Software Design of Motor Controller Test System for New Energy Vehicles

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Abstract: In order to read and write the motor controller parameters, download the motor controller program and make the upper computer interface display the running state of the new energy vehicle drive system. This paper designs a serial communication host computer software using Modbus communication protocol and Ymodem communication protocol. The CAN bus interface is provided by the motor controller. The PC is connected to the CAN bus interface of the controller through USB to realize the communication hardware connection between the upper computer and the lower computer. MFC development framework and C++ programming language are used to complete the development of the upper computer software in Visual Studio 2015. Through the analysis of CAN Bus Analyzer and motor test bench, it shows that the upper computer software runs stably and can correctly read the motor controller parameters and send data to it. The design meets the expected requirements.

1. Introduction
In recent years, with the rapid development of power electronics and microelectronics technology, new motor control theory is proposed and improved, permanent magnet synchronous motor controller has been widely developed. The vehicle drive system composed of permanent magnet synchronous motor and its controller is the core of new energy vehicles. However, there are many complex and variable parameter variables in the drive system of electric vehicles. The control of these parameters determines the safety, operability and energy saving of new energy vehicles.

In order to let the electric vehicle tester to test many electric vehicle drive systems quickly and conveniently. In this paper, a kind of host computer with slave address selection function is designed, which can be used to debug the lower computer of multiple controllers while connecting multiple controllers through parallel can bus. In the main window interface, 193 kinds of vehicle driving system parameters reading and modifying functions are provided. In the debugging window interface, six working modes including throttle mode, torque mode, speed mode, code disc adjustment mode, angle self-learning and current closed-loop are provided.

The new energy vehicle motor controller upper computer designed in this paper perfectly solve the problems of incomplete function and less parameter supply of general motor controller upper computer.
2. Overall scheme design of test system

2.1 Overall structure of the system

The host computer of electric vehicle motor controller designed in this paper is a controller software system combining serial communication technology and embedded technology. Its structure is shown in Figure 1.

According to figure 1, the system is mainly composed of PC software, USB-CAN converter, power supply, motor controller, etc.

Send the message to the upper computer and change the main parameters of the controller to display. At the same time, the software also supports the user to download the controller program. Only by preparing the binary files required by the controller, the upper computer can automatically complete the handshake and program loading with the controller by selecting the file by the upper computer. USB-CAN converter can convert can bus interface to USB interface, which can realize stable two-way communication of industrial field data. The power supply is mainly for the motor controller power supply, the motor controller function is to control the motor.

3. Software design of upper computer

3.1 Function module structure of upper computer

The functional module structure of the upper computer software of the motor controller is shown in Fig. 2. The main window interface consists of: upper computer system initialization, manual loading configuration file module, serial communication module, controller program download module, motor parameter reading module and motor parameter writing module. When you click the debug button in the main window interface, the non modal debugging interface window will pop up, which mainly consists of timer automatic reading module, working state indicator module, and motor parameter writing module under different working modes.
3.1.1 Serial communication module
In the serial port parameter setting window, the user can set the serial port number, baud rate and slave address. The upper computer has built-in three kinds of serial communication parameters by default, which are 8-bit data bit, no parity check and 1-bit stop bit, which are used to simplify the configuration process of user's serial port parameters. The serial port number and baud rate can be configured according to the actual use value. When multiple motor controllers are debugged in parallel with CAN bus, the debugging of different motor controllers can be achieved by switching the slave address.
3.1.2 Controller program download module
The function of downloading controller program adopts the Ymodem communication protocol, which is evolved from Xmodem protocol. It is a very efficient file transfer protocol. When the slave address and the file to be downloaded are selected, the upper computer will send the corresponding character request handshake according to the slave address. The lower computer receives the message reply character "C" and the two sides shake hands successfully.

The data structure of the start frame is shown in Table 1. 00 and FF represent the sequence number of the data frame and reverse the serial number of the data frame respectively. Then enter the file name and file size, both ending with 00. The null part represents 128 bytes of data. After removing the file name and file size, the remaining part is filled with 00. The last two bytes are CRC check, so the start frame has 133 bytes in total.

The structure of the data frame is shown in Table 2. X is an int type number. Starting from 1, each frame data is incremented once, indicating that the data frame number and the data frame number are inverted. Then there are 128 bytes of data and two bytes of CRC, so there are 133 bytes in the data frame. When the remaining transmission data or file size is less than 128 bytes, the remaining data is filled with 0x1a.

The structure of the end frame is shown in Table 3. The frame order is 00 FF, and all 128 bytes are filled with 00. Add two bytes, CRC check a total of 133 bytes.

| Symbol | numerical value | meaning                        |
|--------|-----------------|--------------------------------|
| SOH    | 0x01            | 128Byte data frame             |
| STX    | 0x02            | 1024Byte data frame            |
| EOT    | 0x04            | End transmission (sender)      |
| ACK    | 0x06            | Successful receiver            |
| NAK    | 0x15            | To fail to accept (a recipient) |
| CA     | 0x18            | Transmission aborted           |
| C      | 0x43            | Handshake successful, ready to receive data (recipient) |
| File Name | -                | Download file name             |
| File Size | -                | Download file size             |
| CRCH   | -               | CRC check high byte            |
| CRCL   | -               | CRC check low byte             |

3.1.3 Motor controller parameter reading and writing module
The running state parameters of new energy vehicle drive system are mainly stored in the register of motor controller. So as long as the motor controller parameters read and write, we can achieve the test of the whole vehicle drive system. Modbus communication protocol is used in the module of parameter reading and writing.
Modbus communication protocol is a kind of serial communication protocol, which is also the most commonly used communication protocol in industrial field. This motor controller upper computer Modbus communication protocol PC sends ID: 0x602, PC receives ID: 0x6d2.

Table 2. Modbus send and return frame

| Data0 | Data1 | Data2 | Data3 | Data4 | Data5 | Data6 | Data7 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | n     | addrH | addrL | 0     | nums  | CRCH  | CRCL  |

Table 3. Modbus Sending multiple frames of data

| Data0 | Data1 | Data2 | Data3 | Data4 | Data5 | Data6 | Data7 | Data8 | … | Data(n-1) | Data(n) |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|------------|---------|
| 1     | 16    | addrH | addrL | 0     | nums  | 0     | data1H| data1L| …| CRCH       | CRCL    |

Table 4. Modbus Parameter information return frame

| Data0 | Data1 | Data2 | Data3 | Data4 | Data5 | … | Data(n-1) | Data n |
|-------|-------|-------|-------|-------|-------|---|------------|--------|
| 1     | 3     | bytenums | data1H| data1L| data2H| …| CRCH       | CRCL   |

When reading the data, the software will make n = 3 send the message according to the communication protocol in Table 4. After receiving the message, the controller will send its own parameter information message to the upper computer according to the communication protocol in Table 4. The upper computer displays the corresponding parameters in the main window interface of the software through data type conversion.

When downloading data, the software will send message to the controller according to the communication protocol in Table 3. After receiving the information, the controller will make n = 16 send the message of writing multiple data return frames to the upper computer software according to the communication protocol in Table 2. The host computer checks the returned frame. If the check is passed, it will prompt that the download is successful. Otherwise, it will prompt that the download is wrong.

3.1.4 Adjustment interface module

The debugging interface is mainly composed of three parts: timer automatic reading module, working state indicator module and motor parameter writing module in different working modes.

The function of the timer automatic reading module is to click the debugging button in the main interface to enter the debugging interface of the upper computer software. After that, the upper computer software will cycle to read the motor controller parameters every 0.5 seconds and display on the debugging interface. When the debugging interface is closed, the time cycle will stop. So that the operating parameters of new energy vehicle drive system can be continuously displayed.

Working state indicator in the upper right corner of the debugging interface, through the red and green two kinds of indicators to visually tell the user whether the motor controller is normal operation, and whether there are faults and warning errors.

The upper left corner of the debugging interface will display the current working mode of the controller. When the user switches the tab, the upper computer software will send a message to tell the controller what mode it should be in and wait for the data to be accepted. The user can only switch the working mode of the motor controller when the motor controller enters the mode switching state through the start stop button. Then click the set button to input the target parameter value of the motor in different working modes to realize the debugging of the motor.
4. Conclusion
The upper computer of electric vehicle motor controller can provide real-time display of motor driving system parameters. It is widely used in motor controller development and testing. The upper computer of motor controller designed in this paper can greatly improve the efficiency of testing motor controller. C++ programming language and MFC development framework are used to complete the development of host computer software on Visual Studio 2015 development kit. The data communication between the upper computer and the lower computer is completed by CAN bus, MODBUS communication protocol and Ymodem communication protocol. The software of the same kind of electric motor control system can meet the requirements of similar motor control system. The test results show that the software runs stably and the design meets the requirements.

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