Field Detection System for Electric Vehicle Charging Facilities

Xiang-long LI¹, Xiu-lan LIU¹, Guo-biao LONG¹, Yu-tong ZHAO¹, Hai-yang CHEN¹ and Chao WANG²

¹State Grid Bei Jing Electric Power Company, China
²Beijing University of Technology, China

Corresponding author

Keywords: Electric vehicle, Movable testing platform, Charging facilities.

Abstract. As the country vigorously develops new energy strategies, the electric vehicle industry develops rapidly, and the detection of charging facilities those required to ensure safety is increasingly important. Usually, AC and DC charging piles are installed in a certain position. This test method requires each test equipment to be independently transported to the spot, and then wiring for testing work, which will lead to reduced efficiency and accuracy. Aiming at the above problems, a charging platform and charging pile mobile detection platform applied to the site are proposed. The structure has high equipment integration, fixed wiring in the container, avoiding the repeated wiring of each test, etc., and in function, it has comprehensive accurately test data, fast test speed, high degree of testability, low workload, etc. through the design, the project completes two set of 25kw (35A) AC loads, two AC vehicle interface simulators, and two 35A AC channels, which can be combined to achieve a 70A load, which has strong promotion and demonstration significance.

Introduction

China's new energy automobile industry has entered the golden period of development, and the expansion of the production scale of electric vehicle industry has also led to the rapid development of the electric vehicle charging station industry. But at present, the development of the electric vehicle charging station industry is slow, which in turn affects the expansion of the market for electric cars and the spread of electric cars. As a result, the related industries are actively engaged in the pilot construction of electric vehicles and AC charging piles and direct current charging stations [1-2]. At present, our country has built the largest charging service network in the world, and the construction and operation of the charging facilities are among the highest in the world. Direct current or AC charging pile is the main charging facility of electric vehicle. On-site testing of electric vehicle charging facilities is required to ensure that the charging facility can operate in a safe environment. In this paper, the electric performance test of electric vehicle charging facility is studied and analyzed based on the Working Environment and field test requirements of AC or DC electric vehicle charging pile [3-5], according to the standard of electric vehicle, the method of on-site detection of electric vehicle charging facilities [6-7]. Make sure that electric cars can be charged in a safe environment.

Field detection System Layout of Electric Vehicle Charging Facility

It is planned to set up a set of mobile inspection platform for on-site access of electric vehicle charging facilities, which will allow for single 180 kw and below DC rechargeable pile and the ac-charging pile of 63A and below, to meet the inter-operability and communication protocol Conformance testing of the charging system, mainly for the testing of electrical performance targets, agreement consistency and inter-operability testing of networked electric vehicles. The mobile detection platform is designed as a container, it is mainly equipped with programmable DC load, programmable AC load, recorder, Lithium Battery Group, DC/DC converter, power supply inverter, AC interface simulator, DC interface simulator, integrated control system (collecting cabinet,
system accessory software) and other communication auxiliary equipment. The equipment is arranged as two side and two row machine cabinet, adding control room, instrument cabinet, set control table, container side for testing interface and parameter acquisition equipment and three sets of 60KW programmable DC load, ensure that the equipment is not overheated by the load; two sets of AC loads can be placed on the other side of the container, two sets of DC interface simulator, one set of DC interface simulator, switch controller, parallel machine controller, insulation resistor simulator, off-grid inverter, a set of 18KWH lithium battery system and a set of 50KWDC / DC converters, the rear connection can be tested by opening the side door to the front of the gun and collecting equipment.

**Design of Mobile Test Platform for Electric Vehicle**

**Charging Principle of Electric Vehicle**

Figure 1 shows a typical electric vehicle charging control system, which differs from the continuous current charging and pulsed current charging used in conventional chargers, using an intelligent variable pulse charging method, that is, using the charge current pulse as shown in figure 2, including charging pulse $t_1$ intermittent pulse $t_2$ and discharge pulse $t_3$, suitable for rapid charging requirements.

![Figure 1. The composition of the electric vehicle control system.](image1)

![Figure 2. Charge current waveform.](image2)

Figure 3 is a typical charge-in-charge charger consisting of a rectifier that converts the input alternating current into a direct current rectifier and a power converter that regulates the power of
the direct current, the electrical energy is fed into the battery by plugging a plug with a wire into the socket of the electric car. According to the communication between the charger and the battery management system in the car, the power converter can adjust the DC charging power online, and the charger can display charging voltage, charging current, charging quantity and charging cost.

**Mobile Test Platform-DC**

According to the charging principle of electric vehicle, the mobile test platform is designed. Among them, DC TEST SYSTEM DESIGN: three sets of 60KW DC load, one set of 50 kw battery simulator (50 kw DC / DC converter with 18kwh lithium battery system), two sets of DC vehicle interface simulator and three 60 kw DC channels, the maximum 180KW can be reached between the three channels, a set of recorder, a set of insulation resistance simulator to realize positive polarity to PE, negative pole to PE, symmetrical and asymmetric insulation state simulation, a set of power analyzer, can collect AC electric energy parameter, it's portable, connected to the network and the system. With the addition of 50kw DC / DC converter in the 18kwh lithium-ion Battery System, DC / DC converter can simulate any voltage by setting the input-output voltage ratio of DC / DC converter, and realize the condition of field test the real battery, the performance of AC / DC and DC / DC chargers can be tested, and the energy storage lithium battery group can be used as UPS power supply through the off-grid inverter, and realize the power supply of the whole system.

The flow of energy is: the charging pile is charged to the battery by the interface simulator at the time of testing. The battery consumes the energy through the off-grid inverter, and the test process does not waste electricity. When the power consumption of the off-grid inverter is less than that of the charging machine, it can be consumed by the direct current load.

**Mobile Testing Platform-communication**

The AC test system is designed as two sets of 25kw (35A) AC load, two sets of AC vehicle interface simulator, two 35A channels can be exchanged, and the belt of 70A can be realized simultaneously, and a set of recorder can be connected with the system through the network.

**Mobile Testing Platform-communications**

The communication system is designed as: TWO-WAY USB CAN, a 16-port mosha communication concentrator, CAN realize the communication control of all equipments. As shown in figure 4:
Design Of Power Supply For Equipment And Instrumentation

The power supply of equipment is designed as a 4-kva off-grid inverter, which provides power to the equipment of load, interface and other intermittent actions. As shown in figure 5:

Figure 5. Equipment power supply.

The power supply of instrument design is: 4-kva off-grid inverter, supply power for collect equipment and computer power, to avoid the impact of equipment start-up impact acquisition of instruments and computers. As shown in figure 6:
Introduction of Test Equipment

(1) programmable AC load: satisfying the testing function of single-phase 16A, 32A and 32A AC charging pile. You can multitask.

(2) programmable DC LOAD: Load Power: 60KW, load voltage 0-1000V (500V, 750 V, 1000V) , current: 0-120A, load consists of 4 sets of modularization, can be used in single machine and used in parallel machine. The power of the machine is 300KW, which satisfies a multiple gun test.

(3) DC vehicle interface circuit simulator: with 250A charging seat, battery voltage simulation (0-900V) , r 4 resistance simulation, DC + , DC-, S + , S-, CC1, CC2, a + , a-parameter acquisition, disconnection, DC energy measurement etc, and load fit to simulate the various functions of the vehicle. The Modular design can be installed in the laboratory cabinets and on-site portable containers.

(4) AC vehicle interface circuit simulator: WITH 63A charging seat, PWM occupancy ratio simulation, r 1 resistance simulation, RC resistance simulation, CP output voltage adjustable, the functions of L 1, L 2, L 3, N, PE, CP, CC parameter acquisition, disconnection, AC power measurement and other functions, and load to simulate the various functions of the vehicle. The Modular design can be installed in the laboratory cabinets and on-site portable containers.

(5) insulation State Simulator: Pe to PE, negative pole to PE, symmetry, and asymmetric insulation state simulation, Voltage Resistance 1000V 1k -610K adjustable.

(6) recorder: With six 10m modules, 1 CAN communication module, two differential high-and low-pressure probes, test lines, and portable boxes.

(7) DC / DC BI-DIRECTIONAL CONVERTER: High Voltage bus voltage range: 300-950V low voltage battery voltage range 200-300V, module power 50 kw, multi-module superposition plus power. Simulation of battery characteristics for the test of a charging pile. Rechargeable pile can be used to charge the battery pack.

(8) Energy Storage Lithium Battery Group: Three 24-node 80ah Lithium Battery Modules, the Battery Group, the storage capacity of 18KWh, the DC / DC bi-directional converter, the battery simulation, and the inverter are used to power the whole test system.

(9) OFF-GRID INVERTER: DC input voltage 300V output 220V / 50HZ, power 3KW, and lithium battery to realize UPS uninterrupted power supply function.

(10) system power supply switch: The switch between the mains and the internal power supply, and realizes the power supply of all equipment in the system such as computer, test instrument, load, lighting, sensor, interface simulator etc.

(11) interactive inter-operability testing software: Automate all test items for AC charging pile inter-operability

(12) DC inte-roperability testing software: Automation of All Test Items for DC charging pile inter-operability and protocol consistency.
(13) System integration software: With the function of parameter configuration and loading of programmable AC power supply, load, power analyzer and Oscilloscope, it can meet the function of automatic testing of the electric performance of the equipment charging pile and the charger.

(14) Portable containers for portable equipment: 8U Standard Rack portable cases.

Test Items and Standards for Electric Vehicle Charging Facilities

On-site testing of the DC charging pile in accordance with the national standard, the test items are as follows:

GB / T34567.11-2017 electrical vehicle conductive charging inter-operability test specification-part 1: Power Supply Equipment

GB T34658-2017 telecommunications protocol Conformance testing between non-vehicle-borne conductive chargers and battery management systems for Electric Vehicles

IEC 61851-1:2010 Chapter 11 electric vehicle conductive charging system-part I: General Requirements

SZDB / Z29-2010 technical specification for electric vehicle charging systems-part 1-9GB / T27930-2011 telecommunications protocol for non-vehicle-borne conductive chargers and battery management systems for Electric Vehicles

GB / 50150-2006 electrical installation engineering electrical equipment transfer test standard

GB / T20234.1-2015 electric vehicle conductive charging connectors-part 1: General Requirements

GB / T20234.2-2015 electric vehicle conductive charging connectors-part 2: AC CHARGING INTERFACE

GB / T20234.3-2015 electric vehicle conductive charging connectors-part 3: Direct current charging interface

GB / T 18487.1-2015 electric vehicle conductive charging system-part 1: General Requirements

According to the requirements of the National Standard Test Project, the inter-operability of DC charging piles and the consistency of communication protocols are tested on the spot using the mobile platform. The test results are as shown in Table 1. Some of the test results are as follows: self-testing

Test number: D0.2001

Technical Requirements: testing in accordance with the testing methods specified in 6.3.2.2 of the inter-operability test specification, the control state of the charger shall be in accordance with the provisions of GB / T 18487.1-2015 for B. 3.3 and 6.3.2.3 of the inter-operability test specification.

Test results:

Table 1. D0.2001.1 whether the Battery End Voltage (K1 and k1 external voltage 10 v) can insulate automatically before the beginning of insulation detection.

| No. | Battery end voltage before the insulation test starts | Maximum allowable total voltages in BHM | Whether to perform an insulation test | Requirements | Test Results |
|-----|-----------------------------------------------------|----------------------------------------|--------------------------------------|--------------|-------------|
| 1   | -2.15V                                              | 350.0V                                 | yes                                  | test         | pass        |
| 2   | 298.15V                                             | 350.0V                                 | no                                   | Not allowed for test insulation | pass        |

D0.2001.2 insulation detection voltage compliance.

| No. | Output voltage range of the chargers | Maximum allowable total voltage (V) in BHM MESSAGE | Insulation Detection Voltage (V) | Requirements | Test Results |
|-----|-------------------------------------|----------------------------------------------------|----------------------------------|--------------|-------------|
| 1   | 200-500V                            | 190.0V                                             | Not carried out                  | Not allowed for test insulation | pass        |
| 2   |                                     | 350.0V                                             | 347.01V                          | 350V±5%      | pass        |
| 3   |                                     | 550.0V                                             | 492.71V                          | 500V±5%      | pass        |
### Table 2. D0.2001.3 whether the voltage and current values of the low-voltage Auxiliary Power Supply Circuit of the chargers meet the requirements of B. 1 in GB / t 18487.1-2015.

| No. | Voltage Values of Low-Voltage Auxiliary Power Supply Circuits | Requirements | Test Results |
|-----|--------------------------------------------------------------|--------------|--------------|
|     | Maximum Value(V) | Minimum Value(V) | Average(V) | Voltage: 12V ±5% Electrical Current: 10A |
| 1   | 12.25V            | 11.86V        | 12.08V     | pass |
| 2   | 12.26V            | 11.92V        | 12.08V     | pass |

### Table 3. D0.2001.4 after the insulation test is completed, the discharge process is in accordance with the provisions of GB / t 18487.1-2015.

| No. | Maximum allowable total voltages in BHM PACKETS (V) | insulation detection VOLTAGE (V) | K 1, k 2 disconnect time | VOLTAGE S DOWN TO 60V | Stop sending CHM Messages | Requirements | Test Results |
|-----|-----------------------------------------------------|---------------------------------|--------------------------|-----------------------|---------------------------|--------------|--------------|
| 1   | 350.0V                                              | 347.01V                         | 16.978s                  | 15.599s               | 17.156s                   | First drop the discharge circuit, then disconnect the K1K2 and stop sending the Chm Message | Not pass     |
| 2   | 550.0V                                              | 492.71V                         | 20.337s                  | 19.150s               | 20.572s                   |                                                         | Not pass     |

### Charging Readiness Test

Test number: D0.3001Technical Requirements: testing in accordance with the testing methods specified in 6.3.2.3 of the interoperability test specification, the control state of the charger shall conform to the provisions of B. 3.4 and 6.3.2.3 of the interoperability test specification in GB / t 18487.1-2015.Test results:

### Table 4. D0.3001.1 whether the external voltage of the contactor and the voltage error range of the communication message battery is 5% and / or is not within the normal output voltage range of the charger.

| No. | battery voltage Setting value | battery voltage Measurements | Message voltage | error | Whether to start charging | standard requirement | Test Results |
|-----|-------------------------------|-------------------------------|-----------------|-------|--------------------------|----------------------|--------------|
| 1   | 300V                          | 298.08V                       | 280.0V          | -6.06%| NO                        | Do not allow charging | qualified    |
| 2   | 300V                          | 298.29V                       | 286.0V          | -4.12%| YSE                       | Do not allow charging | qualified    |
| 3   | 300V                          | 298.41V                       | 310.0V          | 3.88% | YES                       | Do not allow charging | qualified    |
| 4   | 300V                          | 297.97V                       | 320.0V          | 7.39% | NO                        | Do not allow charging | qualified    |
| 5   | 510V                          | 588.21V                       | 600.0V          | 2.00% | NO                        | Do not allow charging | qualified    |
| 6   | 190V                          | 97.21V                        | 100.0V          | 2.88% | NO                        | Do not allow charging | qualified    |
| 7   | 0V                            | 0.00V                         | 300.0V          | -     | NO                        | Do not allow charging | qualified    |

### Table 5. D0.3001.2 whether the charger closes K1 and K2 when its output voltage is lower than the contactor's external voltage (1V - 10V).

| NO. | battery voltage(V) | Precharge voltage(V) | standard requirement | Test Results |
|-----|--------------------|----------------------|----------------------|--------------|
| 1   | 298.29V            | 281.84V              | Whether the charger closes K1 and K2 when its output voltage is lower (1V - 10V) than the outer end of the contactor. | Failed |
| 2   | 298.41V            | 306.22V              |                     | Failed |
Table 6. D0.3001.3 whether the communication status is in accordance with GB / t 18487.1—The corresponding stages in b. 6 and GB / t 27930 -- 2015.

| NO. | battery voltage(V) | K5, K6 Closing time | K1, K2 Closing time | standard requirement | Test Results |
|-----|--------------------|----------------------|---------------------|----------------------|--------------|
| 1   | 298.29V            | 20.125s              | 27.487s             | First close K5, K6 and then close K1, K2 | qualified   |

Conclusion

In order to ensure the normal operation of the on-site operation of the electric vehicle charging facilities, an on-site detection system of vehicle-borne electric vehicle charging facilities is studied and designed. Electrical performance testing, inter-operability testing and protocol Conformance testing can be performed on electric vehicle charging facilities in various places. The mobile testing platform of the charging machine and charging pile applied in the field is compared with the same kind of products. It has high integration of equipment, fixed wiring in the container, and avoids the repeated connection of each test. Moreover, the test data is accurate, the test speed is fast, the test can be backdated, and the Tester's workload is small. This study puts forward specific requirements for the function and technology of mobile alternating and DC charging pile, effectively serve the production, and ensure the measurement accuracy of AC and DC charging pile in the field, it ensures that electric vehicle charging facilities can operate in a safe environment and that the benefits and safety of the users of the used and rechargeable pile are guaranteed. The system can be used for periodic test and inspection project acceptance of charging pile. After the test of the electric vehicle charging pile, the installation and the on-site direct use are solved, and the equipment lacks the necessary maintenance and maintenance equipment. It is not necessary to wait for the charging pile cannot be used before it can be troubleshooting troubleshooting. It is of great significance to the safe and orderly development of electric vehicle charging station. It is convenient to record the charging data of the charging pile, the failure rate. The data cloud platform is an important trend of modern development. The system can provide reliable information data for the development of the data cloud platform of electric vehicle charging pile.

Acknowledgements

Thanks to the State Grid Corporation headquarters for science and technology project funding.
Project number: 5202011600U5;
Science and technology projects: Research and application of key technologies for charging intercommunication, safety and remote inspection of electric vehicle charging facilities and demonstration applications.

References

[1] Ouyang Minggao, China's energy saving and new energy vehicle development strategy and countermeasures. Automotive engineering [J], 2006, 28 (4): 317-321.
[2] Wang Xuhua, Li Wei, China's electric vehicle 2013, 31 charging facilities development trends and countermeasures. Power grid technology [J], (5): 32-45.
[3] A Web-Based Remote Laboratory for Monitoring and Diagnosis of AC Electrical Machines. Yazidi, A., Henao, H., Capolino, G.-A., Betin, F., Filippetti, F. Industrial Electronics, IEEE Transactions on. 2011.
[4] Way of Constructing Charging Facilities in Advance and Cracking Problem of Electric Vehicle Market. Li Yang, Lv Nan. Auto Industry Research. 2014.
[5] Wu C Y, Li C B, Du L et al 2010 The method of planning and locating the charge facilities J. Automation of Electric Power System 34 36-39.

[6] Yin J B, Wen Y B and Li R 2010 Discussion on the demand forecasting method of electric vehicle charging facilities construction J. Jiangxi Power 34 1-5.

[7] Xu H, He P and Ai X 2012 Research summary of power demand analysis model of electric vehicle charging J. Modern Electric Power 29 51-56.