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Design and Research of Power Battery Temperature Control by PLC

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Abstract: With the increasingly serious environmental pollution, electric vehicles are more and more favored by people, its power battery temperature control is an important premise to ensure driving safety. At the same time, with the gradual advancement of automobile intelligence and fully automatic driving program, the use of more powerful, more compatible controller has become an important research direction. In this paper, S7 200 Smart PLC, which is currently mature in the field of rail transit and industrial control, is used as the control core to build the hardware platform. Step 7-Microwin Smart collaborates with Kingview software to develop the control algorithm and interface, so as to realize the purpose of power battery temperature control and human-computer interaction. It has high research significance.

Keywords: Power Battery Temperature Control; S7 200 Smart PLC; Kingview.

1. Preface

With environmental pollution becoming more and more serious, electric vehicles are gaining more and more people's favor. As one of the "three major electric" systems of electric vehicles, the energy storage battery is not only related to its driving range, but also crucial to driving safety. At present, with the frequent occurrence of spontaneous combustion of electric vehicles, safety issues such as thermal runaway have become the research focus of electric vehicle manufacturers and major scientific research institutions [1].

At the same time, with the development of automobile intelligence and fully automatic driving program, higher requirements are put forward for the safety, compatibility and data processing ability of automobile controller [2].

In this paper, S7 200 Smart PLC controller, which is widely used in the rail transit industry and industrial control field at present, is adopted to control the start and stop of the battery cooling fan motor by collecting the battery inlet temperature signal, and finally the battery temperature is controlled within a reasonable range [3], thus realizing the power battery inlet air temperature control process. At the same time, Kingview software for interface design, human-computer interaction. Through software and hardware co-development, the temperature control design of power battery is realized. After verification, it has good operation effect.

In the hardware part of the design, Siemens S7-200 Smart SR20 CPU was selected as the controller, and the EM AM06 analog input/output interface module received the temperature signal. Pt100 temperature sensor is selected for battery inlet temperature detection; 14.8V 2200mAh lithium iron phosphate power battery pack is used for energy storage battery simulation; ZD large DC deceleration motor is used for battery cooling fan motor simulation; in addition, UTP1305S DC regulated power supply, motor self-locking knob control box, RXM2AB2JD intermediate relay and other devices are used to realize equipment power supply and motor controller, and jointly complete the construction of hardware platform.

The software part of the design, with S7-200 Smart PLC equipment STEP7-MicroWin Smart computer programming software and Kingview interface software collaborative development, to achieve the battery intake temperature automatic control and interface display effect. Among them, STEP7-MicroWin Smart to realize the battery intake temperature control algorithm and PLC online monitoring function. Kingview is used to monitor the implementation of the interface and realize human-computer interaction.

2. Hardware Equipment Selection

The S7-200 Smart SR20 is a Siemens compact CPU module powered by 220VAC and output by relay, which can directly drive the relay contact action. Comes with 12 switch input and 8 switch output, with RUN, STOP and stop, fault alarm ERROR prompt instruction, can use network cable and monitoring programming host to achieve Ethernet communication. The upper computer can realize programming, downloading, operation control, real-time monitoring and other functions through the STEP7 MicroWIN SMART program [4].

EM AM06 analog input/output module uses 24VDC power supply and has four analog input ports and two analog output ports. The module can collect 0 ~ 5V, 1 ~ 5V, 4 ~ 20mA and 0 ~ 20mA current signals, which is fully matched with the 4 ~ 20mA output of the thermal resistance sensor adopted in this design.

Figure 1. Hardware physical picture

The inlet temperature of the battery is collected by Pt100 temperature sensor, and a 4 ~ 20mA transmitter output module is installed to realize real-time monitoring of the inlet temperature of the battery.

The battery cooling fan motor adopts ZD large 6-300W DC brush motor, which adopts 60 boxes, power of 10W, 24VDC power supply, and speed of 360 revolutions per minute.

The energy storage battery uses 14.8V2200mAh 4 series 1 parallel pattern lithium iron phosphate power battery pack as its simulation product.

The main hardware products are shown in Figure 1.

3. Hardware Design

The Pt100 thermal resistance is used to collect the inlet air temperature signal of the battery and send it to the No.1 terminal of the EM AM06 analog input module. The temperature signal is transmitted by EM AM06 to the SR20 CPU. The SR20 CPU outputs the control command to the relay according to the temperature signal, which controls the opening or closing of the cooling fan motor. The programming PC communicates with the SR20 CPU through network cables. EM AM06 and Pt100 temperature sensors are powered by a UTP1305S DC regulated power supply with 24VDC output, and relays are powered by a UTP1305S DC regulated power supply with 12VDC output. At the same time, a heating device is used to heat the battery and simulate its overheating process. The hardware connection design is shown in Figure 2.

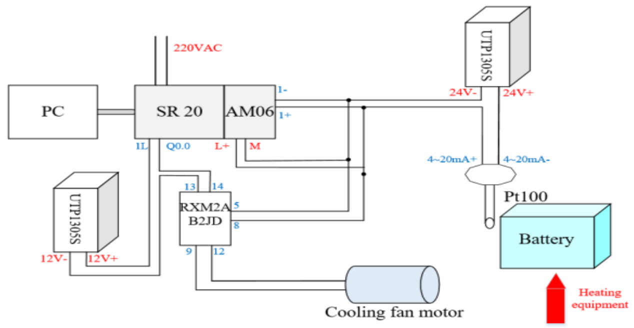

Figure 2. Hardware connection design

4. Software Introduction

The purpose of software design is to use STEP7-MicroWin Smart and Kingview software co-development, to achieve the effect of automatic control of battery intake temperature and interface display.

Among them, STEP7-MicroWin Smart is the S7-200 Smart PLC device control software dedicated by Siemens company. Using this software, it can easily realize the writing, compilation, download of the battery intake temperature control algorithm, as well as the PLC online monitoring, starting, stopping control and other functions.

Kingview is a special interface development software developed by Wellintech, which can realize data communication with S7-200 Smart PLC and visually display information such as battery temperature and motor running state to realize man-machine interaction.

Kingview does not contain drivers that directly communicate with S7-200 Smart devices. Therefore, you need to download the S7_TCP [60.15.44.30] driver from its official website, rewrite it, and install it in the Kingview installation directory [5].

The rewriting method of this design is to replace the contents of the kvS7200.ini file in the driver with the following text:

```
[192.168.2.1:0]
/SMART
LocalTSAP=0200
RemoteTSAP=0200
TpduTSAP=000A
SourceTSAP=0009
```

5. Control Program Design

STEP7-MicroWin Smart control program design according to the following steps.

1. Hardware configuration. Hardware configuration of the system block, Add the SR20 CPU and EM AM06 analog module to the hardware device.

2. Communication configuration. Select the network card connected to the PLC device and configure the communication address of the SR20 CPU by manually adding or scanning the CPU. In this case, 192.168.2.1 is used as its IP address.

3. Program writing. STEP7-MicroWin Smart design and implement 4 ~ 20mA analog signal from the No.1 terminal of analog input/output module EM AM06, and convert it into the battery intake air temperature through data. The data address of terminal 1 is AIW16. When the intake air temperature is higher than 40 ° C, the temperature is considered to be too high and the cooling fan motor is started to dissipate heat for the battery. Otherwise, stop cooling the fan motor. According to the design purpose, the control flow is determined as shown in Figure 3.

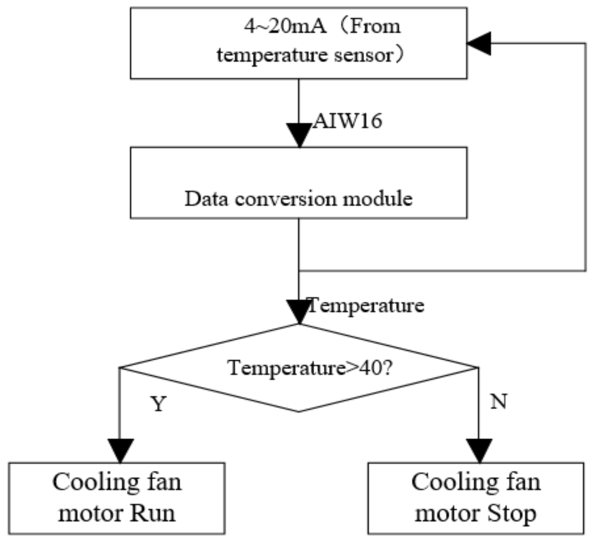

Figure 3. Control flow chart

According to formula (1), the subprogram Data conversion module is designed to convert the 4~20mA analog signal collected by the data into the inlet temperature signal of the quantity battery.

$$\text{Current value of the quantity} = \frac{\text{Upper limit of analog volume - Analog volume off line}}{\text{Quantity upper limit - quantity off line}} \times (\text{Analog volume Current volume - analog volume offline}) + \text{quantity off line} \quad (1)$$

Design the main program to achieve the intake temperature signal and threshold comparison and cooling fan motor start and stop output function. The 4mA data type is Real and the SR20 CPU value is 5530. The 20mA data type is Real and the SR20 CPU value is 27648.

In addition, to increase the readability of the program, I/O symbols are defined for the program as shown in Table 1.

Table 1. I/O symbol table

Symbol	Address	Comment
Battery Inlet temp	AIW16	Battery intake temperature
Cooling fan motor	Q0.0	Battery cooled fan motor

After the symbol table is added, the main program is designed using the T-chart. Wherein, the subprogram Data conversion module is called to convert the 4~20mA signal into the 0~300°C temperature signal. Floating-point comparison instruction [6] is used to compare the temperature parameter with the threshold of 40°C. When the threshold is higher, the cooling fan motor is turned on; when the threshold is lower, the cooling fan motor is turned off.

The main program is shown in Figure 4

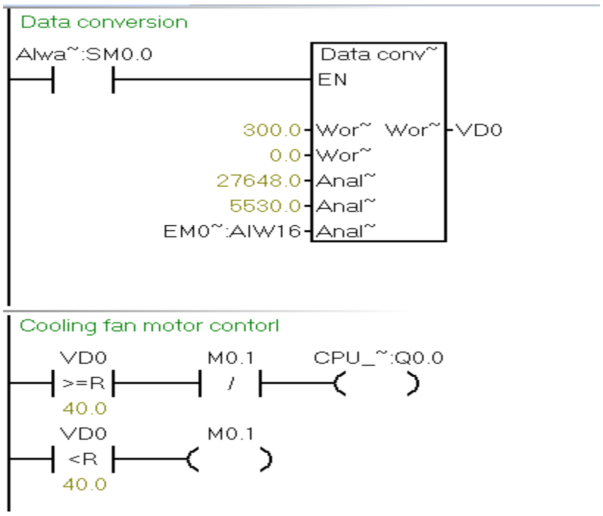

Figure 4. Main control program

4. Program compilation, download and operation.

6. Kingview Design

Kingview software design follows the following steps.

1. Add devices. Kingview can be linked with PLC device, the key is to add a logic device with the same IP address as PLC device. You can click "Device" on the interface, select "COM2" on the displayed port, click "New" to select "PLC", select "Siemens→S7200 (TCP)", name the device "S7200Smart", and set the communication address of the device as (190.168.2.1:0).

2. Add data. The interface drawn by Kingview can realize real-time dynamic display and control of data with PLC equipment. It is necessary to add the same data as the data address in the data dictionary. You can create data by going to "Database" → "Data Dictionary".

When adding data, you need to set the variable name, variable type, connected device, register, data type, and read and write properties of the data. Here, name the battery intake air temperature data as BatteryInletTemp, the variable type is I/O real number, and the connected device is S7200Smart added in Step 1. Select the register address VD0 in STEP7-MicroWin Smart (abbreviated as V0 in Kingview). The read and write property is set to Read-only. Add cooling motor data in the same way. In addition, auxiliary variables are added in order to realize alarm information and dynamic display.

3. Picture production. Click "Picture" → "New" to add the picture, name the picture, and set the location, size, background color and other properties.

Insert temperature display instrument, cooling fan motor, text and other elements on the screen. Click the added pixel to enter the "Animation Connection" interface, and select "analog value output connection", "hidden" and other options to associate with the data added in Step 2 to realize the dynamic display effect of the pixel. Finally, the power battery temperature control monitoring screen as shown in Figure 5 is formed.

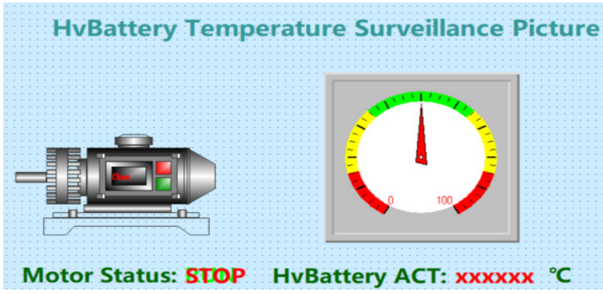

Figure 5. Monitoring screen

7. Run

Connect the hardware device according to the schematic diagram, connect the programming computer to the SR20 CPU with the communication network cable, and adjust the voltage regulator output parameters of relay output to 12VDC, and the voltage regulator output parameters of AM06 and temperature transmitter to 24VDC to supply power to the device.

Heating equipment is used to slowly heat the lithium iron phosphate battery pack, and observe the operation of the motor and the display of Kingview interface.

When the battery intake temperature is lower than 40°C, the cooling motor will not run. At this time, Kingview monitoring interface is shown in Figure 6.

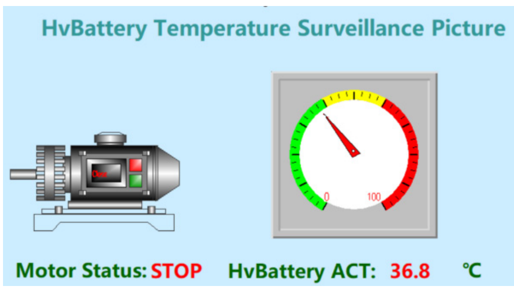

Figure 6. Normal intake temperature

When the battery intake temperature is higher than 40°C, the cooling fan motor starts. The battery is cooled. At this point, the Kingview monitoring interface is shown in Figure 7.

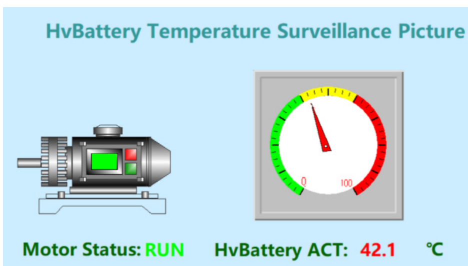

Figure 7. The intake temperature is too high

8. Conclusion

This design uses S7-200 Smart SR20 CPU as the control core, and adopts the way of software and hardware co-development to realize the development process of simulation control of power battery overheating protection. After the hardware verification, the whole function of the system is complete, the operation result reflects well, and the expected design goal is achieved.

At present, the battery temperature control of new energy vehicles is mainly realized by single chip microcomputer or embedded system. In this study, a powerful and compatible PLC system in rail vehicles and industrial control is adopted to realize the overheat protection control of batteries, which provides a new research direction and ideas for the thermal management of power batteries and the intelligent and networked control of vehicles.

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