Design and Research on Air Conditioning Control Network of Electric Vehicle Based on CAN-bus

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Abstract- **The design of the electric air-conditioning CAN bus communication system makes a target of electric vehicles in order to form digital control network of a number of electronic control unit in electric vehicles, develop electric vehicles CAN (Controller Area Network) bus system, adopting communication protocol SAE J1939; the use of microprocessor STC12C5A60S2 complete design of CAN bus interface circuit; The digital simulation of virtual bus is realized by hardware, then the system was equipped a car with to test its Performance. Test results show that the system works stable, has strong anti-jamming ability, and can meet the real-time communication and integrated control requirements.**

Key words- CAN bus; electric vehicles; electric air conditioning; control network;

I. INTRODUCTION

With the continuous development of automotive technology and the increasingly high demand for automotive performance, more and more automotive electronic control units are installed. The use of CAN bus to form a network of vehicle electronic control units have become a research hotspot in automotive electronic field both at home and abroad.[1]

With reference to SAE1939, the CAN agreement used in this system has 29-bit identifier of the Extended Frame and its communication rate reaches 250 k bit/s. Due to the serious electromagnetic interference, in order to ensure the safe communication between various components, this paper designs a network application layer protocol which meets electric vehicle control requirements, and gives a hardware and software implementations, as well as conducting experiments.

II. HARDWARE DESIGN OF INTELLIGENT NODE BASED ON CAN-BUS

A. Overall Structure

The system focuses on the application CAN bus in the electric vehicle air-conditioning control network. The network is mainly composed of vehicle air-conditioning sensors, electric air-conditioning compressor, throttle servo motor and heated windshield. In accordance with the function, these components can be divided into sensors and actuators.

Based on control method, the system designs a central node and three slave nodes. The slave nodes are: node 1 installed in the front left side of the vehicle, node 2 installed in the rear middle part of the vehicle and node 3 installed beside the compressor. Slave node 1 controls 6 throttle servo motors and the front heated windshield glass, slave node 2 controls the rear windshield glass, and slave node 3 controls electric air conditioner compressor.

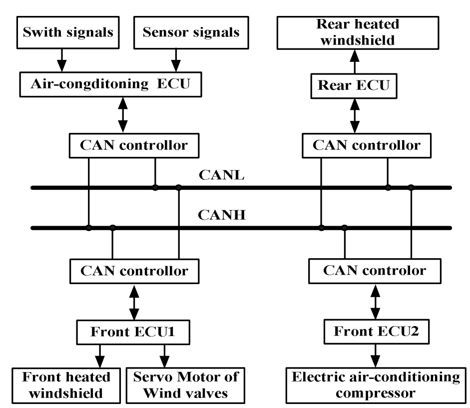

Fig.1.Overall structure of the Electric air-conditioning control network

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The central node mainly receives the driver's operating instructions and the sensor signals, and sends the control instructions to the three slave nodes through the CAN bus. On receiving the control instructions sent through the CAN bus, the slave nodes control the corresponding actuators after judging them. The structure of air-conditioning control network is shown as Figure 1.

B. Hardware Design of CAN-bus Node

Intelligent node hardware circuit block diagram of CAN bus system is shown in Figure 2 and Figure 3 below.

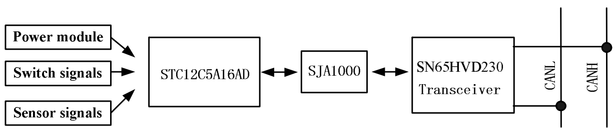

Fig. 2.Schematic diagram of the central node hardware circuit

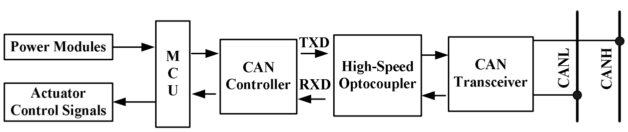

Fig. 3.Schematic diagram of the hardware from the node

1) Main components

STC12C5A60S2/AD/PWM Series MCU is a product of STC®, a microcontroller with single-crystal clock/machine cycle (1T). High-speed, low power consumption and powerful anti-jamming are the features of this new generation of 8051 MCU. Instruction code is completely compatible with the traditional 8051, but 8-12 times faster. Besides the dedicated internal integration MAX810 reset circuit, it has 2-way PWM, 8-Channel High Speed 10-bit A/D converter (250K/S). It is fit for motor control and strong interference sites.

Controller SJA1000 is used for CAN communications. CAN controller SJA1000 is the latest product of PHILIPS which both supports CAN2.0B and CAN2.0A CAN controller. As to hardware and software, it is fully compatible with the independent CAN controller 82C200 which only supports CAN2.0A.

SN65HVD230 is 3.3V CAN bus transceiver, a production of TI®. The device has a strong ability of anti-common-mode interference and anti-electromagnetic interference. Therefore, it can be used in high-jamming environment and has a good capability for sending and receiving the CAN transmission of various rates.[2]

2) Design focus

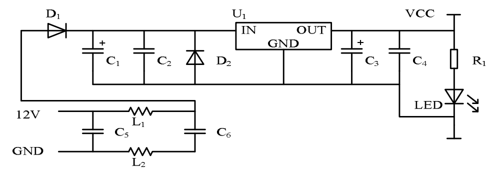

Fig. 4. Voltage Regulator and Transformer Circuit

The key to the design of automotive control network is high reliability, while the power output of the electric car is very unstable. With the decrease of the electricity quantity in battery pack, the power supply voltage lowers too. The voltage fluctuates with the connecting and disconnecting of powerful electrical appliances, which affects MCU greatly and causes the program to crash or run fly.[3] Therefore, voltage stabilizing circuit is installed in each node to ensure the normal operation of CPU. Voltage stabilizing circuit and transformer circuit are shown in Figure 4.

CAN controller SJA1000 is connected to the physical bus through bus driver PCA82C250. PCA82C250 provides differential transmitting capability to the bus and differential receiving capability to CAN controller, and differential driving helps control instantaneous interference in harsh automotive electrical environment.

In order to enhance the anti-jamming ability of CAN-bus node, TX0 and RX0 of SJA1000 are not directly connected to the TXD and RXD of SN65HVD230, but connected to the 82C250 through high-speed optocoupler. Thus electrical isolation is realized between the transceiver and controller, and the core circuit of intelligent nodes can work safely, and the electrical isolation is also realized among the nodes of CAN bus.

In order to further enhance the anti-jamming capability, parallel bi-directional voltage regulator tubes are connected with the entrance of the bus, which can restrict the short over-voltage spikes which may occur in circuit and increase common-mode rejection coils in order to eliminate common-mode signal interference. In addition, when the communication signals are transmitted in the circuit, reflection will occur when the signals reach the conductor endpoint, which will interfere with the transmission of normal signals. To eliminate this influence, two parallel 120Ω resistances are connected to the two ends of CAN bus, which can play the dual role of matching bus impedance and eliminating reflection. The neglect of these measures will greatly reduce the anti-interference ability and reliability of data communication, or even make data communication impossible.[4]

III. Software Design of Intelligent Node Based on CAN Bus

The system's software design consists of the signal acquisition software design on the host computer, the human-computer interaction software design of air-conditioning ECU.

The software design of air-conditioning control system includes the design of intelligent nodes and the compressor control. Intelligent nodes play the role of completing the initialization, temperature sampling, receiving the master node's control command and sending the relevant data, such as the maximum power of the air-conditioning system, etc., detecting air-conditioning switch state and setting temperature, sending operating frequency signal and starting signal to the air-conditioning controller, detecting the operating state of the compressor and fault processing. The compressor controller functions to generate the driving signal of compressor, process position detection signal and receive the air-conditioning start-stop signal and running frequency from smart nodes. Due to the limited space, the essay only studies the programs of the control nodes. The main program flow chart of Control node is shown in Figure 3.

A. CAN Node Configuration

In the software design of CAN bus system, the communication part with the Main Controller is the focus. SJA1000 CAN communications operates mainly through the basic function configurations and interrupt configurations. The basic function configurations of CAN include the following aspects:

1) Enable CAN clock work, configuring the I/O pins;

2)Waiting for CCE set, and beginning to configure the bit timing control registers (CANBTC);

3) Configuring the master control register (CANMC), initializing MSGCTRLn register;

4) Finishing the initialization configuration, sending requests and receiving configuration.

B. Signal Acquisition Software Design

Signal acquisition software design mainly complete the following work: receiving the instruction sent through the CAN bus from host computer so as to start or stop the acquisition function; During the acquisition, sampling and software-calibrating the four signal as required; After calibration, storing the acquisition results in the CAN-mail, and transmitting through CAN control module.

C. Initialization of CAN controller

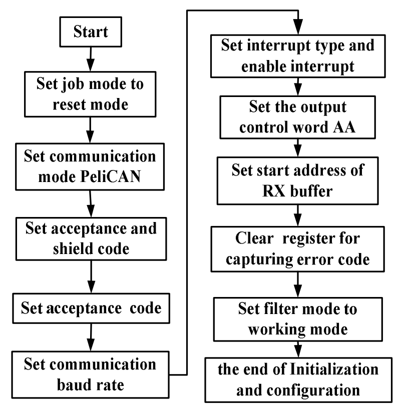

Fig.5. Initialization flowchart of CAN Controller SJA1000

The design of the initial program is the key of whether the system can work properly or not. The content which will be written in the registers must be examined carefully and completely. Otherwise the system will not work smoothly. [5] CAN initialization is mainly to set the parameters of CAN communication, which means determining the working modes of CAN controller through setting the CAN controller register. Configuring bus baud rate is of great significance, as all CAN nodes must bear the same baud rate in order to work properly. VPBDIV and the PLL registers should also be configured properly. The initialization flow chart of CAN controller SJA1000 is shown in Figure 5.

D. Sending and Receiving Data in CAN Bus

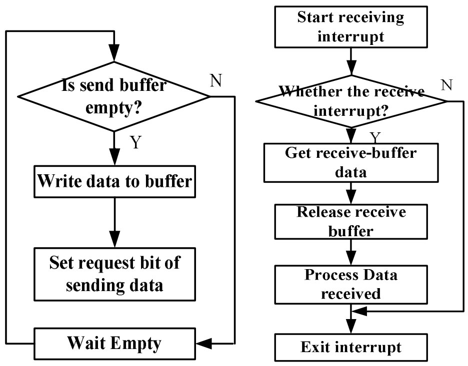

Fig. 6. Sending and Receiving flow chart of CAN bus

Message is automatically sent by the CAN controller, according to the rules of CAN. The main controller must send the message to sending buffer in the CAN controller and set the "sending request ID position" in the command register. The node sends data packets to the bus actively. If fails, it can re-send the data. Therefore, it is relatively easy to deal with the sending part. Querying the control state identifier of CAN controller is suitable. The sending flow chart at query status is shown in Figure 6.

CAN controller automatically receives the message according to the rules, then stores the message received into the receiving buffer. Meanwhile, receiving buffer status flags RBS is set as “1”. Receiving can be realized through the CAN controller interrupt request bit or querying the identity control segments of CAN controller. As the real-time nature of querying the CAN controller receiving status is poor, interrupting method is used to control it. The flow chart of receiving data through interrupt control is shown in Figure 6.

IV. RESULTS

According to the program described above, hardware and software are ready. After detection, Connecting to the power supply, and setting the temperature, the actual output waveforms are obtained as shown in Figure 7. Figure 10 shows the high line and low line are symmetrical, which meet the design requirements.

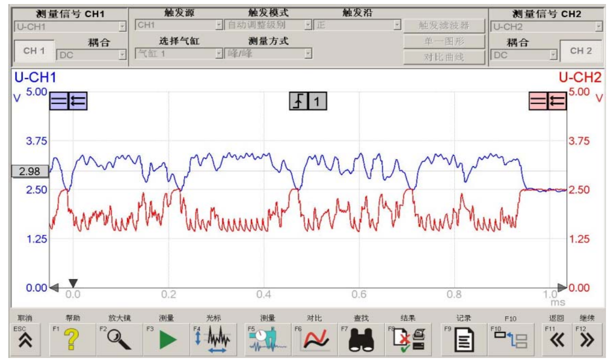

Fig. 7. Waveform of CAN-H and CAN-L

V. CONCLUSIONS

This design enables the electric vehicle air-conditioning control network design based on CAN bus. In the process of communication, a variety of control commands and data transmission are stable and accurate. The results show that the design can transmit commands and data from the vehicle central node to the slave nodes, when the automotive air-conditioning is working. The design focuses on air-conditioning control of electric vehicle, that is to say, it can also be used in hybrid vehicles, pure electric vehicles and fuel cell vehicles. A complete CAN communication network can be established by expanding the number of CAN bus-connected nodes according to different site conditions and user requirements.

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