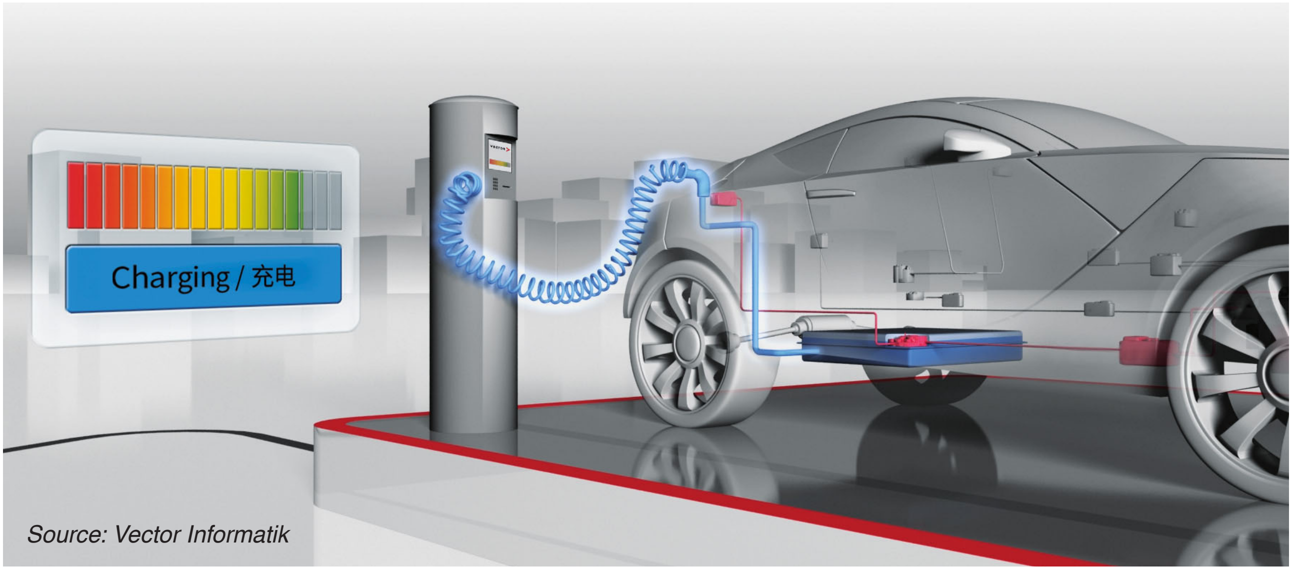
Charging communication in Chinese

Manufacturers around the world who want to sell electric cars in China have to comply with the Chinese standard GB/T 27930. Vector simplifies development and testing GB/T 27930 compliant electric vehicles and charging stations.



Source: Vector Informatik

In China, as everywhere else in the world, the success of electric mobility is closely linked to the availability of a large number of charging stations and optimal compatibility between vehicles and the charging infrastructure. For communication between charging stations and on-board battery management systems, the Chinese standard GB/T 27930 has been established for use in the People's Republic. This is why European, American, and any other manufacturers around the world who want to sell electric cars in China have to comply with this standard. Development for the Far East can be significantly accelerated through the use of corresponding testing and simulation tools and ready-to-use embedded solutions for GB/T 27930 based charging communication.

Like virtually no other nation, China is advancing electric mobility with tremendous effort. The numbers are impressive: In 2018 alone, more than one million electric vehicles were purchased by Chinese consumers. If this trend continues, more than five million electric cars will be on China's roads by 2020. An armada of electric vehicles like this is also going to need an adequate supply of power. At present, around 200 000 charging stations have been installed – and the number is rapidly rising. The growth rate of stations is even noticeably higher than that of the electric vehicles themselves. In order for charging processes to run smoothly everywhere, standardized communication between electric cars and charging stations is essential. This has been described in the Chinese GB/T 27930 standard for charging systems. It defines the communication between a charging station (charger) and the battery management system (BMS) in an electric car for conventional cable charging.

Additional smart charging functions, such as those described in ISO 15118, are not supported by the Chinese communication standard. GB/T 27930 also gives no information about possible uses of the standard. Only the high-level document GB/T 18487.1-2015 mentions that buses, trains, utility vehicles, and off-road machines aren't supported. According to information from China, though, it seems to be common practice to charge all electric vehicles at the same charging stations, regardless of whether they are cars, trucks, or buses. Obtaining accurate information in this regard can be difficult, as hardly any information on GB/T 27930 is freely available on the Internet.

GB/T 27930: Based on J1939

The current version of the standard is GB/T 27930-2015 from 2015, which replaced version GB/T 27930-2011. GB/T 27930 is based on SAE J1939 and accordingly uses a CAN network as a point-to-point connection between the charger and the BMS. Direct connections to other CAN systems in the vehicle, such as the Powertrain CAN, do not exist. A transmission rate of 250 kbit/s is used by default. If the line quality is poor or external interference fields are influencing communication, a reduction to 50 kbit/s

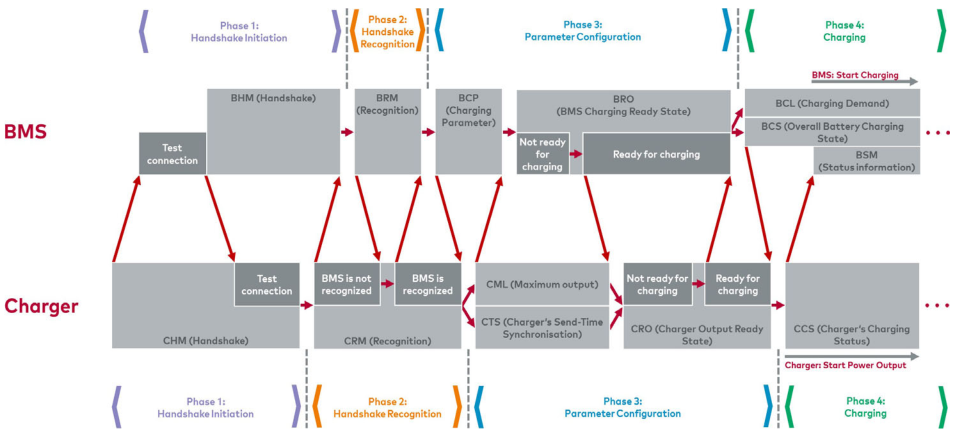


Figure 1: The charging process - Phases 1 through 4 with all relevant messages and state transitions (Source: Vector Informatik)

is possible. The layout of the CAN identifiers adheres to the rules of J1939, and GB/T 27930 supports the transport protocol for directed data transfer from J1939-21 (RTS/CTS or CMDT). Diagnostic options are also provided, for which the standard defines six diagnostic messages designated DM1 through DM6.

Differences between GB/T 27930 and J1939

However, GB/T 27930 differs in several aspects from J1939, such as the lack of address arbitration according to J1939-81. As a result, parameter groups for address claiming, commanded address, and name management are not defined. This is logical and consistent, as the charging station and vehicle's BMS are always the only participants involved in charging communication. The specification clearly defines their addresses: 86 (56_h) for the charger and 244 ($F4_h$) for the BMS, which are conflicting with predefined addresses of J1939. Since the Request mechanism from J1939-21 is used solely for diagnostics, neither the ACKN (PGN $E800_h$) nor Request2 (PGN $C900_h$) nor Transfer (PGN $CA00_h$) parameter group is present.

In addition, GB/T 27930 uses the names DM1 through DM6 and packs the information on arising problems into DTC (diagnostic trouble code) blocks as described in J1939-73, but the function and parameter group numbers (PGNs) are defined differently from J1939, and the DTCs do not start with byte 3, but rather byte 1. In deviation from the recommendations of J1939, GB/T 27930 also uses messages with message lengths (DLCs) shorter than eight.

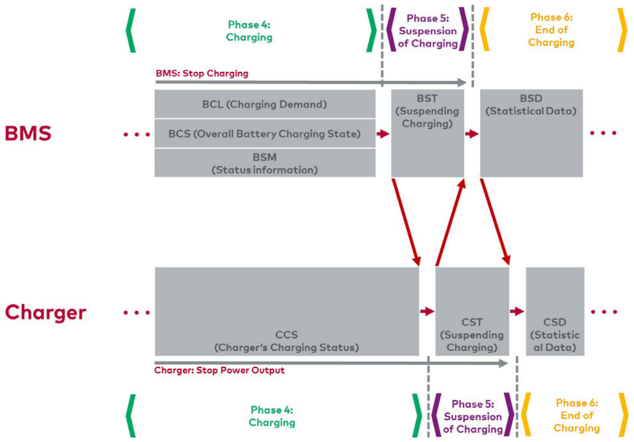


Figure 2: Ending of the charging process initiated by the BMS (Source: Vector Informatik)

Communication phases

Charging communication primarily involves both the battery management system and the charging station agreeing on the energy requirements of the vehicle and both the amperages and voltages used during charging. Following successful connection establishment, the vehicle electronics notifies the charging station of the desired charging current and voltage (request). If the charging station is able to provide the desired energy, the charging process begins with the desired parameters. If insufficient power is available on the power grid overall, for example because too many vehicles want to charge at the same time, the charging station reduces the current and communicates this to the BMS. Based on the boundary conditions, the charging electronics adjusts to different charging currents in this way.

Each charging process can be divided into the following six phases:

1. Handshake initiation
2. Handshake recognition
3. Parameter configuration
4. Charging
5. Suspension of charging
6. End of charging

Phases 1, 2, 3, 5, and 6 work according to the same principle. The charging station begins sending a data record, e.g. a CHM (charger handshake message). The BMS then receives the CHM and carries out the corresponding action, e.g. by checking the connection. To signal that it has carried out the action successfully, the BMS begins sending a BHM (BMS handshake message) to the charging station. As soon as the charging stating has received the BHM, it starts the corresponding action on its part and checks compatibility, for example. Once the task is complete, it begins sending another message. The procedure is like a soccer game, in which two players reach the opponent's goal or target by continually passing the ball back and forth to one another (Figure 1).

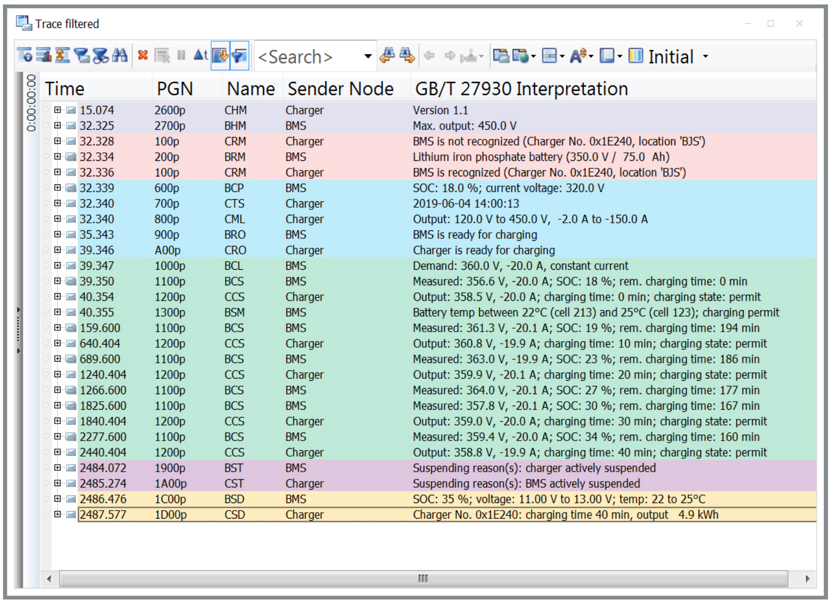
Messages during energy transfer

During phase 4, the actual charging process, communication is considerably clearer, as there are no longer any state transitions. The BMS and charger send their messages back and forth cyclically and independently. The vehicle initiates the charging process, sends the requirements to the charging station using the BCL (battery charging demand) message, and informs it of its own state using the BCS (overall battery charging status) and BSM (power storage battery status information) messages and other messages. The charging station, on the other hand, sends the CCS (charger's charging status) message and informs the vehicle of its status, the current being provided and the maximum voltage which can be generated.

There are also three optional messages with which the vehicle can provide additional information on its internal status to the energy source while charging: BMV (single power storage battery voltage), BMT (temperature of power storage battery), and BSP (reserved message of power storage battery). The charging process lasts until either the battery management system or the charging station initiates the end of charging. This happens either when the battery is fully charged, the specified charging duration is reached, or the passengers wish to continue traveling without a fully charged battery (Figure 2).

Problems and faults while charging

Problems during charging can be classified as communication faults or technical faults. The first group generally includes timeouts, such as when a state transition does not occur within the prescribed time or when cyclical messages are received too late. Overheating, line breakage, deviations from the target current and voltage values, and similar issues are classified as technical faults. As a response to ▷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Time	PGN	Name	Sender Node	GB/T 27930 Interpretation
15.074	2600p	CHM	Charger	Version 1.1
32.325	2700p	BHM	BMS	Max. output: 450.0 V
32.328	100p	CRM	Charger	BMS is not recognized (Charger No. 0x1E240, location 'BJS')
32.334	200p	BRM	BMS	Lithium iron phosphate battery (350.0 V / 75.0 Ah)
32.336	100p	CRM	Charger	BMS is recognized (Charger No. 0x1E240, location 'BJS')
32.339	600p	BCP	BMS	SOC: 18.0 %; current voltage: 320.0 V
32.340	700p	CTS	Charger	2019-06-04 14:00:13
32.340	800p	CML	Charger	Output: 120.0 V to 450.0 V, -2.0 A to -150.0 A
35.343	900p	BRO	BMS	BMS is ready for charging
39.346	A00p	CRO	Charger	Charger is ready for charging
39.347	1000p	BCL	BMS	Demand: 360.0 V, -20.0 A, constant current
39.350	1100p	BCS	BMS	Measured: 356.6 V, -20.0 A; SOC: 18 %; rem. charging time: 0 min
40.354	1200p	CCS	Charger	Output: 358.5 V, -20.0 A; charging time: 0 min; charging state: permit
40.355	1300p	BSM	BMS	Battery temp between 22°C (cell 213) and 25°C (cell 123); charging permit
159.600	1100p	BCS	BMS	Measured: 361.3 V, -20.1 A; SOC: 19 %; rem. charging time: 194 min
640.404	1200p	CCS	Charger	Output: 360.8 V, -19.9 A; charging time: 10 min; charging state: permit
689.600	1100p	BCS	BMS	Measured: 363.0 V, -19.9 A; SOC: 23 %; rem. charging time: 186 min
1240.404	1200p	CCS	Charger	Output: 359.9 V, -20.1 A; charging time: 20 min; charging state: permit
1266.600	1100p	BCS	BMS	Measured: 364.0 V, -20.1 A; SOC: 27 %; rem. charging time: 177 min
1825.600	1100p	BCS	BMS	Measured: 357.8 V, -20.1 A; SOC: 30 %; rem. charging time: 167 min
1840.404	1200p	CCS	Charger	Output: 359.0 V, -20.0 A; charging time: 30 min; charging state: permit
2277.600	1100p	BCS	BMS	Measured: 359.4 V, -20.0 A; SOC: 34 %; rem. charging time: 160 min
2440.404	1200p	CCS	Charger	Output: 358.8 V, -19.9 A; charging time: 40 min; charging state: permit
2484.072	1900p	BST	BMS	Suspending reason(s): charger actively suspended
2485.274	1A00p	CST	Charger	Suspending reason(s): BMS actively suspended
2486.476	1C00p	BSD	BMS	SOC: 35 %; voltage: 11.00 V to 13.00 V; temp: 22 to 25°C
2487.577	1D00p	CSD	Charger	Charger No. 0x1E240: charging time 40 min, output 4.9 kWh

Figure 3: Typical communication between a charging station and an electric car: All six phases are simulated with CANoe 12.0 and represented in a reduced form in the Trace Window through intelligent filtering (Source: Vector Informatik)

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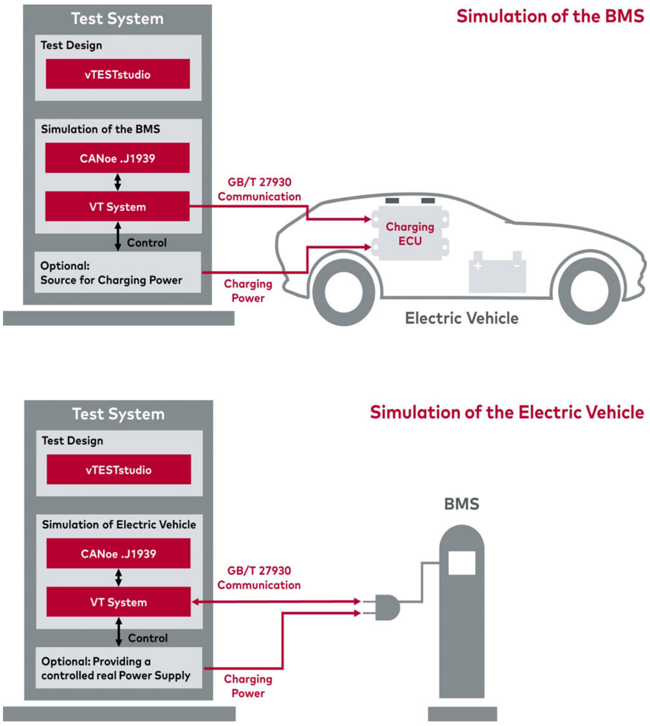

Figure 4: A GB/T 27930 compliant simulation solution (Source: Vector Informatik)

faults, the system either cancels connection establishment or stops the energy output or intake, depending on which side detected a fault. This ends the charging process.

Testing development in an efficient way

In principle, communication as per GB/T 27930 is not unusually complex, but it is characterized by certain pitfalls and quirks. This is made more difficult by the fact that there are a large number of charging station manufacturers in China. Many cities and municipalities have what essentially amounts to their own local charging station production, which bears the risk of each one interpreting the standard in their own way, potentially differing in some small detail.

Because of this, it is in the best interest of everyone who develops electric vehicles for the Chinese market to comprehensively test the vehicle electronics. The required depth of testing can only be realized through systematic tests and corresponding test automation. A GB/T 27930 reference is also required, against which testing can be carried out. Electric vehicles are to be tested as expected using suitable charging station electronics (Figure 3). Manufacturers of charging stations, on the other hand, require a vehicle battery management system which corresponds to the standard.

Automated testing against simulated remote stations

Based on CANoe and the modularly configurable VT System as testing hardware, Vector has developed a GB/T 27930 compliant simulation solution which can simulate either the charging station or the electric vehicle's BMS. CANoe is responsible for sequence control and serves as the user interface for the convenient creation of test scripts with C-like syntax (CAPL) and for checking test reports. The respective simulated system receives and transmits messages according to the GB/T 27930 standard. This makes it possible to simulate rising and falling charging amperages and to request higher or lower current. Also, the temperatures and temperature fluctuations of individual battery elements can be simulated, and the charging duration can be estimated (Figure 4).

If desired, the testing system can confront the test object with software and hardware faults. Artificial line breakage and short circuits can be created by the user by way of the VT System. Controllable power supplies and electronic loads can also be connected up if charge testing with actual amperages and voltages is desired. The graphical interface enables convenient operation and monitoring on the screen, and users can also define their own panels as they see fit.

Additional components and outlook

Complete embedded solutions from the Microsar product line are also available for GB/T 27930 compliant charging communication. Users are able to integrate them directly into their development environment with minimal effort, thus achieving the required level of product maturity as quickly as possible. At the same time, Vector is continuing work on a comprehensive GB/T 27930 testing solution so that compliance tests can also be carried out in the future, for example. ◀

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