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Electric Vehicle Conductive Charging System – Part 1: General Requirements

电动汽车传导充电系统

第 1 部分：通用要求

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Foreword

GB/T 18487 consists of the following parts, under the general title "Electric Vehicle Conductive Charging System":

- Part 1: General Requirements;
- Part 2: Electric Vehicles Requirements for Conductive Connection to an A.C/DC Supply;
- Part 3: AC/DC Electric Vehicle Charging Station.

This part is Part 1 of GB/T 18487.

This part was drafted according to the rules given in GB/T 1.1-2009.

This part replaces "Electric Vehicle Conductive Charging System – Part 1: General Requirements" (GB/T 18487.1-2001); in addition to editorial changes, it mainly differs from GB/T 18487.1-2001 in the following technical changes:

- "3 Terms and Definitions" was modified with terms such as "charging system" specified;
- "4 Classification" was added with different types of supply equipment specified;
- "5 General Requirements for Charging System" was added to specify the use condition and function of charging mode;
- "6 Communication" was added to specify the communication protocol of power supply equipment;
- "7 Electric Shock Protection" was added to specify the direct contact protection grade of power supply equipment;
- "8 Connection between Electric Vehicle and Power Supply Equipment" was added to specify the functionality explanation of power coupler and vehicle coupler;
- "9 Special Requirements for Vehicle Coupler and Plug and Socket-outlet" was added to specify the requirements for coupler temperature monitoring and locking device, etc.
- "10 Structure Requirements for EV Supply Equipment" was added to specify the requirements for residual current device, etc.
- "11 Performance Requirements for EV Supply Equipment" was added to specify the requirements for contact current, etc.
- "12 Overload Protection and Short-circuit Protection" was added to specify the

Electric Vehicle Conductive Charging System – Part 1: General Requirements

1 Scope

This part of GB/T 18487specifies classification, general requirements, communication, electric shock protection, connection between electric vehicle and supply equipment, special requirements of vehicle coupler, plug and socket-outlet, supply equipment structure requirement, performance requirement, overload protection and short circuit protection, emergency stop, service conditions, repair, marking and description for electric vehicle conductive charging system.

This part is also applicable to EV supply equipment which acquires energy from onsite energy storage system (such as buffer battery).

Under the following special conditions, EV supply equipment shall provide additional functions:

a) Where the EV supply equipment is located in dangerous zone where there is flammable gas or steam, fuel or other combustible or explosive substance;

b) Where the EV supply equipment is designed as to be fixed at an altitude above 2 000 m.

This part is not applicable to safety requirements on maintenance of electric vehicle conductive charging system, or to the on-board charging equipment as specified in ISO 17409, or to power supply equipment of trolleybus, railway vehicle, and industrial vehicle and mainly for non-road vehicle.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB 1002	Single Phase Plugs and Socket-outlets for Household and Similar Purposes – Types, Basic Parameters and Dimensions
GB 1003-2008	Three Phases Plugs and Socket-outlets for Household and Similar Purposes – Types, Basic Parameters and Dimensions

GB 2099.1	Plugs and Socket-outlets for Household and Similar Purposes – Part 1: General Requirements
GB 7251.1-2013	Low-voltage Switchgear and Controlgear Assemblies – Part 1: General Rules (IEC 61439-1:2011, IDT)
GB 10963.1-2005	Electrical Accessories – Circuit-breakers for Overcurrent Protection for Household and Similar Installation – Part 1: Circuit-breakers for AC Operation (IEC 60898-1:2002, IDT)
GB 14048.2-2008	Low-voltage Switchgear and Controlgear – Part 2: Circuit-breakers
GB 14048.3-2008	Low-voltage Switchgear and Controlgear – Part 3: Switches, Disconnectors, Switch-disconnectors and Fuse-combination Units (IEC 60947-3:2005, IDT)
GB/T 14048.4-2010	Low-voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters – Low-voltage Electromechanical Contactors and Motor Starters (including Motor Protector)
GB 16895.3-2004	Electrical Installations of Buildings – Part 5-54: Selection and Erection of Electrical Equipment – Earthing Arrangements, Protective Conductors and Protective Bonding Conductors (IEC 60364-5-54:2002, IDT)
GB 16916.1-2014	Residual Current Operated Circuit-breakers without Integral Overcurrent Protection for Household and Similar Uses (RCCB) – Part 1: General Rules (IEC 61008-1:2002, MOD)
GB/T 16935.1-2008	Insulation Coordination for Equipment within Low-voltage Systems – Part 1: Principles, Requirements and Tests(IEC 60664-1:2007, IDT)
GB/T 17045-2008	Protection against Electric Shock – Common Aspects for Installation and Equipment (IEC 61140:2001, IDT)
GB/T 19596-2004	Terminology of Electric Vehicles
GB/T 20234.1-2015	Connection Set of Conductive Charging for Electric Vehicles - Part 1: General Requirements
GB/T 20234.2-2015	Connection Set of Conductive Charging for Electric Vehicles – Part 2: AC Charging Coupler

GB/T 20234.3-2015	Connection Set of Conductive Charging for Electric Vehicles – Part 3: DC Charging Coupler
GB/T 21711.1-2008	Electromechanical Elementary Relays – Part 1: General and Safety Requirements (IEC 61810-1:2003.IDT)
GB 22794-2008	Type B Residual Current Operated Circuit-breakers with and without Integral Overcurrent Protection for Household and Similar Uses (Type B RCCBs and Type B RCBOs) (IEC 62423:2007, IDT)
GB/T 27930-2015	Communication Protocols between Off-board Conductive Charger and Battery Management System for Electric Vehicle
GB/T 28569-2012	Electric Energy Metering for Electric Vehicle AC Charging Spot
GB/T 29317-2012	Terminology of Electric Vehicle Charging/Battery Swap Infrastructure
GB/T 29318-2012	Electric Energy Metering for Electric Vehicle Off-board Charger
GB 50057-2010	Design Code for Protection of Structures against Lightning
IEC 60269 (All Parts)	Low-Voltage Fuses
IEC 60898 (All Parts)	Electrical Accessories – Circuit-Breakers for Overcurrent Protection for Household and Similar Installations
IEC 60947-6-2:2007	Low-Voltage Switchgear and Controlgear – Part 6-2: Multiple Function Equipment – Control and Protective Switching Devices (or Equipment) (CPS)
IEC 61009-1:2013	Residual Current Operated Circuit-Breakers with Integral Overcurrent Protection for Household and Similar Uses (RCBOs) – Part 1: General Rules
IEC 6185l-23	Electric Vehicle Conductive Charging System – Part 23: DC Electric Vehicle Charging Station
IEC 62477-1:2011	Safety Requirements For Power Electronic Converter Systems And Equipment – Part 1: General

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in GB/T 3505-2000 and GB/T 6062-2002 as well as those given below apply.

3.1 Charging system

3.1.1

Charging

Powering the power batteries of electric vehicle, or additionally on-board electric apparatus, at a calibrated voltage/current regulated from AC/DC network (power supply).

3.1.2

Charging modes

Method to power electric vehicle by connecting the electric vehicle to power network (power supply).

3.1.2.1

Mode 1

While electric vehicle is connected to AC network (power supply), plugs and socket-outlets in compliance with GB 2099.1 and GB 1002, as well as phase line, neutral line and grounding protection conductor, are applied at the power supply side.

3.1.2.2

Mode 2

While electric vehicle is connected to AC network (power supply), plugs and socket-outlets in compliance with GB 2099.1 and GB 1002, as well as phase line, neutral line and grounding protection conductor, are applied at the power supply side. Besides, in-cable control and protection device (IC-CPD) is applied for charging connection.

3.1.2.3

Mode 3

While electric vehicle is connected to AC network (power supply), special power supply equipment is used to connect electric vehicle directly with AC network and a control pilot device is installed onto the special power supply equipment.

3.1.2.4

Note: this definition is applicable to those for functional purpose only.

[GB/T 2900.1-2008, definition 3.5.70]

3.2.5

Supplementary insulation

An independent insulation added to provide fault protection, other than basic insulation.

[GB/T 2900.1-2008, definition 3.5.71]

3.2.6

Double insulation

Insulation composed of both basic insulation and supplementary insulation.

[GB/T 2900.1-2008, definition 3.5.72]

3.2.7

Reinforced insulation

Insulation with hazardous live part of an electric shock protection level equivalent to double insulation

Note: a reinforced insulation may be composed of several insulation layers which cannot have separate testing like basic insulation or supplementary insulation.

[GB/T 2900.1-2008, definition 3.5.73]

3.2.8

Exposed conductive part

Accessible conductive part of equipment, which is not live under normal conditions but will be live if the basic insulation is damage.

[GB/T 2900.1-2008, definition 3.5.74]

3.2.9

Live part

Live conductor or conductive part in normal operation, including neutral conductor but practically excluding PEN, PEM and PEL conductors.

Note: this definition does not indicate a definite shock hazard.

Residual current device (RCD)

Mechanical switching device or combined device allowing switching on, load bearing and current breaking under normal operating condition, and contact disconnection where the residual current reaches the specified value under specified condition.

4 Classification

4.1 By input characteristic of power supply equipment

By the power supply system it connected to, EV supply equipment is classified into:

- EV supply equipment connected to AC network (power supply);

- EV supply equipment connected to DC network (power supply).

4.2 By output characteristic of power supply equipment

By its output current, EV supply equipment is classified into:

- AC power supply equipment;

- DC power supply equipment;

- AC/DC power supply equipment.

4.3 By service environment

4.3.1 Normal service environment

- indoor use;

- outdoor use.

4.3.2 Special service environment

The classification may be conducted by the special service conditions specified in 14.2.

4.4 By the output voltage of power supply equipment

By output voltage, EV supply equipment is classified into:

- AC: mono-phase 220 V, three-phase 380 V;

- DC: 200 V~500 V, 350 V~700 V, 500 V~950 V.

Preferred value of DC charging current: 80 A, 100 A, 125 A, 160 A, 200 A, 250 A.

Note: for power supply equipment above 950 V, it is determined as agreed between the vehicle manufacturer and

power supply equipment manufacturer.

4.5 By installation way

By installation way, EV supply equipment is classified into:

- fixed (wall-mounted: installed on wall, pole or other equivalent location; floor-mounted: installed on floor);
- movable (such as movable charging equipment);
- portable (such as IC-CPD for mode 2).

4.6 By electric shock protection

By electric shock protection, EV supply equipment is classified into:

- Category I power supply equipment: using basic insulation as basic protection and protective bonding as fault protection;
- Category II power supply equipment: using basic insulation as basic protection and additional insulation as fault protection, or using reinforced insulation which can serve as both basic protection and fault protection.

Note: See GB/T 17045-2008 for the definitions of Categories I and II.

4.7 By charging mode

By the charging mode as specified in 3.1.2, EV supply equipment is classified into:

- charging mode 1;
- charging mode 2;
- charging mode 3;
- charging mode 4.

Note: more than one charging mode may coexist on the same EV supply equipment.

5 General Requirements for Charging System

5.1 Service conditions of EV charging mode

5.1.1 Charging mode 1

Mode 1 charging system uses standard plug/socket-outlet and shall adopt single-phase AC power supply not greater than 8A and 250V during energy transmission. The plug and socket-outlet conforming to GB 2099.1 and GB 1002 shall

Mode 4 may be directly connected to AC network or DC network.

Only case C connection is applicable to mode 4.

See Appendix B for the control pilot function of Mode 4.

5.2 Functions of charging modes 2, 3 and 4

5.2.1 Function requirements of modes 2, 3 and 4

5.2.1.1 Control pilot function of power supply equipment

EV supply equipment shall at least provide the following control pilot functions:

- continuous monitoring of the continuity of protective earthing conductor;
- confirmation of the right connection of electric vehicle and power supply equipment;
- power supply control function;
- outage control function;
- monitoring of charging current.

When EV supply equipment is capable of charging multiple vehicles simultaneously, it needs to ensure that the above control pilot functions shall operate independently and normally at each charging connecting point.

5.2.1.2 Continuous monitoring of the continuity of protective earthing conductor

When charging at mode 2, mode 3 and mode 4, the electrical continuity of protective earthing conductor shall be monitored continuously by EV supply equipment.

Note: the above requirement is not applicable to Type II power supply equipment.

For mode 2, monitoring is carried out between electric vehicle and in-cable control and protection device.

For mode 3 and mode 4, monitoring is carried out between vehicle and EV supply equipment.

In case that the electrical continuity of protective earthing conductor is lost, the power supply of EV supply equipment shall be cut off within 100ms.

5.2.1.3 Confirmation of the right connection of electric vehicle and power supply equipment

The supply equipment shall be able to determine:

uncoupled with the socket-outlet, the protection grade of plug and socket-outlet shall be: IPXXB;

- in charging mode 4 and case C connection, when the vehicle connector is uncoupled with the vehicle inlet, effective measures shall be taken to avoid human body contacting with DC charging stitches and the conductive parts of sleeve.

7.3 Capacitor discharge

7.3.1 Disconnection of standard plug

After disconnecting the standard plug from standard socket-outlet for 1s, the voltage between any touchable conductive part of standard plug and the protective earthing conductor shall be less than or equal 60V DC, or the equivalent storage charge shall be less than 50μC.

7.3.2 Disappearance of power supply voltage from EV supply equipment

In charging mode 3 and charging mode 4, the voltage between the power lines of output terminal or between power line and protective earthing conductor measured within 1s after the outage of EV supply equipment shall be less than or equal to 60V DC or the equivalent storage electricity shall be less than or equal to 0.2J.

7.3.3 Fault protection

According to GB/T 17045-2008, the following protection measures are allowed:

- automatic disconnection of power supply;

- double or reinforced insulation;

- galvanic separation is only limited to supply power to electric vehicle via an earth-free power supply with simple isolation.

- extra-low voltage (SELV system and PELV system).

In the EV supply equipment, protective earthing conductor and protective bonding conductor permanently installed in mode 3 and mode 4 shall be connected fixedly.

7.4 Dimension of protective earthing conductor

For all modes, protective earthing conductor shall be provided between the earthing terminals of AC network (power supply), DC network (power supply) and vehicle connector.

Protective earthing conductor shall meet the requirements of GB 16895.3-2004.

7.5 Complementary measures

meet the relevant requirements of GB/T 20234.1-2015.

The force used to connect and disconnect plug and socket-outlet shall meet the relevant requirements of GB/T 20234.1-2015.

9.6 Locking device

Where the AC charging current is greater than 16A, the plug and socket-outlet and vehicle coupler shall be provided with locking function which shall meet the relevant requirements of GB/T 20234.1-2015. Electronic locking device shall be installed on socket-outlet and vehicle inlet to prevent from inadvertent disconnection in charging process. Where the electronic lock is not locked reliably, the power supply equipment or electric vehicle shall stop charging or not start charging.

Where DC charging is adopted, the vehicle coupler shall be provided with locking function which shall meet the relevant requirements of GB/T 20234.1-2015. Mechanical locking device shall be installed at vehicle connector side and the power supply equipment shall be able to judge whether the mechanical lock is locked reliably. The vehicle connector shall be installed with electronic locking device; where the electronic lock is placed in locking position, mechanical lock shall be inoperable and power supply equipment shall be able to judge whether the electronic lock is locked reliably. Where the mechanical lock or electronic lock is not locked reliably, the power supply equipment shall stop charging or not start charging. See Appendix C for the locking device of vehicle coupler under DC charging.

Electronic locking device shall be provided with emergency unlocking function and shall not be unlocked with electricity and directly by hands.

9.7 Surge current

In charging mode 4, the surge current (peak value) from vehicle to charging equipment or from charging equipment to vehicle in connecting power supply equipment contactor shall be controlled under 20A.

10 Structure Requirements for EV Supply Equipment

10.1 Overview

AC charging should adopt case B connection and DC charging shall adopt case C connection.

The structure design of power supply equipment must meet the requirements for normal use of plug specified in Appendix B of GB/T 20234.2-2015 and GB/T 20234.3-2015; the auxiliary accessories used in power supply equipment must meet the requirements of Appendix A in GB/T 20234.2-2015 and GB/T 20234.3-2015.

EV supply equipment shall meet the requirements under the normal service condition

in 14.1; and the assembly shall meet the relevant requirements of GB 7251.1-2013 and the power supply equipment manufacturer.

See 14.2 for the usage in extreme environment or other conditions.

10.2 Characteristics of mechanical switch devices

Switch devices shall be provided with the following characteristics.

10.2.1 Switch and disconnector

Switch and disconnector shall meet the relevant requirements of GB 14048.3-2008; their rated current shall not be less than 1.25 times of the rated current of operating circuit and their use category shall not be lower than AC-22A or DC-21A.

10.2.2 Contactor

Contactor shall meet the relevant requirements of GB/T 14048.4-2010; its rated current shall not be less than 1.25 times of the rated current of operating circuit and its use category shall not be lower than AC-1 or DC-1.

10.2.3 Circuit breaker

Circuit breaker shall meet the relevant requirements of GB 10963.1-2005 or GB 14048.2-2008 and be provided with overloading and short-circuit protection functions.

10.2.4 Relay

Relay shall meet the requirements of GB/T 21711.1-2008.

10.2.5 Measurement

If EV supply equipment is provided with electric energy measurement, the electric energy measurement shall meet the relevant requirements of GB/T 28569-2012 or GB/T 29318-2012.

10.3 Residual current device

The residual current device of AC power supply equipment should be provided with Type A or Type B and meet the relevant requirements of GB 14048.2-2008, GB 16916.1-2014 and GB 22794-2008.

Where the AC power supply equipment is provided with the socket-outlet or vehicle connector conforming to GB/T 20234.2-2015, protective measures against fault current shall be provided;

- Type B residual current device, or

- Type A residual current device, or

- Relevant devices conforming to the protection function of Type A residual current.

10.4 Clearance and creepage distance

The power supply equipment only used indoor shall be designed to be capable of operating in the environment of minimum over-voltage Type II.

The power supply equipment used outdoor shall be designed to be capable of operating in the environment of minimum over-voltage Type III.

Where the EV supply equipment is installed by the manufacturer, the clearance and creepage distance shall meet the requirements of GB/T 16935.1-2008 at least.

10.5 IP grade

10.5.1 Protection grade

In charging mode 3 and charging mode 4, the protection grade of EV supply equipment shall not be lower than IP32 (indoor) or IP54 (outdoor).

10.5.2 Dustproof and waterproof grade of plug and socket-outlet

The protection grade of plug and socket-outlet shall meet the requirements of GB/T 20234.1-2015.

10.6 Cable management and storage

For the power supply equipment of case C connection, a storage method shall be provided for unused vehicle connector.

For case C connection, the vehicle connector shall be placed 0.5m~1.5m above the ground.

For the power supply equipment of case C connection over 7.5m in cable length, relevant management and storage measures shall be taken to make the free cable length not exceed 7.5m when unused.

11 Performance Requirements for EV Supply Equipment

11.1 Overview

EV supply equipment shall be able to be used normally in rated voltage and maximum output power & current. Where the power supply equipment is designed to be applicable to certain range of rated voltage, maximum rated voltage shall be adopted.

11.2 Contact current

The test voltage shall be 1.1 times of the rated voltage.

of standard lightning wave is imposed between energized circuits or between each independent energized circuit and the ground (metal shell) according to the requirements specified in Table 2. In the test process, disruptive discharge shall not appear on test positions.

11.6 Temperature requirements

11.6.1 Overview

Where the reference ambient air temperature is 25°C and verification is carried out according to the relevant requirements of GB 7251.1-2013, the power supply equipment and its circuit shall be able to bear the maximum rated current continuously under specified conditions (5.3.1 and 5.3.2 of GB 7251.1-2013). The temperature rise limit is specified in 9.2 of GB 7251.1-2013; for the assemblies without relevant standard, the temperature rise limit is specified in 11.6.2.

11.6.2 Ultimate temperature rise

During long-term continuous operation of the EV supply equipment under rated loads, the temperature rise of the internal heating components and all positions shall not exceed those specified in Table 2 of NB/T 33001-2010.

11.6.3 Allowable surface temperature

Under rated current and 40°C environment temperature, the maximum allowable temperature of the hand-hold touchable surface is:

- 50°C for metal parts;
- 60°C for nonmetal parts.

Under same conditions, the maximum allowable temperature of the surface that is touchable but cannot be hold by hands is:

- 60°C for metal parts;
- 85°C for nonmetal parts.

The power supply equipment shall be designed to:

- keep the temperature of contacting parts not exceeding specific temperature;
- keep the temperature of assemblies, parts, insulators and plastic materials not exceeding the temperature that may degrade the electrical, mechanical or other performances in normal use in the life cycle of facilities.

11.7 Lightning protection

The installation and model selection of surge protection device shall be in accordance with the installation site of power supply equipment and meet the requirements of 6.4

14 Service Condition

14.1 Normal service condition

14.1.1 Ambient air temperature

14.1.1.1 General

EV supply equipment shall be subjected to test under the power class allowed by manufacturer, specified ambient temperature, maximum temperature and minimum temperature.

14.1.1.2 Ambient air temperature of indoor facilities

The ambient air temperature shall not exceed +50°C and the average temperature in 24h shall not exceed +35°C.

The lower limit of ambient air temperature is -5°C.

14.1.1.3 Ambient air temperature of outdoor facilities

The ambient air temperature shall not exceed +50°C and the average temperature in 24h shall not exceed +35°C.

The lower limit of ambient air temperature is -20°C.

14.1.2 Humidity condition

14.1.2.1 Humidity condition of indoor facilities (nonoperational mode)

The relative air humidity shall not exceed 50% while the maximum temperature is +40°C. Higher relative humidity may be allowed under lower temperature, such as 90% at +20°C. Occasional moderate condensation shall be considered due to temperature variation.

14.1.2.2 Humidity condition of outdoor facilities

The relative humidity of outdoor facilities is 5%~95%.

14.1.3 Pollution grade

Pollution grade refers to the macro-environment condition of power supply equipment; it is classified according to IP grade in Chapter, creepage distance in 10.4 and classification in 4.3.

- Outdoor use: pollution grade 3;

- Indoor use: pollution grade 2;

- Exposed to dirty industry environment in door: pollution grade 3.

The pollution grade of power supply equipment in macro-environment may be influenced by the enclosure with proper IP grade.

14.1.4 Altitude

This part is applicable to the power supply equipment with installation altitude not higher than 2 000m.

The clearance and creepage distance, etc. of facilities with altitude higher than 2 000m shall meet the requirements of GB/T 16935.1-2008.

Note: for the power supply equipment used in high altitude, it is necessary to consider the decline of dielectric strength, the switch ability of equipment and the air cooling effect.

14.2 Special service condition

If there are special service conditions required by customers, the charging equipment manufacturer and customers shall reach a special agreement on testing.

Special service conditions include but not limited to:

a) Values different from the temperature, relative humidity and/or altitude specified in 14.1;

b) The variation speed of temperature and/or air pressure leads to the application scenarios of abnormal compression in power supply equipment;

c) Serious air pollution induced by dust, smoke, corrosive substances or radioactive particles, vapor or smoke;

d) Exposed to high field or intense magnetic field;

e) Exposed to extreme climate condition;

f) Subjected to fungus or microbiological corrosion;

g) Area where fire or explosion hazards exist;

h) Exposed to severe vibration, impact or earthquake;

i) Installation environment affected by current carrying capacity or breaking capacity, e.g. power supply equipment is fasted to machine or embedded into wall body;

j) Exposed to conduction and radiation interference different from electromagnetism and the electromagnetic interference different from that specified in IEC 61851-21-1 and IEC 61851-21-2.

k) Abnormal over-voltage environment or voltage fluctuation;

l) Excessive harmonic wave of power supply voltage or load current.

14.3 Special conditions in transportation and storage

If any different or additional condition in transportation and storage process, the manufacturer shall explain it.

15 Maintenance

The design of EV supply equipment shall be convenient for the equipment maintenance and repair.

16 Marking and Description

The power supply equipment shall clearly identify the following contents:

- Company name, abbreviation, trademark or unique marking that may identify the manufacturer;
- Equipment No., product type;
- Serial No. or production lot No.;
- Date of manufacture;
- Rated output voltage (V) and rated output current (A);
- Rated input alternating current (AC) or direct current (DC);
- Indoor use or outdoor use.

Note: if any multiway output, indicate the maximum value and the value of each way.

During charging, the vehicle control device shall monitor the resistance between check point 3 and PE (regarding case B connection and case C connection) and the PWM signal duty ratio of check point 2; the power supply control device shall monitor the voltage of check points 4 and 1 (regarding case A connection and case B connection of charging mode 3).

A.2.4 Stop of charging system

During charging, if it is finished or cannot be continued due to other reasons, the vehicle control device and power supply control device shall stop the charging-related control functions respectively.

A.3 Procedure for control of charging process

A.3.1 Connection of connector and inlet, making the vehicle be in non-running state

After connecting the vehicle connector with vehicle inlet (plug with socket-outlet in case A connection), the overall design scheme of vehicles may start up some trigger condition automatically (e.g. open the connection of charging gate, vehicle connector and vehicle inlet, or have functional triggering setting for the vehicle charging button and switch) to make the vehicle at non-running state by interlocking or other control measures.

A.3.2 Confirming that the plug and socket-outlet is completely connected (for case A connection and case B connection of charging mode 3)

The power supply control device judges whether the plug is completely connected with the socket-outlet by measuring the voltage at check point 1 or check point 4.

A.3.3 Confirming that the vehicle coupler is completely connected (for case B connection and case C connection)

The vehicle control device judges whether the vehicle connector is completely connected with the vehicle inlet by measuring the resistance between check point 3 and PE. In case of no connection, S3 is on, CC is unconnected and the resistance between monitoring point 3 and PE is infinitely great; in case of semi-connection, S3 is off, CC is connected and the resistance between monitoring point 3 and PE is RC+R4; in case of full connection, S3 is on, CC is connected and the resistance between monitoring 3 and PE is RC.

A.3.4 Confirming whether the connection set for charging is completely connected

If the power supply equipment is fault free and the plug and socket-outlet is completely connected (regarding case A connection and case B connection of charging mode 3), switch S1 is shift to PWM connection state from +12V connection state and the power supply control device sends out PWM signal. The power supply

A.3.8.2 The PWM signal of check point 2 is tested continuously by vehicle control device; if any change in duty ratio, the output power of on-board charger is adjusted at real time according to PWM duty ratio and the testing period shall not be greater than 5s.

A.3.9 Charging ending or stopping under normal conditions

A.3.9.1 In charging process, in case that the end condition set for vehicle is satisfied or the driver executes the instruction of stopping charging for the vehicle, the vehicle control device disconnects switch S2 and makes the on-board charger at charging stop state.

A.3.9.2 In charging process, when the end condition set by operator is reached, and the operator executes the instruction of stopping charging for the power supply device, the power supply control device shall be able to switch the control switch S1 to +12V connecting state; when switch S2 is detected to be disconnected, the AC power supply circuit shall be cut off within 100s by disconnecting contactors K1 and K2; if S2 is not detected to be disconnected after 3s, the AC power supply circuit may be cut off by disconnecting contactors K1 and K2 under load forcibly. In case A connection or case B connection, the electronic lock of plug and socket-outlet is released after cutting off the AC power supply circuit for 100ms.

A.3.10 Charging ending or stopping under abnormal conditions

A.3.10.1 In charging process, by testing the resistance between PE and check point 3 (for case B connection and case C connection), the vehicle control device judges the connection states of vehicle connector and vehicle inlet; if switch S3 turns to off state (state B), the vehicle control device makes the on-board charger stop charging within 100ms and then disconnect S2 (if set).

A.3.10.2 In charging process, by testing the resistance between PE and check point 3 (for case B connection and case C connection), the vehicle control device judges the connection states of vehicle connector and vehicle inlet; if vehicle coupler is disconnected rather than completely connected (state A), the vehicle control device makes the on-board charger stop charging and then disconnect S2 (if set).

A.3.10.3 In charging process, the vehicle control device tests PWM signal at check point 2; in case that the signal is interrupted, the on-board charger is controlled to stop charging within 3s, then disconnect S2 (if set).

A.3.10.4 In charging process, if the voltage at check point 1 is 12V (State 1), 9V (State 2) or other states rather than 6V (State 3), the power supply control device shall disconnect the AC power supply circuit in 100ms.

A.3.10.5 In charging process, the power supply control device detects check point 4 (regarding case A connection and case B connection of charging mode 3); if it is detected that the plug and socket-outlet is disconnected (state A) rather than completely connected, the power supply control device makes switch 1 shift to +12V

K2 after the charging current gets less than 5A, re-engage discharge circuit and then disconnect K3 and K4.

B.3.7 Charging ending under abnormal conditions

B.3.7.1 In charging process, in the case that the off-board charger fails to work continuously, "the charger suspends charging message" is sent to the vehicle periodically and the charger is controlled to stop charging; K1, K2, K3 and K4 shall be disconnected within 100ms.

B.3.7.2 In charging process, in the case that the vehicle cannot be charged continuously, "the vehicle suspends charging message" is sent to off-board charger, and K5 and K6 are disconnected within 300ms (determined by the vehicle depending on the failure severity).

B.3.7.3 In charging process, if communication timeout occurs on off-board charger control device, the off-board charger stops charging and K1, K2, K5, K6 shall be disconnected within 10s. The communication interruption is confirmed if three times of communication timeout occur on the off-board charger control device; the off-board charger stops charging and disconnects K1, K2, K3, K4, K5, and K6 within 10s.

B.3.7.4 In charging process, through inspecting the voltage at check point 1, if the off-board charger control device judges that the switch S gets open from closed, the output current shall be reduced to 5A or below within 50ms.

B.3.7.5 In charging process, if judging that the vehicle coupler gets open from completely closed through inspecting the voltage at check point 1, the off-board charger control device controls the off-board charger to stop charging, and disconnects K1, K2, K3 and K4 within 100ms.

B.3.7.6 In charging process, if the output voltage of off-board charger is greater than the maximum permissible total charging voltage for the vehicle, the off-board charger shall stop charging within 1s and disconnect K1, K2, K3 and K4.

Note: if the off-board charger stops charging due to major failure, complete charging start shall be set by the operation personnel for charging restart.

B.4 Principle of charging circuit

B.4.1 IMD circuit is set at the charger end and vehicle end. In the duration after the connection of plug and socket-outlet and before the connection of K5 and K6 for charging, the charger is responsible for insulation inspection of its internal (including charging cable); IMD circuit at the charger end is switched off from DC charging circuit; in the charging period after the connection of K5 and K6, the electric vehicle is responsible for insulation inspection of the overall system. The insulation resistance between DC charging circuit DC+ and PE, and between DC- and PE (the smaller value R) is considered as safe if R>500Ω/V; if 100Ω/V<R≤500Ω/V, abnormal insulation should be alarmed while normal charging may be continued; if R≤100Ω/V, it

is considered as insulation fault, and charging shall stop.

B.4.2 After IMD inspection of the charger, the charging output voltage shall be discharged in time to avoid voltage surge to battery load at charging stage. After the charging ends, the charger shall discharge the charging output voltage in time to avoid electric injury to the operation personnel. The parameters of discharge circuit shall be so selected as to ensure that the voltage of plug and socket-outlet drops to 60V DC below within 1s after disconnection of charging connector.

B.4.3 When the charging circuit or control circuit loses electricity due to power failure or other causes, the off-board charger shall disconnect K1 and K2 within 1s or drop the voltage of charging coupler to 60V DC below within 1s through discharging circuit.

B.5 Charging connection control sequence

See Figure B.6 for DC charging connection procedure and control sequence.

T14	It reaches the charge-off conditions, and the vehicle control device begins to send "the battery management system suspends charging message" periodically, the charger begins to send "the charger suspends charging message" periodically and the charger is controlled to stop working. The charger stops charging and the output current drops to 5A below.
T15	The vehicle control device opens K5 and K6; the charger opens contactors K1 and K2. The electric vehicle stops insulation monitoring.
T16	The charger closes circuit switch to discharge the output voltage so as to avoid electric injury to the operation personnel.
T17	The output voltage of charger drops to 60V below and disconnect the switch of bleeder circuit; the charger opens K3 and K4, both stop communication interaction.
T18	Electronic lock feeds back unlock signal
T19	Press open the vehicle connector switch S.
T20	Keep the switch S open, and plug the vehicle connector from the inlet.
T21	Release the switch S when the vehicle connector and inlet are completely separated.
T19→T21	In the connecting process of vehicle connector and inlet, the voltage at check point 1 of charger changes from 4 V→6 V→12 V→6 V, and the voltage at check point 2 of vehicle changes from 6 V→12 V.

B.6 Flow chart of charging states

See Figure B.3 for the flow of DC charging states. See GB/T 27930-2015 for the definition of data message.

Bibliography

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[5]	IEC 61851-21-2	Electric Vehicle Conductive Charging System – Part 21-2: EMC Requirements for OFF Board Electric Vehicle Charging Systems (under Development)
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