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Research on Control System of Station - type Charging Pile

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ABSTRACT : With the rapid development of electric vehicles, the demand for DC charging piles is becoming more and more urgent. In this paper, a charging control system based on M453VE6AE chip and STM32F103RBT6 chip is designed. The hardware design of the control system is described, including BMS communication unit, human-computer interaction unit, power Module communication unit, the host computer communication unit and signal acquisition and protection function modules.

Keywords : DC charging pile; control system; M453VE6AE; STM32F103RBT6

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I. INTRODUCTION

With the deepening of the concept of green energy, the development of electric vehicles has become the focus of the future development of the automobile industry.[1]. However, according to the current status quo, one of the difficulties in restricting the development of electric vehicles is the charging problem.due to the distribution and design defects of the pile.[2], electric vehicle reliability is affected.so the study of electric vehicle charging pile optimization Design is of great significance.[3]

The traditional DC charging pile charge the electric vehicle power battery through the internal AC-DC module, DC-DC module. Its main consists are three-phase rectifier circuit, power frequency LC filter circuit, DC / DC converter, the output filter circuit. Station-type charging pile is 380V AC to high-frequency pulsating DC by 24 pulse phase shift transformer, rectifier bridge,then the current is input to a number of charging pile terminal.so that the total power can be deployed. Its main circuit and control circuit is relatively simple

DC charging pile is connected with the electric car through the interface, Charging pile can charge the electric car by the corresponding operation in the human-computer interaction interface of the charging pile.[4] . At the same time, it can display the charging voltage, charging current, power, cost, charging time and other information in the charging pile display.[5]. Station charging pile system charge in the background, charging charges by the host computer. The article will introduce the station-type charging pile system firstly, and then it is a detailed description about the charging pile control system based on M453VE6AE chip and STM32F103RBT6.[6-7] chip. Then the design block diagram of the control system is given, and the hardware circuit design of the control system is described in detail.

II. STATION-TYPE CHARGING PILE SYSTEM

The station-type charging pile system is arranged in units of stations.It distributes the total power of the charging pile system with the station size. In this system, 380V AC power will become about 800V DC through the 24-pulse phase shift transformer, rectifier bridge rectifier, then it inputs to each charging pile terminal through the DC bus. charging pile charges the electric vehicle through its control system. Charging pile main circuit shown in Figure 1. Charge module circuit is the power conversion circuit, using Buck Chopper triple circuit design, a film capacitor, IGBT switch, rectifier diode and other components.It has the filter circuit consists of L and C at the output, the filter circui turn pulse voltage and current into DC to meet the battery charging needs.

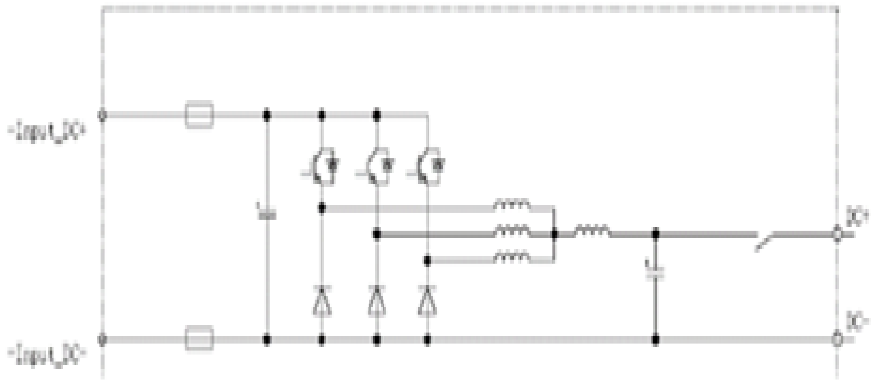

Figure 1 Charging Pile Main Circuit

III. CONTROL SYSTEM HARDWARE CIRCUIT DESIGN

Charging pile control system uses M453VE6AE chip and STM32F103RBT6 chip, the control system block diagram shown in Figure 2. Output voltage sampling and signal conversion circuit and output current sampling and signal conversion circuit collect the pile output voltage and current real-time, and scaled into the voltage value of 0 ~ 3.3V that it can be identified by STM32F103RBT6 chip.STM32F103RBT6 gets Output voltage and current feedback value of the digital signal through A / D conversion, and it will gets the PWM control signal by compared feedback value and the battery management system settings in the control cycle, and then isolated by the IGBT drive circuit to control the output of the main power circuit.

The charging pile has a very perfect protection circuit, which guarantees the reliable operation of the charging pile. The protection of the system are: input overvoltage, undervoltage, high temperature protection, output overvoltage, undervoltage, output overcurrent and so on. Respectively, compared with the corresponding set value, when more than the set value, that is, a failure of the charging pile, stop sending PWM signal to avoid damage to the charging pile. The charging pile uses a logic gate to block and the software blocks the PWM signal. The logic gate is blocked by the logic gate chip and the charging signal of the charging pile is used as the logic enable signal to realize the hardware blockade of the PWM signal, which is more reliable than the software blockade., through it will stop sending PWM signal in the charging pile failure for software blockade.

Input voltage, output voltage over-voltage detection and output current over-current detection achieved by the output voltage sampling and signal conversion circuit and the output current sampling and signal conversion circuit. and current and voltage are sent to STM32F103RBT6 A / D conversion module by their respective detection circuit, it achieves protection by comparing with the set of protection points.The overtemperature detection protection circuit real-time detects the temperature of the charging pile IGBT and provides the status information to the STM32F103RBT6. When the IGBT temperature exceeds a given range, the status information becomes the fault signal. Before the PWM signal output from the STM32F103RBT6 is supplied to the IGBT drive circuit,it is logically combined with the fault signal in the digital logic protection module. The digital logic protection module is programmed in the STM32F103RBT6 to lock the PWM signal in the event of a failure of the charging piles and Issued an interrupt signal to achieve the rapid protection of the charging pile and battery. In addition, the STM32F103RBT6 also provides a trigger signal to the current relay.

At the same time, the charging pile with CAN bus interface circuit, to achieve charging pile and electric vehicle BMS handshake communication. In order to see the charging voltage, charging current, charging time, charging power and other information, the control system has a display communication with the RS232 communication interface circuit. In addition, in order to store the charging data information and control charging, charging pile control system also has a RS485 communication interface circuit with the host computer.it can control to receive emergency stop signal, charge gun electric lock signal,to lock on or off charge the pile of the LED lights, cooling fan, charging gun electric by the M453VE6AE. M453VE6AE and STM32F103RBT6 two chips communicate through the RS485 communication interface circuit.

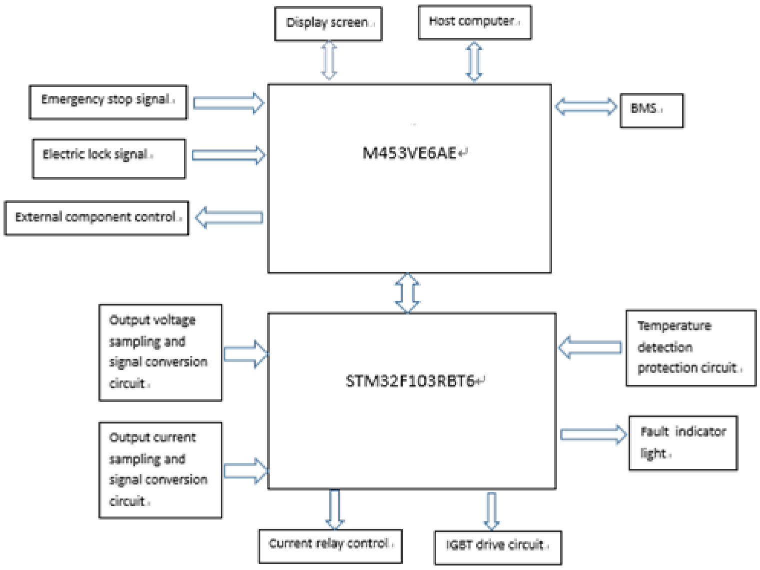

Figure 2 Block diagram of the control system

3.1 IGBT drive circuit

PWM signal output through the STM32F103RBT6 chip enter to the logic gate chip, then into the hardware drive circuit to drive the IGBT turn on and off.The logic gate chip enable pin connect to the charging pile fault signal to achieve PWM signal hardware blockade. Which IGBT hardware drive circuit shown in Figure 3:

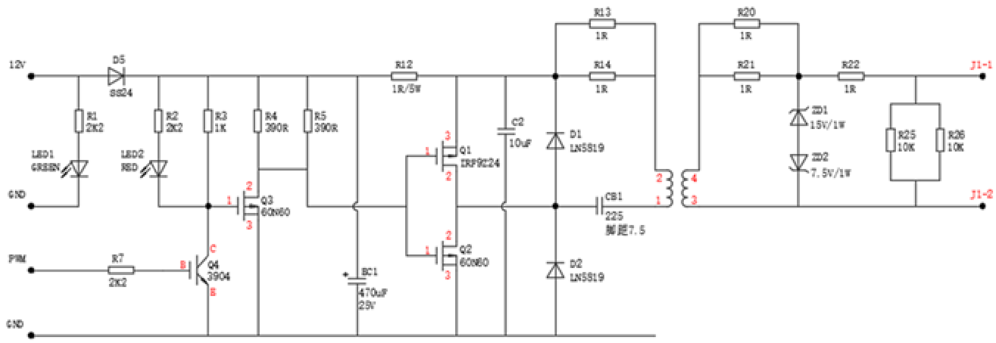

Figure 3 IGBT hardware drive circuit

3.2 output voltage sampling and signal conversion circuit

The output voltage sampling and signal conversion circuit converts the strong electric signal output from the main power circuit into the 0 ~ 3.3V weak signal recognized by the STM32F103RBT6 chip A / D module and isolates the main power circuit and the control circuit. Output voltage sampling and signal conversion circuit using Hall voltage sensor WHV05AS5S6 and one to one of the inverting operational amplifier. WHV05AS5S6 is a closed-loop voltage sensor made using the Hall effect principle, capable of measuring AC, DC, pulse signals and other irregular signals. The rated current IPN is 5mA, the measurement range IP is 0 ~ ± 10mA, the measured voltage VPN is 5V ~ 1200V, the output voltage Vo is 2.5 ± 0.625V * (IP / IPN). Supply voltage of 5V, it has high precision, good linearity, temperature range and other advantages.

Output voltage sampling and signal conversion circuit shown in Figure 4, the voltage sensor input is the current signal, R1 ~ R5 is the matching resistor, matching resistance in accordance with the size of the rated input current to choose. At the same time in order to reduce the output resistance, increase the load capacity of the circuit and the sampling and signal conversion circuit output and input in phase, the output of the Hall voltage sensor connected one by one in-phase op amp.

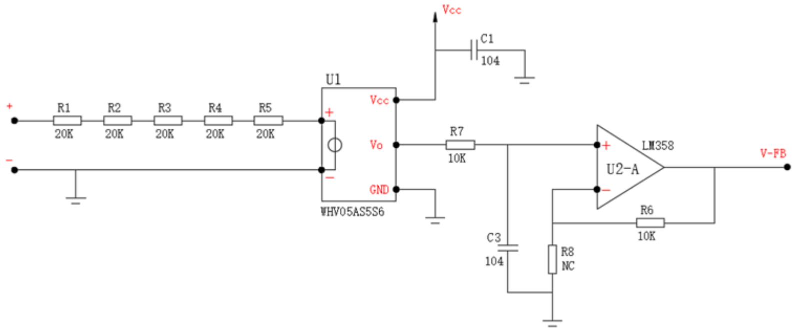

Figure 4 Output voltage sampling and signal conversion circuit

3.3 Output current sampling and signal conversion circuit

Output current sampling is mainly realized by Hall current sensor. Hall current sensor adopts BYY's BSY2-100IOV2L, which has the advantages of good linearity, high precision, wide frequency bandwidth and strong isolation. BSY2-100IOV2L rated input current of 0 ~ 100A, rated output voltage of 4V, power supply voltage of ± 12V ~ ± 15V. The current sensor can scale measured current signal into a voltage signal.when the input is 100A current and current flow direction with the arrow on the sensor, its output is 4V voltage. The voltage signal obtained from the Hall current sensor is reduced to 0 to 3.3V by two inverting ratio operation circuit, and is supplied to the A / D conversion module of STM32F103RBT6 through the current limiting resistor R158 and the diode limiting circuit D22. Output current sampling and signal conversion circuit specific circuit shown in Figure 5, the potential regulator RP5 play zero role.

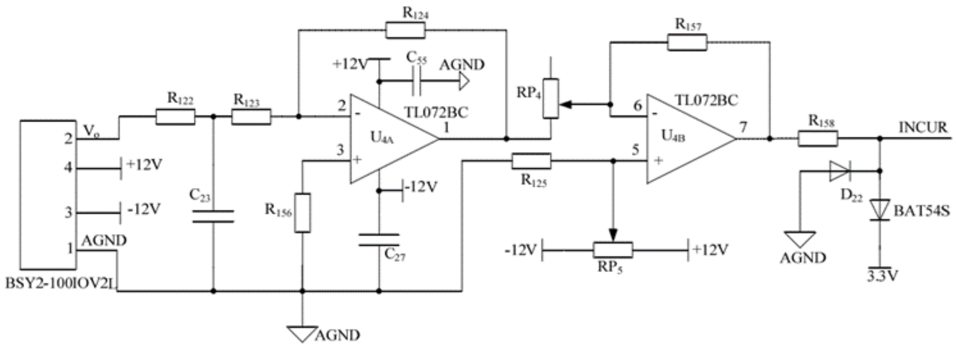

Figure 5 shows the current sampling and signal conversion circuit

3.4 temperature overheating protection circuit

Figure 6 shows the temperature overheat protection circuit. Overheat detection with 75 ° C normally closed contact relay K1. In the main power circuit IGBT, rectifier diodes near the heat sink are equipped with normally closed contact relay, several relays in series. Relay K1 closes to ground when temperature below 75 ° C in the heat sink , the optocoupler U3 diode conduction, excitation conduction secondary transistor, optocoupler U3 pin 6 clamped low, that is, overheat protection circuit Output RA1 is low. When the temperature of the heat sink reaches 75 ° C, the relay K1 is disconnected, the diode in the optocoupler U3 is turned off, the pin 6 of the optocoupler U3 goes high, that is, the output RA1 of the circuit is high, indicating that the system is overheated. STM32F103RBT6 detects that RA1 is high and locks the PWM drive signal until the fault is released and reset.

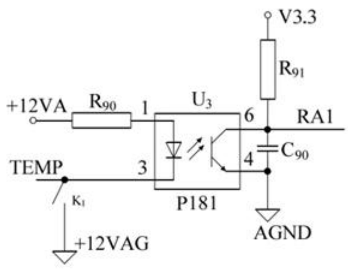

Figure 6 Temperature overheat protection circuit

3.5 communication interface circuit design

The distance between the host computer and the charging pile is relatively far away, and a host computer needs to control several charging piles. So there is the serial communication RS485 interface circuit between charging pile control system and the host computer, STM32F103RBT6 chip and M453VE6AE chip communicate with RS485 communication mode, the communication between the two chips baud rate of 9600, 8 data bits , 1 stop bit, no parity bit. Which M453VE6AE chip control panel is the main equipment, STM32F103RBT6 chip control board is the slave. Specific RS485 interface circuit shown in Figure 7.

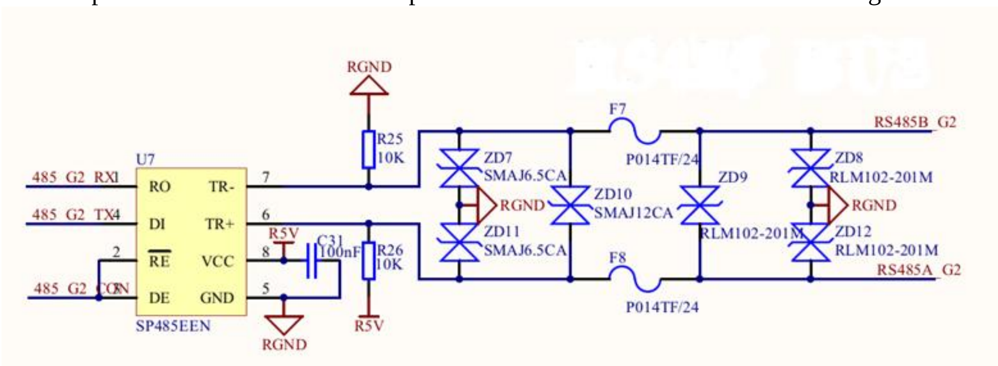

Figure 7 RS485 interface circuit

M453VE6AE chip and display communicate with the use of RS232, maximum communication speed of RS232 is 19.2K / s, which meet the system design requirements. The system uses half-duplex communication mode, and through the level conversion chip SP3232E M453VE6AE and display the level of the agreement, the specific RS232 serial communication interface circuit shown in Figure 8.

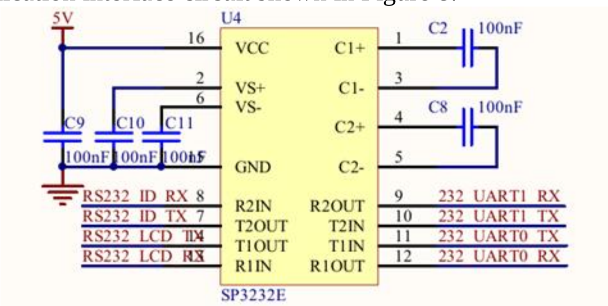

Figure 8 RS232 serial communication interface circuit

M453VE6AE chip has a CAN communication. It is CAN2.0B communication protocol between module.Charging pile and BMS communication network . During the charging process, the charging pile and BMS monitor the voltage, current and temperature parameters, while the BMS manages the entire charging process. The CAN communication network between the charging pile and the BMS shall be composed of the charging pile and the BMS two nodes. Data transmission using the low byte to send the first format, charging pile and BMS communication between the rate of 250Kbit / s. CAN bus because of its fast, low price, simple wiring and other advantages are widely used, CAN bus interface circuit shown in Figure 9.

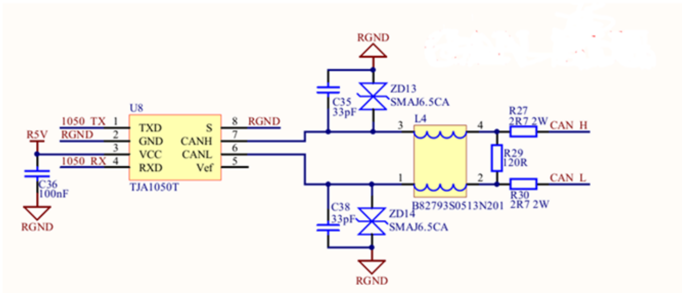

Figure 9 CAN bus interface circuit

IV. CHARGING PILE TEST

When the user needs to charge, the electric car stopped at the station fixed charging position, the specific charging process is as follows:
1, the initial state (power control board does not work, the cooling fan does not turn, LED display does not light, the screen shows standbyScreen).
2, the charging gun into the car (the screen shows "please go to the console to confirm the charge").
3, the console control charging (LED indicator light, charging gun lock, the screen display charging screen, cooling fan work, power control board work).
4, the end of charging (power control board to stop working, the screen shows the completion of charging screen, LED indicator light does not shine, charge gun lock unlock, cooling fan to run for 2 minutes).
5, unplug the charging gun, plug into the charging pile seat. (The screen displays the standby status screen, the fan runs for 2 minutes to stop).

After the field test, electric vehicle charging pile can fully meet the requirements of fast charging, the screen can display real-time charging voltage, charging current, start SOC, the current SOC, prepaid power and other information, the user can easily see the information, field test Indicating that the electric vehicle intelligent charging pile running in good condition.

V. CONCLUSION

This paper introduces the overall design of the station-type charging pile control system, and describes in detail the hardware circuit of the control system. The hardware circuit mainly includes output voltage sampling and signal conversion circuit, output current sampling and signal conversion circuit, IGBT drive circuit, over temperature protection circuit, communication interface circuit. The M453VE6AE is used to receive the control commands and parameters set by the battery management system and the host computer. At the same time, the charging voltage, charging current, charging mode and other information obtained from the battery management system to the STM32F103RBT6, thus controlling the charging power module to charge the electric vehicle. STM32F103RBT6 sent the charging pile parameters to the M453VE6AE,that can communicate with BMS.On the other hand, the data acquisition and calculation of the charging pile are carried out, and various algorithms and combinational logic are programmed and have a large number of registers and I / O resources, which can respond to the fault information of the charging pile. After testing, the charging pile can meet the charging requirements.

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