Design of Simulation Test Platform for Charging Pile Control System

Guojian Li, Libo Ding*
School of Mechanical Engineering, Nanjing University of Science and Technology, Nanjing, Jiangsu, 210094, China
18362963786@163.com

Abstract. A fully functional, safe and stable electric vehicle charging pile is a necessary condition to ensure the widespread promotion of electric vehicles. At present, due to lack of testing methods, a large number of charging pile manufacturers have not performed a systematic test on their charging piles before leaving the factory. These defects make the real availability of charging piles put into operation in the market very low, and it is difficult to meet the charging needs of a large number of charged cars. To solve this problem, this research chooses to develop a simulation testing platform for charging pile control system based on semi-physical simulation technology.

1. Introduction
At present, in the early stage of design and development of charging piles, there is no testing platform that can assist the testing of charging pile manufacturers and developers. Most of the tests performed by developers at this stage are based on the actual environment. The working status of each module of the charging control system is opaque to the tester. The communication data and important flags when the charging pile fails can not be recorded[1]. These factors cause the tester can not accurately locate the cause of the error when the fault occurs. Therefore, this research decided to develop a set of high-efficiency and low-cost charging pile control software test system, which can perform a systematic test on a large number of charging piles before leaving the factory, and solve the potential problems of charging piles.

In view of the advantages of real-world simulation system, such as realism, flexibility and transparency[2], this study selected the semi-physical simulation test platform as the overall framework of the charging control system simulation test platform. The main work done is: Analyze the working principle of different types of charging piles and the composition of hardware peripherals, and formulate an overall design scheme combining the upper computer and the lower computer. Later, in order to realize the flexibility of test configuration, the micro-kernel architecture was used as the overall structure of the upper computer, and the core system and plug-in module design were completed on this basis. Finally, the software and hardware design of the lower computer (that is, the data acquisition board) is completed. The hardware design mainly simulates the control and steering circuits, contactors and communication interfaces of the actual AC and DC piles; the software design uses a double buffer queue and ISR (Interrupt Service Routine) communication structure.

2. Overall design of simulation test platform
The main design idea of the simulation test platform is to design and develop some virtual charging pile peripherals based on the QT_Creator platform. These “virtual peripherals” completely encapsulate
the communication protocols and function implementation of real hardware devices, and can replace real hardware peripherals and charging. The pile control system communicates. At the same time, the "virtual device" can be further expanded. Taking "virtual electricity meter" as an example, the charging process test under different power conditions can be flexibly configured, and the voltage, current and SOC curve diagrams during the entire charging process can be displayed intuitively through the interface.

At the same time, the test items for the charging control system also involve the testing of communication interfaces such as USART, CAN and SPI, so the simulation test platform should also provide the corresponding physical interface to connect with the charging control system. In addition, many switching actions of the safety protection unit and the control and guidance unit of the charging pile are driven by electric signals, so the simulation test platform needs an additional hardware platform to complete the corresponding work. Therefore, the simulation test platform is divided into an upper computer for simulating the hardware peripherals of the charging pile and a lower computer for data collection. The functional architecture of the simulation test platform is shown in Figure 1.

![Figure 1 Functional architecture of simulation test platform](image)

### 3. Host computer design

The functions that the upper computer of the simulation test platform should implement include the following parts: Provide a friendly human-computer interaction interface for testers to select and configure test cases, and graphically display the working status of electricity meters and ACDC modules; Simulate the communication protocol of each real peripheral and replace the real peripheral with the charging control system to form a virtual charging pile; Monitor and store the communication data between the "virtual peripheral" and the charging control system, so as to facilitate the location and correction of the cause of the failure in the later stage; Based on the software testing requirements of the charging pile, the functional structure of the upper computer software of the simulation test platform is shown in Figure 2. Based on the realization of the above functions, in order to flexibly carry out test configuration and function expansion for the simulation test platform, it is planned to develop the upper computer software based on the microkernel architecture which is shown in Figure 3[3].

![Figure 2 Host computer software module division](image)

![Figure 3 Microkernel architecture](image)

The research and design simulation test platform divides the plug-in module structure into a display configuration layer, a protocol processing layer, and a communication interface layer, as shown in Figure 4. The display configuration layer is the uppermost layer of the plug-in module. Testers use this layer to select and configure the charging parameters and test cases. In addition, the display configuration layer can also graphically display the test results. The protocol processing layer is used...
to encapsulate the communication protocol used by the plug-in module. The communication interface layer is the communication interface between the plug-in module and the core system. It is mainly divided into two types: unnamed pipes and virtual serial ports. The communication between the layers is bidirectional, but cross-layer communication is not allowed. An example of a "virtual electricity meter" developed based on the plug-in module structure is shown in Figure 5.

### 4. Data acquisition board design

The data acquisition board is a bridge for communication between the upper computer of the simulation test platform and the charging control system. The national standard GB/T 34657.1-2017 specifies the interoperability test specifications for conductive charging of electric vehicles. The interoperability tests for charging piles mainly include charge control state tests, charging connection control timing tests, and charging abnormal state tests. If you want to use the simulation test system to complete these interoperability tests, the data acquisition board must be able to simulate the control and steering circuits and switching actions of AC and DC charging piles.

#### 4.1. Control-guided simulation and contactor design

The data acquisition board’s analog circuit for DC pile cable detection is shown in Figure 6. Taking charging gun 1 as an example, the microcontroller controls the access of resistor R107 by controlling the high and low levels of the DC_CableTest1_1 pin. This can simulate the charging gun switch S1. action. The single chip microcomputer controls the connection of the resistor R122 by controlling the high and low levels of the DC_CableTest1_2 pin, so that the plugging state of the charging gun can be simulated. The contactors used in the charging pile are mostly 8-pin DC12V relays that are widely used in the industrial field[4]. Their electrical connections are shown in Figure 7. At this point, the DC pile cable detection has been simulated.

#### 4.2. Protocol forwarding module design

According to the actual needs of hardware peripherals, the external communication interfaces of the charging control system mainly include: RS232, RS485, CAN, etc[5]. In order to meet the test requirements of both the AC and DC charging control systems, the protocol forwarding module of the data acquisition board provides three sets of 485 communication interfaces, two sets of 232 communication interfaces, and four sets of CAN communication interfaces. The circuits of these
communication interfaces are shown in Figures 8 and 9, respectively. So far, the data acquisition board can process and forward all communication data sent by the host computer and the charging control system.

The test site of the charging pile control system is shown in Figure 10. The equipment in the figure includes the PC simulation test software, the data acquisition board, the charging control system, and the DC power supply.

5. Conclusion
The purpose of this paper is to address the shortcomings of existing charging pile software testing methods, such as long test cycles, opaque key information during charging, and high testing costs. This paper chooses the hardware-in-the-loop simulation test technology as the solution, and adopts the overall design scheme combining the upper computer and the lower computer to build a simulation test platform for the charging pile control system. Testers can use the charging control system test platform to build different "virtual charging piles" and configure different test scenarios to complete the testing of different types of charging pile software, so that they can query and correct errors when the software is running.

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