IEEE Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles

IEEE Vehicular Technology Society

Sponsored by the
Intelligent Transportation Systems

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USA

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Sponsor

Intelligent Transportation Systems
of the
IEEE Vehicular Technology Society

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Acknowledgments

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CHAdeMO 1.0.1 (21 May 2013), Technical Specifications of Quick Charger for the Electric Vehicle.

Abstract: Direct-current (dc) charging is a method of charging that facilitates rapid energy transfer from the electric grid to plug-in vehicles. This method of charging allows significantly more current to be drawn by the vehicle versus lower rated alternating-current (ac) systems. A combination of vehicles that can accept high-current dc charge and the dc supply equipment that provides it has led to the use of terminology such as "fast charging," "fast charger," "dc charger," "quick charger," etc.

DC charging and ac charging vary by the location at which ac current is converted to dc current. For typical dc charging, the current is converted at the off-board charger, which is separate from the vehicle. For ac charging, the current is converted inside the vehicle, by means of an on-board charger.

The location of the ac to dc conversion equipment, or converter, shapes the complexity of the equipment design. Regarding ac charging, as previously mentioned, the conversion is on board the vehicle. This allows the original equipment maker (OEM) designed systems to control the charging operation in its entirety. The on-board charger (converter) and battery controller solution is under direct control of the vehicle manufacturer.

For dc charging, an entirely new challenge exists for OEMs. The dc charger is now external to the vehicle and requires the vehicle engineers to control an external power device. For the reason of necessary interoperability, standards such as IEEE Std 2030.1.1 are provided to assist developers.

Keywords: automotive, CHAdeMO, dc charger, dc charging, electric vehicle, fast charger, fast charging, IEC 61851-23, IEEE, IEEE 2030.1.1™, rapid charging, SAE, SAE J1772, SAE J2836/2

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Introduction

This introduction is not part of IEEE Std 2030.1.1-2015, IEEE Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles.

This standard defines requirements for the designs of electric vehicles and dc quick chargers that promote efficient and rapid charging between electric vehicles and dc quick chargers. This document specifies the collaborative actions between electric vehicles and quick chargers referencing relevant international specifications.

Contents

IEEE Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles

1. Scope

This standard specifies the design interface of electric vehicles and direct current (dc) quick chargers that promote rapid charging of battery electric vehicles.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC 61851-1, Electric vehicle conductive charging system—Part 1: General requirements.[1]

IEC 62196-3, Plugs, socket-outlets, vehicle connectors and vehicle inlets—Conductive charging of electric vehicles—Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c. /d.c. pin and contact-tube vehicle couplers.

[1] IEC publications are available from the International Electrotechnical Commission, Case Postale 131, 3 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

ISO 11898-1, Road vehicles—Controller area network (CAN)—Part 1: Data link layer and physical signalling.[2]

ISO 11898-2, Road vehicles—Controller area network (CAN)—Part 2: High-speed medium access unit.

SAE J1772, Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler.[3]

SAE J2836/2, Use Cases for Communications 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 Vehicles.

SAE J2931/4, Broadband PLC Communication for Plug-in Electric Vehicles.

3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[4]

3.1 Vehicle terms

charging: Supplying direct current to a battery from an external power source, producing a chemical reaction of the active substances and storing electrical energy in the battery as chemical energy.

electric vehicle (EV): A vehicle using an electric motor as a powertrain.

electric vehicle (EV) contactor: A switching device on dc charging circuit to on-board battery.

on-board battery: A battery for propulsion mounted on an electric vehicle.

on-board dc 12 V power supply: An auxiliary electric vehicle battery used for communication and charging control

vehicle relay: The switch that controls the electric vehicle contactor

3.2 Charger terms

ac input power blackout: Voltage fall of ac input power supply below the specified voltage range.

charging cable: A cable that is connected to the electric vehicle for charging purposes.

charging connector: A connecting apparatus equipped with the charger in order to charge electric vehicles.

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[2] ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[3] SAE publications are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, USA (http://www.sae.org/).

[4] *IEEE Standards Dictionary Online* subscription is available at: http://ieeexplore.ieee.org/xpls/dictionary.jsp.

control power supply: Power supply to supply dc power to communication control circuit in the charger, vehicle, and other accessories.

converter: A device to convert ac power to dc power.

earth leakage circuit breaker (ELCB): A device to detect errors and to break the circuit in case of the following errors:

a) Earth leakage current from the power line

b) Overcurrent on the power line

enclosure: Exterior of the charger, including the knob, handle, grip, etc.

earth fault: Electrically energized condition where the insulation state between main circuit and earth, including insulation deterioration between dc power circuit and charger enclosure or vehicle chassis.

earth fault detection: To detect earth fault.

earthing: To electrically connect the enclosure and metallic pipes, etc., to the earth with electric wires.

inverter: A device to convert dc power to ac power.

main circuit: An electric circuit to supply dc charging current to on-board battery, which consists of power receiving part from input ac power, converting circuit from ac current to dc charging current and charging current output circuit.

main power supply: Power supply to supply dc power to on-board battery.

opto-coupler: An element that converts electric signals to light and transmits it as a signal.

3.3 Communications terms

bus off: A state in which participation in the communications on the shared transmission line for exchange of electronic signals is prohibited.

CAN communication: Communication that is one of the types of vehicle-mounted network protocol and is used between charger and vehicle. A communication method used for transmitting control signals between an electric vehicle and a quick charger in the CHAdeMO system. (ISO 11898-2)

error frame: A data frame that is transmitted when a bus error is detected.

ID: A name that is given to classify data information and transmission node.

4. Conventions

4.1 General

This standard uses binary and hexadecimal notation of fields in text and tables. The interpretation of the bit and nibble ordering in these fields adheres to the rules described in 4.2 through 4.7, unless specifically defined otherwise within Annex A or Annex B.

4.2 Binary representation

Binary fields are used with a prefix of "0b" to indicate the binary (or base-2) nature of the data. The field starts with the most significant bit (MSB).

A general binary representation of a field has the following format:

0bB*n*…B1B0

with bit "B*n*" representing the MSB and bit "B0" representing the least significant bit (LSB).

Examples:

a) 0b001

In this example, "1" is the LSB. The value of this field is equivalent to the value of 1 in decimal notation.

b) 0b10000

In this example, "1" is the MSB. The value of this field is equivalent to the value of 16 in decimal notation.

4.3 Hexadecimal representation

Hexadecimal (Hex) fields are used with a prefix of "0x" to indicate the hexadecimal (or base-16) nature of the data. The field starts with the most significant nibble of the fields. Hex digits A, B, C, D, E, and F are capitalized.

A general hexadecimal representation of a field has the following format:

0xHn…H1H0

with nibble "Hn" representing the most significant nibble and nibble "H0" representing the least significant nibble.

Examples:

a) 0x00E

In this example, "E" is the least significant nibble.

b) 0xE00

In this example, "E" is the most significant nibble.

A hexadecimal field can be converted into a binary field by replacing each nibble with the corresponding binary value (following the representation of binary fields).

In this standard, the term "octet" is used to identify two consecutive nibbles of data (i.e., a bit string of length 8). The term "byte" is synonymous with the preferred term, "octet." The use of the term "byte" has been preserved in normatively referenced material.

Hexadecimal numbers can also be represented in the following form:

H'n,….1,0

4.4 Decimal representation

Values specified in decimal are coded in natural binary unless otherwise stated.

The use of the decimal point in base-10 decimal numbers indicates the separation between units on the left and tenths of units on the right. This standard does not use a comma for the same purpose. Commas are used to separate units of one thousand and one hundred, one million and one-hundred thousand, and so on.

4.5 Transmission sequence

See Annex A, Annex B, and Annex C for their specific transmission sequence.

4.6 Formulas

Multiplication is represented as an “×” rather than as an “x” to avoid confusion with hexadecimal numbers and variables.

4.7 Units of measure

Metric units are used.

Interpretations of common units of measure are as follows:

- k (analog) = 1 000
- K (digital) (e.g., kilobits) = 1024 (2^{10})
- M (analog) = 1 000 000
- M (digital) = 1 048 576 (2^{20})
- n (analog) = 10^{-9}
- Ω = Ohm

5. Common requirements

5.1 Background

In electric vehicles, the charger may be located on board or off board the vehicle. When the charger is on board the vehicle, it is developed for the specific type and size of the battery used in the vehicle. Simple ac voltage may be connected to the on-board charger’s power inlet. However, it may be difficult to charge large batteries quickly using common residential ac voltage and current. If the charger is off board the vehicle, it requires communication with the battery control system. This communication protocol may be different by vehicle model, so off-board chargers can be designed to accommodate multiple technologies. The benefit is that dc chargers can provide more charging energy to the vehicle, which can reduce charge time (“quick charging”).

Clause 5 describes the common requirements pertaining to collaborative actions between electric vehicles and quick chargers.

Annex A and/or Annex B shall be used to implement these charging systems.

5.2 Requirements

These requirements are "common" requirements for the specifications in Annex A and Annex B.

a) General

1) Device shall be able to indicate to the user the status of the charging process and take corrective actions if required.

2) Both the charger and the vehicle shall be equipped with a means to confirm they stay physically and/or electrically connected with each other during charging.

3) The charger shall be equipped with a means to stop charging in the case that communication between the vehicle and the charger (via the communications interface) is interrupted.

4) When the protective conductor between the charger and the vehicle is disconnected**,** the charger shall stop charging within 10 s.

5) The charger shall be able to detect loss of isolation, short circuit, and earth faults.

6) The charger shall be equipped with an overvoltage protection function.

7) The system shall be designed so that a level of voltage that is dangerous to the human body shall not be applied on the charging connector when the connector is not connected to the vehicle.

8) The system shall be designed to prevent users from touching electrically energized parts on the vehicle and the charger.

9) The charger shall be equipped with a means of earth leakage current detection and automatic disconnection to help prevent electric shock.

10) The charger or charging connector shall be equipped with measures (e.g., plastic cap on connector power terminals) to reduce the risk of contact with exposed live parts as a measure against remaining electric charge on the charging connector.

11) The charger shall be equipped with a means of protection against overload and short circuit in the ac main circuit or internal circuit of the charger.

12) The charging system shall be designed so that the voltage level between any accessible conductive parts, including charging cable and charging connector, and any grounding parts decreases to less than 60 V within 1 s or less, after connector removal from station or vehicle.

b) Communications

A data communications interface shall be used to transmit parameters required for charging control. The charger and vehicle shall exchange the parameters through the interface.

c) Outdoor/indoor conductive charging

The charger shall be designed to endure the following environmental conditions:

1) The charger enclosure shall have a rating of IP33 or higher.

2) Ambient temperature (outdoor): −25 °C to 40 °C.

3) Ambient temperature (indoor): −5 °C to 40 °C.

4) Ambient humidity: 5% to 95%.

5) Altitude: Charger shall work between the atmospheric pressures of 860 hPa and 1060 hPa.

Annex A

(normative)

CHAdeMO specifications

A.1 Scope of application

This annex describes specifications that shall be incorporated into the designs of electric vehicles and quick chargers in order to enable efficient and rapid charging between electric vehicles and quick chargers.

This annex describes specifications pertaining to collaborative actions between electric vehicles and quick chargers. Design firms and manufacturers shall also reference relevant international specifications, listed in Clause 2, and domestic laws/regulations on electrical equipment.

IEC 61851-23:2014 [B39] and IEC 61851-24:2014 [B40] have specified general requirements on dc EV charging station.[5] System A in Annex AA of IEC 61851-23:2014 and System A in Annex A of IEC 61851-24:2014 have given specific requirements for dc EV charging station, which use the same interface and digital communication method given in this annex. This annex gives detailed specification for charging station and vehicle manufacturers, which conform to Annex AA of IEC 61851-23:2014 and Annex A of IEC 61851-24:2014.

A.1.1 Protocol number and changing protocol in case of the different versions

Any revisions to specification documents shall be recorded in the revision history, along with the description of the changes or additions made. The CHAdeMO control protocol number is assigned to manage software compatibility between charger and vehicle developed under different specification versions.

A.2 Vehicle coupler

Vehicle coupler shall conform to IEC 62196-3 Standard sheets for configuration “AA.” Shapes and dimensions of the vehicle coupler in A.17 are given for information only.[6]

A.3 Installation conditions and main specifications

The manufacturer shall manufacture the charger with a design that conforms to the following:

a) Standard usage conditions as shown in Table A.1

b) Panel-related specifications as shown in Table A.2

c) Device specifications as shown in Table A.3[7]

d) Design specifications as shown in Table A.4

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[5] The numbers in brackets correspond to those of the bibliography in Annex D.
[6] Information on references can be found in Clause 2.
[7] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

Table A.1—Standard usage conditions

Installation location	Outside
Altitude	1000 m or lower
Ambient temperature	−10 °C to 40 °C
Ambient humidity	30% to 90%, no dew condensation

Table A.2—Panel-related specifications

Panel performance	IP33 or higher
Panel color	In compliance with local ordinances for markings and visibility
Insulation performance	Test voltage a) Withstand ac voltage test (1 min, 50 Hz/60 Hz) 1) Primary side on main circuit (- FG): Un + 1200 Vrms 2) Secondary side on main circuit (- FG): Un + 1200 Vrms 3) Between primary side and secondary side of isolation transformer: — In case of basic insulation:[a] Un + 1200 Vrms — In case of reinforced insulation: [a] 2 × (Un + 1200) Vrms Un: Nominal voltage between neutral and line, or phase and earth If dc voltage is used on this test instead of ac, applied dc voltage shall be equal to the peak value of regulated ac test voltage. b) Impulse withstand voltage test 1) Reinforced insulation part: 4 kV (overvoltage category 2), 6 kV (overvoltage category 3) 2) Basic insulation part: 2.5 kV (overvoltage category 2), 4 kV (overvoltage category 3)

[a] Basic or reinforced insulation shall be implemented on secondary side of isolation transformer against the primary one.

Table A.3—Device specifications

Control method	Constant current control based on the current command from the vehicle
Input power supply	Nominal voltage in each country: AC (±15%), 50 Hz or 60 Hz (±5%). Total power factor: 0.95 or more (on the condition with maximum rated output power and current of the charger). Input power supply can be defined by each manufacturer, but its specification shall comply with standard or regulation of each country. If ac input voltage to earth exceeds 300 V, in case of 6 kV transient voltage application test on main circuit, transient voltage to earth on secondary circuit shall be depressed below 2.5 kV by using arrestor, etc. If an arrestor is used to mitigate transient voltage, the arrestor may be omitted on this test.
Output range	DC 50 V to 500 V, DC 0 A to 125 A or less (see NOTE)
Current ripple	Up to 10 Hz: 1.5 Ap-p or less Up to 5 kHz: 3.0 Ap-p or less
AC/DC conversion efficiency	90% [a] or higher (including auxiliary loss, on the condition with maximum rated output power and current of the charger)
Acoustic noise	65 dB or less (1 m far from each side surface; 1 m high from the floor surface) (on the condition with maximum rated output power and current of the charger)
Communication system	Communication protocol: CAN2.0B Active, [ISO11898-2], Standard format
	Transmission rate: 500 kbps
	Transmission cycle: 100 ms ± 10%
Protection system	Main circuit: Interrupt power supply on occurrence of earth faults and short circuits
	Control circuit: Interrupt power supply on occurrence of earth faults and short circuits
NOTE—In some countries, the upper limit of the maximum voltage requirement may be less than 500 V. (Japan: See A.15.)	

[a] Minimum conversion efficiency recommended by CHAdeMO.

Table A.4—Design specifications

Operating panel	Charge start button: Blue (recommendation). Charge stop button: Green (recommendation).
	Each button or lamp is lighting during standby and blinking during operation (recommendation).
Emergency stop	Emergency stop button: Red.
	Emergency stop button shall retain its pushed condition until reset operation. Emergency stop button shall be reset only by manual operation. Clear panel window to prevent wrong operation (recommendation).

A.4 Requirements for basic design of the charger and the vehicle

A.4.1 Charging method

Constant current charging method is used for charging. The vehicle shall transmit a charging current request to the charger at a constant time interval. The charger shall output current that corresponds to the order value. If the order value from the vehicle changes, the charger shall vary output current that follows the new value.

A.4.2 Control signal line

Dedicated control signal lines shall be used to transmit signals concerning the start and termination of charging.

A.4.3 Data communications

A data circuit shall be used to transmit parameters required for charging control. The charger and vehicle shall exchange the parameters through the circuit.

A.4.4 Essential functions

a) Connection confirmation (Proximity detection): Both the charger and the vehicle shall be equipped with a means to confirm that they stay connected with each other during charging.

b) Power supply shutdown upon communications disruption:

   1) The charger shall be equipped with a means to stop charging immediately in the case that communication between the vehicle and the charger (via the control signal lines or data communication lines) is interrupted.

   2) In addition to data communication, there shall be a means that the vehicle instructs the charger to stop charging. When the vehicle detects disruption of data communication, the charger shall be notified to stop charging by the means.

b) Prevention of false-drive (requirement for the vehicle): The vehicle shall be equipped with a means to prevent drive the vehicle while it is connected to the charger (whether it is before and during charging).

c) Detection of protective conductor disconnection between charger and vehicle and charging termination: When the protective conductor between the charger and the vehicle is disconnected, the charger shall stop charging immediately.

d) Detection and protection of earth fault on the dc power circuit: During charging, the charger shall detect any earth fault on the dc power circuit. In the event that earth fault is detected in the dc power circuit, the charger shall stop applying dc voltage or supplying dc current to the charging cable. If equipped, the on-board fault detection of the vehicle shall not interfere with the earth fault detection capability of the dc charger.

e) DC short circuit protection: The charger shall be equipped with a short circuit protection function.

f) Prevention of overvoltage on on-board systems: The charger shall be equipped with an overvoltage protection function on vehicle systems.

g) Charge current interruption function: The vehicle shall have contactors with sufficient capacity to break charge current.

h) Protection of EV contactor:

   To protect the EV contactor, the charger shall follow the procedure in item 1), 2), and 3) of this subclause when stopping the power supply to the control relay of the EV contactor. This procedure shall be observed even in the event of ac input power blackout or voltage drop of ac input power. See A.7.2.8.

   Procedure for stopping the control power supply (power supply to the EV contactor)

   1) Stop the charging current.

   2) Stop the power supply to the control relay of the EV contactor.

   3) Open the EV contractor.

   The charger shall have welding detection capability for monitoring the EV contactor. See A.10.

i) Design of hardware associated with the stop signals: The stop signals from the vehicle to the charger shall be redundant. Charging processes shall be stopped in the event that analog signal or CAN data signal calls for the "stop" state. The charger shall be equipped with a mechanism to ensure terminating operation according to stop request from the vehicle.

j) Voltage measurement and check: The charger shall be equipped with a means of measuring charging cable voltage in order to judge whether voltage may be applied to the vehicle circuit and charging connector may be removed.

k) Error logging function: The charger and the vehicle shall be equipped with a means of storing the error information and investigating its cause when malfunctions occur on the other side.

A.4.5 Protection against electric shock

The charging system shall be designed so as to prevent users from approaching live parts on the vehicle and the charger.

The charging system shall be designed so that a level of voltage that is dangerous to the human body shall not be applied on the vehicle inlet and charging connector during normal connector removal action as well as the connector fall situation due to an accident.

The charging system shall be designed so that voltage level between any accessible conductive parts, including charging cable and charging connector, and any grounding parts decreases less than 60 V within 1 s after the appearance of live parts on the charger in the case of normal operation or abnormal situation.

The charger shall be equipped with a means of earth leakage current detection and automatic disconnection to prevent electric shock.

The vehicle shall have the function, structure, or combination of function and structure to avoid high voltage application on the vehicle inlet if welding has occurred to prevent users from touching live parts (e.g., redundant EV contactors and protection cover for the vehicle inlet).

The charger or charging connector shall be equipped with measures (e.g., plastic cap on connector power terminals) to reduce the risk of contact with exposed live parts as a measure against remaining electric charge on the charging connector.

A.4.6 Overcurrent protection

The charger shall be equipped with a means of protecting itself and ac main circuit against overload (over current) and short circuit.

A.4.7 CPU monitoring

The charger and vehicle shall each monitor its own CPU status. Any malfunction or failure affecting charge control capability shall result in a termination to the charge operation, initiated by the vehicle or dc charger.

A.5 Circuit requirements

A.5.1 Main circuit

Basic configuration of main circuit is shown in Figure A.1.

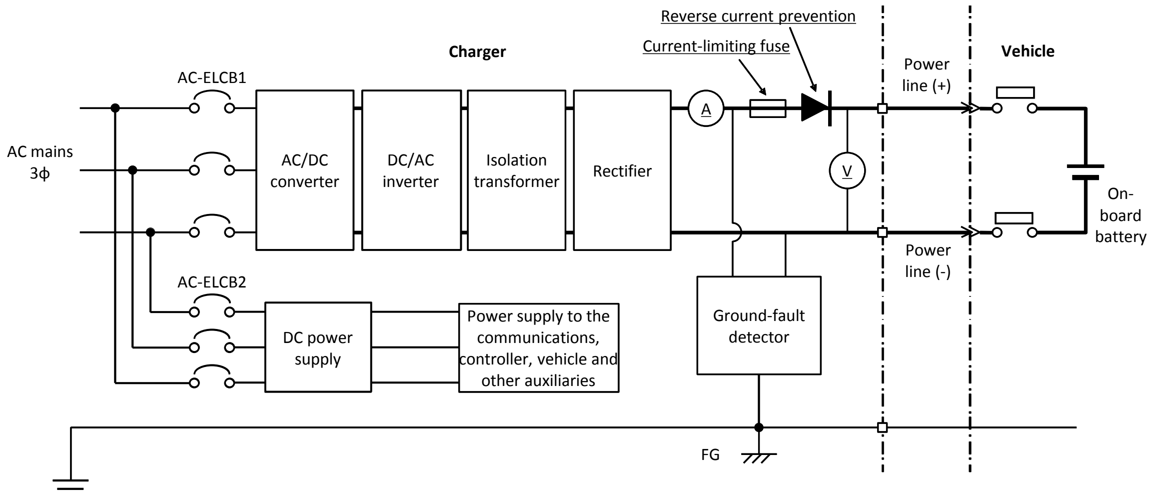


Figure A.1—Typical circuit configuration

A.5.1.1 Isolation of ac and dc circuits

Input ac circuit and output dc circuit shall be separated by reinforced insulation or double insulation.

A.5.1.2 Separation of main power supply and control power supply

Main power supply unit (power supply to supply charging current to on-board battery) and control power supply unit (see A.5.2 and A.5.3) shall be diverged at receiving point of electricity in the charger. Each of the branched circuits shall have circuit breakers (AC-ELCB1 and AC-ELCB2 shown in Figure A.1) that protect short-circuit/overcurrent and earth fault.

Even if a fault occurs on the main power supply circuit, the control power supply circuit shall remain active to maintain the control/communications function with the vehicle, as well as the function for protecting and monitoring the charger itself.

A.5.1.3 Reverse current prevention diode

The charger shall be equipped with reverse current prevention diode on the output circuit in order to prevent reverse current flowing from on-board battery to the charger, and to prevent reverse current flowing to the on-board battery.

The main circuit on the downstream of the reverse current prevention diode shall meet the following requirements.

a) In case that there are capacitive components, the inrush current shall be 20 A or less when the EV contactors are closed.

   NOTE 1—Compliance is checked with the condition that no connecting components exist between P and N on the vehicle-side main circuit between the EV contactor and the vehicle inlet.

b) The components connected in the series on the downstream of the reverse current prevention diode shall meet one of the following conditions:

   1) No fuse shall be installed.

   2) Insulation between the internal wiring downstream of the reverse current prevention diode and other output circuit shall be at least double insulation or equivalent.

c) If there are any components that connect P and N, the downstream of the reverse current prevention diode shall require one of the following conditions:

 1) Rapid-type fuse rated 2 A or less shall be provided.

 2) In the downstream of the reverse current prevention diode, single failure shall not cause a dead short circuit.

 NOTE 2—The single failure means a failure of discrete component or a sequence of failures.

d) Cross section of DC charging cable conductor shall be at least 22 mm^2.

e) Fuse that is possible to protect against a short circuit shall be provided on the vehicle.

A.5.1.4 Current-limiting fuse

The charger shall be equipped with current limiting fuse on the output circuit, so as to prevent short circuit if charging cable is accidentally connected in reverse polarity. The current-limiting fuse shall be in the immediate cut-off type (Rapid type fuse) and its breaking capacity shall be below 250 A. Select a fuse that provides short-circuit protection of the charger, charging cable, and charging connector. The current-limiting fuse shall be installed on the anode side of reverse current prevention diode. See Figure A.1.

NOTE—A similar protective mechanism should be equipped on the vehicle circuit.

A.5.1.5 Power supply to the vehicle

The charger shall prepare dc 12 V power supply to provide power to operate EV contactor (described in A.5.2). This dc 12 V power supply shall be obtained from control power supply described in A.5.1.2. That is, control power supply shall be installed on the circuit configuration that has no influence from malfunctions on the main power supply circuit. Power supply to the vehicle shall comply with the specifications shown in Table A.5.

Table A.5—Requirements of power supply to the vehicle

Supply voltage	12 V (dc) Voltage fluctuation tolerance: ±10% of supply voltage (See Table A.7 and Table A.8)
Continuous rating	2 A, 24 W
Others	The charger shall protect the vehicle from short circuit on the dc 12 V lines. The protection measures shall limit the short-circuit current to the vehicle to 6 A maximum. The wiring for the dc 12 V PS shall also meet this requirement.

A.5.1.6 Current and voltage measurement

The charger shall be equipped with a measuring equipment to measure its output current and voltage. Output voltage shall be measured between reverse current prevention diode and charging connector.

The measured voltage shall adjust to the voltage value of connector terminals taken into account voltage drop in charging cable, and utilizes the charging control described in A.7.2.6.

A.5.1.7 Earthing, grounding and protective conductor

A.5.1.7.1 AC circuit side

a) Conductive parts such as enclosures shall be earthed with protective conductors.

b) Standards regarding earthed conductors shall comply with technical specifications in each country.

c) Design and install the earthed and protective contactors with consideration of electrical noise reduction and electrical shock protection best practices.

A.5.1.7.2 DC circuit side

a) Earth terminals in the charger shall be connected to ones in the vehicle by protective conductor in the charging cable.

d) Protective conductor described in A.5.2 shall be directly connected to earth terminals of the charger rather than via the enclosure of the charger.

e) Chassis ground terminal in the vehicle shall connect to the vehicle chassis.

f) DC earth leakage current monitoring device (see A.5.1.9) shall be connected to earth terminals of the charger. The following insulation conditions shall be monitored:

    1) Between secondary side circuit (from secondary side of insulation transformer) and charger enclosure

    2) Between charging circuit of the vehicle and vehicle chassis

g) In the event that the protective conductor between charger and vehicle is disconnected, the charger shall stop applying voltage and supplying current to the charging cable by passive stop of the communication with control signal line (“Vehicle charge permission” line) between the charger and the vehicle.

A.5.1.7.3 General requirements

The protective conductor shall be connected without resistance.

A.5.1.8 Internal protection

The charger shall have a mechanism for monitoring earth fault, short-circuit, overcurrent, and temperature rise inside the charger, and immediately disconnecting main circuit from external power grid upon detection of any fault.

A.5.1.9 Earth fault detection on the dc power circuit

A leakage current monitoring device for detecting earth fault on dc power circuits (secondary circuit of the charger and vehicle-side circuit) shall be installed in the charger. Figure A.2 and Table A.6 specify a detection circuit and detection sensitivity for dc leakage current monitoring. Requirements for the monitoring device are given in item e) of A.7.2.7.2. The insulation monitoring device on the vehicle shall be disabled while the EV contactors are closed, and shall not affect the operation of the leakage current monitoring in the charger while the vehicle is connected with charging connector.

The charger shall stop in the event of leakage detection and shall not be operable until the expected operating conditions are satisfied.

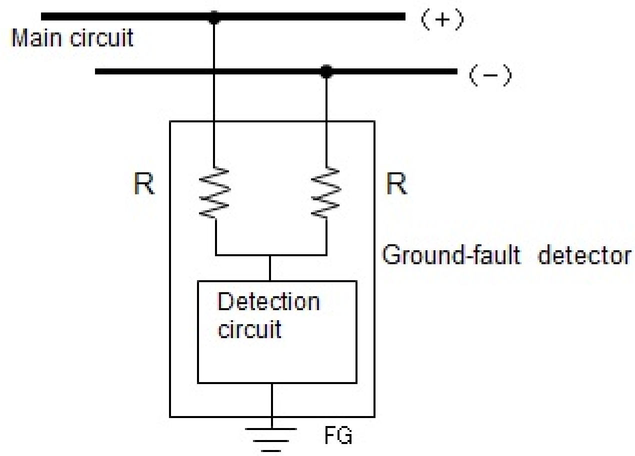


Figure A.2—DC leakage current monitoring circuit

Table A.6—Specification of dc leakage current monitoring

	Item	Specification
1	Detection voltage range	DC 50 V to 500 V
2	Detection method	DC leakage current detection through neutral grounding
3	Sensing performance	The monitoring device shall output trip signal when insulation resistance ratio between main circuit and charger enclosure (including vehicle chassis) gets lower than 100 Ω/V. [V: output voltage][a]
4	Operating time	1.0 s or less
5	False operation prevention time	0.2 s or more (see NOTE 2)
6	Resistance R	40 kΩ or more (see NOTE 3)
NOTE 1—To prevent accidental activation due to short-term noise current. NOTE 2—Resistance should be able to suppress DC leakage current less than 12.5 mA.		

[a] In the operation voltage less than 60 V, the criteria of 100 Ω/V may be not applicable. [In some countries, 100 Ω/V criterion is required from operation voltage of 50 V (UL-standard)]. However, the charger shall be able to detect 0 Ω fault at less than 60 V operation voltage.

A.5.1.10 Overvoltage protection in the event of EV contactor interruption

The charger shall have overvoltage protection function to keep applied voltage on charging connector lower than 600 V during charging in order to protect on-board systems against the following faults:

— Voltage over shoot in the event that “Charge current request” is changed

— Voltage rise in the event of EV contactor interruption during charging (including the voltage uprising resulting from a control by the charger to maintain target current value)

A.5.1.11 Support for EV contactor welding detection

The charger shall have circuit characteristics described in A.7.5 to support the EV contactor welding detection.

A.5.1.12 Charger protection against overvoltage including voltage surge

It is preferable to use voltage surge protection device depending on the usage environment. The criterion of selecting a surge protection device is included in IEC 61643-12 [B38].

A.5.2 Sequence circuit

The interface with the vehicle shall have a sequence circuit as shown in Figure A.3. Circuit constants of this sequence circuit shall be in accordance with Table A.7 (charger side) and Table A.8 (vehicle side).

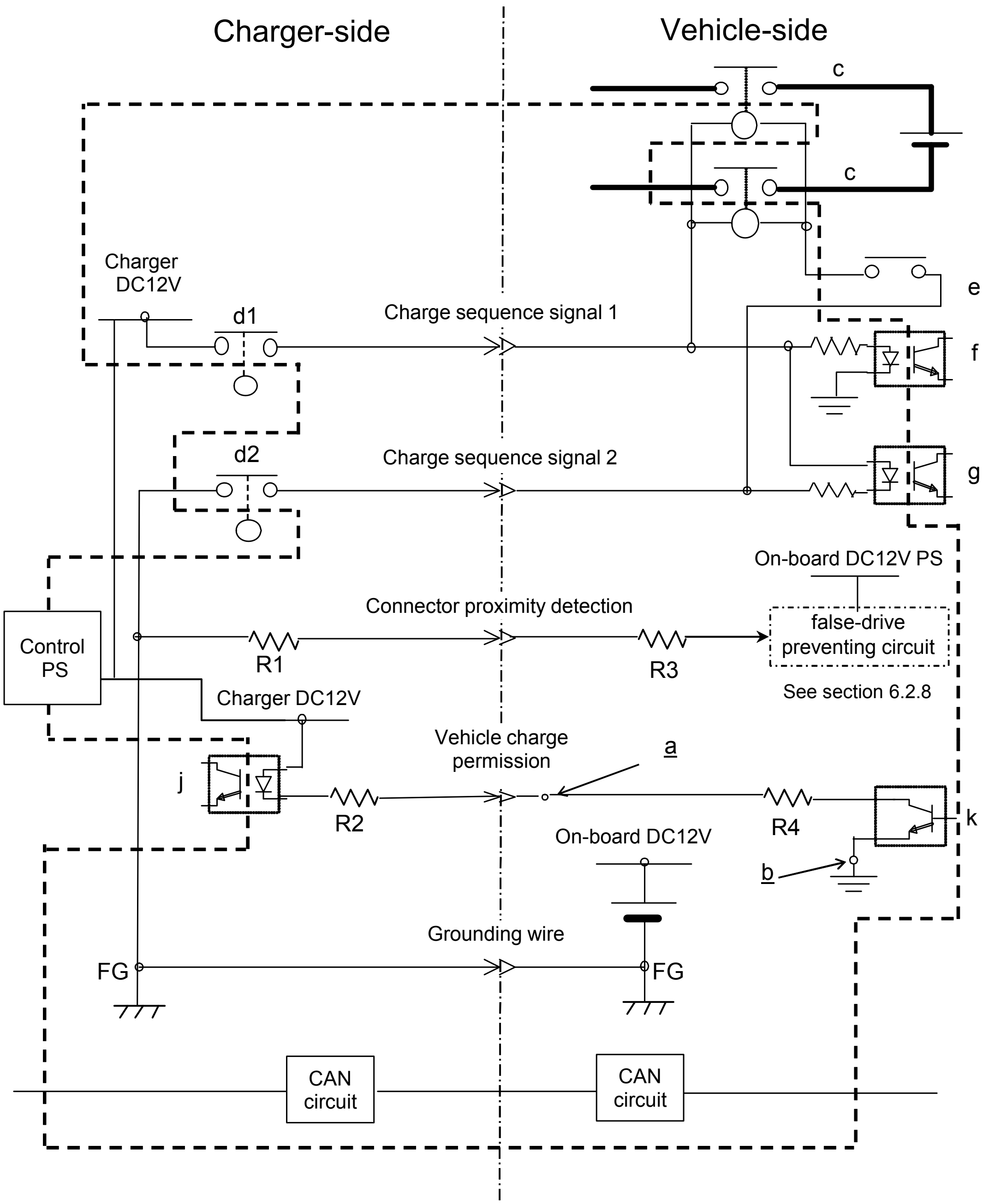


Figure A.3—Sequence circuit

Table A.7—Specification for sequence circuit (charger side)

Terminal	Item	Minimum value	Typical value	Maximum value	Unit
Charge sequence signal 1	Charger dc 12 V	10.8	12.0	13.2	V
Connector proximity detection	Resistor R1	190	200	210	Ω
Vehicle charge permission	Resistor R2	950	1000	1050	Ω
Charge sequence signal 1	Relay d1 load current	2		2000	mA
Charge sequence signal 2	Relay d2 load current	2		2000	mA

Table A.8—Specification for sequence circuit (vehicle side)

Terminal	Item	Minimum value	Typical value	Maximum value	Unit
Charge sequence signal 1	Load current (when d1 ON)	10		2000	mA
Charge sequence signal 2	Load current (when d1 and d2 ON)	10		2000	mA
Connector proximity detection	Resistor R3	950	1000	1050	Ω
	On-board dc 12 V	8	12	16	V
Vehicle charge permission	Resistor R4	190	200	210	Ω
Vehicle charge permission	Load current (leakage current) between a-b when switch k OFF			2	mA
	Vce (collector-emitter voltage of transistor "k") at collector current = 10 mA			0.5	V

NOTE—The purpose to install resistors on the sequence circuit is as follows:

— R1, R3: Current limiting resistors against short circuit between Connector proximity detection line and dc 12 V or FG.

— R2, R4: Current limiting resistors against short circuit between Vehicle charge permission line and dc 12 V or FG.

A.5.2.1 Circuit voltage

The charger and the vehicle shall supply dc 12 V to the other side.

A.5.2.2 Signal line

The wire diameter shall be selected and determined so as not to affect opto-coupler operation on both the charger and the vehicle and equipotential bonding of signal ground.

A.5.2.3 Prevention of noise and unintended current flow

The noise and unintended current flow from the vehicle or the charger to the interface circuit shall be prevented by opt-coupler or other means. Reference Figure A.3.

A.5.2.4 Power supply to the EV contactor

The charger shall supply dc 12 V power to make EV contactor on the main circuit operable.

This is intended to help protect users from electric shock caused by applied voltage of on-board battery in the event of charging connector detachment or EV contactor activation before charging connector attachment.

A.5.2.5 Grounding wire

Negative terminal of on-board dc 12 V system shall be connected to the vehicle chassis ground terminal (connected to vehicle chassis). Negative terminal of the charger's dc 12 V system shall be connected to the charger's earth terminal (connected to charger enclosure).

A.5.2.6 Signal line protection

On the charger and vehicle, the "Connector proximity detection" line and "Vehicle charge permission" line shall have resistors with specified resistance and be connected in series to prevent short-circuit and ground fault on dc 12 V system on each signal circuit. See Table A.7 and Table A.8 for resistance values.

The vehicle shall have current-limiting fuses (less than 15 A × 5 s) on other vehicle signal lines that may short to "charge sequence signal 1 and 2."

A.5.2.7 Redundancy of hardware associated with stop signal

To improve the reliability of stop request to the charger, the vehicle shall use both "Vehicle charge permission" signal and "CAN communication" data as a means of transmitting termination signal. This shall prevent the charger from losing the function (ability to break output charging current according to termination signal sent from the other side) in the event that one of these signals is lost. The control signals for "Vehicle charge permission" and "Connector lock malfunction" shall be transmitted to an inverter unit through a different connection from the Inverter control start/stop signal. Each path may be installed on one printed circuit board.

In addition, in case the internal inverter unit is controlled by software, the following conditions shall be met.

a) The "vehicle charge permission" shall be processed by a separate CPU other than the CPU that runs the inverter control.

b) The Monitoring function for "connector malfunction detection" shall run in a separate CPU other than the CPU that runs the inverter control

Other than using the gate block on the inverter unit, installing a contactor on the output circuit may be used for a means to interrupt the current flow. "Vehicle charge permission" and "connector malfunction detection" may be installed onto a single CPU. The requirement in this clause may be overridden if the vehicle protocol number is 1.0 or less connected.

The charger and the vehicle shall meet the following specifications in order to achieve these functions:

A.5.2.7.1 Charger

a) Signal path and processing unit of "signal communication" on "control signal line ("Vehicle charge permission")" and "digital communication ("CAN")" shall be divided in the hardware design.

b) To separate the processing units for "signal communication" and "digital communication." The "control signal line" shall be physically connected to inverter circuits in the charger, and the charger shall be directly terminated by the control signal on this line. An example of system configuration is shown in Figure A.4.

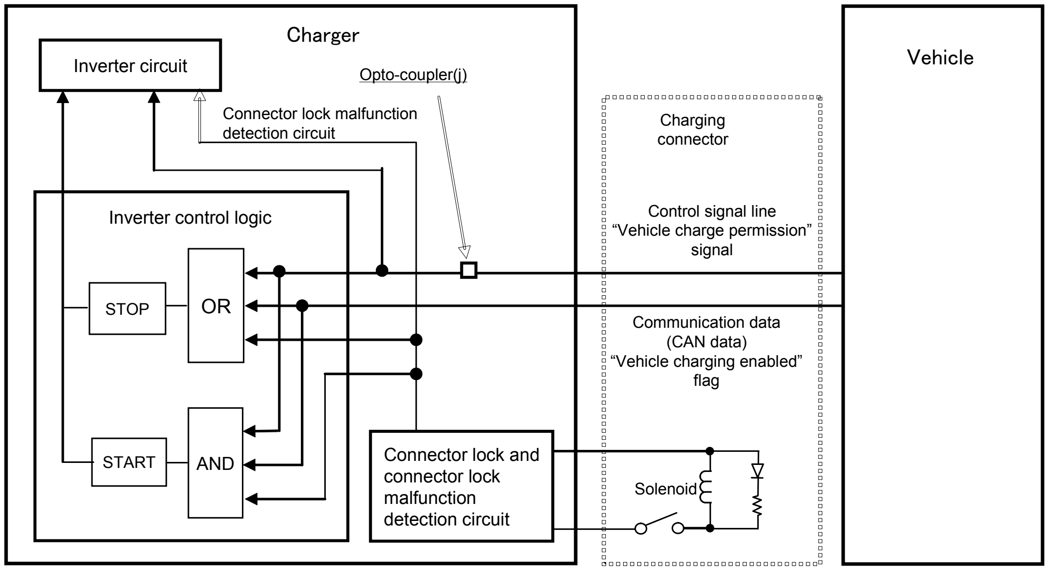


Figure A.4—System configuration example of inverter circuit termination system

c) Control sequence shall be programmed to check the changing point where "control signal line" ("Vehicle charge permission") and "CAN data" ("Vehicle charging enabled" flag described in 0) change from OFF (Charging prohibition) to ON (Charging permission) at the beginning of charging process.

d) Proper filtering components shall be installed on the signal processing units for "control signal line" with consideration for operating frequency of the charger to avoid its noise influence.

e) The charger shall monitor logical discrepancy between "control signal line" and "CAN data." In the event of discrepancy detection, the charger shall set "Charging system malfunction" flag and stop charging.

f) Monitoring items are described as follows:

1) When the charge start button is pushed:

When the "control signal line "Vehicle charge permission" from the vehicle is in the ON state before transmitting first CAN communication data from the charger, the charger shall regard it as logical inconsistency, since the "control signal line: Vehicle charge permission" could be always ON due to vehicle CPU error (as indicated as "1" in Figure A.5).

Also when the "communication data: Vehicle charging enabled" flag from the vehicle is ON before the "control signal line: Vehicle charge permission" from the vehicle is turned ON, the charger shall regard it as logical discrepancy (as indicated as "2" in Figure A.5).

2) Before charging:

If "control signal line" and "CAN data" both do not indicate ON, the charger shall regard this situation as logical discrepancy.

Time delay shall be taken into consideration due to the difference of processing system or signal transmission method.

3) When charging process is terminated:

The charger shall stop charging if either of "control signal line" and "CAN data" indicates OFF. The charger shall not evaluate logical discrepancy.

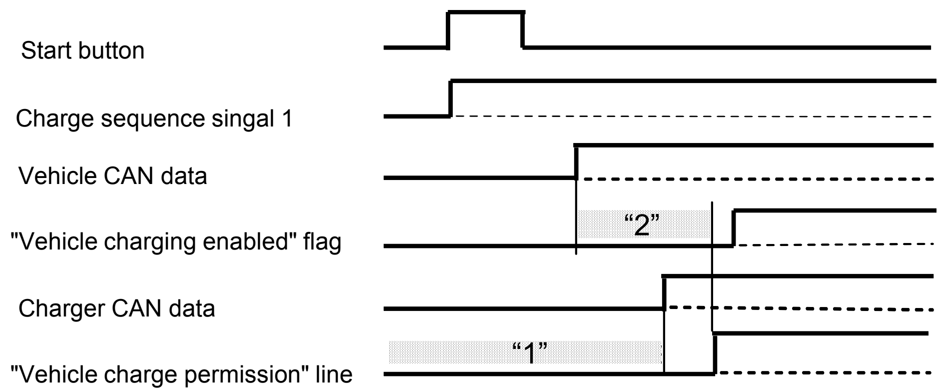


Figure A.5—Timing of logical discrepancy detection after charge start button pressed

A.5.2.7.2 Vehicle

The vehicle shall comply with the following requirements to secure redundancy of terminating system. (See the timing shown in Figure A.6.)

a) At the beginning of the charging, the vehicle shall maintain a certain time interval “a” for turning on both the “Vehicle charge permission” and the “Vehicle charging enabled flag.” This regulation is required to make the inverter circuit of the charger ready for operation as soon as possible.

b) At the end of the charging, except in an emergency stop, the vehicle shall maintain a certain time interval “b” for turning off both the “Charging stop control flag” and “Vehicle charge permission line.” This regulation allows the inverter to soft-stop so that fluctuations on the ac mains shall be mitigated.

c) These regulations shall not be applied in case of emergency stop.

A.5.2.8 Usage of “Connector proximity detection” line

The vehicle shall not always connect “Connector proximity detection” line and vehicle ECU circuit during the period from charge permission [Switch (k) ON] to EV contactor open. See Figure A.3.

If the vehicle uses “Connector proximity detection” line during this period, the vehicle can adopt only the method that does not form the bypass circuit between the vehicle and the charger (the bypass circuit is explained in detail in A.12. An example of “false-drive preventing circuit” that does not form the bypass circuit is shown in Figure A.7.

If the vehicle needs to check the proximity of charging connector continuously or intermittently without the aforementioned false-drive preventing circuit, the vehicle shall use other signal lines [opto-coupler (f), (g)] or CAN data information from the charger. Figure A.3.

A.5.2.9 Vehicle false-drive prevention measures during the charging connector connection

The vehicle shall be equipped with a means to prevent from moving by driving force of its own during connecting the charging connector. Also, the vehicle may be equipped with a means to stop moving without driving force of its own if needed.

The vehicle shall use the “Connector proximity detection” line for a means of connection confirmation of the charging connector during all except for the charging operations.

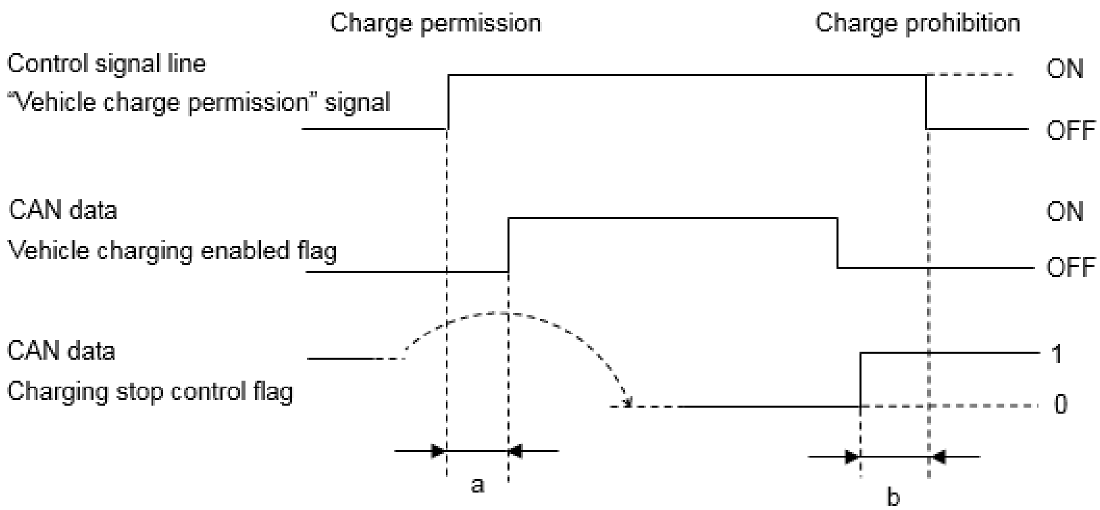


Figure A.6—"Vehicle charge permission" signal timing

Table A.9—"Vehicle charge permission" signal timing

Point	Timing
ON ("a" range)	0.0 s < = a < = 1.0 s
OFF ("b" range)	1.5 s < = b < = 2.0 s

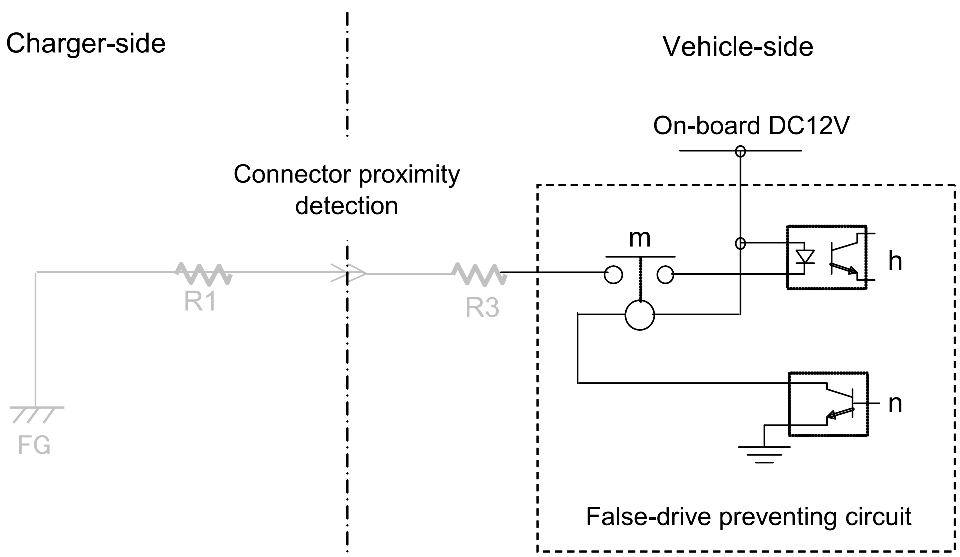


Figure A.7—Example of false-drive preventing circuit

Table A.10—Explanation of figure symbols

Symbol	Explanation
On-board dc 12 V	On-board dc power source (voltage value is not regulated)
h	Signal element used to indicate charging connector proximity (opto-coupler, etc.)
n	Switch on the vehicle. Interlocked with the vehicle ignition.
m	Switch on the vehicle. Interlocked with Switch “n.” Connect on-board control circuit and “Connector proximity detection” line after turning Switch “n” on.

A.5.3 Communication circuit

There shall be a data circuit for CAN communication (see ISO 11898-1 and ISO 11898-2), which facilitates one-on-one communication between the vehicle and the charger. Parameters for charge control (current order value, voltage/current measurement results, flags indicating charging/vehicle conditions, etc.) shall be exchanged via this communication circuit.

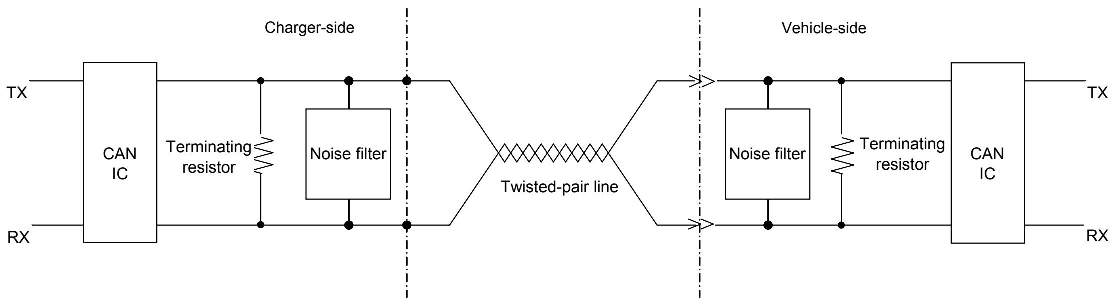


Figure A.8—CAN communication circuit

A.5.3.1 Terminating resistor

Both the charger and the vehicle shall be equipped with a terminating resistor (nominal resistance: 120 Ω, its tolerance in compliance with ISO 11898-2).

A.5.3.2 Noise filter

Both the charger and the vehicle shall be equipped with separate noise filters to reduce conducted noise in common mode and differential mode.

A.5.3.3 Twisted-pair line

A twisted pair line shall be used as the communication line that links the charger with the vehicle so as to reduce differential mode noise.

A.5.3.4 CAN transceiver

The CAN transceiver shall be capable of generating/regulating communication bus signals, supplying the operating current, protecting wires, and reducing noise to micro-computer or other control systems.

A.5.4 Connector lock circuit

The charger shall have a mechanism to lock the charging connector in place during charging (from insulation test to the end of charging). The charging connector shall also have a means of notifying users of lock/unlock status by a lamp, etc.

A.5.4.1 Charging connector and connector lock circuit

The charging connector shall have a mechanism to fix itself to the vehicle inlet mechanically with detachment-proof latch, etc., as well as a mechanism to retain this mechanical locking electrically, so that it would not be detached during charging.

The charger shall have a function to control electrical lock/unlock of this charging connector. The charger shall check the voltage applied on charging connector and confirm that it is below a specified value before unlocking.

A.5.4.2 Lock mechanism

The lock mechanism in the charging connector shall have sufficient mechanical strength.

A.5.4.3 Detection of charging connector lock malfunction

The charger shall monitor and detect disconnection of the solenoid circuit in the connector lock mechanism and retaining latch position. The following items shall be satisfied:

a) The charger shall measure flowing current through the connector locking solenoid.

b) Malfunction of charging connector locking solenoid shall be detected at any time during charging (including insulation test).

c) If a malfunction is detected, the charger shall set “Charging connector lock” flag to 0.

The disconnection detection signal of the charging connector lock (see Figure A.9) shall be embedded in charging start/termination logic. To realize this, the “Disconnection detection signal” line shall be connected to the invertor control circuit of the charger physically, and the charger output shall be terminated by this control signal directly. An example of the system configuration is shown in Figure A.4.

A.5.4.4 Detection of charging connector latching

The charger shall check that the connector locking latch works mechanically. In the event that the connector is not fixed to a vehicle inlet by a latch, a function to interrupt a connector lock malfunction detecting circuit shall be provided in the connector. The function shall be located on the earth side of solenoid of the circuit (see Figure A.9).

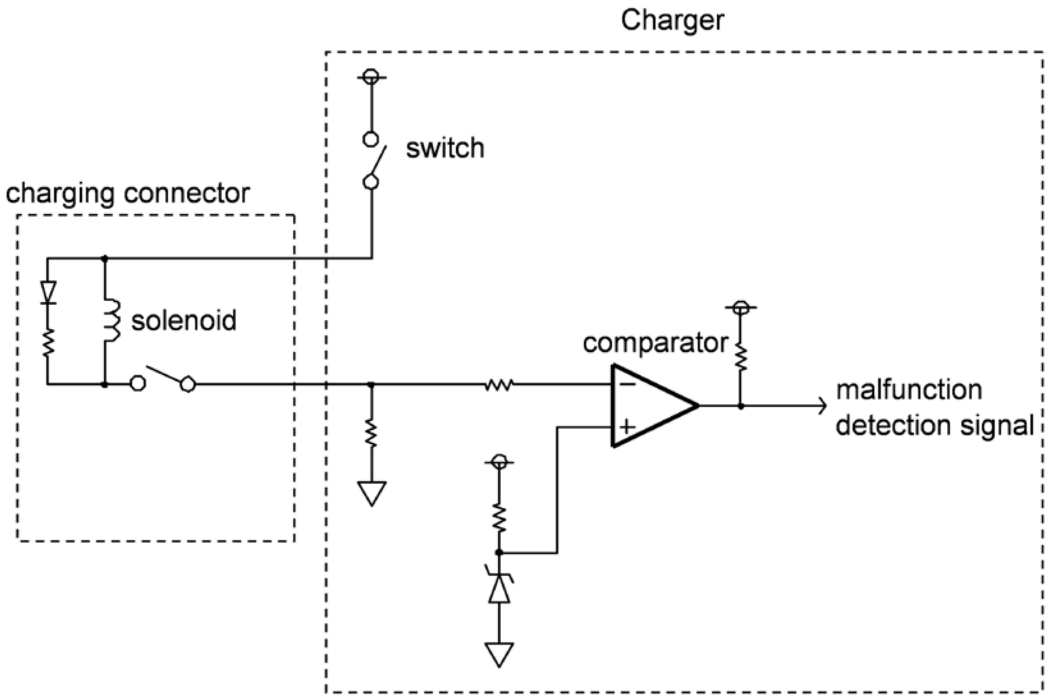


Figure A.9—Example of charging connector lock circuit and disconnection detection circuit

A.5.5 EMC performance

The following items shall be met and criteria such as limit values as described in A.9.

However, if there are other national standards or guidelines, the charger shall also conform to them.

a) The charger shall conform to IEC 61851-1:2010.

b) The manufacturer shall take into account the use of pacemakers in human beings and, if needed, shall call attention to the charger by use of cautionary statements or other means.

c) Emission

   1) Usage environment and the charger category
   2) (High-frequency) harmonics current
   3) AC conducted emission
   4) DC conducted emission
   5) Radiated emission
   6) Voltage surge
   7) Current ripple
   8) Influence of smart key (remote keyless system)
   9) Noise limit on the protective conductor between charger and vehicle

A.6 Communication control

A.6.1 Communication protocol

Communication protocol implemented on the charger or the vehicle shall comply with the specifications shown in Table A.11.

Table A.11—Communication protocol

Item	Specifications
Protocol	CAN 2.0B Active
Format	Standard format (ID length: 11 bits) —An extended format shall not be used.
Communication speed	500 kbps
Bit sample point	72.5% to 87.5%

A.6.2 CAN bus

The bus circuit for CAN communication between the charger and the vehicle (shown in Figure A.10) shall be prepared independently for quick charging.

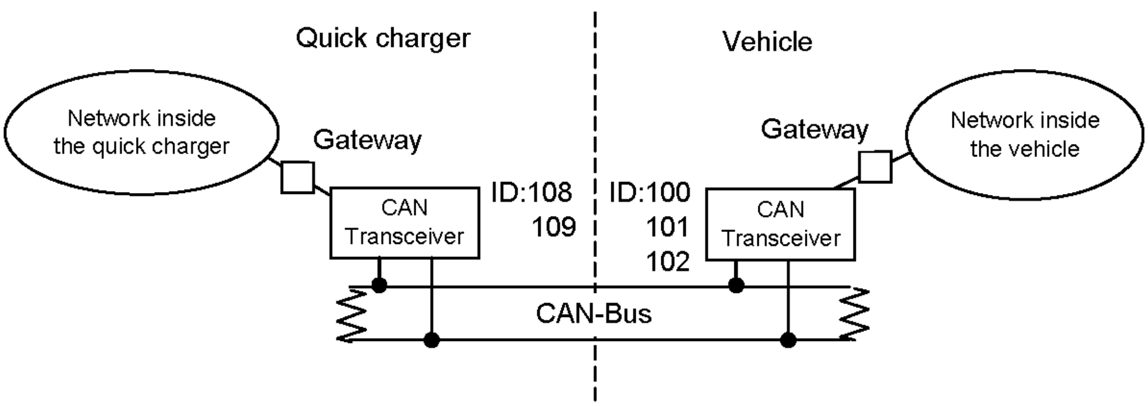


Figure A.10—CAN bus

A.6.3 Transmission method

Follow the specifications in Table A.12.

Table A.12—Transmission method

Item		Specifications
Transmission order	Data frame	Both the charger and the vehicle shall transmit data frames in the ascending order of ID.
	Data byte	Transmit from byte 0 in Table A.14.
	Data bit	Transmit from MSB.
Synchronization		No synchronization between the charger and the vehicle shall be defined. All data frames shall continue to be transmitted from the start to the end of charging according to the transmission cycle.
Transmission cycle		Transmit each data frame at the cycle of 100 ms (±10 ms). See Figure A.11.

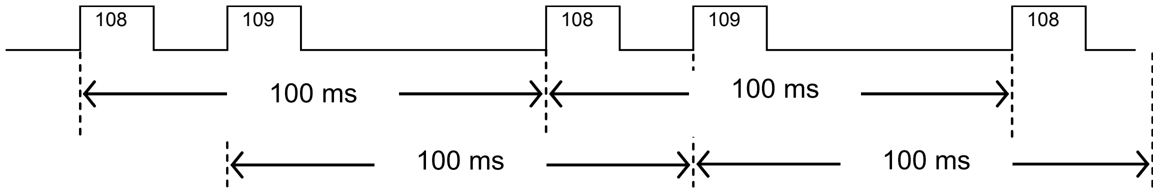


Figure A.11—Transmission cycle (example of transmission from the charger)

A.6.4 Reception method

Received data shall not be echoed in both the charger and the vehicle. Any received error frames shall be discarded.

A.6.5 CAN reception error

The charger shall stop charging if the charger and the vehicle cannot receive data frames for more than 1.0 s. Errors detection starts after the reception of the first CAN data.

Condition

a) Any IDs may be used for detecting non-arrival of data frames.

b) The value of the most recently received normal data shall be used while the state of frame non-arrival continues.

The following conditions are not interpreted as reception errors:

c) Incorrect ID order (when data frames are not received in the ascending order).

d) Out of the transmission cycle (when the transmission cycle deviates beyond the margin of 10% from 100 ms).

e) If CAN receipt is not notified from the vehicle after charge start button is pushed, the charger shall not judge it as a malfunction.

   It is discretionary whether error passive/bus off is considered to be a reception error.

A.6.6 Data format

a) ID

   IDs shown in Table A.13 shall be assigned to the charger and the vehicle.

Table A.13—ID allocation

	ID number
Charger	H'108, H'109 (See NOTE)
Vehicle	H'100, H'101, H'102 (See NOTE)
NOTE—H' indicates hexadecimal	

b) Data length: Fixed at 8 bytes

c) Data allocation: See Table A.14.

d) Format: See 0 and A.6.6.2.

Table A.14—Data table

Source	Destination	ID	Byte	Content	Remarks
Vehicle	Charger	H'100	0		Reserved
			1		Reserved
			2		Reserved
			3		Reserved
			4, 5	Maximum battery voltage	
			6	Charged rate reference constant	
			7		Reserved
		H'101	0		Reserved
			1	Maximum charging time (by 10 s)	
			2	Maximum charging time (by minute)	
			3	Estimated charging time (by minute)	
			4		Reserved
			5, 6	Total capacity of battery (Declared value)	Option
			7		Reserved
		H'102	0	CHAdeMO control protocol number	
			1, 2	Target battery voltage	
			3	Charging current request	
			4	Fault flag	
			5	Status flag	
			6	Charged rate	
			7		Reserved
Charger	Vehicle	H'108	0	Identifier of support for EV contactor welding detection	
			1, 2	Available output voltage	
			3	Available output current	
			4, 5	Threshold voltage	
			6		Reserved
			7		Reserved
		H'109	0	CHAdeMO control protocol number	
			1, 2	Present output voltage	
			3	Present charging current	
			4		Reserved
			5	Status / fault flag	
			6	Remaining charging time (by 10 s)	
			7	Remaining charging time (by minute)	

A.6.6.1 Data format of the vehicle

a) Maximum battery voltage [ID: H‘100]

Byte	5		4	
Max	0	2	5	8

16 bit (High byte: 5, Low byte: 4)
1V/bit, 0 V to 600 V

b) Charged rate reference constant (for display) [ID:H‘100]

Byte	6	
Fix	6	4

8 bit
1% / bit, 100% (fixed)

c) Maximum charging time [ID: H‘101]

To specify the charging time by 10 s : Use Byte1
To specify the charging time by 1 min : Use Byte2

If the vehicle uses Byte2, set Byte 1 as “0xFF”

1) Maximum charging time (by 10 s)

Byte	1	
Max	F	F

8 bit
10 s/bit, 0 s to 2540 s, “0xFF” indicates usage of Byte 2 (by minute).

2) Maximum charging time (by minute)

Byte	2	
Max	F	F

8 bit
1 min/bit, 0 to 255 min

d) Estimated charging time (by minute) [ID: H‘101]

Byte	3	
Max	F	F

8 bit
1 min/bit, offset 1, 0 min to 254 min

e) Total capacity of battery [ID:H‘101] (Option)

Byte	6		5	
Max	F	F	F	F

16 bit (High byte: 2, Low byte: 1)
0.1 kWh/bit, 0.0–6553.5 kWh

f) CHAdeMO control protocol number [ID:H‘102]

Byte	0	
Max	F	F

8 bit
1/bit, Ver. 0 to 255
Refer to A.7.6

g) Target battery voltage [ID:H‘102]

Byte	2		1	
Max	0	2	5	8

16 bit (High byte: 2, Low byte: 1)
1 V/bit, 0 V to 600 V

h) Charging current request [ID:H‘102]

Byte	3	
Max	F	F

8 bit
1 A/bit, 0 A to 255 A

i) Fault flag (vehicle) [ID:H‘102]

Byte	4							
Max	1				F			
Bit	0	0	0	1	1	1	1	1
				(4)	(3)	(2)	(1)	(0)

(0) Battery overvoltage (0: normal, 1: fault)
(1) Battery under voltage (0: normal, 1: fault)
(2) Battery current deviation error (0: normal, 1: fault)
(3) High battery temperature (0: normal, 1: fault)
(4) Battery voltage deviation error (0: normal, 1: fault)

j) Status flag (vehicle) [ID:H‘102]

Byte	5							
Max	1				F			
Bit	0	0	0	1	1	1	1	1
				(4)	(3)	(2)	(1)	(0)

(0) Vehicle charging enabled (0: disabled, 1: enabled)
(1) Vehicle shift position (0: “Parking” position, 1: other position)
(2) Charging system fault (0: normal, 1: fault)
(3) Vehicle status (0: EV contactor close or during welding detection, 1: EV contactor open or termination of welding detection)
(4) Normal stop request before charging (0: No request, 1: Stop request)

k) Charged rate (for display) [ID: H‘102]

Byte	6	
Max	6	4

8 bit
1% / bit, 0% to 100%

A.6.6.2 Data format of the charger

a) Identifier of support for EV contactor welding detection [ID: H‘108]

Byte	0	
Max	F	F

8 bit
1/bit, Ver. 0 to 255
0: Not supporting EV contactor welding detection described in A.10
Other number: Supporting for EV contactor welding detection described in A.10

b) Available output voltage [ID: H‘108]

Byte	2		1	
Max	0	2	5	8

16 bit (High byte: 2, Low byte: 1)
1 V/bit, 0 V to 600 V

c) Available output current [ID: H‘108]

Byte	3	
Max	F	F

8 bit
1 A/bit, 0 A to 255 A

d) Threshold voltage [ID: H‘108]

Byte	5		4	
Max	0	2	5	8

16 bit (High byte: 5, Low byte: 4)
1 V/bit, 0 V to 600 V

e) CHAdeMO control protocol number [ID: H‘109]

Byte	0	
Max	F	F

8 bit
1/bit, Ver. 0 to 255
Refer to A.7.6

f) Present output voltage [ID: H'109]

Byte	2		1	
Max	0	2	5	8

16 bit (High byte: 2, Low byte: 1)
1 V/bit, 0 V to 600 V

g) Present charging current [ID: H'109]

Byte	3	
Max	F	F

8 bit
1 A/bit, 0 A to 255 A

h) Status / fault flag (charger) [ID: H'109]

Byte	5							
Max	3				F			
Bit	0	0	1	1	1	1	1	1
			(5)	(4)	(3)	(2)	(1)	(0)

(0) Charger status (0: standby, 1: charging)
(1) Charger malfunction (0: normal, 1: fault)
(2) Charging connector lock (0: open, 1: locked)
(3) Battery incompatibility (0: compatible, 1: incompatible)
(4) Charging system malfunction (0: normal, 1: malfunction)
(5) Charging stop control (0: operating, 1: stopped or stop charging)

i) Remaining charging time [ID: H'109]

1) Remaining charging time (by 10 s)

Byte	6	
Max	F	F

8 bit
10 s/bit, 0 s to 2540 s, "0xFF" indicates usage of Byte 2 (by minute)

2) Remaining charging time (by using minutes)

Byte	7	
Max	F	F

8 bit
1 min/bit, 0 min to 255 min

i) If the vehicle use Byte7, set Byte6 as "0xFF".

ii) If Byte 6 is set as "0xFF" at the start of charging, continue to count down Byte 7 until the end of charging.

iii) Round up the time value.

A.7 Charging Control

A.7.1 Overview

The charger charges the on-board battery using the “constant current charging method” with the vehicle as master and the charger as slave. The charger outputs charging current according to charging current request, transmitted by the vehicle to the charger. The order value from the vehicle is notified to the charger in CAN communication with the cycle of 100 ms. When the vehicle changes its order value, the charger shall change output current to correspond to the change.

A.7.2 Basic requirements

A.7.2.1 Start

Charging control process shall start when “Charge start button” of the charger is pushed.

A.7.2.2 Permission

a) The charger shall not apply voltage/current on charging circuit of the vehicle until it receives the “charging permission” signal from the vehicle.

b) The “Charging permission” signal from the vehicle to the charger shall be transmitted via both the “control signal line” and “CAN communication signal line.”

c) The charger shall determine that the vehicle has given it charging permission only when signals from both the “control signal line” and “CAN communication signal line” convey “permission” information.

d) The vehicle indicates charging permission with the following signals:

   1) “Charge permission signal line”: When on-board switch (k) is ON.

   2) “Vehicle CAN data”: When #102.5.0 (“Vehicle charging enabled” flag) is “1”.

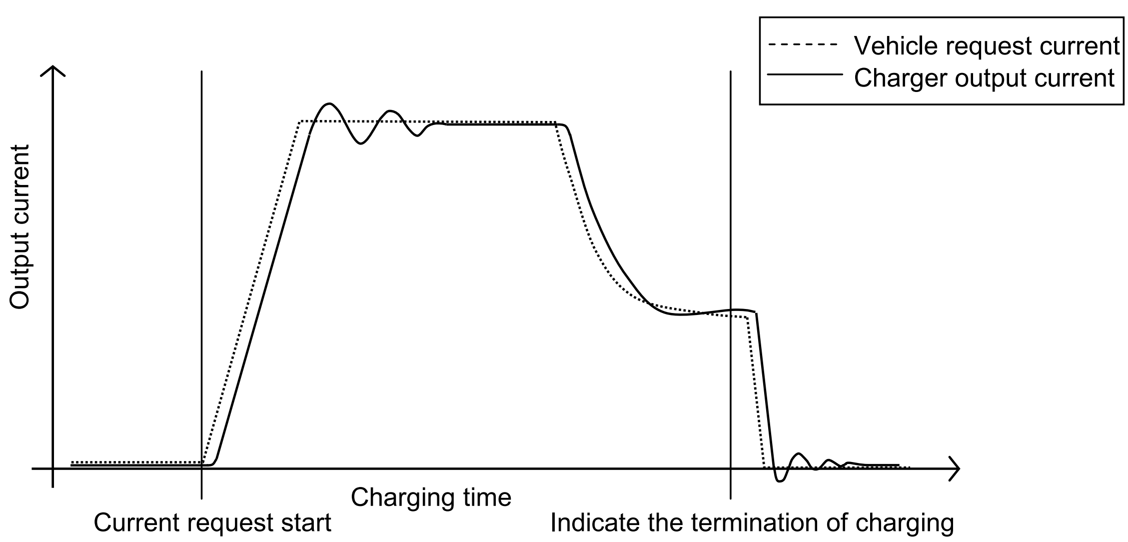
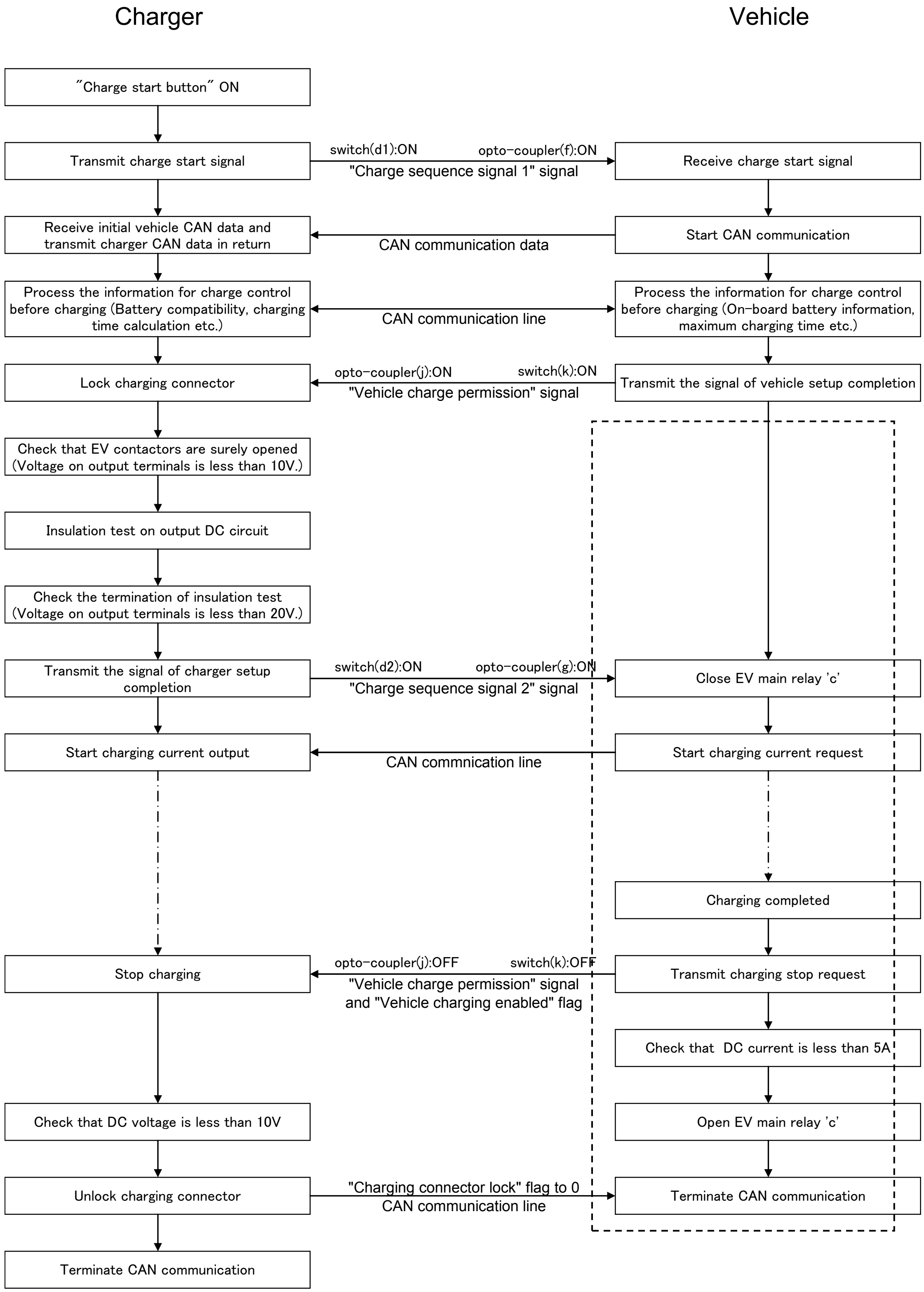


Figure A.12—Relationship between vehicle order and charger output



NOTE—For proximity detection between the connector and the inlet see A.5.2.8, and Control and communication timing are specified in A.11. Reference Figure A.3 for the sequence circuit.

Figure A.13—Charging control flow

A.7.2.3 Termination

a) Both the charger and the vehicle shall be able to indicate the termination of charging control to each other.

b) Both the charger and the vehicle shall support "Charge control termination command patterns" described in Table A.15.

c) If even one of the "Notice to the other party" items described in each command pattern in Table A.15 is performed, the receiver side shall determine that the sender has instructed charge control termination, and immediately shift to the charge termination process.

Table A.15—Charge control termination command patterns

Command pattern	Source	Reason	Notice to the other party		Destination
			Noticing way	Signal status	
1	Vehicle	Charged rate of on-board battery has reached a specified level.	— #102.5.0 (Vehicle charging enabled) — Switch (k) [a]	0 OFF	Charger
2	Charger	"Charge stop button has been pushed." Or "Charging time has reached a specified value."	— #109.5.5 (Charger Stop control)	1	Vehicle
3	Vehicle	Vehicle malfunction detected Charger malfunction detected	— Switch (k) — #102.5.0 (Vehicle charging enabled) — Fault-related flags in #102	OFF 0 1	Charger
4	Charger	Charger malfunction detected Vehicle malfunction detected	— Fault-related flags in #109.5 — #109.5.5 (Charger Stop control)	1 1	Vehicle
NOTE—#XXX.Y.Z stands for CAN data defined in A.6.6. #XXX: CAN data ID, Y: byte position and Z: bit position.					

[a] Turned off in a specified period of time after #102.5.0 becomes 0.

A.7.2.4 Control timing

A.7.2.4.1 Method

Both the charger and the vehicle shall control charging together with predetermined sequence as defined in A.11.

A.7.2.4.2 Observing time constraints

Both the charger and the vehicle shall have two time constraints, Compliance time, and Time-out time, defined for each charging control process to manage time required in the processes. The time constraints are defined as A.7.2.4.2.1 and A.7.2.4.2.2.

A.7.2.4.2.1 Compliance time

The compliance time is the processing time with which both the charger and the vehicle shall comply. It shall be defined in the following two approaches:

a) Maximum time: Within XX.X seconds

b) Specified time: Between YY.Y seconds and ZZ.Z seconds

A.7.2.4.2.2 Time-out time

The time-out time is the time to monitor any delay in control processes of the other party, the vehicle, or the charger, and to force the charging control to shift to the termination process in the event of excessive delay. It shall be specified as follows:

a) Time-out: UU.U seconds

When the control process of the other party, the vehicle, or the charger does not end after UU.U seconds have elapsed, the system shall determine that there is an error, and shift to the termination process within 2 s. In this case, for the time-out process by the vehicle, change #102.5.2 (charging system fault) to a 1 in the CAN message data and transmit to the charger.

For the time out process by the charger, change #109.5.4 (Charger system malfunction) to a 1 in the CAN message data and transmit to the vehicle.

A.7.2.5 Parameter exchange

Both the charger and the vehicle shall control charging with exchanging CAN charging parameters specified in A.11.

A.7.2.6 Measurement

A.7.2.6.1 Circuit current and voltage

The charger shall measure output current and voltage and send these values to the vehicle via CAN network continuously through all charging control processes from charging start (CAN communication start) to charging termination (Unlock charging connector and CAN communication termination).

With regard to circuit voltage, the vehicle and the charger shall measure and estimate voltage value at the point described in Table A.16. If it is difficult to measure voltage at specified points directly, monitored value shall be compensated to adopt as measured value.

Table A.16—Voltage estimating point

Measurer	Measurement point
Charger	Output terminals in the charger[a, b]
Vehicle	Terminals at the vehicle inlet

[a] Monitored value should be corrected as the one measured at the charging connector terminals and the charger shall use it for charging control and sending voltage data to the vehicle.
[b] Resistance value of the charging cable, required for the voltage compensation should be measured by Figure A.14.

A.7.2.6.2 Resistance measure with a voltage drop method

a) Short the charging cable on the charger side.

b) Apply current from external power supply equipment equivalent to the charger maximum output current, measure the voltage, and calculate the resistance of charging cable.

c) See Equation (1) to calculate the resistance of the charging cable (R).

$$R = Vcbl/I \tag{1}$$

where

R is the resistance of the charging cable
Vcbl is the voltage of the charging cable at the charging connector
I is the current through the shunt resistance

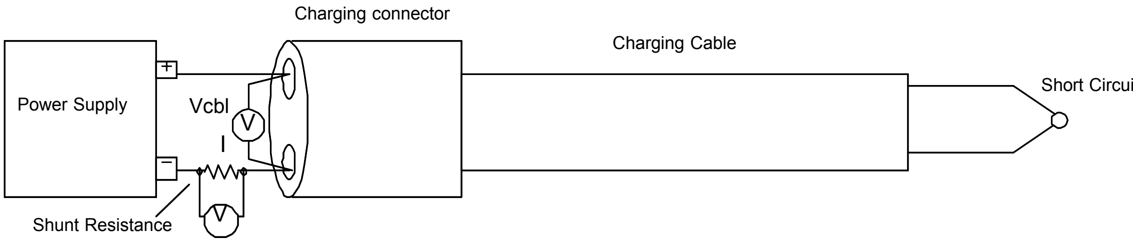


Figure A.14—Resistance measurement with voltage drop method

A.7.2.6.3 Measuring system evaluation

a) The vehicle shall compare the voltage value measured by itself with the value by the charger.

b) As a result of the comparison mentioned in item a), if the deviation more than previously specified value is detected, the vehicle shall judge that charging fault has occurred and notify the charger of charging termination. The judging method is described in A.8.

A.7.2.7 Monitoring and protection

A.7.2.7.1 Continuous monitoring

The vehicle and the charger shall constantly monitor the items listed in A.7.2.7.1.1 and A.7.2.7.1.2, respectively.

The manufacturer shall prescribe the specific implementation methods.

A.7.2.7.1.1 Vehicle

a) Problems on the charging circuit of the vehicle

b) Control timing and process time for the charger and the vehicle

c) Output response of the charger to the charging current request

d) Difference between measured voltage value the vehicle and the one of the charger

e) Connection with the charger

f) Immobility of the vehicle (check the position of shift lever, etc.)

g) Problem with CAN communication reception

h) Problem with vehicle CPU (monitoring by a watch-dog timer, etc.)

A.7.2.7.1.2 Charger

a) Earth fault on dc power circuit

b) Circuit problem (main charging circuit, control/communication circuits)

c) Power supply problem (charging inverter, power supply for control/EV contactor)

d) Control timing and processing time for the charger and the vehicle

e) Immobility of the vehicle (check “Vehicle shift position,” etc.)

f) Locking status of charging connector

g) Status of the “Charge start button,” “Charge stop button,” and “Emergency stop button”

h) Problem with CAN communication reception

i) Problem with CPU (monitoring by a watch-dog timer, etc.)

A.7.2.7.2 Requirements for the charger

The charger shall have the following diagnosis and monitoring functions in addition to continuous monitoring:

a) Compatibility check of on-board battery

Before the start of charging, the charger shall receive the following information related to on-board battery from the vehicle through CAN communication:

— Maximum battery voltage: #.100.4, #.100.5

— Target battery voltage: #.102.1, #.102.2

The charger shall compare the voltage setting value of the vehicle and its maximum output voltage.

If the vehicle requires charging voltage beyond maximum output voltage of the charger the charger shall set “Battery incompatibility” flag #109.5.3 to 1 and notify that it is incapable of charging.

The voltage information exchanged between the vehicle and the charger via CAN communication shall be corrected value of the measuring parts stipulated in Table A.16.

b) Insulation test for output dc circuit

— The charger shall apply test voltage on output dc circuit of the charge circuit (from the charger to the vehicle inlet) in order to check no existence of earth fault (DC current leakage) and short circuit inside the charger and on the charging cable. If abnormal events have occurred during this test, the charger shall immediately stop applying the test voltage on output dc circuit. This test shall be conducted each time before the start of charging. Now, the charger shall check that EV contactors are surely opened before application of test voltage on dc circuit.

— The vehicle shall close its contactors after confirming that the charger is operating properly according to the result of the above test.

— The charger shall conduct the insulation test with dc leakage current monitoring device regulated in A.5.1.9. Test voltage shall be dc 500 V (±25 V = 5%), and shall be applied for at least “False operation prevention time” defined in Table A.6.

— DC leakage current monitoring shall be carried out throughout the charging period, including not only during insulation diagnosis, but also from the start to the end of charging and charging connector unlocking.

— The vehicle shall have more than 100 kΩ insulation resistance between power line (+) and power line (−) from vehicle inlet terminals to EV contactor on charging circuit. (It also prevents erroneous judgment at short circuit detection between power line (+) and power line (−) line by the charger.)

— Judging criterion shall be 100 kΩ or less when the charger performs insulation test and short circuit diagnosis between power line (+) and power line (−) on the vehicle. The charger shall avoid making erroneous decision with this criterion.

c) On-board battery protection

— If the circuit voltage exceeds “Maximum battery voltage” described in item a) of A.7.2.7.2, during charging, the charger shall stop charging.

— The charger shall monitor the charging time, and stop charging when charging time exceeds the specified time "Maximum charging time" received from the vehicle.

d) Voltage check

The charger shall check the circuit voltage at the following stages, and compare it with the stipulated value given in Table A.17. In the event that the voltage does not meet the stipulated value, the charger shall make the shift to termination process.

e) Self-diagnostic features of the dc leakage current monitoring device

- The charger shall confirm the dc leakage current monitoring device is operating normally before the start of charging (during the insulation test).
- The charger shall not start the charging operation if a malfunction or abnormality in the dc leakage current monitoring device is detected.

Table A.17—Charging stage and check item

Charging stage	Check item
Before insulation test	The EV contactors shall be open (voltage: ≤10 V).
After insulation test	On completion of the insulation test, the measured voltage shall be ≤20 V.
Before charge current output	The EV contactors shall be closed and the voltage of the on-board battery shall be confirmed on the charging cable. After the insulation test, do not apply voltage on vehicle circuit before the EV contactors are closed and until the charger receives the charging current order. (To prevent EV contactors from being damaged by inrush current.)
Before charging connector unlocking	Except for a power outage, do not unlock the charging connector if the vehicle inlet voltage is ≥10 V. Even in the event of power outage, drop charge output circuit to 60 V or less within 1 s unless EV contactors are welded.

A.7.2.8 Protection of EV contactor

- (d1) and (d2) switches of the sequence circuit in the charger shall not be opened until charge current to the vehicle falls to the specified value.
- The specified value is 5 A.
- The vehicle shall operate EV contactor unless in emergency such as in “emergency stop.”
- Even at “emergency stop,” the switches (d1) and (d2) of the charger shall not open until the current output is halted.
- Even if ac input power blackout or load fluctuations are lowering the power supply voltage, the dc 12 V power supply voltage to the vehicle shall be maintained until the charge current to the vehicle reaches a specified level (5 A) or below. Also make sure to keep the (d1) and (d2) switches ON (closed state). See Requirement i) of A.4.4.

A.7.2.9 Termination process in emergency stop

The following means shall be taken to immediately stop supplying power to main charge circuit and the charger to bring the charger to an emergency stop when the “Emergency stop button” is pushed or when a significant fault or problem occurs on the charger.

a) Turn off inverter gate of the charger.

b) Immediately open the main circuit breaker AC-ELCB1 (see A.5.1).

Even in this case, do not immediately interrupt power supply of the control circuit in conjunction with the occurrences of malfunction and abnormality, and observe the provisions described in Requirement i) of A.4.4 and A.7.2.8.

A.7.2.10 Recovery from charging suspension

If charging is suspended due to a problem or power outage, the charging operation shall not be recovered automatically. The charger shall be equipped with a means permitting the charging station user or the maintenance personnel to reset to operational mode.

A.7.3 Charging current order from the vehicle and response performance of the charger

Charging current order from the vehicle and output current response of the charger shall meet the characteristics shown in Table A.18.

Table A.18—Requirement for charging current request of the vehicle (#102.3)

Item	Symbol	Condition	Specification			
			Min	Typ	Max	Unit
Charging current request range	Ireq		0	—	(#108.3) Available output current	A
Changing speed of order value during charging	ΔIreq1		−20	—	20	A/s
Descending speed at the time of stop	ΔIreq2	Except at an emergency stop	—	—	200	A/s

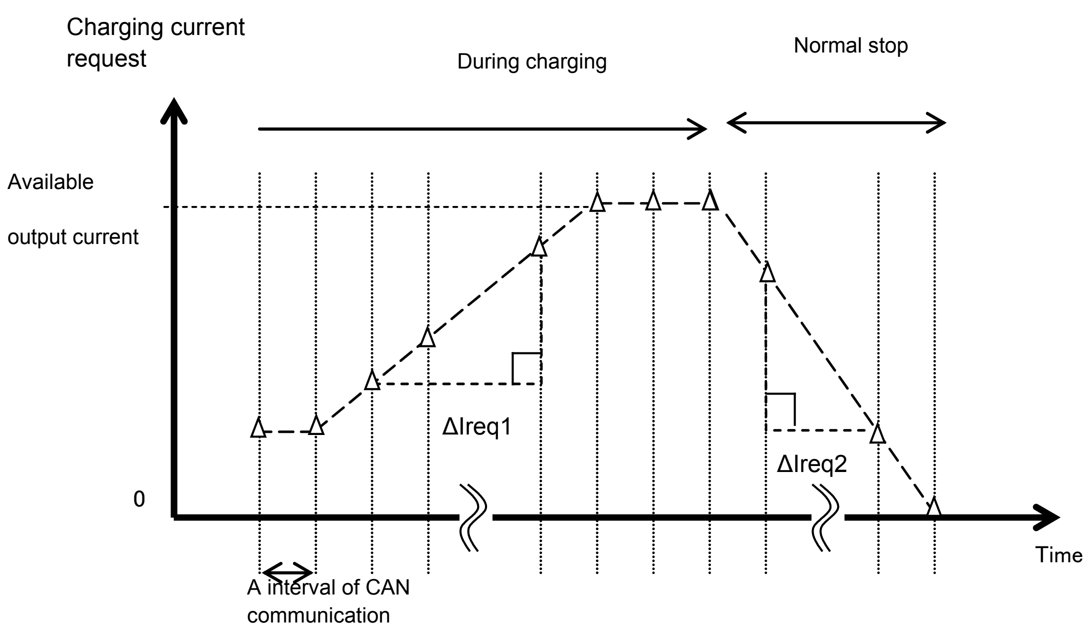


Figure A.15—Regulation for the charging request

Table A.19—Requirements for the charger's output response performance

Item	Symbol	Condition	Specification			
			Min	**Typ**	**Max**	**Unit**
Output accuracy	Idev	Charging current request: 0 A to 50 A	Typ − 2.5 A	Charging current request	Typ + 2.5 A	A
		Charging current request: 50 A to 125 A	Typ × 95%		Typ × 105%	
Control delay to vehicle request	Td		—	—	1.0	s
Output response speed	ΔIout1	At charging (for both rise and fall)	20	—	—	A/s
Output current descending speed	ΔIout2	At a normal stop	100	—	200	
		At an emergency stop	200	—	—	
		At an emergency stop [e.g., switch (k) OFF)]	The output current shall drop to 5 A within 30 ms			
Ripple content rate	IRip	For the criteria and the testing methods, the charger shall comply with A.9.7.				

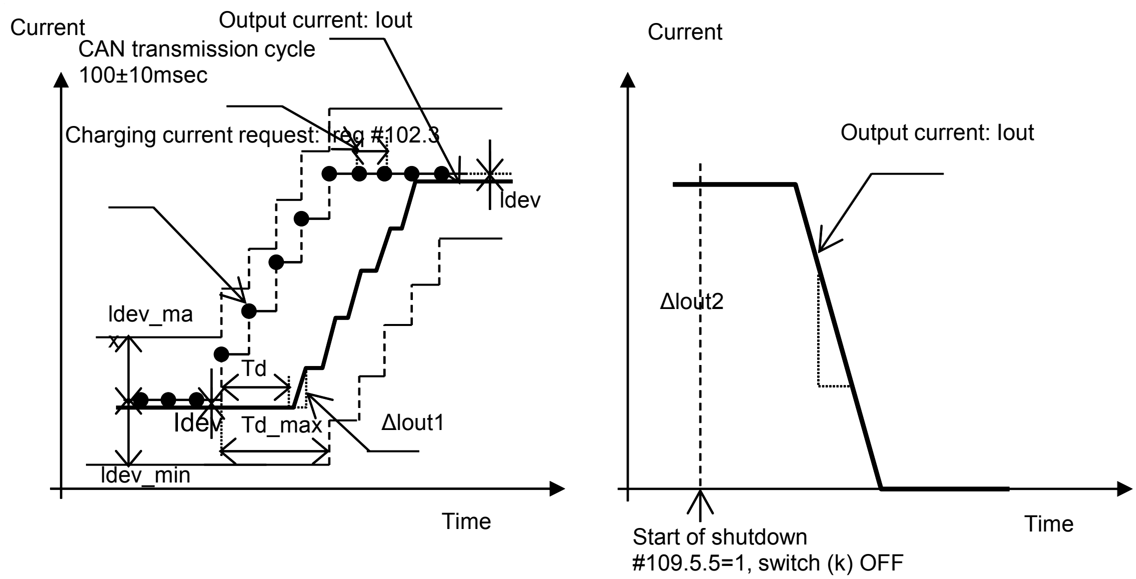


Figure A.16—Output response performance of charger without CAN communication error left side: during charging, right side: at the time of stop

A.7.4 Current/voltage measurement accuracy and its reflection to CAN information

Voltage/current measurement accuracy of the charger and permissible delay in transmitting CAN data to vehicles are specified in Table A.20.

Table A.20—Voltage and current measurement accuracy

Item	Accuracy
Current (instrumental precision)	Within ± (1.5% of actual value + 1.0 A)
Voltage (instrumental precision)	Within ±5 V
CAN data update delay	Transmit current/voltage data within 0.5 s including measurement delay and CAN communication transmission delay.

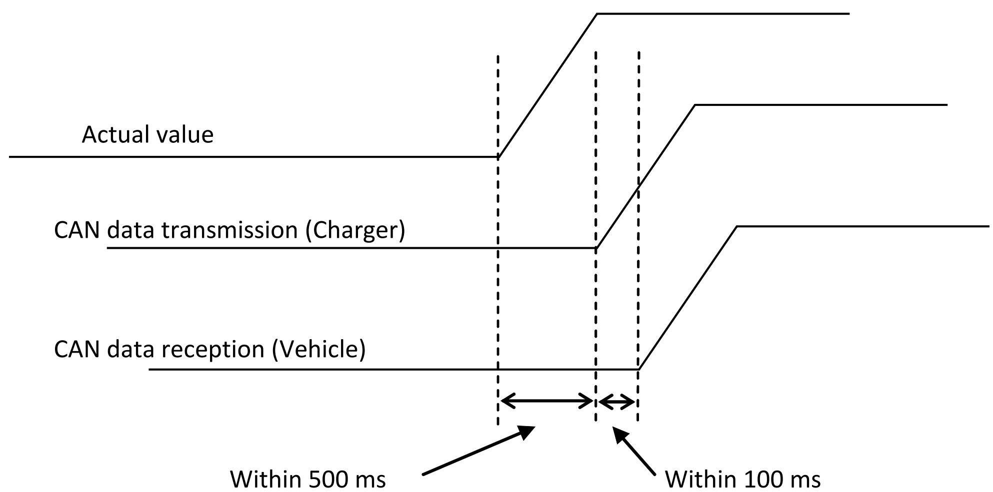


Figure A.17—Definition of measurement delay and data transmission delay

A.7.5 Support for EV contactor welding detection

To assist welding detection on the vehicle (option of vehicle manufacturers), the output circuit of the charger shall have the following characteristic:

— The circuit voltage shall drop below 25% of circuit voltage, which is monitored before EV contactors are opened, within 1 s after the charger terminates charging output and EV contactors are opened.

See A.10 for details.

A.7.6 CHAdeMO control protocol number

The charger and the vehicle shall respectively set #.109.0 and #.102.0 to the protocol number values specified in Table A.21 from first CAN communication data, and they shall not be changed until the end of sequence.

Table A.21—CHAdeMO control protocol number settings

CHAdeMO version of standard specifications	CHAdeMO control protocol number
Before 0.9	0
0.9, 0.9.1	1
1.0.0, 1.0.1	2

A.7.7 Display

A.7.7.1 Information to charger users

The following information relating to charging control shall be displayed (display by lamp, letters, sound, images, labels, and the combination of these).

a) Charger status
   1) Standby stage
   2) Preparation stage
   3) Charging stage
   4) Charging termination stage
   5) Emergency stop stage
b) Removal of the charging connector. When the charging process stops abnormally, displayed information may prohibit usage of the charging connector. (Display may show a message indicating a risk of electric shock.)
c) Display in the case of CAN communication failure. If CAN data is not sent from the vehicle after the start of charging, the charging connector may not be properly inserted in the vehicle inlet. If this event occurs, it is preferable to display the message “Please check charging connector for proper insertion.”

A.7.7.2 Guidance related to users

Warnings that are necessary for users shall be displayed as appropriate, regardless of output charging current.

A.8 Error definition

A.8.1 Error list

The following requirements shall be met:

a) The charger shall monitor its operational status as well as the vehicle status, and the vehicle shall do the same.
b) The requirements detailed in Table A.22 and Table A.23 (types of trouble, judging criteria, notice to the other device via CAN communication) shall be met.
c) The charger and vehicles shall be designed with thorough considerations on error display and recording functions, so that, when error conditions are detected, the charger's users or maintenance personnel can take corrective action efficiently.
d) If the charger or the vehicle receives a flag indicating trouble or fault (see A.6.6), acknowledgment shall not be required (e.g., when the vehicle notifies the charger, via CAN, of trouble, the charger shall not send a CAN message to acknowledge the vehicle trouble). This is so as to help identify on which side the trouble has occurred.

Table A.22—Error information list (detected by the vehicle)

Error detector	Location of error	Reason for error judgment	Judging criteria	CAN message			
				Item name	ID	Byte	bit
Vehicle	Vehicle	On-board battery voltage has reached the upper limit during charging.	On-board battery voltage > Vehicle CAN “Maximum battery voltage.”	Battery over-voltage	H’102	4	0
Vehicle	Vehicle	On-board battery voltage has reached the lower limit during charging.	On-board battery voltage is lower than the lower limit of voltage specified by the vehicle (due to over-discharge, etc.).	Battery under-voltage	H’102	4	1
Vehicle	Charger or vehicle	Output current of the charger does not follow the charging current request sent from the vehicle (current deviation).	Vehicle shall evaluate the current deviation error by comparing “Present output current,” “Charging current request,” measured current by vehicle and etc. Judging example: In the case of charger’s CHAdeMO control protocol number is 0x00. The vehicle shall judge that an error has occurred if the circuit current exceeds at least 12 A above the “maximum value of Charging current request in the last 1 s.” In the case of charger’s CHAdeMO control protocol number is 0x01 or higher. The vehicle shall judge that an error has occurred if present circuit current is either at least 12 A above the “maximum value of Charging current request in the last one second” or at least 12 A below the “minimum value of Charging current request in the last 1 s,” when the charger is in the charging mode (#.109.5.5 Charging stop control) is 0.	Battery current deviation error	H’102	4	2
Vehicle	Vehicle	On-board battery temperature has reached the upper limit during charging.	On-board battery temperature exceeds the upper limit.	High battery temperature	H’102	4	3

Table A.22—Error information list (detected by the vehicle) *(continued)*

Error detector	Location of error	Reason for error judgment	Judging criteria	CAN message			
Vehicle	Charger or vehicle	Voltage figure sent from the charger (Present output voltage) is different from the on-board battery voltage.	Vehicle shall evaluate the battery voltage differential error by comparing "Present output voltage," measured voltage by vehicle, and etc. Judging example: The vehicle shall judge that an error has occurred if measured voltage in the charger cannot be contained within ±10 V of measured on in the vehicle for consecutive 5 s.	Battery voltage differentia error	H'102	4	4
Vehicle	Charger or vehicle	Various procedures in the charger exceed the time-out value specified in the specification document.	Time-out value is exceeded.	Charging system fault	H'102	5	2
Vehicle	Charger or vehicle	CAN data from the charger cannot be received during charging.	CAN reception error [a] continues for 1 s or longer.	Charging system fault	H'102	5	2
Vehicle	Charger or vehicle	Any other faults.	Of errors detected by the vehicle, those that are caused by the charger. Based on manufacturers'own criteria.	Charging system fault	H'102	5	2
Vehicle	Vehicle	The vehicle becomes movable state during charging.	Position of the shift lever, etc.	Vehicle shift position	H'102	5	1
Vehicle	Vehicle	Any other faults that occur inside the vehicle.	Of errors that vehicles detect, those that are caused by the vehicle. Based on manufacturers' own criteria.	Charging system fault	H'102	5	2

[a] Defined in A.6.5.

Table A.23—Error information list (detected by the charger)

Error detector	Location of error	Reason for error judgment	Judging criteria	CAN message			
				Item name	ID	Byte	bit
Charger	Charger	An error has occurred in the charger.	— Fault detection and tripping operation by AC-ELCB1. — Based on manufacturers' criteria (e.g. Short circuit, earth fault and/or etc on the primary side of the isolated transformer)	Charger malfunction	H'109	5	1
Charger	Charger	Charging connector lock error.	Malfunction of charging connector lock circuit.	Charger malfunction	H'109	5	1
Charger	Vehicle or Charger	Main circuit error	DC short circuit, dc earth fault	Charging system malfunction	H'109	5	4
Charger	Charger	Emergency stop button is pushed.	Emergency stop button is ON.	Charger malfunction	H'109	5	1
Charger	Vehicle or charger	The voltage required by the vehicle is higher than charger "Available output voltage."	Vehicle "Target battery voltage" > Charger "Available output voltage.""	Battery incompatibility	H'109	5	3
Charger	Vehicle or charger	Various procedures of the vehicle exceed the time-out value specified in the specification document.	Time-out value is exceeded.	Charging system malfunction	H'109	5	4
Charger	Vehicle or charger	CAN data from the vehicle cannot be received during charging.	CAN reception error[a] continues for 1 s or longer.	Charging system malfunction	H'109	5	4
Charger	Vehicle or charger	On-board battery voltage is not applied to the main circuit before the start of charging.	Measured voltage is less than 50 V after d2 is ON.	Charging system malfunction	H'109	5	4
Charger	Vehicle or charger	The voltage required by the vehicle is higher than charger "Available output voltage."	Vehicle "Charging current request" > Charger "Available output current."	Charging system malfunction	H'109	5	4
Charger	Vehicle or charger	On-board battery continues to apply voltage to the main circuit after the termination of charging.	Voltage measured by the charger > 10 V.	Charging system malfunction	H'109	5	4
Charger	Vehicle or charger	When "DC Voltage" exceeds "Threshold Voltage."	"Vdc" > Vehicle CAN "LIMIT_VOLT" = False	Charging system malfunction	H'109	5	4

Table A.23—Error information list (detected by the charger) *(continued)*

Error detector	Location of error	Reason for error judgment	Judging criteria	CAN message			
Charger	Vehicle	Any other faults	Of errors that the charger detects, those that are caused by the vehicle. Based on manufacturers' own criteria.	Charging system malfunction	H'109	5	4
Charger	Vehicle or charger	A discrepancy between CAN parameter and sequence signal	Cases specified in A.5.2.7.1. f)1) :When a charge start button is pushed f)2) Before charging				

[a] Defined in A.6.5.

A.9 EMC performance (emission)

EMC tests shall be performed according to the following conditions:

a) Operating condition: On the condition with maximum rated output power and current of the charger.

b) Load condition: Resistance load, LISN, Capacitor (refer to the load condition and circuit diagram described in each test).

c) Charging cable length: According to the design of each manufacturer.

d) LISN specs. on ac lines: Compatible with CISPR 16.

e) LISN specs. on dc lines: Compatible with CISPR 25.

A.9.1 Usage environment and charger category

a) Environment category

Category	Definition
First environment	Residential environment, and/or environments including industrial and light industrial facilities connected to low-voltage commercial power grid for residences without intermediate transformers.
Second environment	Commercial, industrial, and light industrial environments except First environment.

b) Category of quick charger

Category	Definition
C1	Chargers that are assumed to be used without any constraints under First environment.
C2	The charger that is assumed to be used without any constraints under First environment. If it is used under First environment, make sure that there is no building categorized as First environment within a 10 m radius.
C3	The charger that is assumed to be used under Second environment. Make sure that the charger is more than 30 m away from buildings categorized as First environment.
NOTE—In any categories, if electromagnetic disturbance is caused by the charger, consult with users and consider additional measures, etc.	

A.9.2 Harmonic current

a) Test method
   1) Test standard: IEC 61000-4-7
   2) Load condition: Resistance load

b) Limit value
   1) Comply with IEC 61000-3-12

A.9.3 AC conducted emission

a) Test method
   1) Test standard: CISPR 16-1-2
   2) Load condition: Resistance load and LISN (CISPR 16)

c) Limit value
   1) Unit: dBμV

Table A.24—Limit value of ac conducted emission

	Frequency (MHz)	Category of quick charger		
		C1	C2	C3
AC line	0.15 to 0.5	66-56 (QP) 56-46 (AV)	79 (QP) 66 (AV)	100 (QP) 90 (AV)
	0.5 to 5.0	56 (QP) 46 (AV)	73 (QP) 60 (AV)	86 (QP) 76 (AV)
	5.0 to 30.0	60 (QP) 50 (AV)	73 (QP) 60 (AV)	90-73 (QP) 80-60 (AV)

NOTE—
C1： Cited from limit value of Class B device in CISPR 11
C2： Cited from limit value of Class A device (≤20 kVA) in CISPR 11
C3 ：Cited from limit value of Class A device (>20 kVA) in CISPR 11

A.9.4 DC conducted emission

a) Test method

Test circuit: See Figure A.18.

Load condition: Resistance load and LISN (CISPR 25).

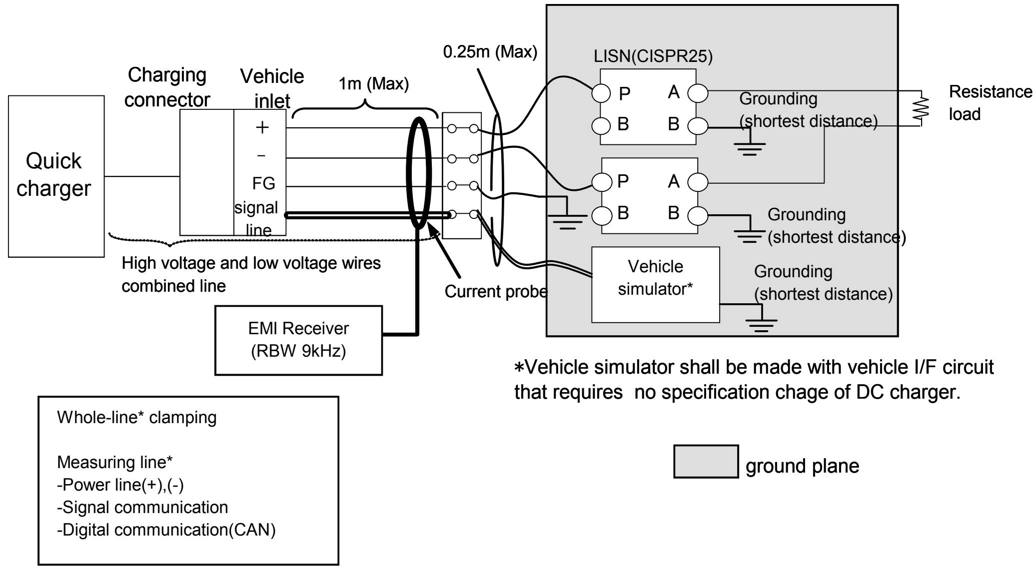
b) Limit value

Unit: dBμA

Table A.25—Limit value of DC conducted emission (RF band)(a)

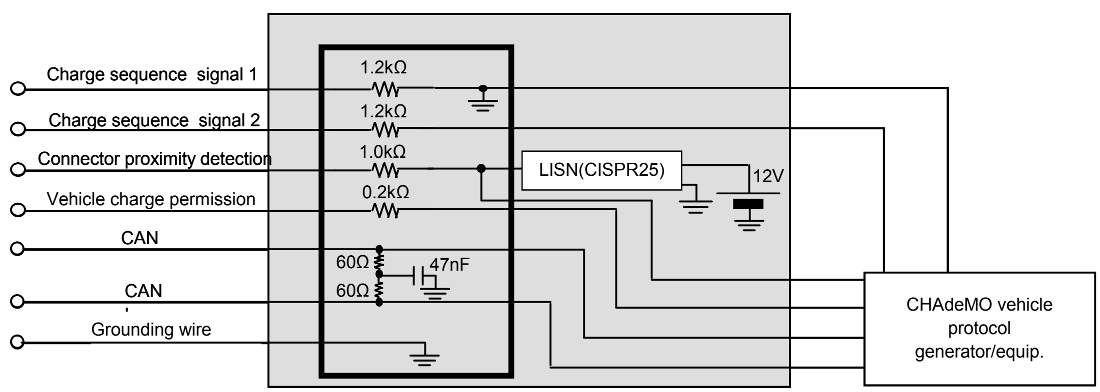
	Frequency (MHz)	Category of quick charger		
		C1	C2	C3
DC line	0.15 to 0.5	108-66 (QP) 96-56 (AV)	121-89 (QP) 108-76 (AV)	142-110 (QP) 85-55 (AV)
	0.5 to 5.0	66-35 (QP) 56-25 (AV)	82-53 (QP) 69-40 (AV)	95-65 (QP) 85-55 (AV)
	5.0 to 30.0	40 (QP) 30 (AV)	53 (QP) 40 (AV)	70-53 (QP) 60-40 (AV)

[a] The limit value is calculated by adding 14 dB to the value in Table A.24 and reflecting impedance characteristics of CISPR 25 LISN circuit.



Configuration of test circuit

Vehicle simulator (detailed)：Equivalent impedance described in the bold line and controlled by CHAdeMO vehicle protocol generator/equip.



Vehicle signal simulating circuit

Figure A.18—DC conduction emission measuring circuit

A.9.5 Radiated emission

a) Test method

Test standard: CISPR 16-2-3 (10-meter measuring distance)

Load condition: Resistance load

b) Limit value

Unit：dBμV/m

Table A.26—Limit value of radiation emission

Test method	Frequency (MHz)	Category of quick charger		
		C1	C2	C3
CISPR 16-2-3	30 to 230 230 to 1 000	30 (QP) 37 (QP)	40 (QP) 47 (QP)	50 (QP) 50 (QP)

A.9.6 Voltage surge (spike noise)

a) Test method

Test circuit: See Figure A.19 and Figure A.20. Load condition: Resistance load and LISN (CISPR 25) with the termination resistance set at 300 Ω.

b) Limit value: See Table A.27.

If the termination resistance set at 50 Ω, the measuring result shall be multiplied by 6, and compared to the values in the table.

Measuring item: Impulse-form wave pattern (spike noise), shown in Figure A.21, generated in charger switching with time T more than 0.1 μs. Compare pulse height U of this wave with its limit value. In case of measurement between H- and L-signal of CAN communication lines, test voltage described in this figure may be regarded as 0 V.

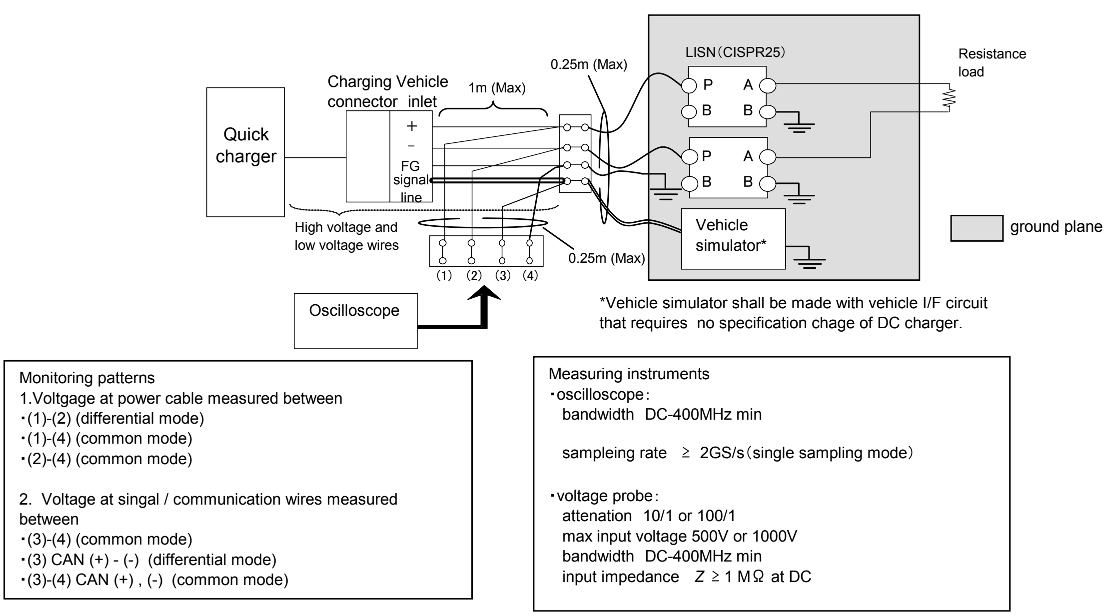


Figure A.19—Voltage surge measurement circuit for dc line

c) Configuration of test circuit

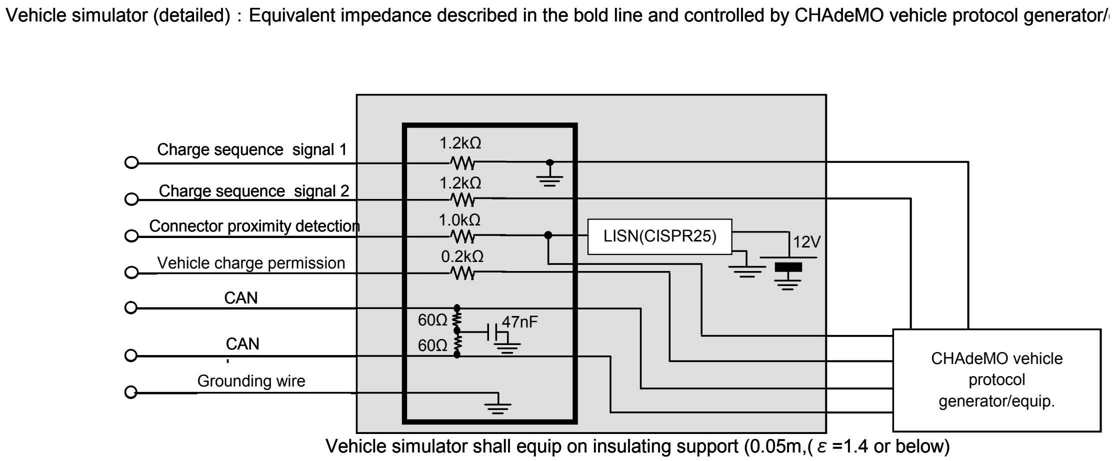


Figure A.20—Voltage surge measuring circuit

d) Vehicle signal simulating circuit

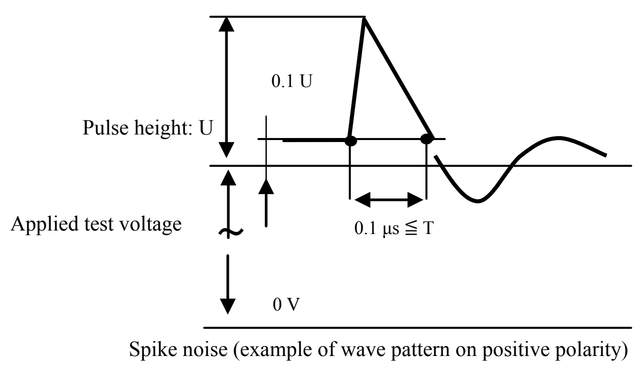


Figure A.21—Definition of measuring wave form of voltage surge

Table A.27—Limit value of voltage surge

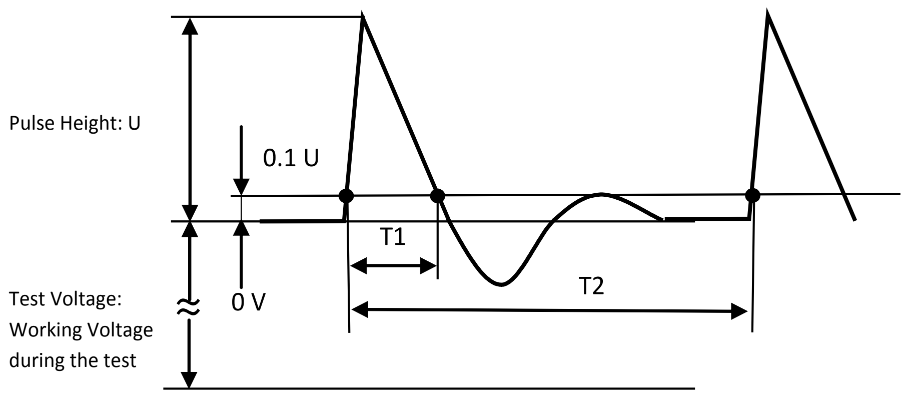
Unit: V

Measuring item	Between P and N	Between P and GND	Between N and GND
Limit value (dc line) Including spike noise	±50 V	±50 V	±50 V

Unit: V

Measuring item	Between signal and GND	Between CANH,L and GND	Between CAN-H and CAN-L
Limit value (signal line) Including spike noise	±25 V (5% or lower) [a] ±15 V (5% to 20% or lower) [a] ±10 V (20% to 50% or lower) [a]	±25 V	±0.5 V (Under recessive condition)

[a] Duty cycle. Note that “duty cycle” is defined as T1/T2.



Spike noise on signal lines (Example of wave pattern on positive polarity)

Figure A.22—Definition of duty cycle

A.9.7 Current ripple

A.9.7.1 Test method

Test circuit: For an example of a vehicle simulating circuit, see Figure A.23.

Load condition: Resistance load and Capacitor (5600 μF)

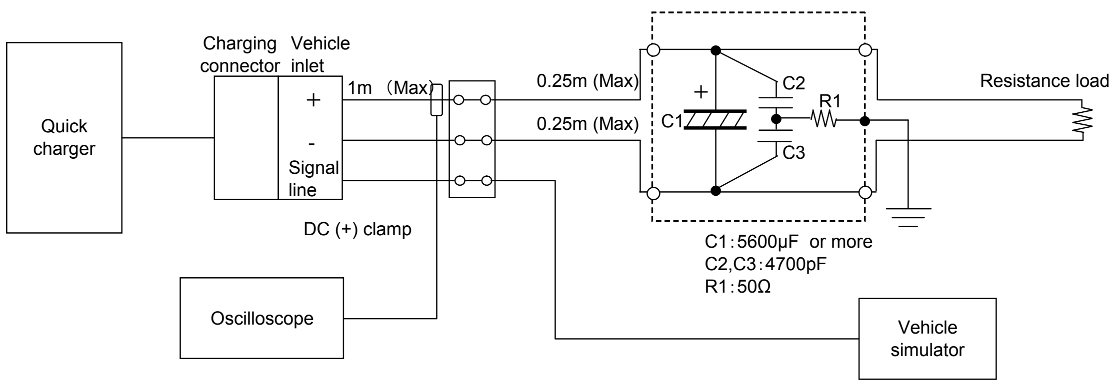


Figure A.23—Current ripple measuring circuit

A.9.7.1.1 Measuring equipment requirements

A.9.7.1.1.1 Digital oscilloscope specifications

a) Sampling rate: 1 MS/s or more

b) Record length: 1 M point or more

c) Record span: 1.1 s or more

d) Vertical resolution: 12 bits or more

e) Frequency characteristic: DC − 300 kHz or more
(Example: YOKOGAWA DL850, YOKOGAWA 701251)

A.9.7.1.1.2 Current probe specifications

a) Rated current: 125 A or more

b) Frequency band: DC − 300 kHz or more

c) Measurement accuracy: Within ±1%rdg
(Example: HIOKI 3274)

A.9.7.2 Limit value

Table A.28—Limit value of current ripple

Frequency [a]	Limit value
10 Hz or less	1.5
5 kHz or less	3.0

[a] Cut-off frequency of the filter for measuring current ripple. See A.9.7.3.
Unit: Ap-p

A.9.7.3 Processing acquired data (in the case of exponential filtering)

The filter in each frequency band shall use the following equations.

$$y_{(t)} \;:\; y_{(t)} = \alpha \times \chi_{(t)} + (1-\alpha) \times y_{(t-1)} \tag{2}$$

Exponential smoothing filter

$$\alpha \;:\; \alpha = 1 - e^{-\frac{1}{\tau} \times \frac{1}{fs}} \tag{3}$$

Smoothing factor

$$\tau \;:\; \tau = \frac{1}{2 \times \pi \times fc} \tag{4}$$

Time constant

fc Cut-off frequency (Hz)
fs Sampling rate (Hz)
$y_{(t-1)}$ Previous exponential smoothing data
$\chi_{(t)}$ Input value(measured value)

Spreadsheet (software) shall handle the data with one million lines. The smoothed data in early 4.6τ s shall not use ripple evaluation. Among exponential smoothing data, the data that do not reach 99% shall be abandoned.

$$\mathrm{Max}\{y_{(1)}, y_{(2)}, y_{(3)},,,\} - \mathrm{Min}\{y_{(1)}, y_{(2)}, y_{(3)},,,\} \tag{5}$$

A.9.8 Smart key influence

A.9.8.1 Test method

a) Test circuit: See Figure A.24.

b) Load condition: Resistance load.

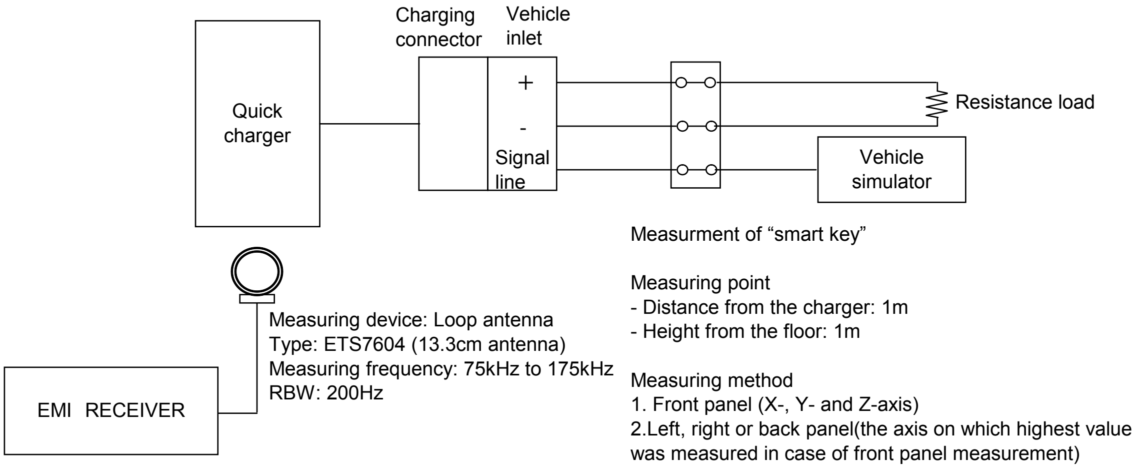


Figure A.24—Measuring circuit of smart key influence

A.9.8.2 Limit value

See Table A.29.

a) If radiated noise exceeds the limit value, warning messages and notes shall be displayed on the charger.

b) Unit : dBμA/m

Table A.29—Criteria of smart key influence

Frequency (kHz)	Condition	
	Without warning messages	With warning messages (under consideration)
75 to 120	95 to 55[a]	105 to 65 [a]
120 to 140	55	65
140 to 185	55 to 95[a]	65 to 105[a]

[a] Linear interpolation.

A.9.9 Noise limit on the protective conductor between charger and vehicle

A.9.9.1 Test method

a) Test circuit: See Figure A.23.
   R1: 0 Ω
   C1: 5 600 μF
   C2, C3: 4 700 pF or 4.0 μF (Conduct a measurement for each case)

b) Measurement condition:

   Under the each of the following conditions 1 and 2, current that flows to the protective conductor between the charger and the vehicle shall be measured by the current probe and the oscilloscope shown in Table A.30.

1) 10 s measurement

Increase the charging current from the charge start (0 A) to the maximum current to simulate the ramp-up. After reaching the maximum current, the charger shall keep the current constant. Collect data for 10 s from the start of the charge.

2) Arbitrary time span

Measuring the current flow on the protective conductor at the maximum charging current

Table A.30—Conditions of an instrument for measuring noise

Instrument	Resolution and accuracy
Oscilloscope	Bandwidth : 1MHz or more (Sampling rate: 2 MS/s or more)
Current probe	Bandwidth : 1 MHz or more Accuracy : 50 mA or less

A.9.9.2 Limit value

Within ±1.0 A of measured current in the measuring conditions 1 and 2.

A.10 Welding detection procedure by the vehicle

This clause describes an EV contactor welding detection method, which detects welded EV contactors by measuring voltage dropping transition of the charger. The charger shall have circuit characteristics specified in this clause as a requirement.

A.10.1 Requirement for the charger

If capacitance on the vehicle circuit is 1 μF or less, the charger shall have the circuit characteristics shown in Figure A.25.

A.10.2 Precautions for the vehicle

a) The vehicle shall carry out welding detection.

b) The vehicle shall carry out the welding detection within 4 s from charging output stop (output current falls below 5 A and “Charger status” flag = 0) to open of switch (d1) and (d2).

c) If the charger carries out emergency stop operation, the vehicle is not required to perform welding detection.

d) Capacitance of on-board circuit between the vehicle inlet and contactors shall be 1 μF or less.

e) If the vehicle uses voltage value (“Present output voltage”) that is measured by the charger and sent to the vehicle via CAN communication to check vehicle inlet voltage, diagnostic logic shall be designed in consideration of “CAN data update delay” stipulated in Table A.20.

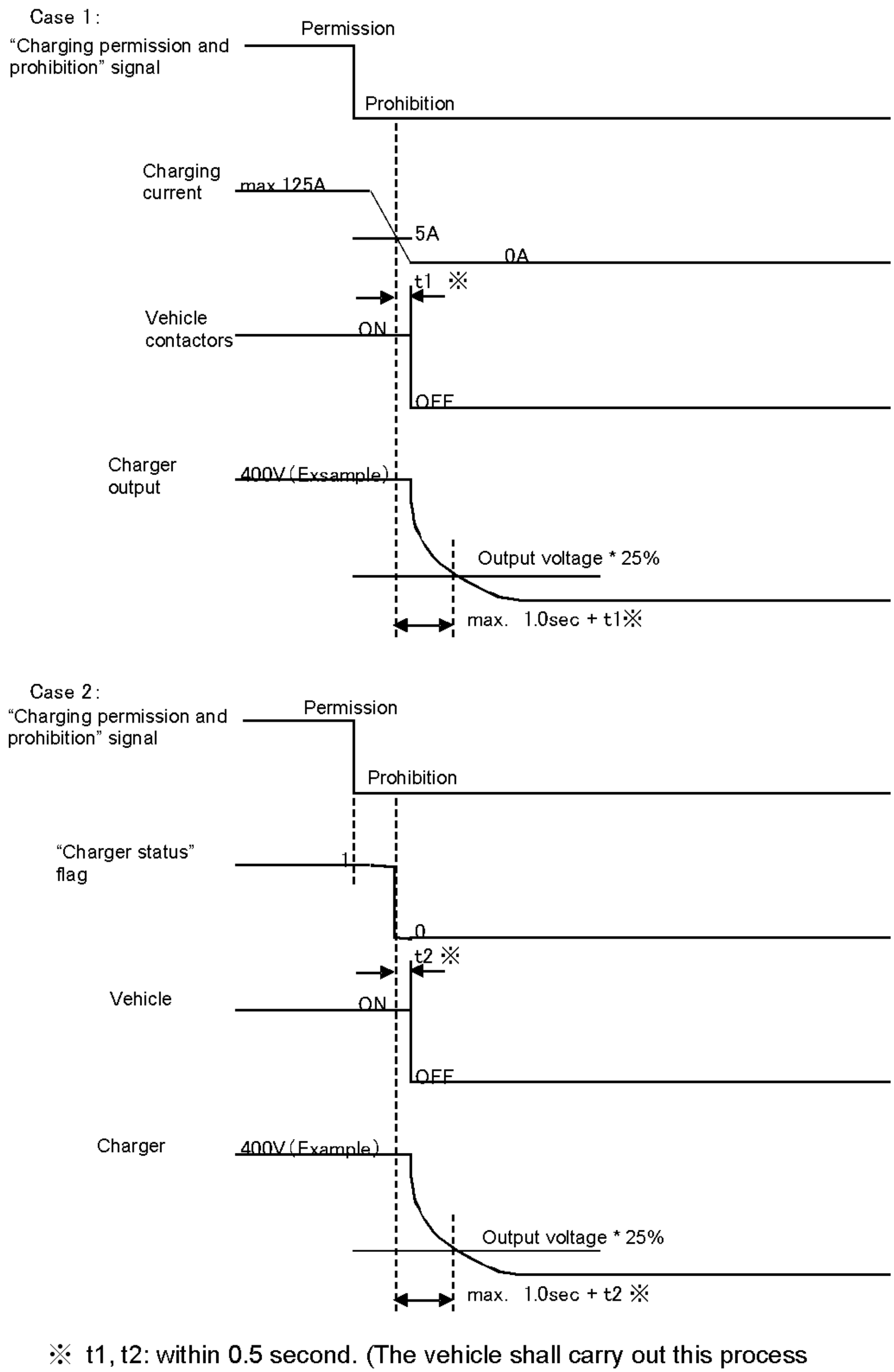


Figure A.25—Requirement for voltage drop characteristic of charger output circuit (case 1: current drop driven; case 2: "Charger status" flag driven)

A.10.2.1 Example of welding detection logic on the vehicle

a) Check less than 5 A of charging current and “Charger status” flag #.109.5.0=0.

b) Open the EV contactor on power line (+).

c) Check the voltage at vehicle inlet terminals. If the voltage exceeds the specified value, it is determined that the EV contactor is welded.

d) Close the EV contactor on power line (+).

e) Check the voltage at vehicle inlet terminals.

f) Open the EV contactor on power line (−).

g) Check the voltage at vehicle inlet terminals. If the voltage exceeds the specified value, it is determined that the EV contactor is welded.

h) Close the EV contactor on power line (−).

i) Check the voltage at vehicle inlet terminals.

j) Open the EV contactors on power (+) and power line (−).

k) Terminate welding detection logic sequence.

A.11 Charging Sequence

A.11.1 CHAdeMO charging system: CAN Communication vehicle message specifications

CAN communication messages sent from the vehicle to the charger shall be in accordance with Table A.31.

A.11.2 CHAdemo charging system: CAN communication charger message specifications

CAN communication data sent from the charger to the vehicle shall be in accordance with Table A.32.

Table A.31—VEHICLE_MESSAGES

ID	byte (bit)	Data name	Content	Vehicle processing: Processing related to main content	Vehicle processing: Set timing	Charger processing
H'100	4,5	Maximum battery voltage	Voltage value[a] to decide that the charger stops charging in order to protect on-board battery.	There is a backup protection from the charger, but the vehicle shall stop charging before charging voltage exceeds this value. — This value shall be set in consideration of voltage measuring accuracy (stipulated in A.7.4) of the charger and the vehicle or voltage drop between vehicle inlet and on-board battery.	This value shall be updated until switch (k) is turned on. Do not update this value after final value is set.	— Use this value to calculate "Threshold voltage."
H'100	6	Charged rate reference constant	Maximum charged rate of on-board battery.	Note that the unit of this parameter is changed from kWh to %. 100% (fixed)	This value shall be updated until switch (K) is turned on. Do not update this value after final value is set.	— Use this value only to display charged rate on the charger. — Charged rate(for display) = Charged rate(#102.6) / Charged rate reference constant(#100.6) × 100
H'101	1	Maximum charging time (by 10 seconds)	Maximum charging time permitted to the charger by the vehicle.	— Use this value when the vehicle sets charging time by 10 seconds. — Calculate and set this value based on charger CAN "Available output current" and "Available output current."	This value shall be updated until switch(K) is turned on. Do not update this value after final value is set.	— Use this value to terminate charging by timer.
H'101	2	Maximum charging time (by minute)	Same as above.	— Use this value when the vehicle sets charging time by minute.	This value shall be updated until switch(K) is turned on. Do not update this value after final value is set.	— Use this value to terminate charging by timer. — If H'101.1 is 0xFF, use this value in "Maximum charging time calculation" process.
H'101	3	Estimated charging time (by minute)	Estimated time of charging termination calculated by the vehicle.	Send to the charger as reference information. Set this value to 0x00 if this value is not notified to the charger.	The vehicle shall decide update frequency.	— Use only for display. — Use for charging control (stop condition etc.) is prohibited. — Show users the notice to take this time for reference. — Do not display if this value is 0. — Do not use this time for display during terminating procedure. In this period, the charger shall display remaining charging time as 0 min or not display it.

Table A.31—VEHICLE_MESSAGES *(continued)*

ID	byte (bit)	Data name	Content	Vehicle processing		Charger processing
				Processing related to main content	Set timing	
H'101	5, 6	Total capacity of battery (Declared value)	Total capacity of traction battery	Input the battery capacity declared in product catalogs. Note that this parameter is optional. Set 0x0000, if not used.	This parameter shall be updated until Switch (k) is turned on.	Use this parameter when is necessary for display on the charger, etc. This declared value may differ from the actual one. When the charger recognizes 0x0000, it shall not use this parameter for any information.
H'102	0	CHAdeMO control protocol number	Charge specification version that the vehicle corresponds.	Set the number stipulated in this specification.	Set the number from initial CAN data transmission and do not update it.	Use this value to switch version of charge control sequences.
H'102	1,2	Target battery voltage	Target charging voltage value.[a]	Set this value as voltage value at vehicle inlet terminals.	This value shall be updated until switch (K) is turned on. Do not update this value after final value is set.	— Use to check "Battery incompatibility" and calculate "Available output current."
H'102	3	Charging current request	Current value sent to the charger from the vehicle during charging.	Set this value in consideration of the following conditions. — Request range: below "Available output current" — Changing rate: from –20 A/sec to +20 A/sec	Set default value to 0 and update as needed.	The charger shall set this value as target one and output current — Some vehicles, whose software is older than ver.0.9, set this value to 1 as default value before the vehicle sends current order. The charger shall avoid charging control error by masking or ignoring this default value before current output.
H'102	4(0)	Battery overvoltage	Status flag indicating the voltage status of on-board battery.	— Set this flag to 1 when an error stipulated in Table A.22 has occurred. — At the same time, turn the switch (k) off.	Update as needed, and hold "1" after the malfunction is determined.	— Regardless of opto-coupler (j) status, the charger shall regard this flag as charging termination order from the vehicle if it is equal to 1, and stop charging.
H'102	4(1)	Battery undervoltage	Status flag indicating the voltage status of on-board battery.	— Set this flag to 1 when an error stipulated in Table A.22 has occurred. — At the same time, turn the switch (k) off.	Update as needed, and hold "1" after the malfunction is determined.	Same as battery overvoltage.

Table A.31—VEHICLE_MESSAGES *(continued)*

ID	byte (bit)	Data name	Content	Vehicle processing		Charger processing
				Processing related to main content	Set timing	
H'102	4(2)	Battery current deviation error	Flag indicating the result of judgment regarding the difference between charging current order and measured output current.	— Set this flag to 1 when an error stipulated in Table A.22 has occurred. — At the same time, turn the switch (k) off.	Update as needed, and hold "1" after the malfunction is determined.	Same as battery undervoltage.
H'102	4(3)	High battery temperature	Status flag that indicates temperature conditions of on-board battery.	— Set this flag to 1 when an error stipulated in Table A.22 has occurred. — At the same time, turn the switch (k) off.	Update as needed, and hold "1" after the malfunction is determined.	Same as battery current deviation error.
H'102	4(4)	Battery voltage deviation error	Flag indicating the result of judgment regarding the difference between measured voltage of on-board battery and "Present output voltage" measured by the charger.	— Set this flag to 1 when an error stipulated in Table A.22 has occurred. — At the same time, turn the switch (k) off.	Update as needed, and hold "1" after the malfunction is determined.	Same as high battery temperature.
H'102	5(0)	Vehicle charging enabled	Flag indicating charge permission status of the vehicle.	Charging enabled: 1, charging disabled: 0	— After CAN communication starts and the vehicle sends the charger data required for prior to a start of charging, change the flag 0 to 1. — Change this flag 1 to 0 when the vehicle sends the "charging stop" notification to the charger.	— Regardless of the status of opto-coupler (j), if this flag is 0, the charger shall regard this flag as charging stop order from the vehicle and terminate charging process after charging starts. — In the event that this flag is 0, do not conduct an insulation test.
H'102	5(1)	Vehicle shift position	Status flag indicating the shift lever position	— Set this flag to 0 when the shift lever is in "parking" position. Set to 1 when it is in other position. — Turn the switch (k) OFF if the shift position is changed except "parking" during charging.[b]	Set a value from initial CAN data transmission and coordinate with the shift position.	Regardless of the status of opto-coupler (j), if this flag is 1, the charger shall regard this flag as charging stop order from the vehicle and terminate charging process.[c]

Table A.31—VEHICLE_MESSAGES *(continued)*

ID	byte (bit)	Data name	Content	Vehicle processing		Charger processing
				Processing related to main content	Set timing	
H'102	5(2)	Charging system fault	Flag indicating the presence of the malfunction originated in the vehicle among the malfunctions detected by the vehicle.	When an error stipulated in Table A.22 has occurred, the flag is changed to 1. At the same time, turn switch (k) OFF.	Update as needed, and hold "1" after the malfunction is determined.	Regardless of the status of opto-coupler (j), if this flag is 1, the charger shall regard this flag as charging stop order from the vehicle and terminate charging process.
H'102	5(3)	Vehicle status	Flag indicating the OPEN/CLOSE status of EV contactors and the result of vehicle contactor welding detection.	Set the flag to 0 when the vehicle relay is closed, and set as 1 after the termination of welding detection.	Set the flag to 0 when the vehicle relay is closed, and set as 1 after the termination of welding detection.	If this flag is 0 even after charger termination process has started, stop the charger by time-out processing.
H'102	5(4)	Normal stop request before charging	Flag used by the vehicle to instruct the charger to stop charging control.	Set the flag to 1 when the vehicle instructs charging termination, and set to 0 in reverse case.	This value shall be updated until initial value of "Charging current request" is set. Do not update this value after initial value transmission.	— If this flag is 1, start normal termination process before charging. — This flag cannot be used as judging condition for charge control termination after reception of initial value of "Charging current request." — The charger shall not regard this flag "1" as vehicle malfunction.
H'102	6	Charged rate	Present charged rate of the on-board battery.	(Note) Unit of this parameter for EV on-board battery is changed from kWh to %.	Set the number from initial CAN data transmission and update as needed.	Use this value only to display charged rate on the charger. Charged rate(for display) = Charged rate(#102.6) / Charged rate reference constant(#100.6) × 100

[a] Voltage value at vehicle inlet terminals.
[b] Parking: It is a state that the vehicle cannot easily move.
[c] The charger shall not regard this flag "1" as vehicle malfunction.

Table A.32—CHARGER_MESSAGES

ID	byte (bit)	Data name	Content	Vehicle processing		Vehicle processing
				Processing related to main content	Set timing	
H'108	0	Identifier of support for EV contactor welding detection	Identifier indicating whether the charger deals with EV contactor welding detection.	— See article A.10 welding detection procedure by the vehicle	Set the number from the initial CAN data transmission and do not update it.	According to this value, the vehicle shall: — In case of 0: skip EV contactor welding. — In case of except 0: perform EV contactor welding.
H'108	1,2	Available output voltage	Maximum output voltage value of the charger[a]	— If the charger receives "Target battery voltage" exceeding this value from the vehicle, regard this situation as "Battery incompatible" and shift to charge termination process.	Set the number from initial CAN data transmission and do not update it.	Use to set "Target battery voltage" etc.
H'108	3	Available output current	Maximum output current value of the charger.	— If the charger receives "Charge current request" exceeding this value from the vehicle, regard this situation as "Charging system fault" and shift to charge termination process	This flag may be updated until the initial value of charging current request is sent from the vehicle.	— Use for upper limit restriction of "Charge current request." — Use to calculate "Maximum charge time."
H'108	4,5	Threshold voltage	Judgmental voltage value to stop charging process for on-board battery protection.	— The charger shall compare vehicle CAN "Maximum battery voltage" with charger CAN "Available output voltage," set the lower value to this value. — When circuit voltage reaches to this value, the charger stops charging output.	This flag may be updated until the initial value of charging current request is sent from the vehicle.	The vehicle receives this value as a charger's information.
H'109	0	CHAdeMO control protocol number	Number indicating software version of charging sequences that the charger deals with.	Set the number stipulated in the specifications.	Set the number from initial CAN data transmission and do not update it.	Use to switch charging sequence version.
H'109	1,2	Present output voltage	Measured voltage value of output circuit in the charger	—See A.5.1.6. —See A.7.4.	Set the number from initial CAN data transmission and update it as needed.	Use to judge "Battery voltage deviation error."
H'109	3	Present charge current	Measured current value of the output circuit in the charger.	—See A.5.1.6. —See A.7.4.	Set the number from initial CAN data transmission and update it as needed.	The vehicle receives this value as a charger's information.

Table A.32—CHARGER_MESSAGES *(continued)*

ID	byte (bit)	Data name	Content	Vehicle processing		Vehicle processing
				Processing related to main content	Set timing	
H'109	5(0)	Charger status	Flag indicating that the charger is outputting charge current.	— Default value is 0. — Set this flag to 0 during insulation test. — Set this flag to 1 after the charger outputs charging current. — Set this flag to 0 after the charger gets off inverter and output current is less than 5 A.	Set this value to 1 from the start of current output, and update it to 0 after output current stops.	Use to determine control mode of the charger.
H'109	5(1)	Charger malfunction	Flag indicating the presence of the malfunction originated in the charger among the malfunctions detected by the charger.	Set this flag to 1 if an error stipulated in Table A.23 has occurred. When malfunction is detected, shift to termination process immediately.	Update as needed, and hold "1" after the malfunction is determined.	Turn switch (k) off when this flag is set to 1.
H'109	5(2)	Charging connector lock	Flag indicating electromagnetic lock status of charging connector.	— Set the value according to the electromagnetic lock status. — Locked: 1, unlocked: 0	Set this flag to 0 from initial CAN data transmission and set to 1 when charging. connector is locked. This flag shall be 0 after the connector lock is released.	— The vehicle shall operate EV contactors after checking locking status of charging connector. — The vehicle shall terminate CAN communication after unlocking status of charging connector.
H'109	5(3)	Battery incompatibil ity	Flag used if maximum output voltage of the charger is not suitable for on-board battery charging.	— Set this flag to 1 if an error stipulated in Table A.23 has occurred.	Update as needed, and hold "1" after the malfunction is determined.	Turn switch (k) off when this flag is set to 1.
H'109	5(4)	Charging system malfunction	Flag used if there is a problem such as improper connection with the vehicle or wrong vehicle status.	Set this flag to 1 if an error stipulated in Table A.23 has occurred. When malfunction is detected, shift to termination process immediately.	Update as needed, and hold "1" after the malfunction is determined.	Turn switch (k) off when this flag is set to 1.

Table A.32—CHARGER_MESSAGES *(continued)*

ID	byte (bit)	Data name	Content	Vehicle processing		Vehicle processing
				Processing related to main content	Set timing	
H'109	5(5)	Charging stop control	Flag indicating that the charger changes charging control to charging current stopping process.	1 indicates that the charger shifts to charging preparation or stop process, stops charging. 0 indicates that the charger outputs current according to "Charging current request" from the vehicle. During charge, the charger set this flag from 0 to 1 when one of the following conditions is satisfied: (1) Opto-coupler(j) OFF (2) "Charge stop button" ON (3) "Emergency stop button" ON (4) "Remaining charge time" becomes 0 (5) Charger detects abnormality See-Figure A.26	Set this flag to 1 when charger shifts to the control mode to decrease charging current for termination.	The vehicle receives this value as a charger's information. See Table A.22, which is used to select termination cases in judgment of "Battery current deviation error."
H'109	6	Remaining charge time (by 10 seconds)	Remaining charge time retained by the charger.	— Set based on the "Maximum charge time" sent from the vehicle. — The charger shall shift to charge termination process if this value becomes 0.	Set after obtaining the "Maximum charge time" of the vehicle. Update as needed after the charging output has started. After charging termination process starts, set this value to 0 when the current becomes 5 A or less.	The vehicle receives this value as a charger's information.
H'109	7	Remaining charge time (by minute)	Same as above.	— Use this value if the vehicle set "Maximum charging time (by minute)." — If the charger set remaining charging time to this value, count down on charging time until the end of charging.	Set after obtaining the "maximum charge time" of the vehicle. Update as needed after the charge output has started. After charging termination process starts, set this value to 0 when the current becomes 5 A or less.	Same as above.

[a] Voltage value on the charger circuit (at charging connector terminals)

A.11.3 CAN communication message transmission default value set

The default value set shown in Table A.33 shall be transmitted to the charger.

CAUTION

a) "Maximum charging time" shall be set by the time the charging permission [switch (k) on] is given to the charger

b) "Maximum battery voltage" shall be set by the time the switch (k) is turned on. Do not update after setting.

c) Setting of the "target battery voltage" shall be started after the "available output voltage" of the charger is received. If a value which exceeds the "available output voltage" is set, the value shall then be judged by the charger as "battery incompatibility" and charging control shall be suspended.

d) Set the unused bytes (extension) to 0x00

Table A.33—CAN communication message transmission default value set

ID	Byte,bit	Item	Content
100	0	Reserved	Set 0x00
	1	Reserved	Set 0x00
	2	Reserved	Set 0x00
	3	Reserved	Set 0x00
	4	Maximum Battery Voltage (Low)	Voltage upper limit (low byte)
	5	Maximum Battery Voltage (High)	Voltage upper limit (high byte)
	6	Total Battery Capacity	Vehicle battery capacity
	7	Reserved	Set 0x00
101	0	Reserved	Set 0x00
	1	Maximum Charging Time	Provided by the vehicle to the charger
	2	Maximum Charging Time (extension)	Provided by the vehicle to the charger. Set 0x00 as default
	3	Estimated charging time (by 1 minute)	Estimated time until charger completion (option) Set 0x00 when not calculated
	4	Reserved	Set 0x00
	5	Reserved	Set 0x00
	6	Reserved	Set 0x00
	7	Reserved	Set 0x00
102	0	charging sequence control number	Set the number accordingly
	1	target battery voltage (low)	Upper limit of the target charging voltage (low)
	2	target battery voltage (high)	Upper limit of the target charging voltage (high)
	3	charging current request	Set 0x00
	4	fault flag	Set the present vehicle status, charger abnormality status, etc.
	5	status flag	Set the present vehicle status, charging enabled condition, etc.
	6	battery remaining capacity (for display)	Remaining capacity of the vehicle battery. Display on the charger side
	7	Reserved	Set 0x00

A.11.4 Explanatory diagram for status flags of the charger and the vehicle

Charger and vehicle status flag are shown in Figure A.26.

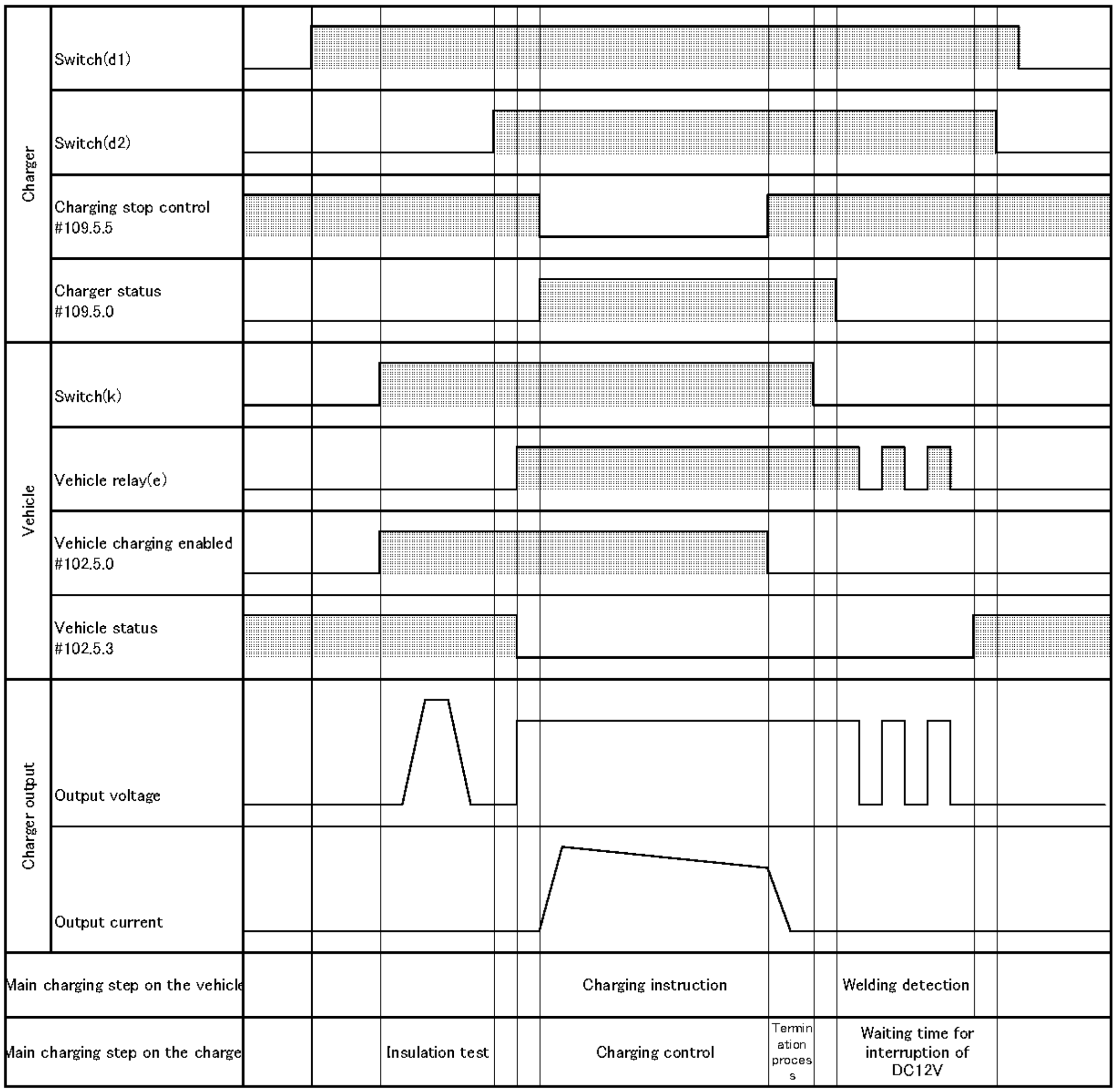


Figure A.26—CHARGER_STATUS

A.12 Introduction of unintended current flow through “Connector proximity detection” line and countermeasures to prevent it

In the event that “Connector proximity detection” line is connected with on-board control power line, a closed circuit is formed between this line and “Vehicle charge permission” line.

In this situation, “Connector proximity detection” line acts as a return circuit. In this case, even if “protective conductor” is disconnected, <opto-coupler f> and <opto-coupler j> are not turned off. As a result, the charging process continues.

To prevent this problem, the vehicle shall adopt only “false-drive prevention” circuit that does not form the unintended current flow during charging.

Besides this, the vehicle shall be designed so that the unintended current flow through EV relay (e) line, etc. cannot be formed in circuits.

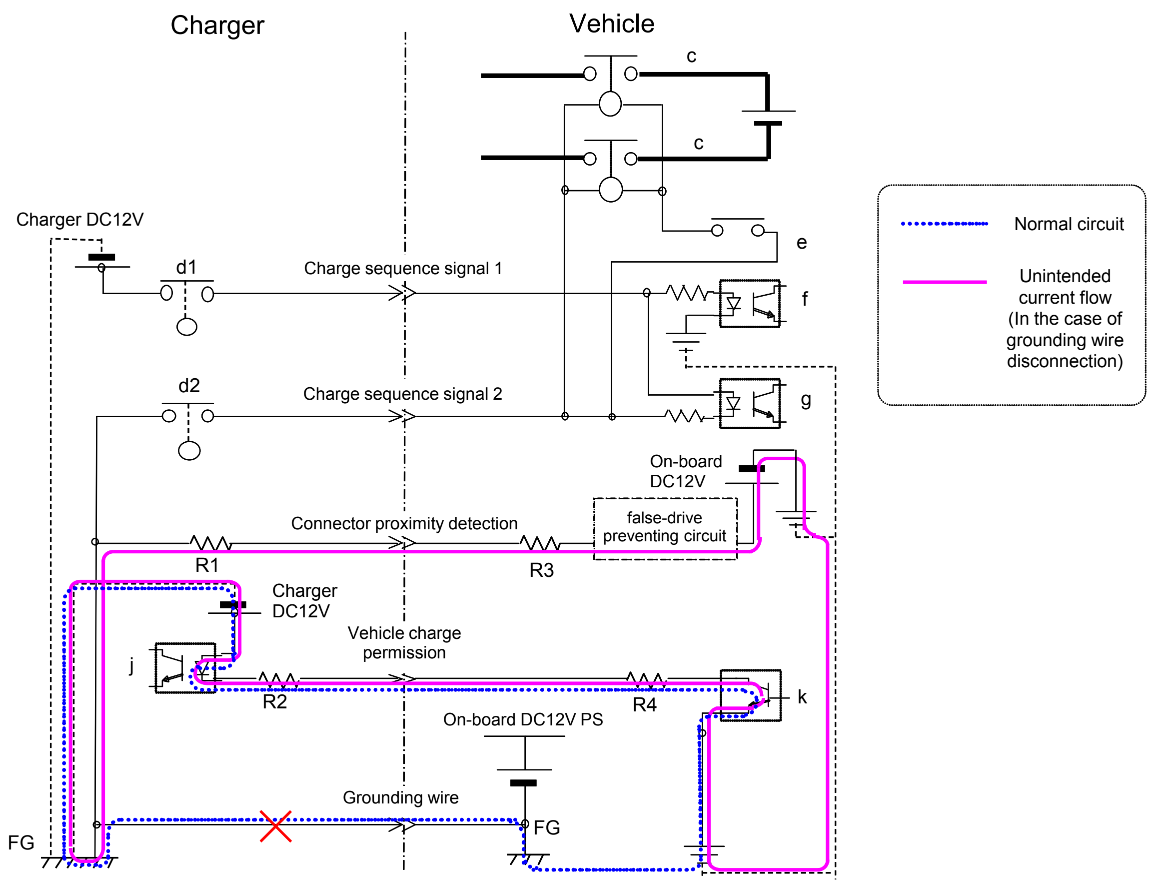


Figure A.27—Example of unintended current flow

A.13 Guideline for the user instruction using screen display of charger

To facilitate the trouble shooting for customers encountering problems, the instruction examples shown in Table A.34 are recommended. The charger manufacturers can decide the detail of the wording.

Table A.34—Trouble shooting instruction examples for manufacturers

Category	Charging termination condition example	Display example	Priority
Emergency	Emergency stop button	Emergency stop button has been pushed. The charger has been deactivated. Please call ….	1
	In case the voltage at the DC coupler dose not drop to 10 and less at the end of the charge	The Voltage remains at the charging connector. Please wait. If this message does not disappear, call …	
Abnormality of charger	Charger malfunction	Charger is in trouble, please pull out the charging connector and call ….	2
Abnormality of vehicle	— Battery overvoltage — Battery under voltage — High battery temperature	Vehicle is in trouble, please pull out the charging connector and call your car customer service.	
Abnormality of charger or vehicle (In case that it can’t be judged which is the cause of abnormality)	— Charging system malfunction (e.g., short circuit, DC earth fault) — Battery current deviation error — Battery voltage deviation error	Charger or vehicle is in trouble, please pull out the charging connector and call ….	3
Abnormality which a retry could resolve	— Timeout (before charging is completed) — Communication failure (before completion of charging) — Voltage measurement value is less than 50 V after d2 is ON —[Charging current request] ＞ [Available output current]	Please pull out the charging connector and redo the charging.. If this message appears again and again, please call…	
Stop by incorrect user operation	Incorrect shift lever position	Please put your shift lever position into Parking, and redo the charging.	4
	Others	— Please check the connector is properly connected. — Please turn off the power key (switch) of EV.	
Stop not caused by abnormality	Stop button	Charging has been interrupted	5
	Reaching the maximum charging time		
	Battery incompatibility	This charger cannot charge your vehicle.	6

A.14 Guideline for the emergency stop of charger

Table A.35 describes the emergency stop operation during charge.

Table A.35—Emergency stop operations

Type of fault or failure Information from the EV		**Termination of charging current**		**Disconnection of DC circuit**	
		Operation of inverter	**Transition to 5 A current**	**Charger (See NOTE 3, NOTE 4)**	**Vehicle**
"Switch(k)" off or Disconnection of "Vehicle charge permission line"		Gate block of inverter (inverter-gate block)	Within 30 ms (See NOTE 2)	(a) or (b) or (c) or (d) **(a)** Disconnect dc circuit from the supply **(b)** Disconnect dc circuit from the supply at the same time of inverter-gate block **(c)** Disconnect dc circuit after inverter-gate-block **(d)** Monitoring inverter-gate block and if the function is not working, disconnect dc circuit from the supply	EV contactor open
Fault flag from vehicle		Reduce the output current with 200 A/s or more.	According to the main flow chart and the control timing chart	Not defined	EV contactor open
Detected a malfunction by charger	Earth fault on dc circuit	Reduce the output current with 200 A/s or more.	According to the main flow chart and the control timing chart	**See NOTE 5**	EV contactor open
	Short circuit on dc circuit	Depending on the design of the charger	According to the specification of the fuse	Disconnect dc circuit from the supply by opening fuse	Disconnect dc circuit from the supply by opening fuse
	Other malfunction	Reduce the output current with 200 A/s or more.	According to the main flow chart and the control timing chart	(a) or (b) or (c) or (d) **(a)** Disconnect dc circuit from the supply **(b)** Disconnect dc circuit from the supply at the same time of inverter-gate block **(c)** Disconnect dc circuit after inverter-gate-block **(d)** Monitoring inverter-gate block and if the function is not working, disconnect dc circuit from the supply	EV contactor open
	Disconnection of connector lock circuit (see NOTE 1)	Gate block of inverter (inverter-gate block)	Within 30 ms (see NOTE 2)	(a) or (b) or (c) or (d) **(a)** Disconnect dc circuit from the supply **(b)** Disconnect dc circuit from the supply at the same time of inverter-gate block **(c)** Disconnect dc circuit after inverter-gate-block **(d)** Monitoring inverter-gate block and if the function is not working, disconnect dc circuit from the supply	EV contactor open
	Emergency stop button pushed	Reduce the output current with 200 A/s or more.	Follow the specifications.	AC-ELCB1 trip	EV contactor open
	Connector pulled out (at normal operation)	Depending on the design of the charger	—	(a) or (b) **(a)** Disconnect dc circuit from the supply **(b)** Monitoring output voltage and if hazardous voltage is observed, disconnect dc circuit from the supply.	EV contactor open

Table A.35—Emergency stop operations *(continued)*

NOTE 1—Including lock circuit disconnection due to a latch failure. NOTE 2—Reference value, review any changes with international standards. NOTE 3—Follow your national regulation, if any. NOTE 4—The disconnect location may be chosen according to the design policy of the charger and follow your national regulation, if any. NOTE 5—Reference Value, review any changes with international standards.

A.15 Regulation regarding the charger output voltage (Japan)

Recently the electrical code in Japan has been amended, so that the voltage to the earth (the line-to-line voltage in the case of non-earthed circuit) is limited to 450 V or less.

To meet this new code,[8] the chargers and EVs in Japan shall comply with the following requirements:

a) The charging voltage shall not exceed 450 V.

b) The charger shall set "Maximum available voltage, H'108 1, 2" to 450 V.

c) The insulation test voltage before charging shall be 450 V ± 5%.

d) The vehicle shall not require voltage exceeding 450 V.

A.16 Pin assignment of the charging connector

This clause describes the pin assignment of a charging connector. The interface circuit (between the charger and the vehicle) is shown in Figure A.28. The pin assignment of the charging connector is shown in Figure A.29.

[8] Published on June 29, 2012.

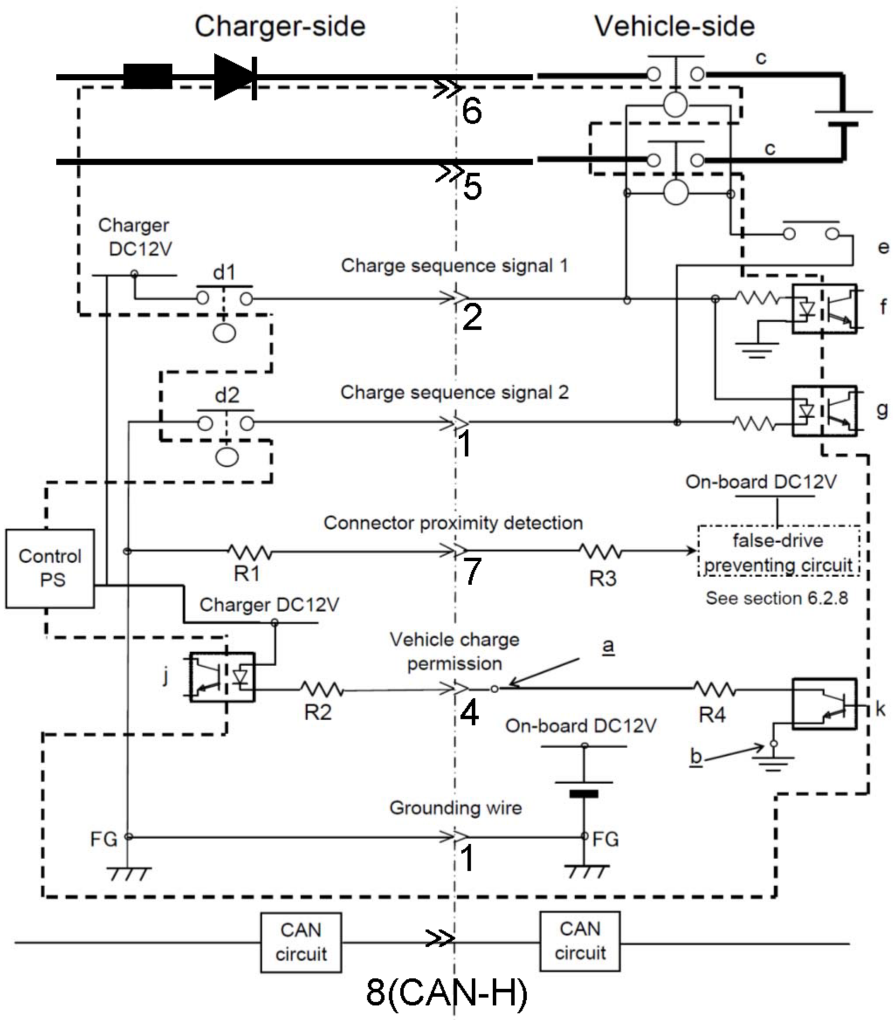


Figure A.28—Interface circuit (between the charger and vehicle)

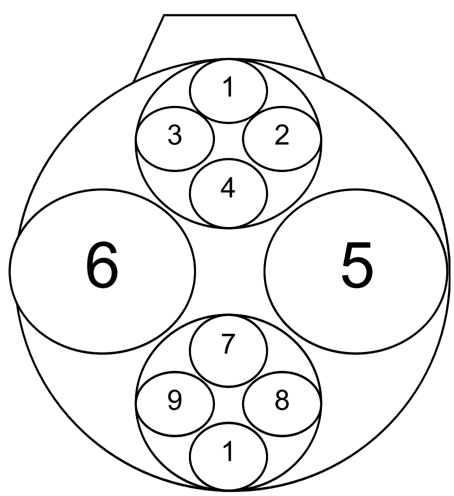
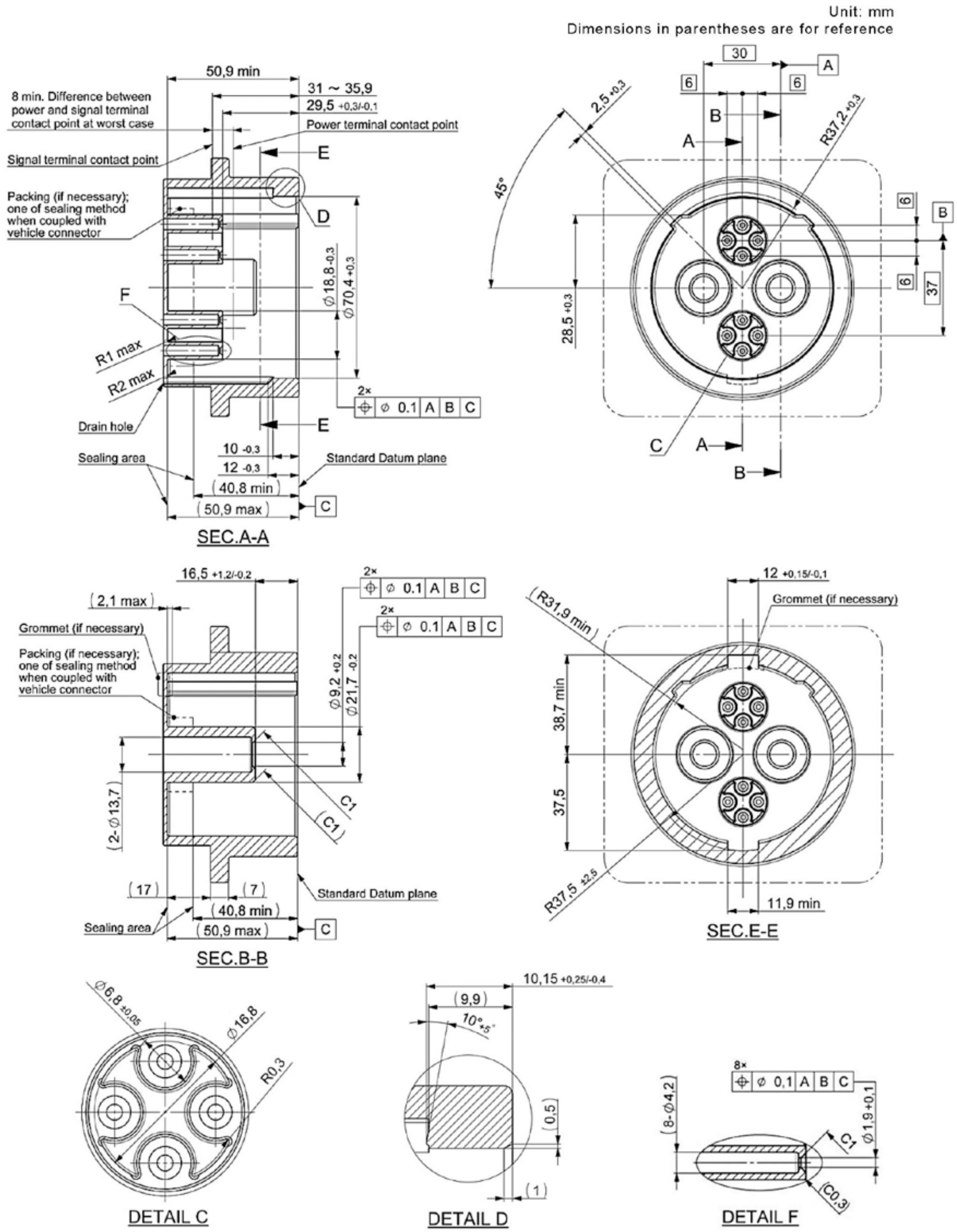


Figure A.29—Pin assignment of the charging connector

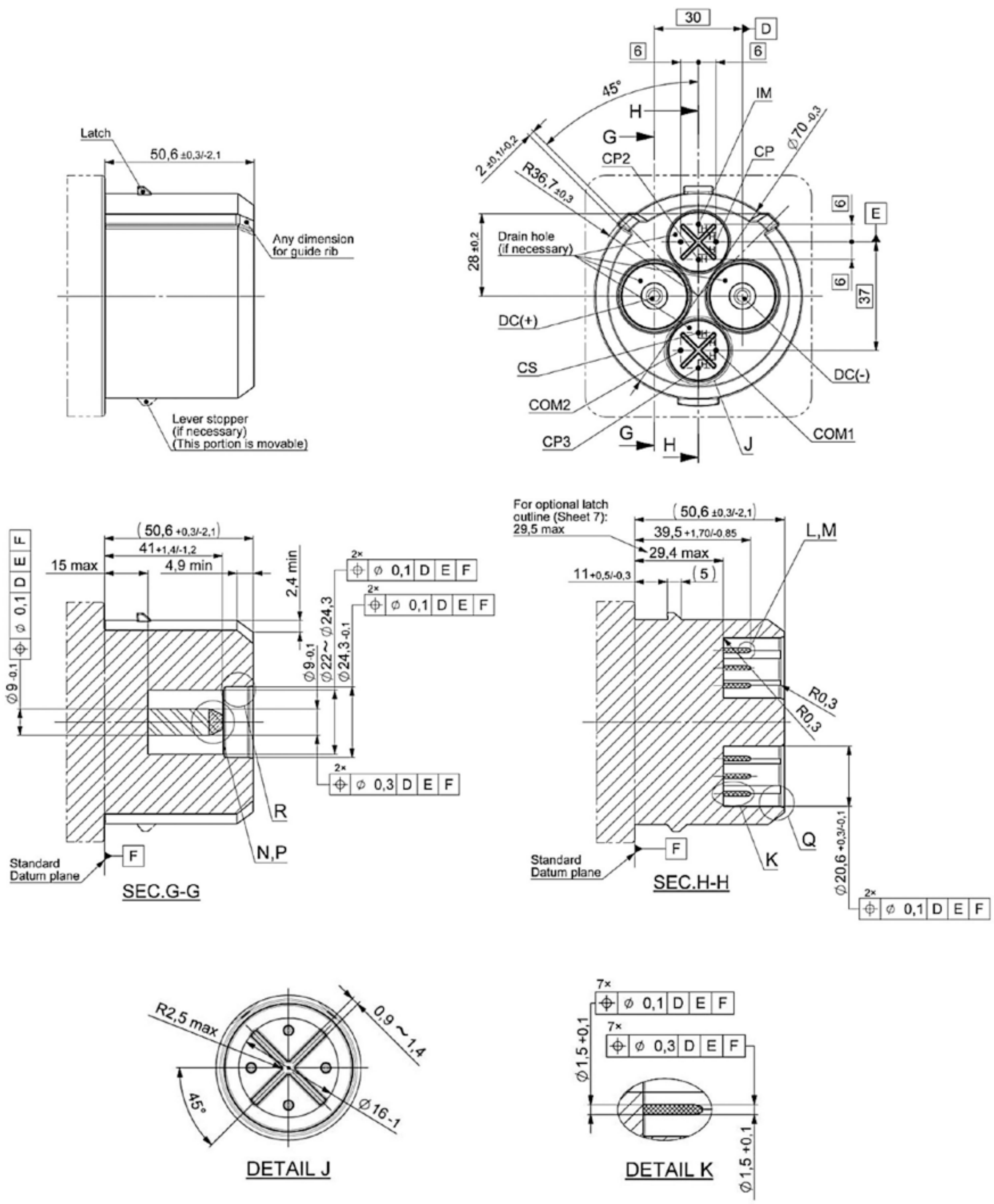
A.17 Shape and dimensions of the charging connector



GENERAL TOLERANCE			
10 MAX	50 MAX	100 MAX	ANGLE
± 0,15	± 0,2	± 0,3	± 30'

Figure A.30—Charging connector—Diagram 1

Unit: mm
Dimensions in parentheses are for reference



GENERAL TOLERANCE			
10 MAX	50 MAX	100 MAX	ANGLE
± 0,15	± 0,2	± 0,3	± 30'

Figure A.31—Charging connector—Diagram 2

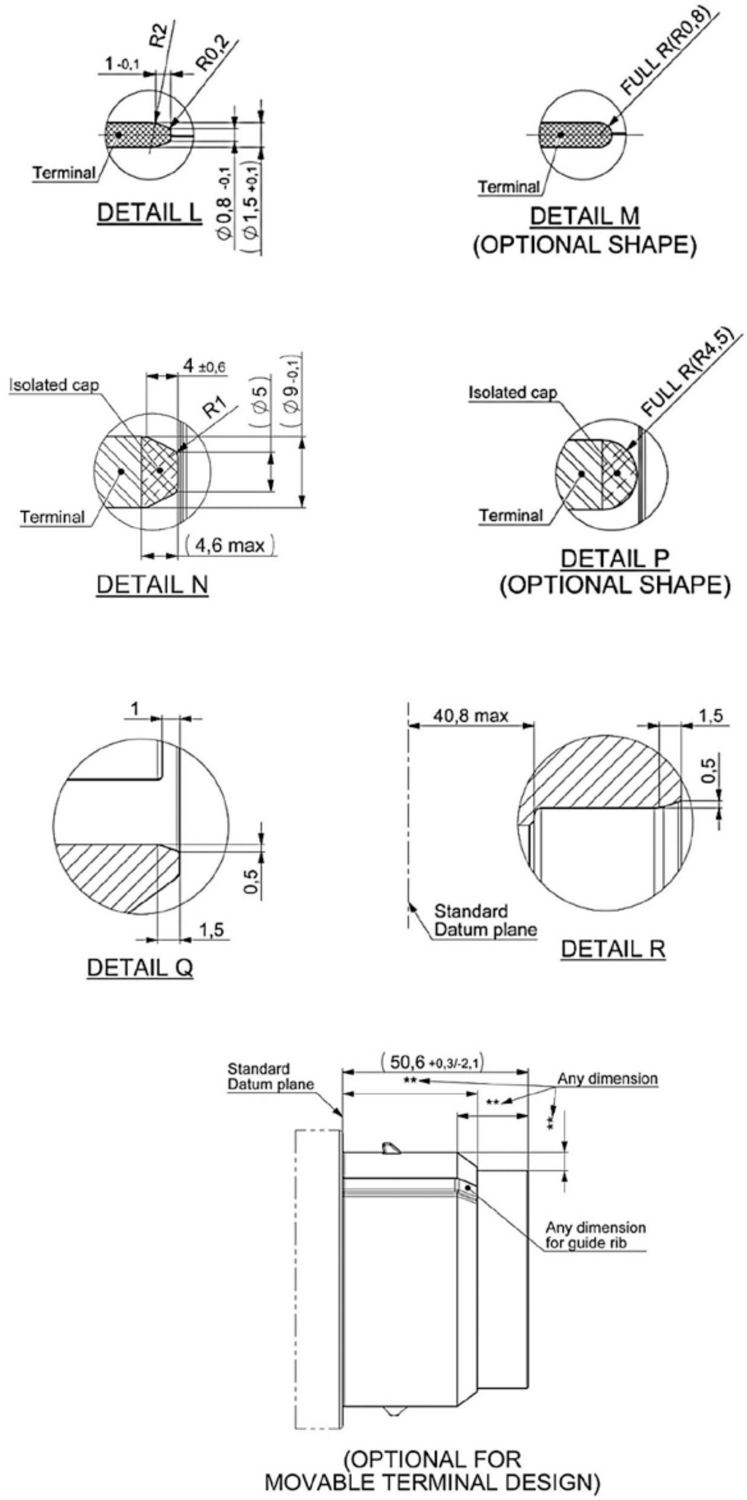
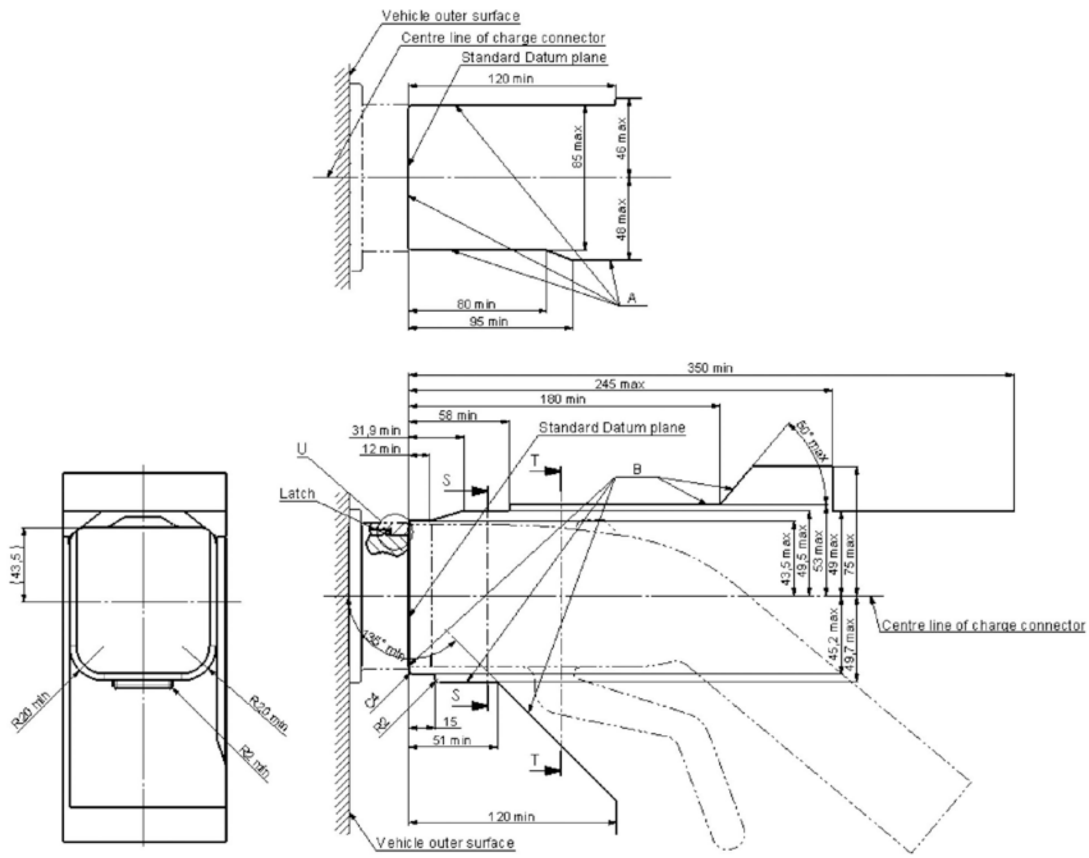


Figure A.32—Charging connector—Diagram 3

Unit: mm



Note: At note A and B, sketches are not intended to restrict design of vehicle connector.

Figure A.33—Charging connector—Diagram 4

Unit: mm

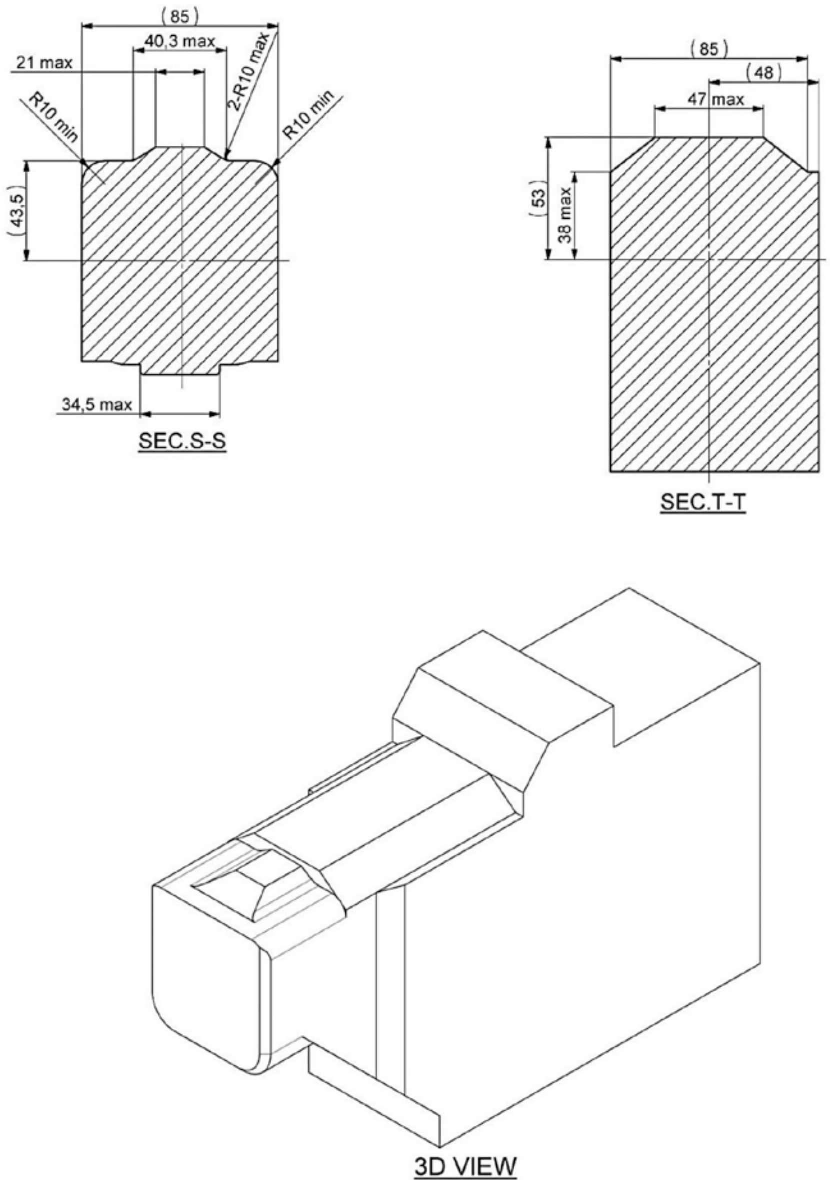
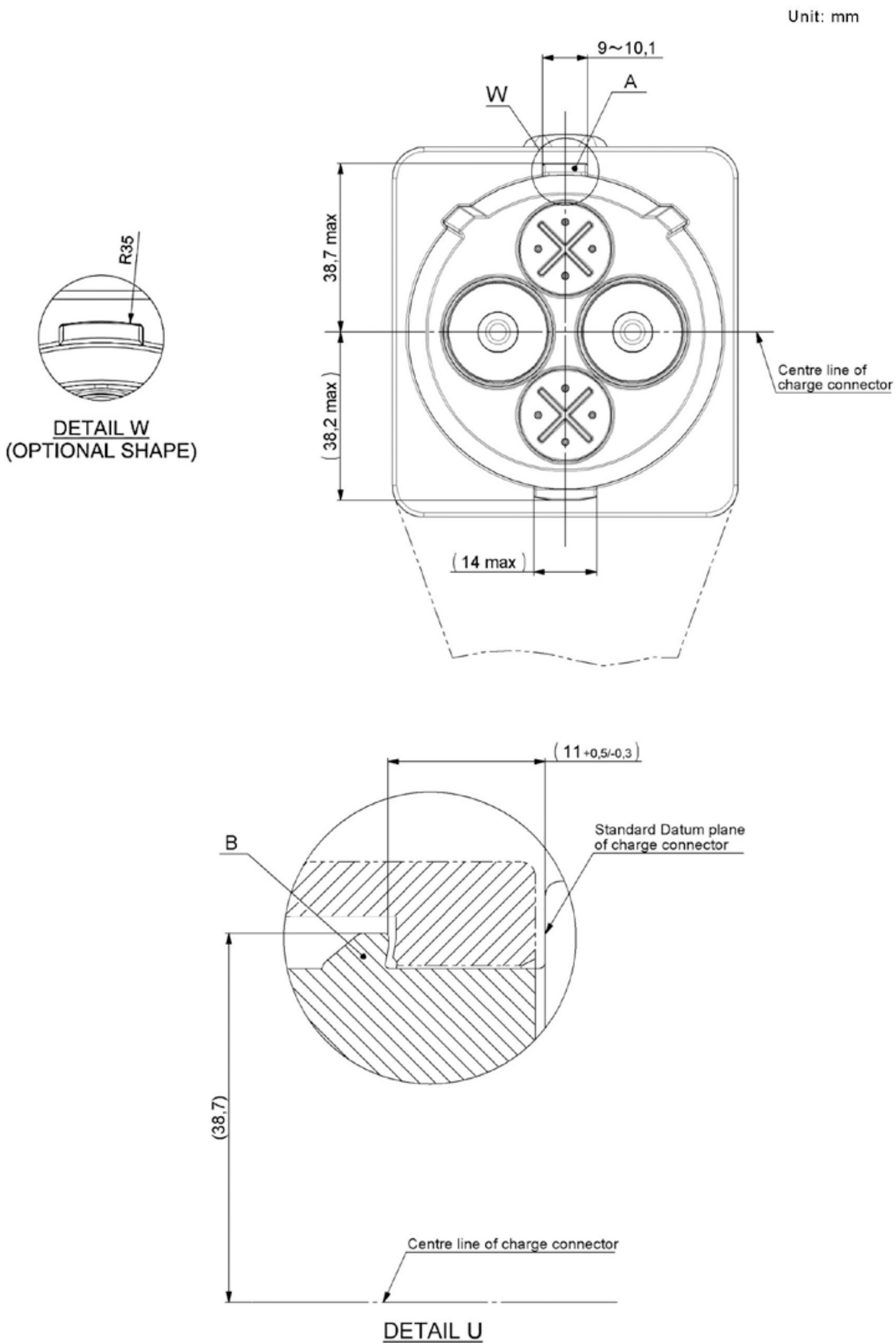


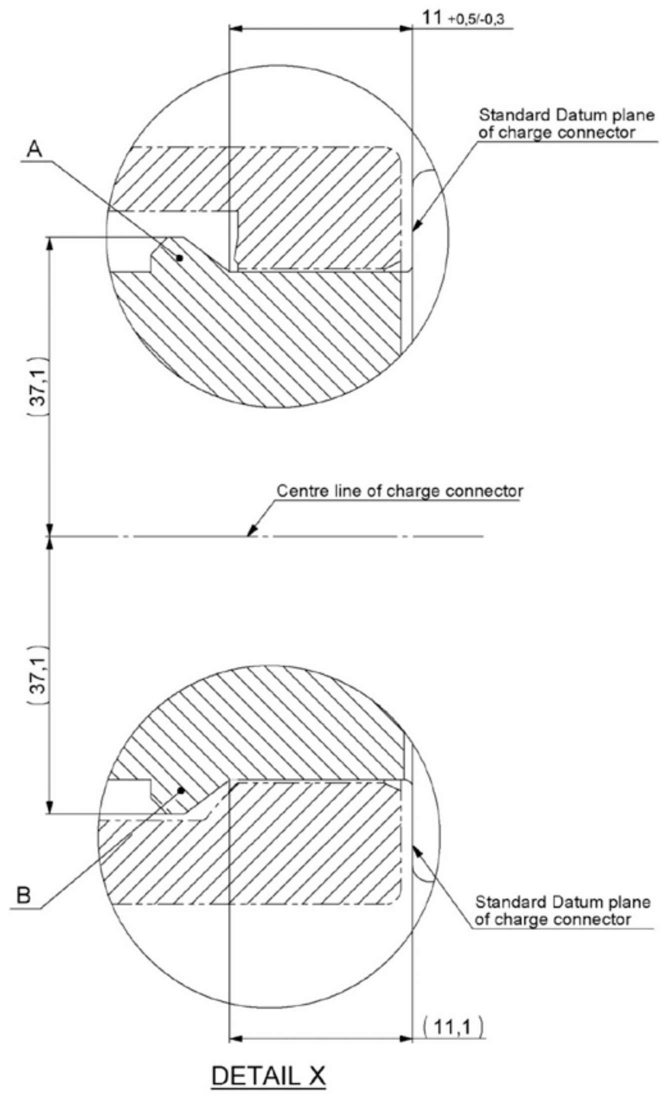
Figure A.34—Charging connector—Diagram 5



Note: At note A and B, sketches are not intended to restrict design of latch shape.

Figure A.35—Charging connector—Diagram 6

Unit: mm



Note: At note A and B, sketches are not intended to restrict design of latch shape.

Figure A.36—Charging connector—Diagram 7

Annex B

(normative)

Technical specifications for combination ac/dc charging systems for use with electric vehicles

B.1 Overview

This annex describes the specifications normative to the implementation of the (ac and dc) combined charging system (commonly referred to as “combo” chargers). The combo charging systems use a single multipurpose vehicle inlet connection for both ac and dc charging.

Comprehensive usage measures, electromagnetic compatibility issues, and other topics to cover all charging scenarios are cited in B.2.

B.2 Applicable normative references

The applicable normative references to implement a complete ac/dc charging system for use with electric vehicles for combo charging are cited in this clause.

The SAE and ISO/IEC have harmonized the material content of these standards and recommended practices, even if the document numbering structure differs. The bibliography (Annex D) includes equivalent DIN and ISO/IEC documents required to build a combo charging system.

SAE J1772

SAE J2836/2

SAE J2847/2

SAE J2931/1

SAE J2931/4

Annex C

(informative)

Charging connector temperature rise testing

C.1 Overview

This annex describes the procedure that should be applied to environmentally condition the dc charging connector and perform heat rise testing.

C.2 Test description

C.2.1 Basic information

Develop or obtain test jig as defined in Figure C.1.

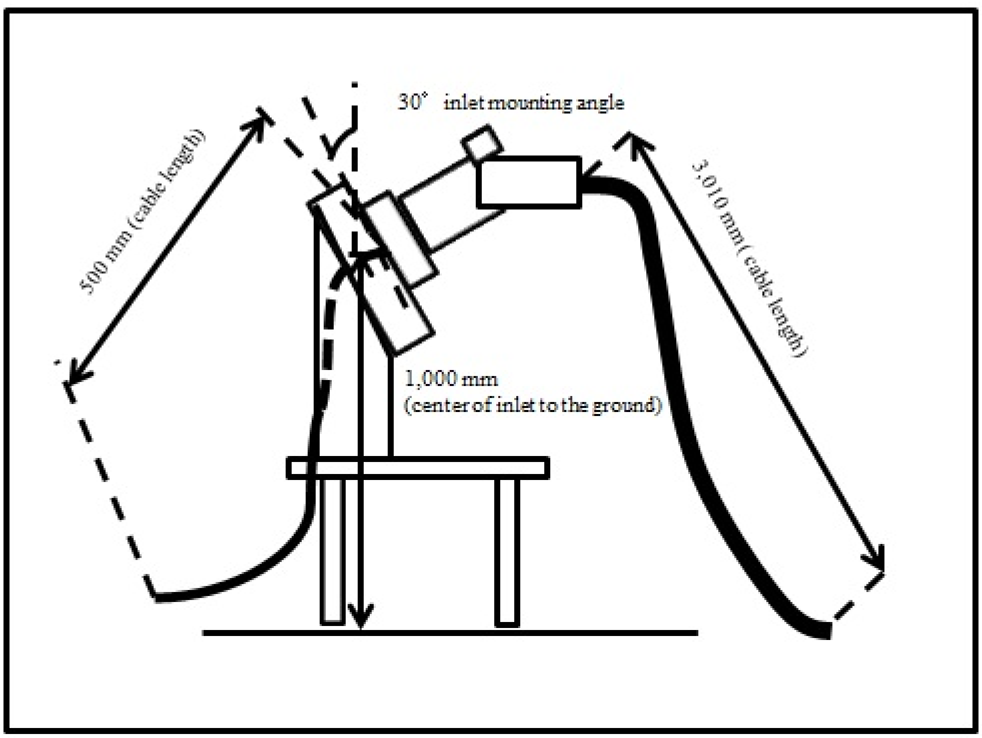


Figure C.1—Test jig

C.2.2 Characteristic check

a) Attach coupler to test jig

b) Ambient condition is defined as follows:

   1) Room Temperature = 23 °C ± 5 °C

   2) Relative Humidity = Ambient (unregulated environment)

c) Apply rated current for 2 h or more while monitoring temperature rise and voltage each second or less. The setup and measuring points are shown in Figure C.2. Attach thermal couples at the crimp for each terminal.

d) After applying current for 2 h or more, apply 100N perpendicular loads to coupler handle for 10 s in each direction as defined in the following list. Apply in each direction three times.

 1) Y to +Y axis
 2) +Y to −Y axis
 3) X to +X axis
 4) +X to −X axis

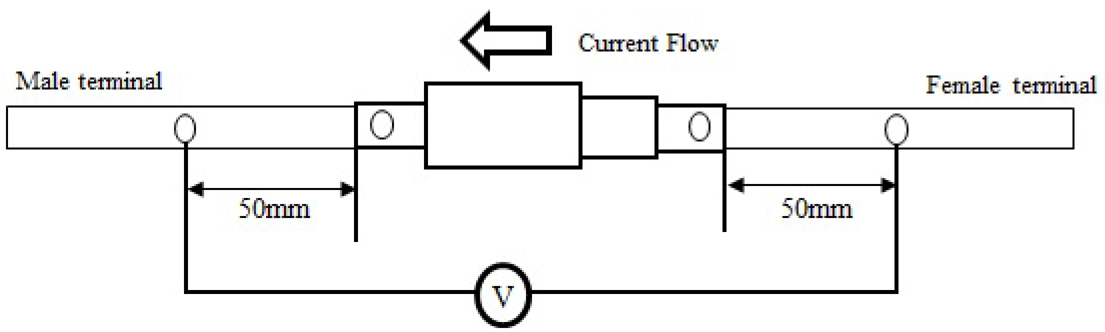


Figure C.2—Circuit measuring points

C.2.3 Performance criteria

a) For power terminal
 1) Resistance value 1 mV/A or less
 2) Maximum resistance value fluctuation: ≤3 mV/A (See Figure C.3)
 3) Temperature rise: 50 °C or less
 4) Maximum temperature rise fluctuation: ±10 °C (See Figure C.4)

b) For signal terminal
 1) Resistance value: 10 mV/A or less

C.2.4 Temperature and humidity exposure

a) Apply the following conditions to the couplers and inlet in an environmental chamber:
 1) 85 °C
 2) 95% Relative Humidity

b) Condition for 240 h with connector and inlet in unmated state

C.2.5 Exposure to contaminates

Expose the coupler to salt and sand per ISO 12103-1 A4 coarse test dust.

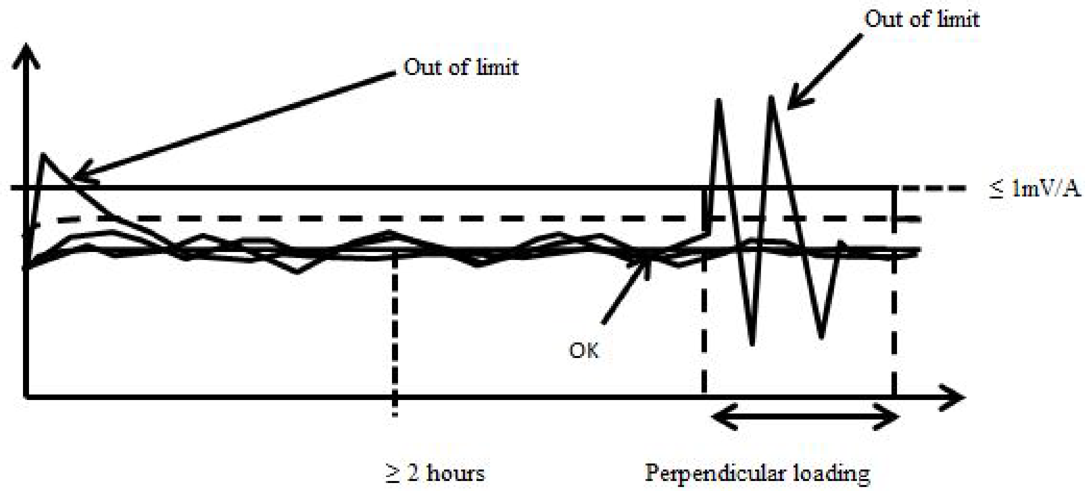


Figure C.3—Maximum resistance value fluctuation

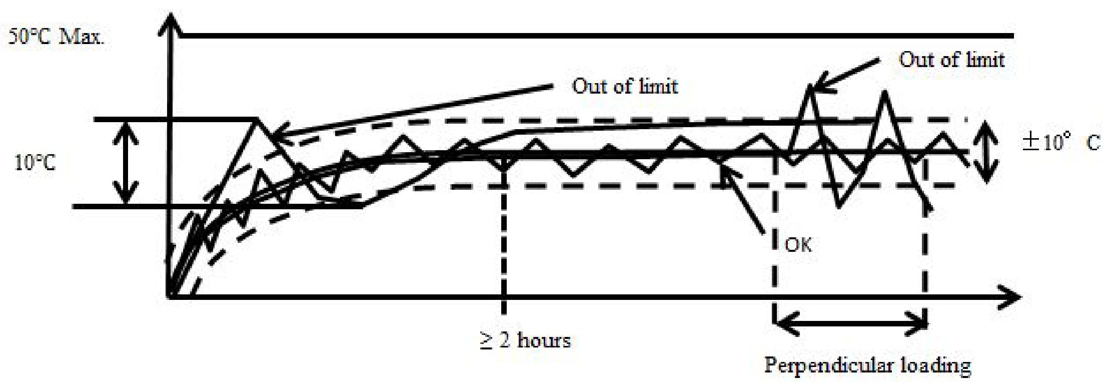


Figure C.4—Maximum temperature rise fluctuation

C.3 Test procedure

a) Obtain 10 unused coupler samples and follow C.2.2.
   1) If C.2.3 is not met, the test has failed.
   2) If C.2.3 is met, follow item b).
b) Obtain three samples from item a). Obtain three unused inlets.
   1) Conduct C.2.4.
   2) Conduct C.2.2. If the criteria of C.2.3 is not met, the test has failed.
   3) Conduct C.2.5.
   4) Mate and un-mate each coupler and inlet pair 2500 cycles.
   5) Conduct C.2.5.
   6) Mate and un-mate each coupler and inlet pair 2500 cycles.

    7) Conduct C.2.5.
    8) Mate and un-mate each coupler and inlet pair 2500 cycles.
    9) Conduct C.2.5.
    10) Mate and un-mate each coupler and inlet pair 2500 cycles.

c) Conduct C.2.2 and evaluate criteria of C.2.3.
    1) If C.2.3 criteria are not met, the test has failed.
    2) If C.2.3 criteria are met, conduct C.2.4.

d) Conduct C.2.2 and evaluate criteria of C.2.3.
    1) If C.2.3 criteria are not met, the test has failed.
    2) If C.2.3 criteria are met, the test procedure is concluded.

Annex D

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] CISPR 11, Industrial scientific and medical equipment—Radio frequency disturbance characteristics—Limits and methods of measurement.[9]

[B2] CISPR 16-1-2, Specification for radio disturbance and immunity measuring apparatus and methods—Part 1-2: Radio disturbance and immunity measuring apparatus—Ancillary equipment—Conducted disturbances.

[B3] CISPR 16-2-3, Specification for radio disturbance and immunity measuring apparatus and methods—Part 2-3: Methods of measurement of disturbances and immunity—Radiated disturbance measurements.

[B4] CISPR 25, Vehicles, boats and internal combustion engines—Radio disturbance characteristics—Limits and methods of measurement for the protection of on-board receivers.

[B5] DIN Specification 70121, Electro mobility—Digital communication between a DC PEV charging station and an electric vehicle for control of DC charging in the Combined Charging System, December 10, 2013.

[B6] HomePlug Powerline Alliance, HomePlug Green PHY TM Specification, Release Version 1.1.1, 2013.

[B7] IEC 60068-2-1, Environmental testing—Part 2-1: Tests—Tests A: Cold.[10]

[B8] IEC 60068-2-2, Environmental testing—Part 2-2: Tests—Test B: Dry heat.

[B9] IEC 60068-2-14, Environmental testing—Part 2-14: Tests—Test N: Change of temperature.

[B10] IEC 60146-1-1, Semiconductor convertors—General requirements and line commutated convertors—Part 1-1: Specifications of basic requirements.

[B11] IEC 60146-1-2, Semiconductor convertors—General requirements and line commutated convertors—Part 1-2: Application guide.

[B12] IEC 60146-1-3, Semiconductor convertors General requirements and line commutated convertors—Part 1-3: Transformers and reactors.

[B13] IEC 60146-2, Semiconductor converters—Part 2: Self-commutated semiconductor converters including direct dc. converters.

[B14] IEC 60228, Conductors of insulated cables.

[B15] IEC 60245-4, Rubber insulated cables—Rated voltages up to and including 450/750 V—Part 4: Cords and flexible cables.

[B16] IEC 60269-1, Low-voltage fuses—Part 1: General requirements.

[9] CISPR documents are available from the International Electrotechnical Commission, 3, rue de Varembé, Case Postale 131, CH 1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). They are also available in the United States from the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[10] IEC publications are available from the International Electrotechnical Commission, Case Postale 131, 3 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[B17] IEC 60269-2, Low-voltage fuses—Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application).

[B18] IEC 60364-4-43, Low-voltage electrical installations—Part 4-43: Protection for safety—Protection against overcurrent.

[B19] IEC 60364-5-53, Electrical installations of buildings—Part 5-53: Selection and erection of electrical equipment—Isolation, switching and control.

[B20] IEC 60364-5-54, Low-voltage electrical installations—Part 5-54: Selection and erection of electrical equipment—Earthing arrangements and protective conductors.

[B21] IEC 60479-1, Effects of current on human beings and livestock—Part1: General aspects.

[B22] IEC 60529 Degrees of protection provided by enclosures (IP code).

[B23] IEC 60664-1, Insulation coordination for equipment within low-voltage systems—Part 1: Principles, requirements and tests.

[B24] IEC 60947-1, Low-voltage switchgear and control gear—Part 1: General rules.

[B25] IEC 61000-2-2, Electromagnetic compatibility (EMC)—Part 2-2: Environment—Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems.

[B26] IEC 61000-3-2, Electromagnetic compatibility (EMC)—Part 3-2: Limits—Limits for harmonic current emissions (equipment input current ≤16 A per phase).

[B27] IEC 61000-3-6, Electromagnetic compatibility (EMC)—Part 3-6: Limits—Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems.

[B28] IEC 61000-3-12, Electromagnetic compatibility (EMC)—Part 3-12: Limits—Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase.

[B29] IEC 61000-4-2, Electromagnetic compatibility (EMC)—Part 4-2: Testing and measurement techniques—Electrostatic discharge immunity test.

[B30] IEC 61000-4-3, Electromagnetic compatibility (EMC)—Part 4-3: Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test.

[B31] IEC 61000-4-4, Electromagnetic compatibility (EMC)—Part 4-4: Testing and measurement techniques—Electrical fast transient/burst immunity test.

[B32] IEC 61000-4-5, Electromagnetic compatibility (EMC)—Part 4-5: Testing and measurement techniques—Surge immunity test.

[B33] IEC 61000-4-6, Electromagnetic compatibility (EMC)—Part 4-6: Testing and measurement techniques—Immunity to conducted disturbances, induced by radio-frequency fields.

[B34] IEC 61000-4-7, Electromagnetic compatibility (EMC)—Part 4-7: Testing and measurement techniques—General guide on harmonics and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto.

[B35] IEC 61000-4-8, Electromagnetic compatibility (EMC)—Part 4-8: Testing and measurement techniques—Power-frequency magnetic field immunity test.

[B36] IEC 61000-4-11, Electromagnetic compatibility (EMC)—Part 4-11: Testing and measurement techniques—Voltage dips, short interruptions and voltage variations immunity tests.

[B37] IEC 61140, Protection against electric shock—Common aspects for installation and equipment.

[B38] IEC 61643-12, Low-voltage surge protective devices—Part 12: Surge protective devices connected to low-voltage power distribution systems—Selection and application principles.

[B39] IEC 61851-23:2014, Electric vehicles conductive changing system—Part 23: DC Electric vehicle charging station.

[B40] IEC 61851-24:2014, Electric vehicles conductive charging system—Part 24: Control communication protocol between off-board DC charger and electric vehicle.

[B41] ISO 1996-1, Acoustics—Description, measurement and assessment of environmental noise—Part 1: Basic quantities and assessment procedures.

[B42] ISO 1996-2, Acoustics—Description, measurement and assessment of environmental noise—Part 2: Determination of environmental noise levels.

[B43] ISO 12103-1, Road Vehicles- Test dust for filter evaluation. Arizona Test Dust.

[B44] JEC-2410, Semiconductor converters.

[B45] JEC-2440, Self-commutated semiconductor converters.

[B46] JEVS G105, Connectors applicable to Quick Charging System at Eco-Station for Electric Vehicles.

[B47] JEVS G109, Electric vehicle conductive charging system, General requirement.

[B48] JIS C0365, Protection against electric shock—Common aspects for installation and equipment.

[B49] JIS C2811, Terminal blocks for industrial and similar use.

[B50] JIS C3327, 600 V Rubber insulated flexible cables.

[B51] JIS C3663-4, Rubber insulated cables—Rated voltages up to and including 450/750 V—Part 4: Cords and flexible cables.

[B52] JIS C3664, Conductors of insulated cables.

[B53] JIS C8201-1, Low-voltage switchgear and control gear—Part 1: General rules.

[B54] JIS C8269-1, Low-voltage fuses—Part 1: General requirements.

[B55] JIS C8269-2, Low-voltage fuses—Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application).

[B56] JIS C8314, Particular requirements for low-voltage cartridge fuses.

[B57] JIS C8319, Particular requirements for screw fuses and D-type fuses.

[B58] JIS C8352, General requirements for fuses for the protection of low-voltage cables and lines.

[B59] JIS Z8731, Acoustics—Description and measurement of environmental noise.

[B60] UL 50 Standard for Enclosures for Electrical Equipment.

[B61] UL 1439 Determination of Sharpness of Edges on Equipment.

[B62] UL 2231-1 Personnel Protection Systems for Electric Vehicle Supply Circuits: General Requirements.

[B63] UL 2231-2 Personnel Protection Systems for Electric Vehicle Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems.

[B64] UL 2251 Plugs, Receptacle, Couplers for Electric Vehicles.

[B65] UL 2594 Outline of Investigation—Electric Vehicle Supply Equipment.

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