



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

IEEE Vehicular Technology Society

Developed by the
Intelligent Transportation Systems

IEEE Std 2030.1.1™-2021
(Revision of IEEE Std 2030.1.1-2015)



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**Intelligent Transportation Systems
of the
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Approved 9 November 2021

IEEE SA Standards Board

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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 2030.1.1™, rapid charging, SAE, SAE J1772, SAE J2836/2

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Introduction

This introduction is not part of IEEE Std 2030.1.1-2022, IEEE Standard for Technical Specifications of a DC Quick and Bidirectional 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.

Acknowledgment

Grateful acknowledgment is made to the CHAdeMO Association for permission to use the following source material in Annex A: CHAdeMO 1.0.1 (21 May 2013), Technical Specifications of Quick Charger for the Electric Vehicle.

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1. Overview

1.1 Scope

This standard specifies the design interface of electric vehicles and direct current (dc) bidirectional ~~quick~~ chargers that utilize ~~promote rapid charging of~~ battery electric vehicles as power storage devices.

1.2 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{1,2}

¹ The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

² The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

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 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.³

ISO 11898-1, Road vehicles—Controller area network (CAN)—Part 1: Data link layer and physical signalling.^{4 2}

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

³ IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

⁴ ISO publications are available from the International Organization for Standardization (<https://www.iso.org/>) and the American National Standards Institute (<https://www.ansi.org/>).

² ~~ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, 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/>).~~

SAE J1772, Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler.^{5 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.

[UL 2202, Electric Vehicle \(EV\) Charging System Equipment \(AC to DC\).](#)⁶

UL 2251 Plugs, Receptacle, Couplers for Electric Vehicles.

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

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

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.^{7 4}

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

^{5 3} SAE publications are available from the Society of Automotive Engineers, ~~400 Commonwealth Drive, Warrendale, PA 15096, USA~~
(<https://www.sae.org/>).

⁶ UL publications are available from Underwriters Laboratories (<https://www.ul.com/>).

⁷ *IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

⁴ ~~IEEE Standards Dictionary Online subscription is available at: <http://ieeexplore.ieee.org/xpls/dictionary.jsp>.~~

3.1 ~~Vehicle 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 11898-2⁸)

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.

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

3.2 ~~Charger terms~~

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

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

~~**earth fault detection:** To detect earth fault.~~

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

⁸ [Information on references can be found in Clause 2.](#)

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.

electric vehicle supply equipment (EVSE): The equipment that controls charging and discharging current to and from a vehicle. It comprises an indicator, charge/discharge cable assemblies, and so on.

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

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

ground fault (sometimes described as earth fault):

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

ground fault detection: To detect ground fault.

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.

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.

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

3.3 Communications terms

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

vehicle relay: The switch that controls the electric vehicle contactor.

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:

$$0xH_n \dots H_1 H_0$$

with nibble “ H_n ” representing the most significant nibble and nibble “ H_0 ” 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:

$$H'_n, \dots, 1, 0$$

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 Equations ~~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) = 1000
- 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 internally ~~on-board~~ or externally to ~~off-board~~ the vehicle. When the charger is internal to ~~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 external to ~~off-board~~ the vehicle, it requires communication with the battery control system. This communication protocol may be different by vehicle model, so external ~~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 ground ~~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) IP degree (outdoor): more than or equal to IP44.

2) IP degree (indoor): more than or equal to IP41: In the following country, the Rain Test in UL 2202 is applicable: U.S.

~~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):~~ -10 5 °C to 40 °C~~;~~

In the following country, the test at -35 °C may be required in UL 2231-1: U.S.

4) Ambient humidity: 5% to 95%.

5) Altitude: Charger shall work at 1000 m or lower ~~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 [B40 B39] and IEC 61851-24:2014 [B41 B40] have specified general requirements on dc EV charging station.^{9 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.

In the following country, UL 2202 is applicable as a safety standard: U.S.

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.

^{9 5} The numbers in brackets correspond to those of the bibliography in Annex C D.

A.2 Vehicle coupler

Vehicle coupler shall conform to IEC 62196-3 Standard sheets for configuration “AA.” [In the following country, UL 2251 is applicable as a safety standard: U.S.](#) ~~Shapes and dimensions of the vehicle coupler in A.17 are given for information only.~~⁶

[A.2.1 Vehicle inlet](#)

[Vehicle inlet shall comply with IEC 62196-3 standard sheets for configuration AA as a connected object of the vehicle coupler that is part of the charging cable assembly, and its soundness shall be confirmed.](#)

[In the following country, UL 2251 is applicable as a safety standard: U.S.](#)

[A.2.2 Charging cable](#)

[The charging cable should consist of power wires and signal wires, and it shall comply with international standards such as IEC or the requirements in national standards of each country. The power wires and signal wires shall have conductor size and electric wire coating material that is appropriately designed for the charging current. In addition, the signal wires that are applicable to CAN communication shall be twisted pair wires in order to reduce conductive noise of differential mode signals.](#)

[In the following country, UL 62 is applicable as a safety standard: U.S.](#)

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 [and Table A.3](#)

⁶~~Information on references can be found in Clause 2.~~

- c) Device specifications as shown in Table A.4⁷
- d) Design specifications as shown in Table A.5⁴

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

In Table A.1, a test at −35 °C may be required in UL 2231-1 in the following country: U.S.

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.2—Panel-related specifications

Panel performance ^{ab}	Indoor use: more than or equal to IP41 Outdoor use: more than or equal to IP44	
Panel color	In compliance with local ordinances for markings and visibility	
Insulation performance	Item	Insulation performance
	Input circuit—Output circuit	Double insulation or Reinforced insulation
	Input circuit—SELV ^{bc}	Double insulation or Reinforced insulation
	Output circuit—SELV ^{bc}	Less than 500 V: Basic insulation More than 500 V and up to 1000 V: Double insulation or Reinforced insulation
	Input circuit—Protective conductor	Basic insulation
	Output circuit—Protective earthing conductor	Less than 500 V: Basic insulation More than 500 V and up to 1000 V: Double insulation or Reinforced insulation
Test voltage		
a) Withstand ac voltage test (1 min, 50 Hz/60 Hz) 1) Primary side on main circuit (- GND): $U_n + 1200 \text{ Vrms}$ 2) Secondary side on main circuit (- GND): — 500 V or below: $U_n + 1200 \text{ Vrms}$ — More than 500 V and below 1000 V: $2 \times (U_n + 1200) \text{ Vrms}$ 3) Between primary side and secondary side of isolation transformer:^c $2 \times (U_n + 1200) \text{ Vrms}$ U_n: Nominal voltage between neutral and line or phase and earth If dc voltage is used on this test instead of ac, the applied dc voltage shall be equal to the peak value of regulated ac test voltage.		
b) Impulse withstand voltage test 1) Perform the impulse withstand voltage test as defined in IEC 60664-1. The test voltage of the impulse withstand voltage test shall be defined in Table A.3. Overvoltage category III shall be applied in the charger. If the charger manufacturer shall apply the overvoltage category corresponding to its installation environment, the manufacturer shall separately discuss that agreed upon between the charger manufacturer and a certifying body. One step higher voltage than the test voltage defined in Table A.3 shall be applied in case the insulation level between input circuit and output circuit is either Double insulation or Reinforced insulation. 2) The charger shall reduce the output impulse voltage that may be applied to a vehicle to less than or equal to 2500 V. Perform the impulse withstand voltage test as defined in IEC 60664-1. In addition, measure the voltage between P and N of the output circuit in charger while applying the test voltage defined by IEC 60664-1. Applied points shall meet the following requirements: — Each phase voltage to protective earthing conductor (perform the test at all combinations of each phase including a neutral line) — Line voltage performs the test at all combinations of line voltage		

(New)

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): $U_n + 1200$ Vrms 2) Secondary side on main circuit (- FG): $U_n + 1200$ Vrms 3) Between primary side and secondary side of isolation transformer: — In case of basic insulation:^a $U_n + 1200$ Vrms — In case of reinforced insulation:^a $2 \times (U_n + 1200)$ Vrms U_n: 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)

(Deleted)

^a Basic or Reinforced insulation shall be implemented on the secondary side of the isolation transformer against the primary one. In the following country, the potential shall be 1000 V plus twice the maximum rated voltage: U.S.

^b In the following country, the Rain Test in UL 2202 is applicable: U.S.

Table A.3— Test voltage of the impulse withstand voltage test

Nominal voltage of the supply system		Voltage line to neutral derived from nominal voltages up to and including [V]	Test voltage			
Three phase [V]	Single phase [V]		Overvoltage category [V]			
			I	II	III	IV
	120–240	50	330	500	800	1500
		100	500	800	1500	2500
		150	800	1500	2500	4000
230/400, 277/480		300	1500	2500	4000	6000
400/690		600	2500	4000	6000	8000
1000		1000	4000	6000	8000	12 000

(New)

Table A.4—Device specifications

Control method	Constant current control based on the current command from the vehicle
Input power supply	Nominal voltage in each country: AC ($\pm 15\%$), 50 Hz or 60 Hz ($\pm 5\%$). 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	Output voltage range: 150 V up to 500 V (Mandatory) 50 V up to 500 V (Recommended) 150 V up to 1000 V (optional)^b Output current range: 0 up to 125 A (standard operating condition) 0 up to 200 A (standard operating condition/specific operating condition)^c 0 up to 400 A (standard operating condition/specific operating condition)^c
Current ripple	Up to 10 Hz: 1.5 Ap-p or less Up to 5 kHz: 3.0 Ap-p or less Up to 150 kHz: 9.0 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 $\pm$ 10%
Protection system	Main circuit: Interrupt power supply on occurrence of ground fault and short circuits
	Control circuit: Interrupt power supply on occurrence of ground faults and short circuits

[\(New\)](#)

Control method	Constant current control based on the current command from the vehicle
Input power supply	Nominal voltage in each country: AC ($\pm 15\%$), 50 Hz or 60 Hz ($\pm 5\%$). 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, [ISO1898-2], Standard format Transmission rate: 500 kbps Transmission cycle: 100 ms $\pm$ 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.)	

(Deleted)

^a Minimum conversion efficiency recommended by CHAdeMO.

^b Refer to A.11.5.3.3. ^c Refer to A.5.5 and A.11.5.3.2.

Table A.5—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). Emergency stop button is only required if specified by applicable legislation where charger is installed.

(New)

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).

(Deleted)

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

A.4.1 Charging method

The ~~Constant~~ current ~~control~~ ~~charging~~ method ~~shall be adopted~~ ~~is used~~ for charging. The vehicle shall ~~send~~ ~~transmit~~ a charging current request to the charger at a constant time interval. The charger shall output ~~dc~~ current ~~for charging corresponding~~ ~~that corresponds~~ to the ~~request~~ ~~order~~ value. ~~The charger shall regulate the output current in response to the change in the request~~ ~~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

The essential functions are as follows:

- 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. The vehicle that applied to “Plug and Charge” (see NOTE) shall supply the “connector proximity detection” line with a 12 V signal. The charger shall detect the status of connector mating and use it as a trigger to start charging. However, the vehicles before version 1.2 that do not supply the “connector proximity detection” line with a 12 V signal is not applicable during charging.

NOTE—Instantly starting charge at the same time that connect mating is confirmed.¹⁰

- 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.
- c) Prevention of false-drive (requirement for the vehicle):
 - 1) The vehicle shall monitor the status of the connection between the vehicle and the charger and shall have ~~be equipped with~~ a means to prevent drive ~~the vehicle~~ while the charging connector ~~it~~ is connected with ~~to~~ the vehicle inlet (including ~~charger (whether it~~ is before and after ~~during~~ charging).

¹⁰ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

2) The vehicle shall use a “connector proximity detection” circuit for the confirmation of a connection excluding the period from the point at which the “vehicle charge permission” circuit is turned on to the point at which the EV contactor is opened.

- d) 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.
- e) Detection ~~and protection~~ of ground earth fault on the dc power circuit: During charging, the charger shall detect any ground earth fault on the dc power circuit. In the event that ground earth fault is detected in the dc power circuit, the charger shall stop applying dc voltage or supplying dc current to the charging cable immediately. If equipped, the on-board fault detection of the vehicle shall not interfere with the ground earth fault detection capability of the dc charger.
- f) Protection against short circuit in the dc power circuit: The charger shall have means to protect itself and vehicle and prevent problems in the power supply such as the ac mains from short circuit. In addition, the dc power circuit and exposed live parts of a charger shall be properly designed to prevent a short circuit that may be caused by water leakage and ingress of foreign materials.
- ~~e) DC short circuit protection: The charger shall be equipped with a short circuit protection function.~~
- g) Prevention of overvoltage in vehicle system ~~on on-board systems~~: The charger shall have means to limit ~~be equipped with an~~ overvoltage in ~~protection function on~~ vehicle systems.
- h) Charge current interruption function: The vehicle shall have contactors with sufficient capacity to break charge current.

i) Protection of EV contactor: The charger shall continue to provide dc 12 V to the EV contactor, keeping both switch (d1) and switch (d2) turned on, until the output charging current has become less than or equal to 5 A. This requirement shall also be applied to the event of an abnormality including power failure, load fluctuation, pressing of the emergency stop button, and so on.

j) Safety design for receiving stop signals: The charger shall stop charging when it receives a stop instruction by either “control signal” or “CAN communication.”

~~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.~~

k) Voltage and current measurement: The charger shall have ~~welding detection capability for monitoring the EV contactor. See A.10~~ means to measure voltage and current in the output circuit.

~~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.~~

l) Error logging function: The charger ~~and the vehicle~~ shall ~~have be equipped with~~ a means ~~to store and display of storing the~~ error information ~~for users and maintenance personnel and investigating its cause when malfunctions occur on the other side.~~

m) Charging cable assembly: The charger shall be equipped with the charging cable assembly in compliance with the requirements defined in A.2.2, A.4.7, A.5.4, and A.13 and the maximum output voltage and current of the charger.

A.4.5 Protection against electric shock

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

The voltage or electric charge of a level harmful ~~charging system shall be designed so that a level of voltage that is dangerous~~ to the human body shall not be applied ~~to on~~ the vehicle inlet and the charging connector during the normal insertion or release of the charging connector, ~~removal action~~ as well as when the charging connector has been disconnected by ~~fall situation due to an~~ accident.

In case the accessible live parts on the charger or the charging cable assembly have been exposed, the ~~charging system shall be designed so that~~ voltage ~~level~~ between the exposed any accessible conductive parts, ~~including charging cable and~~ the protective earthing conductor shall be ~~charging connector, and any grounding parts decreases~~ less than 60 V within 1 s after the exposure ~~appearance of live parts on the charger in the case of normal operation or abnormal situation.~~

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

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

The ~~charger or~~ charging connector shall not be released when energized ~~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.~~

The charger shall reduce the charging current to less than or equal to 5 A within 30 ms after the control signals are interrupted during energization. The control signals for detecting the interruption can be selected by charger manufacturers.

The charger shall have a circuit breaker for protection against short-circuit/overload current and ground fault/earth leakage at the receiving point of electricity. To satisfy the requirements for function maintenance of the control circuit, it is recommended the charger shall have a circuit breaker (AC-ELCB1 and AC-ELCB2 drawn in Figure A.1) on each of the branched circuits just after the branch of the main circuit and the control circuit. Although the circuit breakers may be installed in the upstream of the charger, it is necessary to instruct installers to install the circuit breakers equipped with adequate performance.

NOTE—AC-ELCB (Earth Leakage Circuit Breaker) can be replaced with an alternative equivalent equipment.

The charging cable assembly shall have sufficient strength and preventive measures against mechanical stresses under normal use. The connector holder of the charger shall be located at a height ranging between 0.5 m to 1.5 m above ground.

A.4.6 Overload current ~~Overcurrent~~ protection

The charger shall have a function against overload and short-circuit current to prevent hazards in the power supply. The charger and the vehicle shall have a function against overload and short circuit in each circuit in order to protect each other and shall have a protective coordination to protect the charging cable and accompanying circuit from short circuit and overload current.

~~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 Fire or heat hazard protection

The cross-sectional size of the conductor of power wires in a charging cable shall be greater than or equal to the “reference cable size” defined in Table A.6 (see NOTE in table). Also, the requirements for a charging cable having a cross-sectional size less than the reference cable size are defined in A.5.4.3.

The cable size of the protective conductor shall be 0.75 mm² or more.

Table A.6—Cross section of conductor for power wires of charging cable

Standard	Reference cable size
IEC standard (in compliance with IEC 60228)	25 mm ²
UL standard (in compliance with UL 62)	4 AWG (21.2 mm ²)
NOTE—Even when the cross-sectional size of the conductor of power wires in a charging cable greater than or equal to the “reference cable size,” the requirements of A.5.4.3.1 and A.5.4.3.2 can be applied in order to prevent the welding of the EV contactor in case of a short circuit. In the following country, wire size shall comply with UL 2251: U.S.	

(New)

NOTE—Even when the cross-sectional size of the conductor of power wires in a charging cable greater than or equal to the “reference cable size,” the requirements of A.5.4.3.1 and A.5.4.3.2 can be applied in order to prevent the welding of the EV contactor in case of a short circuit. In the following country, wire size shall comply with UL 2251: U.S.

A.4.8 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.

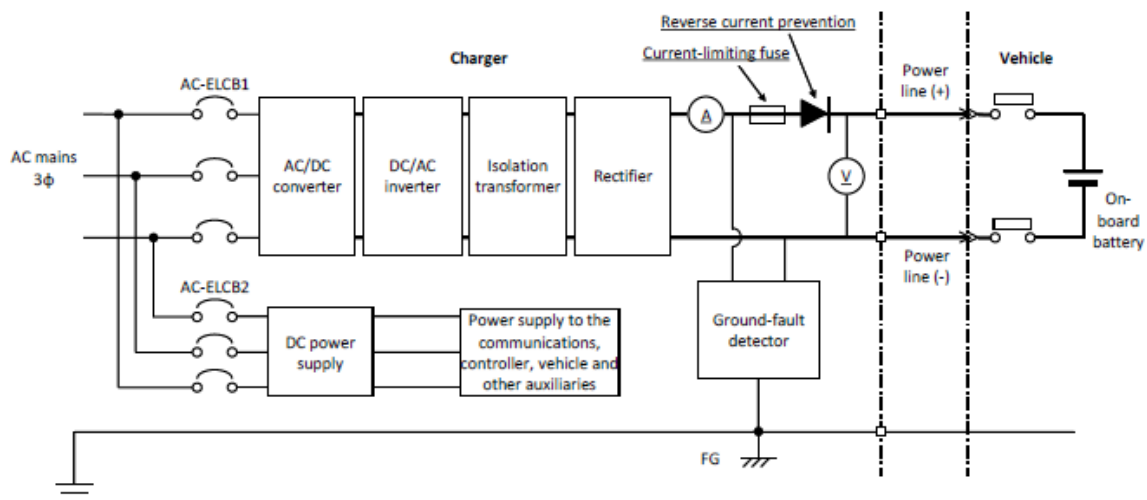


Figure A.1—Typical circuit configuration

A.5.1.1 Isolation of **input ac** and **output dc** circuits

Input ac circuit and output dc circuit shall be separated by reinforced insulation or double insulation. [In the following country, insulation shall comply with UL 2202: U.S.](#)

~~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.~~

A.5.1.2 Function maintenance of the control circuit

Even in the case when an abnormality ~~if a fault~~ occurs in ~~on~~ the main ~~power supply~~ circuit, the control functions, such as controlling and communicating ~~power supply circuit shall remain active to maintain the control/communications function~~ with the vehicle and, as well as the function for protecting and monitoring ~~the charger itself, by the control circuit shall not be terminated.~~

A.5.1.3 Reverse current prevention diode

The charger shall have a ~~be equipped with~~ reverse current prevention diode in ~~on~~ the output circuit in order to prevent reverse current flowing from the traction ~~on-board~~ battery to the charger, including inrush ~~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 mm².~~
- ~~e) Fuse that is possible to protect against a short circuit shall be provided on the vehicle.~~

A.5.1.4 Current-limiting fuse

A.5.1.4.1 Requirements for charger

The charger shall ~~have a~~ be equipped with current-limiting fuse (passive device) in ~~on~~ the output circuit in order, so as to protect itself and the output circuit between a vehicle inlet and a vehicle fuse from the prevent short circuit of P and N of the output circuit if charging cable is accidentally connected in reverse polarity. The requirements of the current-limiting fuse of the charger are shown in Table A.7 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.~~

Table A.7 – Specification of the current-limiting fuse

Item	Requirement
Electrical characteristic	Fast-acting
Ampere rating	More than the maximum current of the charger
Operating joule-integral I^2t	Less than or equal to $0.4 \text{ MA}^2\text{s}$

(New)

A.5.1.4.2 Requirements for vehicle

The vehicle shall have the means to protect the vehicle circuit in accordance with the requirements of ISO 17409. The operating joule-integral of the fuse on the vehicle side shall be less than or equal to $2.5 \text{ MA}^2\text{s}$.

A.5.1.5 Coordination of short-circuit current protection and overload current protection

A.5.1.5.1 Requirements for charger

The charger shall comply with the following requirements. In addition, if a charging cable with the cable size of the power lines being less than the reference cable is installed, the charger shall not only comply with the requirements of A.5.1.5 but also protect the charging cable by the current-limiting fuse inside the charging connector as defined in A.5.4.3.1.

A.5.1.5.1.1 Short-circuit current protection

The charger shall be equipped with a short-circuit protection function. The charger shall interrupt the short-circuit current immediately by using an inverter gate block of the charger as soon as the short circuit between P and N of the output circuit is detected. However, the overload current shall be interrupted by the gate block earlier than the specification of the short-circuit current protection specified by each charger manufacturer, which is defined in A.5.1.5.1.2.

If a charging cable with the cable size of the power lines more than or equal to the reference cable size is installed, the short-circuit withstand rating (operating joule-integral I^2t) of the wiring including the charging cable in the output circuit of the charger shall be more than or equal to 6.4 MA²s.

If a charger equipped with the current limiting fuse in the connector is installed, the charging connector latch shall not be released when the current limiting fuse is blown.

A.5.1.5.1.2 Overload current protection

There are cases where the wiring including the charging cable in the output circuit of the charger and the cable of the vehicle side cannot be protected by the current limiting fuse of the charger. Therefore, the charger shall shift to an error stop within 5 s after the output current is larger than the error judgment value defined in Table A.8 is detected.

Table A.8—Overload current protection

Charging current request (H'102.3) (see NOTE)	Error judgment value
0 A–50 A	Charging current request (H'102.3) + 10 A
50 A–400 A	Charging current request (H'102.3) × 120%
NOTE—“Charging current request (extended) (H'110.1, H'110.2)” should be used instead of “Charging current request (H'102.3)” in case “High current control” as defined in A.11.5.3.2 is applied.	

(New)

A.5.1.5.2 Requirements for vehicle

The vehicle shall interrupt the short-circuit current and the overload current by using protective means such as the fuse on the vehicle side in case the cable of the vehicle side cannot be protected by the short-circuit protection and the overload current protection.

A.5.1.6 Power supply to the vehicle

The charger shall ~~have a prepare~~ dc ~~12 V~~-power supply to provide power ~~for the to-operate~~ EV contactor, ~~and so on. The (described in A.5.2). This~~ dc ~~12 V~~-power supply shall be ~~provided by the obtained from~~ control ~~circuit and shall not be influenced by abnormality in the main circuit (e.g., earth leakage and overload current) as described in A.5.1.2 and item i) in A.4.4 power supply described in A.5.1.2.~~

~~The requirements of the 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 be defined comply with the specifications shown in Table A.9 5.~~

Table A.9—Requirements of power supply to the vehicle

Supply voltage	12 V (dc) Voltage fluctuation tolerance: $\pm 10\%$ of supply voltage
Continuous rating	2 A, 24 W
Circuit Protection	Short-circuit current to the vehicle shall decrease less than 6 A within 1 s after the short circuit occurs. The wiring of the signal wires shall tolerate the short-circuit current in consideration of the applicable wire size.

(New)

Supply voltage	12 V (dc) Voltage fluctuation tolerance: $\pm 10\%$ 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.

(Deleted)

A.5.1.7 Current and voltage measurement

The charger shall ~~be equipped with a measuring equipment to measure its output current and~~ voltage and current in the output circuit. The output voltage shall be measured at a point between the reverse current prevention diode and the charging connector. ~~between~~

When placing the current-limiting fuse on the vehicle side of the reverse current prevention diode, the output voltage shall be measured at a point between the current-limiting fuse and the ~~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.5.1.8 Earthing, grounding, and protective conductor

A.5.1.8.1 General requirements

Protective earthing conductors of the input circuit shall be connected to the protective conductor of the output circuit without any resistance.

A.5.1.8.2 AC input 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.5.1.8.3 DC output circuit ~~side~~

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

b) 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.

c) 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.5.1.9 Internal protection

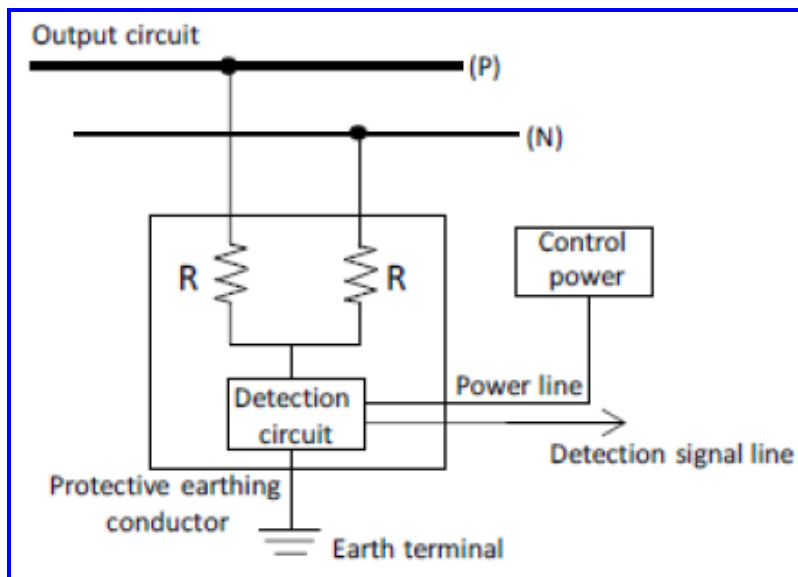
The charger shall have a mechanism for monitoring ground ~~earth~~ fault, short-circuit, overcurrent, and temperature rise inside the charger, as well as for ~~and~~ immediately disconnecting main circuit from external power grid upon detection of any fault.

A.5.1.10 Ground ~~Earth~~ fault detection on the dc output ~~power~~ circuit

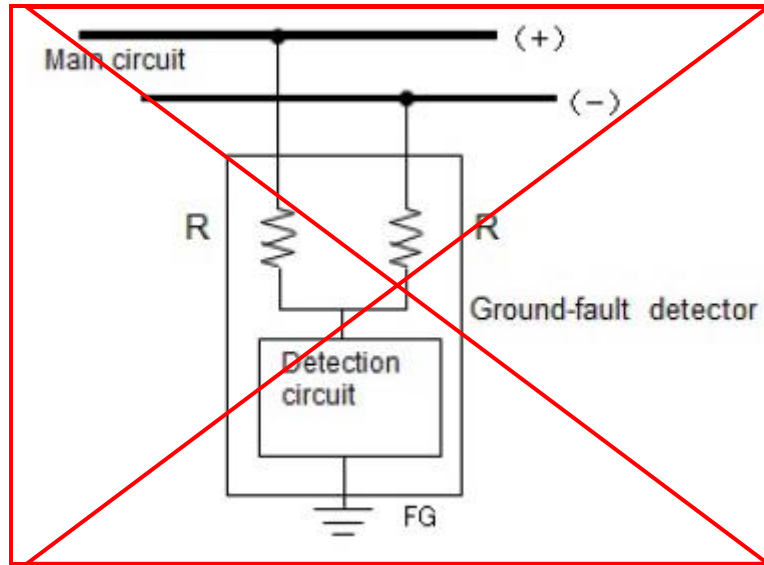
A.5.1.10.1 Basic requirements

A leakage current monitoring device for detecting ground ~~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.10 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.7.2.87.2. The insulation monitoring device on the vehicle shall be disabled while the EV contactors are closed, and it shall not affect the operation of the leakage current monitoring in the charger while the vehicle is connected with the charging connector.

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



(New)



(Deleted)

Figure A.2—DC leakage current monitoring circuit

Table A.10—Specification of dc leakage current monitoring

	Item	Specification
1	Detection voltage range	Comply with the output range of charger.
2	Detection method	DC leakage current detection through neutral grounding
3	Sensing performance	The monitoring device shall output the trip signal when the insulation resistance ratio between the main circuit and charger enclosure (including vehicle chassis) gets lower than $100 \Omega/V$. [V: output voltage] ^a
4	Operating time	1.0 s or less
5	False operation prevention time	0.2 s or more (see NOTE)
6	Resistance R	The resistance shall be installed to limit the maximum ground fault current to 12.5 mA. For example, in the case of a charger with dc 150 V to dc 1000 V, the resistance value is 80 k Ω or more. In the following country, the measuring output current shall be 5 mA: U.S.
NOTE—To prevent accidental activation due to short-term noise current.		

(New)

	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 k Ω 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.		

(Deleted)

^aIn 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.5.1.10.2 Failure detection of ground fault detection circuit (Self-diagnostic function)

The charger shall check the integrity of its ground fault detection circuit in the period from when switch (d1) is turned on to when switch (d2) is turned on. The charger shall shift to an error stop process in case a failure in the ground fault detection circuit is detected. The charger shall at least diagnose the following defined items:

- a) Open failure and short-circuit failure of resistance R
- b) Open failure of ground fault detection circuit (e.g., open detecting resistor of ground fault current)
- c) Open failure of power lines
- d) Open failure of protective earthing conductor
- e) Voltage abnormality of control power (including short circuit of power lines)

A.5.1.11 Overvoltage protection in the event of EV contactor interruption

The charger shall control the output ~~have overvoltage protection function to keep applied~~ voltage to not exceed the maximum value shown in Table A.11 to protect a vehicle system in case EV contactors are opened ~~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)~~

Table A.11 – Requirements of the overvoltage protection

Target battery voltage (H'102.1, H'102.2)	Maximum value of overvoltage
500 V or less	600 V
750 V or less	900 V
1000 V or less	1200 V

(New)

A.5.1.12 Support for EV contactor welding detection

The charger shall have the following output circuit characteristics ~~described in A.7.5~~ to support the EV contactor welding detection (see A.10 for details):-

- a) Within 1 s after the vehicle opens the EV contactor, the voltage in the output circuit of the charger shall be reduced to less than or equal to 25% of the voltage before opening the EV contactor.
- b) Within 2 s after the vehicle opens the EV contactor, the voltage in the output circuit of the charger shall be reduced to less than or equal to 10 V.

A.5.1.13 Charger protection against overvoltage including voltage surge

The charger and the vehicle shall satisfy the following requirements in order to prevent the disconnection of the protective conductor due to the ground fault in the output circuit of charger:

- a) The surge protective device (SPD) shall not be installed at the vehicle between P and GND or N and GND.
- b) When the surge protective device (SPD) is installed at the charger between P and GND or N and GND, the SPD shall not cause a short circuit with the single fault between P and GND or N and GND.
- c) Y capacitors or any other device shall not cause a short circuit with the single fault between P and GND or N and GND (see NOTE 1).

However, chargers and vehicles should install the SPD such as a bidirectional Zener diode (see NOTE 2) on the CAN communication circuit. Installation of the SPD on other sequence circuits is recommended.

NOTE 1—Y capacitors designed as fail open type can be placed between P and GND or N and GND.

NOTE 2—See IEC 61643-12.

~~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.5.1.14 Output circuit requirements

A.5.1.14.1 Inrush current

Inrush current through the power lines of the charging connector when the EV contactor is closed shall be less than or equal to 20 A.

A.5.1.14.2 Impedance requirements for charger

The impedance between P and N of the output circuit of the charger from the reverse current prevention diode to the tip of the charging connector shall meet the requirements that follow during the time period from (d2) ON to charging current request (H'102.3) that becomes more than or equal to 1 A:

— Capacitance: Less than or equal to 1 μ F

— Resistance: More than or equal to 40 k Ω

In addition, the charger shall comply with the requirements defined in Table A.12 to prevent electric shock from touching the live parts.

Table A.12—Requirements for preventing electric shock

Target battery voltage	Requirement
500 V or less	The Y capacitance of the charger output circuit shall be 0.5 μ F or less per rail.
More than 500 V up to 1000 V	The charger shall have double or reinforced insulation between P and N, P and GND, and N and GND of the output circuit.

(New)

A.5.1.14.3 Circuit requirements

The output circuit of the charger shall meet either of the following requirements a) or b). In addition, either the requirement c) or d) shall be satisfied if an element connecting P and N exists:

a) No fuse shall exist in series with the output circuit from the reverse current prevention diode to the tip of the charging connector. However, the following cases are excluded:

1) When the current-limiting fuse is placed to the vehicle side of the reverse current prevention diode, double insulation or reinforced insulation shall be implemented in the output circuit from the reverse current prevention diode to the current-limiting fuse between P and N.