with terminating resistors.

– Noise filter

The vehicle and the DC EV charging station shall be equipped with noise filters to reduce the conducted noise of the common mode and differential mode.

– Twisted-pair line

Twisted pair line shall be utilized as the communication line that links the DC EV charging station with the vehicle so as to reduce differential mode noise.

– CAN transceiver

CAN transceiver shall be equipped to send and receive CAN communication data.

The CAN-bus circuit shall be established independently for DC charging, as shown in Figure F.2.

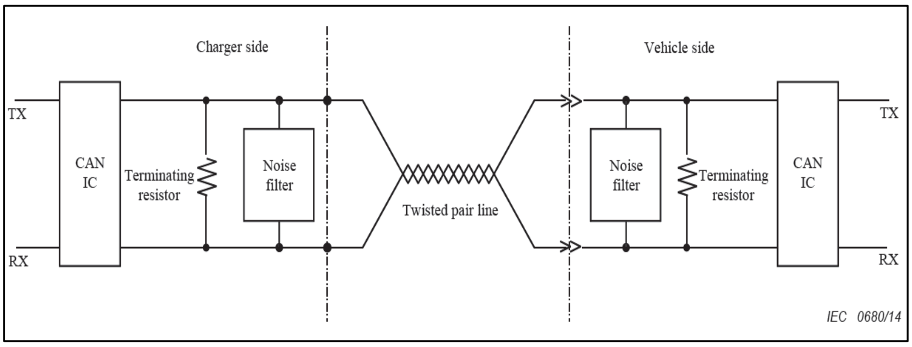


Figure F.2
CAN-bus circuit diagram

F.5.3 **Transmission**

Data frames shall be transmitted in ascending order of ID number specified in Table F.1. The data frames shall be continuously transmitted at 100 ms (± 10 %) interval through the charging process.

F.5.4 **Reception**

When the vehicle or the DC EV charging station receives data frames from the other party, the received frames should not be echoed. Furthermore, the received error frames shall be destroyed.

F.5.5 **CAN communication**

Figure F.3 shows the basic specifications related to the dedicated CAN communication between the vehicle and the DC EV charging station.

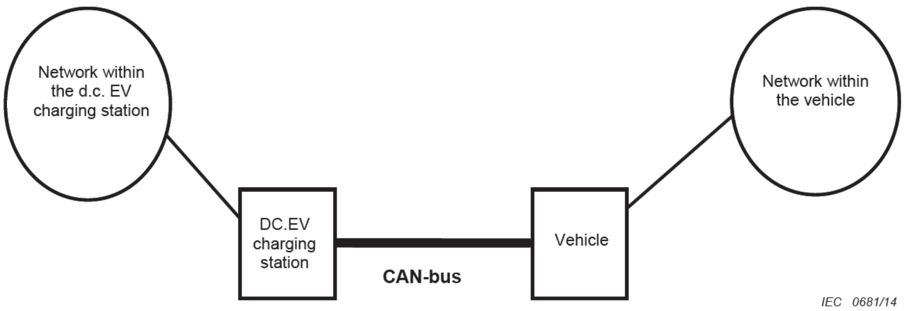


Figure F.3

Dedicated CAN communication between vehicle and DC EV charging station

ANNEX G

Digital communication for control of DC EV charging system B (normative)

G.1 General

This annex shows the specification of DC charging control digital communication for the DC EV charging station of system B (in this annex, referred to as "System B station" or "charger") as specified in Annex BB of IEC 61851-23.

G.2 Digital communication of DC charging control

The parameters for digital communication of DC charging control shall be exchanged according to the sequence diagram as shown in Figure G.1.

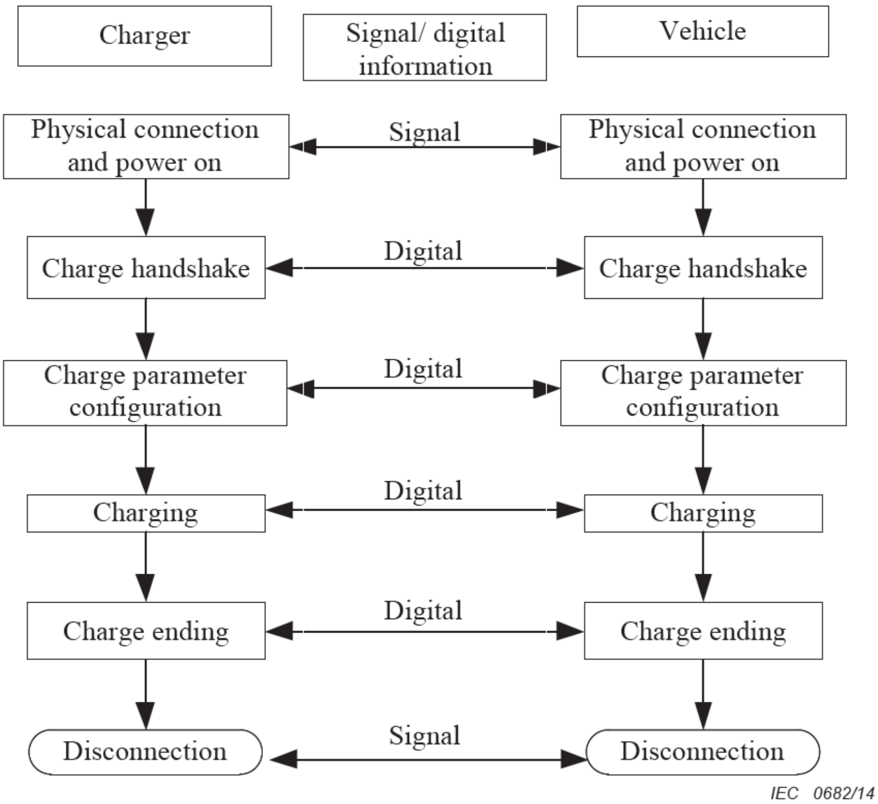


Figure G.1

Sequence diagram of DC charging control communication for system B

G.3 Digital communication actions during charging control process

The communication actions and parameters during DC charging control process are shown in Table G.1

Table G.1

Communication actions and parameters during DC charging control process between system B station and vehicle

Charging control stage (process)	Digital communication action	Information	Source	Destination	Parameter cycle
Handshaking	Confirm the necessary parameters of battery and charger.	Charger recognition parameter	Charger	Vehicle	250 ms
		Vehicle recognition parameter	Vehicle	Charger	250 ms
Charging parameter configuration	Exchange of charging control parameters.	Battery charge parameter	Vehicle	Charger	500 ms
		Charger time synchronization	Charger	Vehicle	500 ms
		Charger max/min output parameter	Charger	Vehicle	250 ms
		Vehicle charge ready	Vehicle	Charger	250 ms
		Charger output ready	Charger	Vehicle	250 ms
Charging stage	Send charging status to each other, according to the battery charge level requirements sent by Vehicle; the charger adjusts the charging process.	Battery charge requirement	Vehicle	Charger	50 ms
		Charger charge status	Charger	Vehicle	50 ms
		Battery charge status 1	Vehicle	Charger	250 ms
		Battery charge status 2	Vehicle	Charger	250 ms
		Battery cell voltage	Vehicle	Charger	1 s
		Battery temperature	Vehicle	Charger	1 s
		Vehicle stopping command	Vehicle	Charger	10 ms
		Charger stopping command	Charger	Vehicle	10 ms
Charging ending stage	Energy transfer shut-off.	Vehicle statistic data	Vehicle	Charger	250 ms
		Charger statistic data	Charger	Vehicle	250 ms
Communication error	Restart communication program or stop charging process.	Vehicle receiving error	Vehicle	Charger	250 ms
		Charger receiving error	Charger	Vehicle	250 ms

G.4 Parameter definition

The definition of parameters during DC charging control process are shown in Tables G.2, G.3, G.4, G.5 and G.6.

Table G.2

Parameters in charge handshake stage for system B

Information	Parameter	M[a] /O[b]	Unit	Resolution	Status flag	Item in Table 1
Charger recognition parameter	Recognition result	M	-	-	0x00: unrecognized 0xAA: recognized	-
	Charger number	M	-	-	-	-
	Charger/charge station location code	O	-	-	-	-
Vehicle recognition parameter	Vehicle communication protocol version	M	-	-	-	b-1
	Battery type code	M	-	-	-	-
	Battery system rated capacity	M	Ah	0,1 Ah/bit	-	-
	Battery system rated voltage	M	V	0,1 V/bit	-	-
	Battery manufacturer code, ASCII	O	-	-	-	-
	Battery pack number	O	-	-	-	-
	Battery pack product date	O	-	-	-	-
	Battery pack charging times	O	-	1/bit	-	-
	Battery pack property right mark	O	-	-	0: Lease 1: Private	-
	Vehicle identification number (VIN)	O	-	-	-	-

[a] M = Mandatory

[b] O = Optional

NOTE The communication protocol version includes 3 bytes. The current version is V1.0, which is expressed: Byte 3, Byte 2 - 0001H; Byte1 - 00H.

Table G.3

Parameters in charge parameter configuration stage for system B

Information	Parameter	M[a] /O[b]	Unit	Resolution	Status flag	Item in Table 1
Battery charge parameter	Maximum permissible charge voltage of battery cell	M	V	0,01 V/bit	-	-
	Maximum permissible charge current	M	A	0,1 A/bit	-	-
	Maximum permissible charge energy	M	kWh	0,1 kWh/bit	-	-
	Maximum permissible charge voltage of battery system	M	V	0,1 V/bit	-	b-2
	Maximum permissible temperature	M	°C	1 °C/bit	-	-
	The initial SOC	M	%	0,1 %/bit	-	-
	Total voltage of battery system	M	V	0,1 V/bit	-	-
Charger time synchronization	Year/month/date/hour/minute/ second	O	-	-	-	-
Charger max/min output parameter	Maximum output voltage	M	V	0,1 V/bit	-	a-3
	Minimum output voltage	M	V	0,1 V/bit	-	-
	Maximum output current	M	A	0,1 A/bit	-	a-4
Vehicle charge ready	If the vehicle is ready to be charged	M	-	-	0x00: unready 0xAA: ready	-
Charger output ready	If the charger is ready to charge	M	-	-	0x00: unready 0xAA: ready	-

[a] M = Mandatory

[b] O = Optional

Table G.4
Parameters in charging stage for system B (1 of 2)

Information	Parameter	M[a]/O[b]	Unit	Resolution	Status flag	Item in Table 1
Battery charge requirement	Voltage requirement	M	V	0,1 V/bit	-	a-2
	Current requirement	M	A	0,1 A/bit	-	a-1
	Charge mode	M	-	-	-	-
Charger charge state	Output voltage	M	V	0,1 V/bit	-	-
	Output current	M	A	0,1 A/bit	-	h-1
	Accumulated charge time	M	min	1 min/bit	-	-
Battery charge state 1	Measured charge voltage	M	V	0,1 V/bit	-	-
	Measured charge current	M	A	0,1 A/bit	-	-
	Maximum cell voltage and corresponding battery pack number[c]	M	V	0,01 V/bit	-	-
	SOC	M	%	1 %/bit	-	-
	Estimated remainder time	M	min	1 min/bit	-	-
Battery charge state 2	Cell number of maximum cell voltage	M	-	-	-	-
	Maximum battery temperature	M	°C	1 °C/bit	-	-
	Test point number of maximum temperature	M		-	-	-
	Minimum battery temperature	M	°C	1 °C/bit	-	-
	Test point number of minimum temperature	M	-	-	-	-
	Cell voltage over-high	M	-	-	0: normal 1: over-high	-
	Cell voltage over-low	M	-	-	0: normal 1: over-low	-
	Battery charge overcurrent	M	-	-	0: normal 1: overcurrent	-
	Battery temperature over-high	M	-	-	0: normal 1: over-high	-
	Battery insulation state	M	-	-	0: normal 1: abnormal	-
	Connection state of battery output connector	M	-	-	0: normal 1: abnormal	-
	Charge permission	M	-	-	0: forbidden 1: permission	c, d
Battery cell voltage	Voltage of each battery cell	O	V	0,01 V/bit	-	-
Battery temperature	Temperature of each test point	O	°C	1 °C/bit	-	-

Information	Parameter	M[a]/O[b]	Unit	Resolution	Status flag	Item in Table 1
Vehicle stopping command	Vehiclestopping reason	M	-	-	-	-
	Vehiclestopping failure reason	M	-	-	-	h-2
	Vehicle stopping error reason	M	-	-	-	-
Charger stopping command	Charger stopping reason	M	-	-	-	e
	Charger stopping failure reason	M	-	-	-	-
	Charger stopping error reason	M	-	-	-	-

[a] M = Mandatory

[b] O = Optional

[c] Maximum cell voltage and corresponding battery pack number includes 2 bytes.

1 - 12 bit: the maximum cell voltage in the battery system, 0,01 V/bit;

13 - 16 bit: the battery pack number in which the maximum cell voltage has occurred, 1/bit.

Table G.5
Parameters in charge ending stage for system B

Information	Parameter	M[a]/O[b]	Unit	Resolution	Status flag	Item in Table 1
Vehicle statistic data	The final SOC	M	%	1 % /bit	-	-
	Minimum cell voltage	M	V	0,01 V/bit	-	-
	Maximum cell voltage	M	V	0,01 V/bit	-	-
	Minimum battery temperature	M	°C	1 °C/bit	-	-
	Maximum battery temperature	M	°C	1 °C/bit	-	-
Charger statistic data	Accumulated charge time	M	min	1 min/bit	-	-
	Accumulated output energy	M	kWh	0,1 kWh/bit	-	-

[a] M = Mandatory

[b] O = Optional

Table G.6
Error parameters for system B

Information	Parameter	M[a]/O[b]	Unit	Resolution	Status flag	Item in Table 1
Vehicle receiving error	Receiving timeout of information from charger	M	-	-	-	g
Charger receiving error	Receiving timeout of information from vehicle	M	-	-	-	g

[a] M = Mandatory

[b] O = Optional

G.5 Physical/data link layer

The physical/data link layer specifications are shown in Table G.7. The physical/data link layer refers to SAE J1939-11 and SAE J1939-21. The application layer refers to GB/T 27930.

Table G.7

Physical/data link layer specifications for system B

Communication system	Communication protocol	CAN 2,0 B, ISO 11898-1
	Transmission rate (kbps)	250
	Cycle	10/50/250/500/1 000 ms ± 10 %

ANNEX H
Digital communication for control of DC charging system C (Combined system) (normative)

H.1 General

The digital communication for the DC EV charging station of system C as specified in Annex CC of IEC 61851-23 is defined in the following standards: DIN 70121, ISO/IEC 15118-1, ISO/IEC 15118-2 and ISO/IEC 15118-3.

The following SAE specifications can also be used as information: SAE J2836/2™, SAE J2847/2, SAE J2931/1 and SAE J2931/4.

Systems implementing these specifications incorporate the following features:

• Security concept including encryption, signing, key management, etc.
• Robust PLC-based communications,
• Automatic address assigning and association,
• IPv6-based communications,
• compressed XML messages,
• Client-server approach,
• Safety concept including cable check, welding detection, etc.
• Extension concept for added-value services.

H.2 Required exchange parameters

The parameters to be exchanged for DC charging control are shown in Table H.1, Corresponding to Table 1. Additional parameters can be found in DIN SPEC 70121 and ISO/IEC 15118-2.

Table H.1
Required exchanged parameters for DC charging control for system C

Item in Table 1	Information	Parameter name (ISO/IEC 15118-2:—)
a-1	Current request for the controlled current charging (CCC) system	CurrentDemandReq/EVTargetCurrent
a-2	Voltage request for the controlled voltage charging (CVC) system	CurrentDemandReq/EVTargetVoltage
a-3	Maximum rated voltage of d.c. EV charging station	CurrentDemandRes/EVSEMaximumVoltageLimit
a-4	Maximum rated current of d.c. EV charging station	CurrentDemandRes/EVSEMaximumCurrentLimit
b-1	Communication protocol	supportedAppProtocol{Req,Res}
b-2	Maximum voltage limit of EV	CurrentDemandReq/EVMaximumVoltageLimit
b-3	EV minimum current limit, only for the controlled voltage charging (CVC) system	ChargeParameterDiscoveryRes / DC_EVSEChargeParameter / EVSEMinimumCurrentLimit
c	Insulation test result	{PowerDeliveryRes, CableCheckRes, PreChargeRes, CurrentDemandRes, WeldingDetectionRes} / DC_EVSEStatus / EVSEIsolationStatus
d	Short circuit test before charging	CableCheck{Req,Res}
e	Charging stopped by user	{ChargeParameterDiscoveryRes,PowerDeliveryRes, CableCheckRes, PreChargeRes, CurrentDemandRes, WeldingDetectionRes} / DC_EVSEStatus / EVSEStatusCode / EVSE_Shutdown {ChargeParameterDiscoveryRes, PowerDeliveryRes, CableCheckRes, PreChargeRes, CurrentDemandRes, WeldingDetectionRes} / DC_EVSEStatus / EVSENotification / StopCharging
f	EVSE real time available load current (optional)	CurrentDemandRes/EVSEMaximumCurrentLimit
g	Loss of digital communication	Message timers Control pilot state
h-1	Zero current confirmed	PowerDeliveryRes/ResponseCode CurrentDemandRes/EVSEPresentCurrent
h-2	Welding detection	WeldingDetection{Req, Res}

	Bibliography
IEC 60364-7-7224	Low-voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicle
IEC 61851-21-25	Electric vehicle conductive charging system – Part 21-2: EMC requirements for off board electric vehicle charging systems
JIS/TSD0007	Basic function of quick charger for the electric vehicle
SAE J2836/2™	Use cases for communication between plug-in vehicles and off-board DC charger
SAE J2847/2	Communication between plug-in vehicles and off-board DC chargers
SAE J2931/1	Digital Communications for Plug-in Electric Vehicle.

ANNEX I
(See Introduction)

COMPOSITION OF AISC PANEL *

Name	Organization
Convener	
Mr. A. A. Deshpande	The Automotive Research Association of India (ARAI)
Members	**Representing**
Mrs. Ujwala Karle	The Automotive Research Association of India (ARAI)
Mr. Yoshihisa Hara	Honda Car R & D India Ltd.(SIAM)
Mr. Akshay Tarte	Hero Electric Vehicle Pvt. Ltd. (SIAM)
Mr. Neel Mathews	Mahindra Reva Electric Vehicles (SIAM)
Mr. Sumit Kumar	Maruti Suzuki India Ltd (SIAM)
Mr. Amit Bharti	Maruti Suzuki India Ltd (SIAM)
Mr. K. Suresh	Renault Nissan India. Pvt. Ltd. (SIAM)
Mr. Sivam Sabesan	Renault Nissan India. Pvt. Ltd. (SIAM)
Mr. A. Tajima	Renault Nissan India. Pvt. Ltd. (SIAM)
Mr. Kartik Palaniappan	Tata Motors Ltd. (SIAM)
Mr. Datta Sagare	Tata Motors Ltd (SIAM)
Mr. Ravindar Naik	TVS Motors Ltd. (SIAM)
Mr. W. P. van der varrt	Asia Electric Compony
Mr. S. Chandrakumar	ABB India Limited
Mr. Utkarsh Sharma	Delta Electronics
Mr. Ashish Kavimandan	Exicom Tele-systems Ltd.
Mr. Ashwani Malik	Exicom Tele-systems Ltd.
Mr. Akshay Ahuja	India Smart Grid Forum
Mr. Vishwajit Joshi	KPIT Technologies Ltd.
Mr. Abhay Patwardhan	KPIT Technologies Ltd.
Mr. Anurag Patil	Masstech Controls Pvt. Ltd.
Mr. Bhushan Bharambe	Masstech Controls Pvt. Ltd.
Mr. Vilas Randil	Nichicon

Mr. Rakesh Dhonde	Nichicon
Mr. R. Selvakumar	Nichicon
Mr. S. Ramesh	RRT Electro Power Pvt. Ltd.
Mr. V. Ravikumar	RRT Electro Power Pvt. Ltd.
Ms. Anitha Dhianeshwar	TCOE – IITM
Mr. Nushreen Ahmed	Tata Power Mumbai
Mr. Suhas Dhapare	Tata Power Mumbai
Ms. Yashika Kapoor	Tata Power Mumbai

* At the time of approval of this Automotive Industry Standard (AIS)

ANNEX- J

(See Introduction)

COMMITTEE COMPOSITION*

Automotive Industry Standards Committee

Chairperson	
Mrs. Rashmi Urdhwareshe	Director The Automotive Research Association of India, Pune
Members	**Representing**
Shri Priyank Bharti	Ministry of Road Transport and Highways (Dept. of Road Transport and Highways), New Delhi
Representative from	Ministry of Heavy Industries and Public Enterprises (Department of Heavy Industry), New Delhi
Shri S. M. Ahuja	Office of the Development Commissioner, MSME, Ministry of Micro, Small and Medium Enterprises, New Delhi
Shri Shrikant R. Marathe	Former Chairman, AISC
Shri R.R. Singh	Bureau of Indian Standards, New Delhi
Director	Central Institute of Road Transport, Pune
Director	Indian Institute of Petroleum, Dehra Dun
Director	Vehicles Research and Development Establishment, Ahmednagar
Director	International Centre for Automotive Technology
Director	Global Automotive Research Centre
Director	Indian Rubber Manufacturers Research Association
Representatives from	Society of Indian Automobile Manufacturers
Shri T. R. Kesavan	Tractor Manufacturers Association, New Delhi
Shri Uday Harite	Automotive Components Manufacturers Association of India, New Delhi

Member Secretary
Shri Vikram Tandon
Dy. General Manager
The Automotive Research Association of India, Pune

* At the time of approval of this Automotive Industry Standard (AIS)