Research and Design of an Intelligent Charging and Self-checking Car Charging Pile

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Abstract. This paper develops an intelligent, efficient, stable and reliable AC charging pile system. In order to achieve the goal of stability and reliability, the power supply uses a high-frequency switching power supply. The topology design must be reasonable. The power components selected can meet the working needs of the high-frequency switching power supply. In order to realize the automatic control function of the charging pile system and achieve the requirements of intelligence, the S3C44BOX embedded microprocessor is designed as the main controller of the charging pile system to realize various functions such as charging control and communication.

1. Introduction
With the continuous development of society and economy, people have become more and more aware of environmental issues and energy crisis. This has become two issues that must be solved on the way of human development. Energy conservation and emission reduction have become the current theme of the world. [1-6] As a new energy vehicle, electric vehicles have higher resource utilization and no exhaust emissions. They are an important means to achieve energy conservation and emissions reduction, and to solve environmental problems and energy crises. They are also the focus of the future development of the automotive industry.

2. Functional requirements of the system
In the case where the 2011 version of the charging interface and communication protocol standards has been implemented for less than four years, the new standards have emerged in 2015. Because the 2011 version of the old standard does not match the 2015 version of the new standard, the old standard car is inserted in the new standard pile, and the charging gun is likely to be locked. This requires us to clearly clarify the difference between the new and old national standards. In terms of safety, the new standard adds functions such as charging interface temperature monitoring, electronic locks, insulation monitoring, and bleeder circuits, refines the safety protection measures of the DC charging car interface, and explicitly prohibits the application of unsafe charging modes, which can effectively avoid Accidents such as electric shocks and equipment burning occur to ensure the safety of electric vehicles and users during charging. In terms of compatibility, the type and structure of the AC and DC charging interface are compatible with the original standard. The new standard has modified some contact and mechanical lock dimensions. However, the old and new plugs and sockets can cooperate with each other. The electronic locking device added to the DC charging interface does not affect the electrical connection between the new and old products. The user only needs to update the
communication protocol version to realize that the new power supply equipment and electric vehicles can guarantee basic charging. Features. The mapping relationship between the duty cycle and the current limit of AC charging is compatible with international standards, and reserves space for future digital communication of AC charging.

According to the above functional requirements, the overall plan mainly includes four parts: a charging pile system, a server, a background management client, and a background management web page. The charging pile is mainly responsible for users to charge and meet the basic functions of the charging pile. At the same time, it can upload its status information, charging data, and transaction settlement data to the server through the wireless communication module; the server mainly saves the data uploaded by the charging pile to the database. At the same time, data is provided to the client and the web page according to the request of the background management personnel; the client and the web page mainly display the charging pile and the status and information of the user to the user according to the operation of the management personnel.

According to the analysis of system function requirements above, according to the modular design principle of the system, the AC charging pile is divided into the following functional modules: a microcontroller module, which is used to control the functional modules of the entire system and data processing; control guidance Module, used to confirm the connection status of the charging pile and the electric vehicle during the charging process, control the start and end of the charging process, and monitor the current and voltage during the charging process in real time, and provide the information to the microcontroller Module to further control the entire charging process; human-computer interaction module is used for the user to communicate with the charging pile and perform various operations, display the current interface, various charging parameters, and feedback the user's operation to the microcontroller module, and then The microcontroller then controls the next operation; the data communication module is used to upload and verify the user data of the charging pile, report the status information of the charging pile, report the charging process information, and perform parameter configuration and data update of the charging pile in the background; energy measurement Module for the measurement of charging current and voltage, and the calculation of charging power, and Microcontroller module is provided for cost calculation; electrical protection module is used for emergency protection of charging piles in various dangerous situations, including level detection, charging temperature detection and leakage, overcurrent, surge detection and protection When the above situation occurs, the charging pile can be powered off in time to protect the safety of the equipment; the reader module is used to read and write the charging radio frequency card, the charging of the charging card and the transaction settlement at the end of charging; the power module is used to provide energy A power module that enables the entire device to work properly.

3. Design

Charging piles are divided into AC charging piles and DC charging piles. The DC charging pile is commonly known as "fast charging", which uses three-phase four-wire power supply, directly connected to the AC grid, and outputs adjustable DC power to charge the electric vehicle battery. The car charger is needed to charge the electric vehicle battery, which plays a role of power control. The main differences are:

a). Different equipment
   The difference between the devices is whether an additional vehicle charger is required. The AC charging station requires an additional vehicle charger, while the direct charging station does not.

b). Different charging speed
   There is a big difference in charging speed. The charging time for DC charging piles is 2-3 hours, while the charging time for AC charging piles is about 8 hours.

c). Different fast charge capabilities
   The DC charging pile provides enough power and can output a wide range of adjustable voltage and current to achieve fast charging requirements, while the AC charging pile is limited by the power of the vehicle charger and cannot achieve fast charging.

d). Different efficiency
The efficiency of the DC charging pile is generally 95% - 97%, while the AC charging pile is generally 98%, and the efficiency of the car charger is about 88%.

e). Different cost
The price of DC charging pile is significantly higher than AC charging pile, and the cost of production will be more expensive.

4. System structure of charging pile
The circuit composed of the charging pile system is designed in a modular manner, and each circuit interacts to complete a good charge and discharge control function and related supporting functions, as shown in Figure 1. The components of the charging pile system mainly include a battery management system, a management service system, and a man-machine interface operating system.

The battery management system is mainly used to monitor battery charge and discharge parameters, such as voltage, current, and temperature. At the same time, it can predict the capacity of the battery according to the use situation. When the battery is abnormal, it can take protective measures to improve the battery storage capacity and extended battery life.

The service management system can implement battery parameter management, user IC card information management, and charging pile use information management, which is convenient for users and managers to make comprehensive queries. The management service system adopts the network interface connection, and uses CAN bus to communicate with the charging pile system.

The human-machine interface operating system is used for human-computer interaction to achieve the effect of intuitive control and display. All the information during the charging process can be clearly displayed on the man-machine interface, such as the charging time and the amount of charging.

![Figure 1. Structural diagram of charging pile system](image)

The electric vehicle charging pile system is mainly composed of a charging module, a main control unit module, a protection control module, a metering module, and an auxiliary function module.

5. Charging pile system module

5.1. Charging module
The energy source of an electric vehicle is mainly a battery, which converts the electrical energy of the battery into mechanical energy to drive the car. Therefore, charging equipment is the best device to supplement electrical energy.

The main function of the car charger is to charge the battery of the electric vehicle after converting the input AC power to DC output. The charger needs to be paired with the battery. The battery is the main device that provides power, and its performance has a direct impact on the performance of electric vehicles. The main function of the charging pile is to charge the battery through the charger, and its charging method and charging strategy directly affect the battery life.

Therefore, an important part of the circuit design of the charging module is the design of the main circuit topology of the charging power supply. The reasonable design of the topology is the most important task in the design of the circuit of the charging module. The degree of its design plays a key role in the performance of the charging module.
As an important device of electric vehicles, the electric motor is a typical active load, which can realize energy input from the input end and output from the output end. During the driving process of an electric vehicle, the speed needs to be frequently changed, and a wide range of rotation speed is required. Since the motor is driven by a battery, a wide range of voltage changes of the battery is required. In order to improve the performance of the motor, a two-way DC / DC converter is used for control. Its advantages are unmatched by other common driving methods.

![Figure 2. Charging power structure diagram](image)

220 V AC power is converted into DC power through rectification. After switching the inverter and reducing the voltage of the transformer, it is connected to the bidirectional DC / DC circuit after rectification, and then connected to the storage battery.

4.2. Main control unit module

The charging pile system completes the communication and control tasks between the various modules under the coordination of the main controller. Therefore, a real-time operating system that supports multitasking is needed for unified coordination and scheduling, that is, the main control unit. According to the design requirements, this article uses the S3C44BOX processor, combined with various types of peripheral circuits to complete battery charge and discharge control, user IC card verification, charge settlement, charge inquiry, consumption record printing, information display, and its own control functions. The schematic is shown in Figure 3.

![Figure 3. Charging pile control system](image)

5.2. Protection control module

The protection control module of the charging pile refers to protection measures that can be taken when an abnormality occurs during the charging control process. With different levels of protection functions, such as over-voltage protection, over-current protection, leakage protection and lightning protection; with wrong connection protection function, if the connection circuit is reversed, it can automatically judge and take measures to cut off the power, only the positive charging connector. The charging system can be started only after it is correctly connected with the charging cable; at the same time, it also has the function of self-recovery after a failure. All protection requirements have the characteristics of reliability, quick-action, selectivity and sensitivity.

In consideration of safety requirements, the charging pile should also have an emergency stop function in an emergency or abnormal situation to forcibly terminate the charging.
5.3. Metering module
Energy metering devices are the minimum devices that should be configured in smart meters, mainly including inductive, electromechanical, electronic and smart meters. Inductive and electromechanical have low accuracy, single function, narrow frequency range, and even susceptible to interference. They are usually used Occasionally, the requirements are not high, and some have even been eliminated. Although the electronic type has the characteristics of high accuracy and good expansion performance, it is expensive and susceptible to interference. It is mainly aimed at places with higher requirements. The smart energy meter has a high degree of integration and functionality Rich, high precision, and has the advantages of communication protocol interface, mainly suitable for special requirements.

This article designs and selects the smart meter as the metering module design selection. It mainly considers the functions of battery charge management, service management system, and human-machine interface operating system. It has functions such as counting, timing, and remote communication and control to assist decision-making and analysis functions.

5.4. Auxiliary Function Module
When designing the charging pile, consider adding some modules with auxiliary functions, highlighting individual requirements, such as IC read-write card function, GPRS communication function, etc. In addition, during the charging process, if some users negligently cause the charging equipment to be continuously connected to the charging pile, the long-term charging will cause great damage to the electric vehicle, so the system can automatically cut off the charging according to the longest charging time of the electric vehicle. Power supply for protection purposes.

6. Conclusion
This article describes the hardware design module of the charging pile system, analyzes the functions of each circuit module, determines the basic design framework, and elaborates the functions of the charging module, the single-chip main controller module, and the protection control module, etc. The system has a holistic understanding.

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