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Analysis of Communication Protocol Standard for Conductive Charging of Electric Vehicles Based on GB/T 27930-2015

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Abstract: *GB/T 27930-2015 named Communication Protocol Between Off-board Conductive Charger and Battery Management System of Electric Vehicles is one of the most important standards in the field of conductive charging of electric vehicles in China. In order to help relevant industries, enterprises and users better understand the standard, its scope of application, communication principle, typical communication process, as well as communication message format and content were introduced in this paper. Based on a group of communication messages collected by a "real vehicle-virtual charger" test platform, the analytic method of the message was given.*

Keywords: *GB/T 27930-2015, Conductive charging, Communication protocol, Standard analysis*

1. Introduction

With the concerted efforts of a series of policies such as "Adhering to the development direction of electrification, networking and intelligence" and "Implementing double carbon work"[1-3], vehicle intelligence and low-carbon energy will become the development trend of the electric vehicle industry of China in the next stage. Based on this background, the electric vehicle industry is facing new opportunities and challenges. Therefore, accelerating technological change has become an important measure to ensure industrial optimization and upgrading, and achieve a high-quality development.

As an important part that directly determines the energy supply of electric vehicles, electric vehicle charging technology has a far-reaching impact. According to the classification of China Automotive Standardization Technical Committee, the electric vehicle charging technology can be divided into conductive charging with conductor transmission and wireless charging with space invisible soft media (such as electric field, magnetic field, microwave, etc.) according to different electric energy transmission media. However, the wireless charging technology is immature at present and the commercial development is still in the market penetration period. In 2022, the electric vehicle charging technology reform of China will continue to focus on conductive charging, and focus on the increasingly rich charging demand of the user level, the DC charging demand of the industry level and the level of charging and discharging integration demand of the nation, which promotes the R&D and application of new charging technologies such as rapid charging, orderly charging and vehicle network interaction. Therefore, in order to help relevant industries, enterprises and users better understand the technical principle of conductive charging of electric vehicles in China, this paper will carry out an analysis based on the current national standard GB/T 27930-2015 named Communication Protocol Between Off-board Conductive Charger and Battery Management System of Electric Vehicles[4].

2. The communication protocol of conductive charging

2.1. Scope of application and communication principle

Based on the recommended national standard GB/T 27930-2015, the conduction charging communication protocol follows the controller area network (CAN) 2.0B bus protocol. The communication mode is digital communication, and the communication rate is 250kbit/s. It is applicable between off-board conductive charger (a DC power supply equipment[5] in accordance with charging

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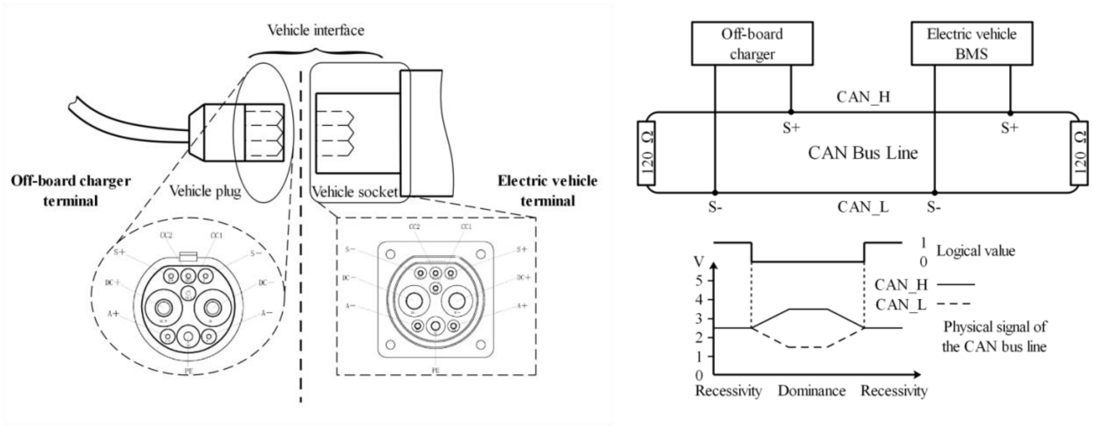
mode 4 and connection mode C specified in GB/T 18487.1-2015, hereinafter referred to as “Charger”) and battery management system (BMS) of the electric vehicle (EV).

As shown in Figure 1(a), the vehicle plug of the charger terminal and the vehicle socket of the EV terminal shall be physically connected before DC conductive charging. In the process of plug-in connection, the S+ and S- contact pairs in the vehicle plug and vehicle socket are coupled correspondingly[6]. After the EV terminal confirms that the vehicle interface is fully connected, the low-voltage auxiliary power supply circuit is connected. At this time, as shown in Figure 1(b), the charging CAN communication network composed of two nodes of charger and EV BMS is successfully established. The charger and BMS can realize energy interactive control by sending and receiving CAN messages based on this network. When any node starts sending CAN message, the CAN controller of this node sends “logic 0” to adjust the voltage CAN_H=3.5V and CAN_L=1.5V, then the charging CAN bus is at the dominant level, and the CAN message is sent. After the message is sent, the CAN controller sends “logic 1” to adjust the voltage CAN_H=CAN_L=2.5V, the charging CAN bus is at the recessive level, and the CAN message receiving state of node is restored.



(a) *(b)*

Figure 1: (a) The connecting device for DC conduction charging. (b) The node connection and physical signal of charging CAN bus.

2.2. Typical Communication flow

The conductive charging communication process between off-board conductive charger and EV BMS can be divided into four stages. According to the order of communication, it can be summarized as charging handshake stage, charging parameter configuration stage, charging stage and charging end stage. The charging handshake stage includes handshake initiation stage and handshake recognition stage. As shown in Figure 2, after the charging CAN communication network is established, the charger node firstly sends the charger handshake message to the EV BMS node. After receiving the message, the EV BMS node responds to the vehicle handshake message from the charger node. After the handshake between two sides succeed, the charger terminal starts the insulation monitoring inside the charger (including the charging cable). If the insulation is safe, send the charger recognition message SPN2560=0x00 to the EV BMS node. If the charging CAN communication is connected normally, the EV BMS node shall send the vehicle recognition message to the charger node and wait for the charger node to respond to the charger recognition message with SPN2560=0xAA. If the recognition of both sides is successful, the charging parameter configuration stage will be entered.

As shown in Figure 3, after entering the communication process of charging parameter configuration stage, the EV BMS node firstly sends the battery charging parameter message to the charger node. After receiving the message, the charger node responds to the EV BMS node with the time synchronization message and the maximum output capacity message of the charger. After receiving it, the EV BMS node sends BRO message SPN2829=0x00 to the charger node, and estimates whether the EV meets the conditions for conductive charging. If the conditions are met, the EV BMS node sends BRO message SPN2829=0xAA to the charger node. After the battery ready state of EV BMS is confirmed, the charger node will respond CRO message SPN2830=0x00 and estimates whether the charger has the condition of power output. If the condition is met, the charger node sends CRO message SPN2830=0xAA. After the EV BMS node confirms that the charger is ready for charging, the charging parameter configuration stage is completed and the charging stage will be entered for both sides.

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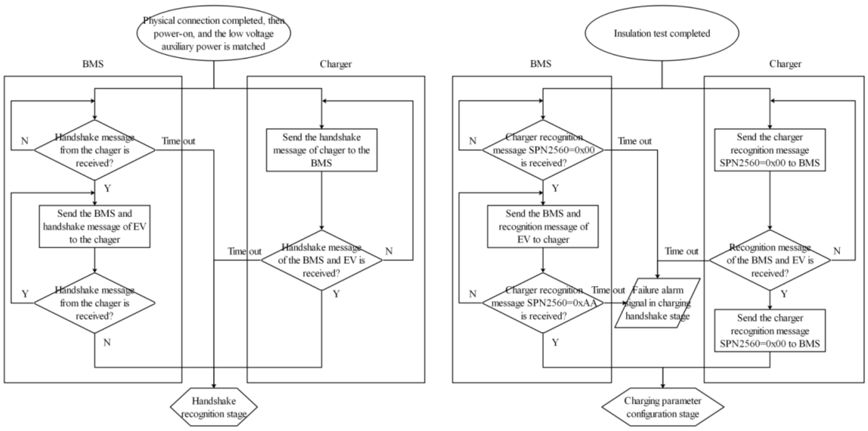

(a) *(b)*

Figure 2: Communication flow chart of charging handshake stage. (a) Handshake initiation stage. (b) Handshake recognition stage.

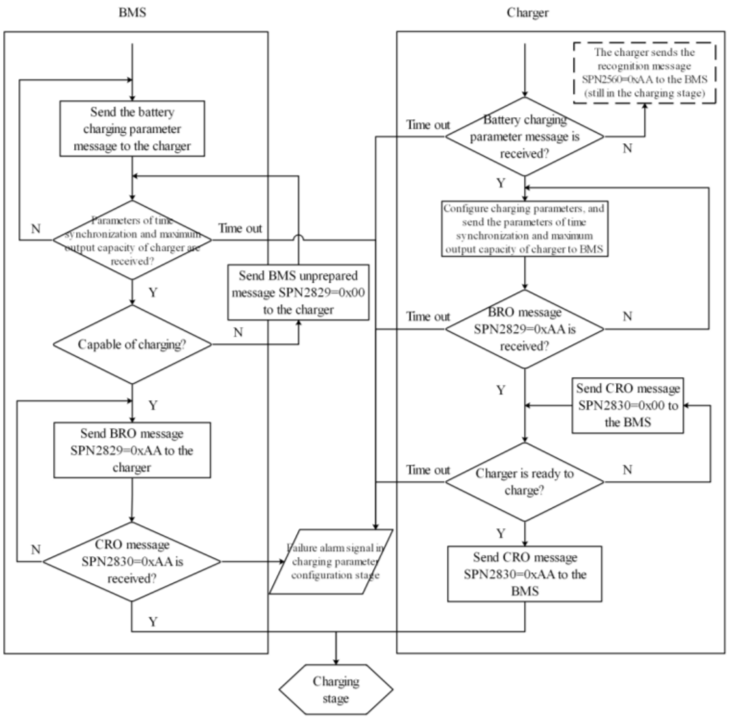

Figure 3: Communication flow chart of charging parameter configuration stage.

As shown in Figure 4, after entering the communication process of charging stage, the EV BMS node firstly sends the battery charging demand message and battery charging state message to the charger node. After the charger node receiving the messages, it starts the energy output by adjusting the current and sends the charging state message to the EV BMS node. In the process of energy transmission from the charger to the EV, the EV BMS node sends the battery state message, and keeps interacting with the battery charging demand message, total battery charging state message and charging state message of the charger node in real time until the stop charging message is send by any node. After the receiving node responds to the charging end message, both sides will enter the charging end stage.

If the charging end request is initiated after the EV is fully charged, the EV BMS node will firstly send the BMS statistics message to the charger node after entering the charging end communication process, which can be seen in Figure 5. After receiving the message, the charger node will respond the charging statistics message, then the charging ends normally. If abnormal communication conditions such as message timeout occur in any communication stage during the charging process, the BMS node and the charger node of the EV will send error messages with high priority to each other to directly end the charging.

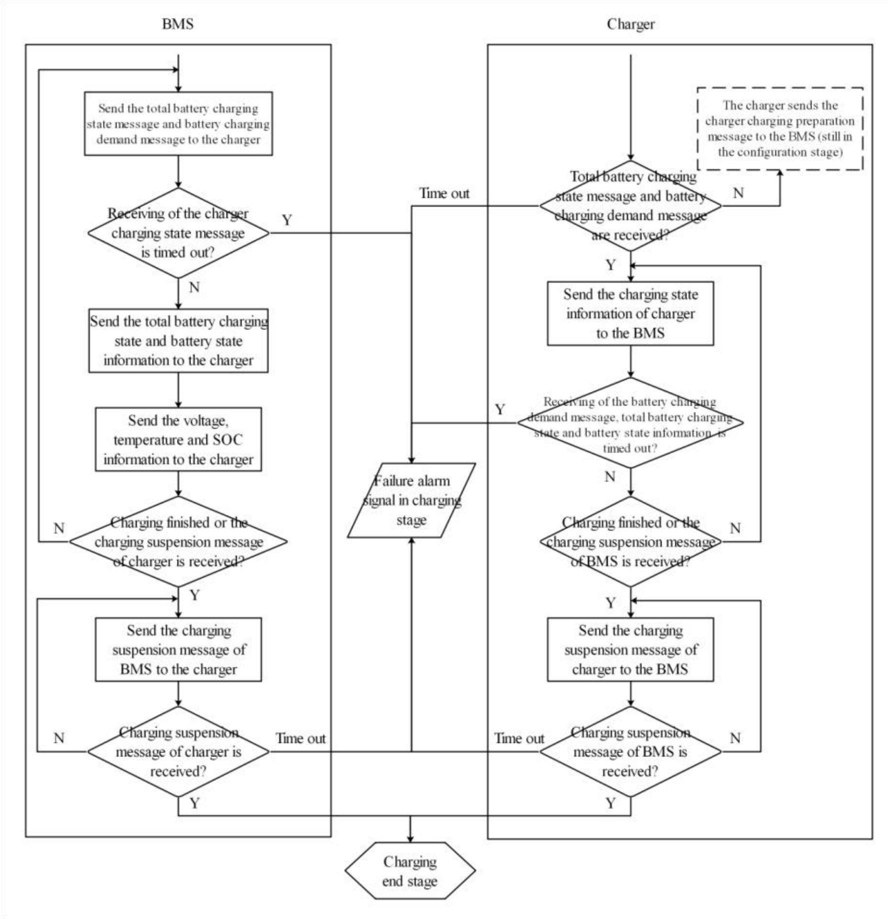

Figure 4: Communication flow chart of charging stage.

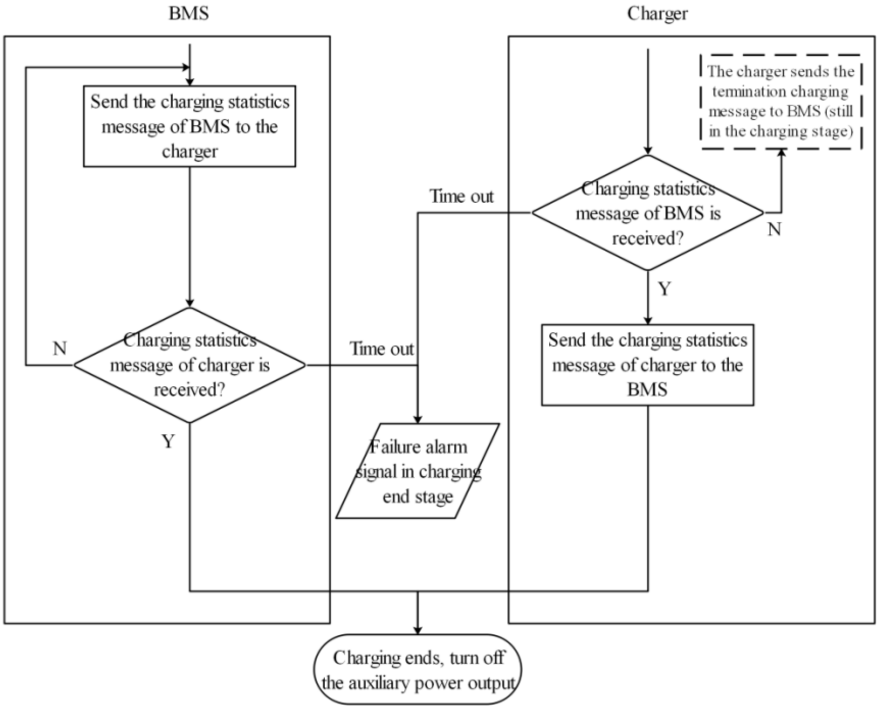

Figure 5: Communication flow chart of charging end stage.

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2.3. The format and content of message

Table 1: Communication message required in charging handshake stage.

Message description	Message code	Source address	Destination address	PGN (Hex)	Priority	Message cycle /ms	Data length /byte	Mandatory byte: Starting position	Length /byte	Description
Charger handshake message	CHM	Charger	BMS	002600H	6	250	3	1	3	Charger communication protocol identifier No.
Battery handshake message	BHM	BMS	Charger	002700H	6	250	2	1	2	Maximum allowable charging voltage
Charger recognition message	CRM	Charger	BMS	000100H	6	250	8	1	1	Recognition result
								2	4	Charger identifier No.
								6	3	Charger area code
Battery recognition message	BRM	BMS	Charger	000200H	7	250	41	1	3	BMS communication protocol No.
								4	1	Battery type
								5	2	Rated capacity of vehicle battery system
								7	2	Rated voltage of vehicle battery system

According to the conductive charging communication process between the off-board conductive charger and the EV BMS, the format and content of the mandatory message at each stage are summarized in Table 1-Table 4, including the message description, message code, parameter group hexadecimal notation PGN (HEX), priority, message cycle, data length, byte information of message mandatory items, etc.

Table 2: Communication message required in charging parameter configuration stage.

Message description	Message code	Source address	Destination address	PGN (Hex)	Priority	Message cycle /ms	Data length /byte	Mandatory byte: Starting position	Length /byte	Description
Battery charging parameters	BCP	BMS	Charger	000600H	7	500	13	1	2	Battery cell maximum allowable charging voltage
								3	2	Maximum allowable charging current
								5	2	Battery nominal total energy
								7	2	Maximum allowable charging voltage
								9	1	Maximum allowable temperature
								10	2	Battery SOC
								12	2	Battery immediate voltage
Charger time synchronizatio n	CTS	Charger	BMS	000700H	6	500	7	1	7	Year/ Month/ Day/ Hour/ Minute/ Second
Charger maximum Output capacity	CML	Charger	BMS	000800H	6	250	8	1	2	Maximum output voltage
								3	2	Minimum output voltage
								5	2	Maximum output current
								7	2	Minimum output current
Battery ready option	BRO	BMS	Charger	000900H	4	250	1	1	1	Battery ready option
Charger ready option	CRO	Charger	BMS	000A00H	4	250	1	1	1	Charger ready option

Table 3: Communication message required in charging stage.

Message description	Message code	Source address	Destination address	PGN (Hex)	Priority	Message cycle /ms	Data length /byte	Mandatory byte: Starting position	Length /byte	Description
Battery charging demand	BCL	BMS	Charger	001000H	6	50	5	1	2	Voltage demand
								3	2	Current demand
								5	1	Charging mode
Battery charging state	BCS	BMS	Charger	001100H	7	250	9	1	2	Charging voltage measurement
								3	2	Charging current measurement
								5	2	Maximum battery cell voltage and its group number
								7	1	Immediate SOC
								8	2	Estimated remaining charging time
Charger charging state	CCS	Charger	BMS	001200H	6	50	8	1	2	Output voltage value
								3	2	Output current value
								5	2	Cumulative charging time
								7.1	2bit	Charging permit judgment
Battery state	BSM	BMS	Charger	001300H	6	250	7	1	1	Identifier number of the maximum battery cell voltage

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message								2	1	Battery maximum temperature
								3	1	Identifier number of the maximum temperature detection point
								4	1	Battery minimum temperature
								5	1	Identifier number of the minimum temperature detection point
								6.1	2bit	Battery cell voltage over-range judgement
								6.3	2bit	Battery SOC over-range judgement
								6.5	2bit	Battery charging current over-range judgement
								6.7	2bit	Battery temperature over-range judgement
								7.1	2bit	Battery insulation status
								7.3	2bit	Connection status of battery output connector
								7.5	2bit	Charging permit judgement
BMS discontinue	BST	BMS	Charger	001900H	4	10	4	1	1	The reason of BMS discontinuing charging
								2	2	The failure reason of BMS discontinuing charging
								4	1	The error reason of BMS discontinuing charging
Charger discontinue	CST	Charger	BMS	001A00H	4	10	4	1	1	The reason of charger discontinuing charging
								2	2	The failure reason of charger discontinuing charging
								4	1	The error reason of charger discontinuing charging

Table 4.1: Communication message required in charging end stage.

Message description	Message code	Source address	Destination address	PGN (Hex)	Priority	Message cycle /ms	Data length /byte	Mandatory byte		
								Starting position	Length /byte	Description
BMS statistic data	BSD	BMS	Charger	001C00H	6	250	7	1	1	SOC at abort time
								2	2	Battery cell minimum voltage
								4	2	Battery cell maximum voltage
								6	1	Battery minimum temperature
								7	1	Battery maximum temperature
Charger statistic data	CSD	Charger	BMS	001D00H	6	250	8	1	2	The cumulative charging time
								3	2	Total output energy value
								5	4	Charger Number

Table 4.2: Communication message required in charging end error stage.

Message description	Message code	Source address	Destination address	PGN (Hex)	Priority	Message cycle /ms	Data length /byte	Mandatory byte		
								Starting position	Length /bit	Description
BMS error message	BEM	BMS	Charger	001E00H	2	250	4	1.1	2	Timeout judgment of “SPN2560 =0x00” CRM message
								1.3	2	Timeout judgment of “SPN2560 =0xAA” CRM message
								2.1	2	Timeout judgment of CTS and CML message
								2.3	2	Timeout judgment of CRO message
								3.1	2	Timeout judgment of CCS message
								3.3	2	Timeout judgment of CST message
								4.1	2	Timeout judgment of CSD message
Charger error message	CEM	Charger	BMS	001F00H	2	250	4	1.1	2	Timeout judgment of BRM message
								1.3	2	Timeout judgment of BCP message
								2.1	2	Timeout judgment of BRO message
								2.3	2	Timeout judgment of BCS message
								3.1	2	Timeout judgment of BCP message
								3.3	2	Timeout judgment of BST message
								4.1	2	Timeout judgment of BSD message

3. Message analysis

In section 2, the control of charger energy transmission of EV is realized by digital communication, therefore it is important to analyze the message applied in the communication. As shown in Figure 6, this paper relies on the EVTS-17 vehicle interoperability test system, which is developed by Beijing QunLing Energy Resources Technology Co., Ltd., to build the test platform and collect communication messages. And, the key information of CAN message is the frame ID, data content and message sending time.

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Figure 6: The conductive charging communication protocol test platform between real vehicle and virtual charging pile.

3.1. Analysis of the frame ID and message sending cycle

The frame ID is used to locate the message code of the current frame and confirm the charging progress. In Table 5, the example shows that when the frame ID of the message is “0x1826F456”, it can be determined that the message currently sent is the charger handshake message by confirming the message with PGN(HEX)=002600H is the CHM message according to Table 1, then the charging handshake stage is in progress. It can be seen that the cycle of CHM message and BHM message are 250ms, which is consistent with the standard requirements, by reading the sending time of two adjacent frame ID messages.

Table 5: Example 1 of the communication message.

Serial number	Time	Frame ID	Frame data	Frame description
1	9:27:31:874	1826F456	01 01 00	CHM message, Charger communication protocol version number
2	9:27:32:4	182756F4	82 11	BHM message, BMS maximum allowable total charging voltage
3	9:27:32:134	1826F456	01 01 00	CHM message, Charger communication protocol version number
4	9:27:32:384	1826F456	01 01 00	CHM message, Charger communication protocol version number
5	9:27:32:504	182756F4	82 11	BHM message, BMS maximum allowable total charging voltage
6	9:27:32:634	1826F456	01 01 00	CHM message, Charger communication protocol version number
7	9:27:32:754	182756F4	82 11	BHM message, BMS maximum allowable total charging voltage
8	9:27:32:884	1826F456	01 01 00	CHM message, Charger communication protocol version number

3.2. Data content analysis

The data content is used to read the real-time charging parameter value and confirm the charging state. According to GB/T 27930-2015, each frame of message can transmit 8-byte data frames at most. When the data content does not exceed 8 bytes, the data will be sent in a single packet, otherwise it will be transmitted in multiple packets.

(a) Single-packet transmission

As the example shown in Table 6, when the transmitted message frame ID is “0x1812F456”, it can be determined that the message currently sent is the charging state message of the charger by confirming the message with PGN(HEX)=001200H is the CCS message according to Table 1. Then, it can be determined that the data content of CCS message are the voltage output value, current output value, cumulative charging time and charging permission judgment, correspondingly.

In Table 6, the frame data of CCS message is “6C 0F 16 08 0D 00 FD”. According to the starting position and length, it can be seen that the voltage output value corresponds to “0F6C”, the current output value corresponds to “0816”, the cumulative charging time corresponds to “000D” and the charging permission judgment corresponds to “FD”. The calculation shows that the voltage output value is 394.8V, the current output value is 193.0A, the cumulative charging time is 13mins and the charging permission

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judgment is allowed.

Table 6: Example 2 of the communication message.

Serial number	Time	Frame ID	Frame data	Frame description
60017	9:41:32:694	1812F456	6C 0F 16 08 0D 00 FD	CCS message, charger charging state

(b) Multi-packet transmission

In Table 7, it indicates that the transmitted message is a multi packet message when the frame ID is “0x1CECF456”. According to the frame data “130D 00 02 FF 00 06 00”, PGN=000600H and the number of packets is 2, thus the transmitted message is BCP message. Then, according to the byte information of BCP required items, it can be calculated that the maximum allowable charging voltage of single power battery is “01B2”=4.34V, the maximum allowable charging current is “0825”=191.5A, and the nominal total energy of power battery is “0294”=66kW/h-1. Moreover, the maximum allowable total charging voltage is “1182”=448.2V, the maximum allowable temperature is “69”=105℃, the charging state of the whole vehicle power battery is “000A”=1%, and the current battery voltage of the whole vehicle power battery is “0E25”=362.1V.

Table 7: Example 3 of the communication message.

Serial number	Time	Frame ID	Frame data	Frame description
116	9:27:43:994	1CECF456	13 0D 00 02 FF 00 06 00	Transmission complete
117	9:27:43:994	1CEB56F4	01 B2 01 25 08 94 02 82	Multi frame transmission
118	9:27:43:994	1CEB56F4	02 11 69 0A 00 25 0E FF	Multi frame transmission
119	9:27:44:4	1CECF456	13 0D 00 02 FF 00 06 00	Transmission complete

4. Conclusions

GB/T 27930-2015 named Communication Protocol Between Off-board Conductive Charger and Battery Management System of Electric Vehicles is one of the most important standards in the field of conductive charging of electric vehicles in China. Agreeing with the communication protocol, vehicle battery management system can control the whole energy output process of charger through digital communication message exchange. In this paper, communication protocol application scope, principle and its typical communication process, as well as communication message format and content were described. Then, a “real vehicle-virtual charger” test platform was built. Based on the test platform, the analytic method of the message was given.

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