Research on Intelligent Charging Control System of Electric Bicycle

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Abstract. This article designs a basic electric bicycle charging management system, which can solve the problem of difficult charging of electric bicycles and completely eliminate the safety hazards of private wire connection. The electric bicycle charging management system is divided into charging station intelligent terminal, server background, WeChat client, web management terminal, etc. The intelligent terminal of the charging station adopts the RS-485 bus to realize the communication with the intelligent charger and grasp the charging status in real time. The back-end server adopts the MVC architecture, which provides a query interface for the client and the web management back-end to monitor the charging status in real time. The management system also implements the WeChat payment function, which can realize charging on time and according to the amount. Practice has proved that the charging management system can well solve the current charging disorder and has a good market prospect.

Keywords: Electric bicycle, smart charging, charging system, reservation function.

1. Introduction

As an energy-saving, convenient, and low-cost means of transportation, electric bicycles have been favoured by more and more people, especially in schools and residential communities. Electric bicycles have become a means of transportation used by most people. Due to the shortage of charging equipment and the large weight of the battery, there are more and more cases of charging electric bicycles by privately pulling cables, which brings huge safety risks to the community. According to the notice from the Office of the State Council Security Committee on the implementation of comprehensive fire safety management of electric bicycles, the government encourages new residential communities to simultaneously set up centralized parking lots and intelligent charging control equipment with functions such as timed charging, automatic power-off, and fault alarm. To this end, this paper designs a charging control system based on the WeChat platform [1]. The charging system can establish data communication between the charging pile, mobile phone client, and cloud server. Mobile phone users can remotely open the charging pile and pay through the WeChat platform. At the same time, you can view the charging status of the electric car, the remaining charging time and other information in real time on the mobile phone client.
2. System Architecture

2.1. Overall system architecture

The electric bicycle charging management system can be divided into two parts: on-site service and remote service according to the work location. The on-site service part is mainly composed of a controller, a QR code socket, a mobile phone, and a coin. The remote service is mainly composed of firewall, WAB group server, database cluster, etc. Among them, the on-site service mainly completes the direct control of the electric bicycle charging power supply. Each controller realizes the management of 10 power sockets, and can accept charging commands from the remote server and save the information of on-site charging status [2]. Mobile phones and coins correspond to two payment methods, making it convenient for users to make payments in multiple scenarios. The remote service is responsible for issuing the control commands sent from the mobile phone to the on-site controller, information processing, data storage and query. The basic architecture of the electric bicycle charging system is shown in Figure 1.

![Basic architecture of electric bicycle charging system](image)

The server sends the charging command to the controller, and the controller parses the command statement and controls the opening and closing of the relay of the designated socket. At the same time, users can monitor the charging status of electric bicycles at any time through their mobile phones. The second control mode is on-site coin-operated control. This mode is for non-mobile users. The user charges through coin-operated payment on the controller, selects the appropriate charging socket, coin-operated and time-charged, and the battery is fully charged. In this mode, the controller will send the number of coins and charging time to the server and save them in the database.

2.2. System function

The main functions of the management machine system of the charging station are divided into four modules, namely the charging card issuing module, the electric bicycle management module, the data analysis module and the about help module. The functional module structure diagram of the management machine is shown in Figure 2 below:
As the charging card in ACMS, similar to the citizen cards currently popular in major cities, this charging card is an exclusive charging card for this system, which is used for the corresponding expenses that citizens need to deduct when charging electric bicycles. This system combines the analysis of various popular IC cards, and finally determines that the dual interface CPU card is the best solution to achieve the ultimate goal of the system [3]. The charging card management module in this system mainly has card creation function, recharge function and logout function. Card building function: The user enters the card purchaser's basic information at the card sales point with his valid personal certificate, and then the system calls the third-party card building module to generate the key, and finally the system sends the relevant data to the server-side management system. Recharge function: After entering the recharge amount at each recharge point, the amount is written into the electronic account corresponding to the card. Cancellation function: In order to protect the interests of cardholders, when the charging card is lost, the charging card can be cancelled with a valid certificate.

2.3. System working principle

The working principle of the system is: The system obtains the real-time active power, voltage and current value of the charging load through the combination of active power measurement module, zero-crossing detection and RC resistance-capacitance absorption surge pulse circuit, and analyses whether the current charging voltage and current are If the present threshold of the system is exceeded, the real-time monitoring of active power is used to determine whether the current load is connected to the system, and the voltage drop generated by the Schottky diode is monitored through the closed-loop detection and control mechanism, so that the system can effectively detect the online state of the load within 0.5s. At the same time, the system uploads multiple collected parameters to the cloud server, which can promptly feedback the latest charging status and various detection information to the administrator and charging users. The schematic diagram of the closed-loop detection control mechanism is shown in Figure 3.

**Figure 2.** System function diagram
Figure 3. Schematic diagram of closed-loop detection control mechanism

At present, most of the electric bicycle charging piles on the market only provide charging power for vehicles, and there is no systematic collection and analysis of information such as vehicle charging voltage/current, active power, battery status, etc., and they cannot effectively provide charging functions at the same time. Monitoring the status of vehicles and the use of electric energy, and it is impossible to effectively monitor and prevent their fire safety. The intelligent charging management system for electric bicycles designed by the author realizes effective monitoring of vehicle access, battery status, and the status of the equipment itself through real-time monitoring of parameters such as voltage/current, active power, and device temperature during vehicle charging. In order to accurately monitor the active power of the load during charging, the single-phase energy meter chip RN8208G is used to measure the active power of the load [4]. The chip has accurate measurement functions such as active power, active energy, and voltage/current effective value. Its active energy error is 8000: 1, within the dynamic range <0.1%, the accuracy can reach 0.5s. In order to ensure that the life of the main power switch module can adapt to the frequent use of electric bicycle charging, the system hardware adopts the design of zero-crossing detection on-off relay combined with RC resistance-capacitor absorbing surge pulse circuit to protect the relay contacts.

3. System hardware and software design

3.1. Hardware design

3.1.1. Main control module. The main control module includes crystal oscillator circuit, reset circuit, download circuit, etc., to control the entire system in real time. Among them, STM32 needs to provide two crystal oscillator sources externally, one is 8MHz crystal oscillator circuit, the other is 32.768MHz crystal oscillator circuit, input from 12, 13 and 8, 9 pins respectively. The reset circuit is connected to the No. 14 pin of STM32, which is the reset pin. When the level of the reset pin changes from high to low, the chip is reset.
3.1.2. Power supply circuit. The operating voltage of the STM32F103 chip is 3.3V, and the 5V input voltage of the adapter needs to be converted to 3.3V. LM2596 series integrated voltage regulator chip package standard, simple to use, small output voltage error, and built-in protection circuit, even if the user's wrong operation will not immediately burn the circuit, it is a high accuracy and good safety factor All-in-one voltage regulator chip [5]. The LM2596-3.3V power chip can perfectly meet the power requirements of this design.

3.1.3. Voltage amplifier circuit. The amplifying circuit adopts MCP6002 operational amplifier. The MCP6002 operational amplifier can be used in applications such as automobiles, photodiode amplifiers, battery-powered systems, etc. The requirements for power supply are extremely low, even if the supply voltage of a single power supply is only 1.8V, the operational amplifier can be normal jobs. In addition, the operational amplifier uses advanced CMOS technology in the integrated circuit design. The maximum operating temperature range of MCP6002 is 85°C, which effectively prevents the chip from malfunctioning due to heat generated during circuit operation. The voltage amplifying circuit is shown as in Fig. 4.

![Figure 4. Voltage amplifier circuit](image)

The first-stage operational amplifier is a voltage follower, which can reduce the input resistance and achieve impedance matching with the next stage. The second-stage operational amplifier constitutes a voltage forward proportional amplifier circuit. The magnification is:

\[ A_u = \frac{V_{out}}{V_{in2}} = 1 + \frac{R_{13}}{R_{12}} \]  

(1)

When there is a voltage signal input, the voltage taken by the comparator U8A (U8A takes the voltage on R17) is compared with the sampling voltage (R26, R27) to control the on and off of the MOSFET. The magnification formula of working state is:

\[ I_{out} = 100R_{15}V_{in3} / R_{16} \]  

(2)

3.2. System software design
The intelligent charger software design of this system adopts a modular design, which mainly includes AD data acquisition module, digital filter module, RS-485 communication module, and switching control of charging power supply. After the system is powered on, the microcontroller reads various
initialization parameters, and starts AD conversion to collect voltage and current data, and transmits the charging data to the control terminal in real time via the RS485 bus. The system uses interruption mode to monitor the control data sent by the control terminal to realize the on and off control of the charging power supply [6]. In this paper, the average filter algorithm is used to digitally filter the collected voltage and current data, which can effectively filter out the effects of random interference and grid voltage fluctuations.

3.3. Server design
The WeChat official account can be set with a custom menu, making the official account a lightweight application. The custom menu improves the interactive properties of the official account, and the user can click the custom menu to get the corresponding content. In addition, for view-type menu buttons, the WeChat client will open the URL that the developer fills in the button, and interact with the web app through the built-in WeChat browser, so that users can quickly enter the web application. In order to facilitate the administrator to monitor and manage the system, this article also implements a web version of the management background [7]. The web version of the management backend adopts the separation method of front and back ends, and the front end and the WeChat public platform share a JAVA server. The server uses the Spring MVC framework. Spring MVC is an MVC framework developed in recent years, which well embodies the idea of layering, namely model, view, and controller. The MVC model makes the software layered well and makes the program easier to maintain. Each part of the MVC model has its own role. The model layer controls the storage of data and the business logic of the software. The view layer is used to provide a user interface. The controller is a bridge between the model layer and the view layer to control the flow of data in the view layer. Figure 4 is a diagram of the server background architecture.

![Figure 5. Server backend architecture diagram](image)

4. Conclusion
This paper implements a design of a public electric bicycle charging pile based on WeChat. The system includes three parts: charging pile terminal, mobile phone client and cloud server. This article mainly introduces the charging terminal design. First, the overall structure design of the charging pile is described, and then the hardware circuit design, including the software and hardware realization of the main control circuit, power supply circuit, power metering circuit, and 4G communication module. The
actual test proves that the design scheme in this paper can control the on and off of multiple pile ports, and users can use the WeChat client to operate.

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References
[1] Pellitteri, F., Campagna, N., Castiglia, V., Damiano, A., & Miceli, R. Design, implementation and experimental results of an inductive power transfer system for electric bicycle wireless charging. IET Renewable Power Generation, 14 (15) (2020) 2908 - 2915.
[2] Guidon, S., Becker, H., Dediu, H., & Axhausen, K. W. Electric bicycle-sharing: a new competitor in the urban transportation market An empirical analysis of transaction data. Transportation research record, 2673 (4) (2019) 15 - 26.
[3] Chen, Y., Yang, N., Yang, B., Dai, R., He, Z., Mai, R., & Gao, S. Two-/three-coil hybrid topology and coil design for WPT system charging electric bicycles. IET Power Electronics, 12 (10) (2019) 2501 - 2512.
[4] Chen, Z., Hu, Y., Li, J., & Wu, X. Optimal deployment of electric bicycle sharing stations: model formulation and solution technique. Networks and Spatial Economics, 20 (1) (2020) 99 - 136.
[5] Mai, R., Chen, Y., Li, Y., Zhang, Y., Cao, G., & He, Z. Inductive power transfer for massive electric bicycles charging based on hybrid topology switching with a single inverter. IEEE Transactions on Power Electronics, 32 (8) (2017) 5897 - 5906.
[6] Li, Y., Hu, J., Chen, F., Liu, S., Yan, Z., & He, Z. A new-variable-coil-structure-based IPT system with load-independent constant output current or voltage for charging electric bicycles. IEEE Transactions on Power Electronics, 33 (10) (2018) 8226 - 8230.
[7] ADEJUMOBI, I. A., ADEBISI, O. I., & MATTI, S. O. Development of a hybrid solar-dynamo powered charging system. ABUAD Journal of Engineering Research and Development (AJERD), 1 (1) (2017) 1 - 9.