

Design of motor control system for over-current protection inspection and voltage regulating device of explosion-proof electrical appliances

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Abstract: In order to improve the automation level of over-current protection inspection device for explosion-proof electrical appliances, a voltage regulation control system based on AVR microcontroller and motor special driver chip MC33035 is proposed. Based on the introduction of three underground protections, explosion-proof electrical protection functions and AVR single-chip performance, the overall structure of the voltage regulation control system is designed, with emphasis on the design of the voltage regulation position detection unit and the winding current detection unit, and the corresponding software program is compiled.

1. Introduction

Coal is the foundation of China's energy structure and plays an important role in primary energy production and consumption. With the continuous increase of coal mining depth, the underground power supply system continues to extend, and the reliability requirements for underground power supply and distribution and electrical equipment are getting higher and higher. Explosion-proof electrical appliances are the main power transmission and distribution and control equipment underground, mainly composed of explosion-proof enclosures, isolation reversing switches, contactors and protection devices, which are used to control and protect low-voltage motors. Over-current, leakage and grounding of explosion-proof appliances are the three major protections of explosion-proof appliances in coal mines. Over-current protection refers to the protection when the current of explosion-proof appliances exceeds the rated value, including short-circuit protection, overload protection and open-phase protection. At present, the voltage regulation process of over-current protection test adopts manual regulation, which is slow in regulation speed, low in regulation precision, too dependent on staff experience and poor in stability. Therefore, the research on automatic voltage regulation system is a hot spot in the technical field of over-current protection inspection of explosion-proof appliances.

2. ATmega16L microcontroller

The voltage regulation system of overcurrent protection inspection device of coal mine electromagnetic starter selects AVR single chip microcomputer as the core. The single chip microcomputer is an 8-bit processor with low power consumption, high cost performance and complete functions. The single chip microcomputer integrates powerful hardware interface circuit and memory with large storage space. The performance of ATmega16L is similar to that of MEGA series high-end single-chip microcomputers. Due to the pin package structure of DIP40 mode, its price is similar to that of other low-end single-chip microcomputers. The advantages of ATmega16L are as follows:

1. ATmega16L MCU runs fast and has a simple command instruction set structure, which can reach 16MIPS at the highest, which is 10 times faster than ordinary CISC MCU at the same frequency;
2. Atmega16L microcontroller integrates a PWM pulse width modulation signal module with adjustable frequency, which can adjust the phase and frequency of the output signal according to the actual needs;
3. The ATmega16L microcontroller has specific interrupt program permission bits and different interrupt sources. 18 interrupt sources can work independently, which greatly improves the stability and security level of the system;
4. ATmega16L MCU has a large number of nonvolatile data, programs and working memories, which can meet the needs of the system and has external expansion functions.
5. Atmega16L MCU has strong port driving ability and can be programmed to the input / output direction according to the control requirements. Most I / O ports can be used as general I / O ports or as the second function, which is convenient to cooperate with external circuits. At the same time, the output of I / O ports can directly drive high current loads;
6. The timer/counter of ATmega16L single-chip microcomputer not only has conventional timing and counting functions, but also can realize signal comparison, capture and modulation output, and can also perform real-time clock calculation.
7. ATmega16L single chip microcomputer has the function of mutual conversion between digital quantity and analog quantity, and has 8 standard 10-bit ADC conversion ports.
8. Once the program of ATmega16L MCU enters the infinite loop, it can be reset by watchdog circuit, which improves the stability of the system and provides a good guarantee for the safety of the control system.

3. Control system design

The motor control system for explosion-proof electrical overcurrent protection inspection and voltage regulating device adopts AVR single-chip microcomputer and MC33035 combined control (the block diagram is shown in Figure 1), and mainly includes control panel, single-chip microcomputer, drive chip, position detection unit, speed detection unit, PWM modulation Unit, rectifier unit, drive circuit, inverter unit, CAN communication unit and protection unit. The single-chip microcomputer is used to collect and calculate the operation button signal, position detection unit signal, speed detection unit signal, and send control instructions; the drive chip is based on the microcontroller's The control command sends the drive signal, and at the same time receives the speed signal and feeds it back to the single-chip microcomputer; The speed detection unit collect that signal of the position detection circuit and calculates the rotate speed of the motor according to the change of the position signal; The PWM unit is use for adjusting that duty ratio of the control signal and realize the adjustment of the running speed of the motor; The detection circuit is used to detect the motor temperature, voltage, current and other signals, and feed them back to the single-chip

microcomputer to realize real-time detection and dynamic protection of the main operating parameters of the driving motor.

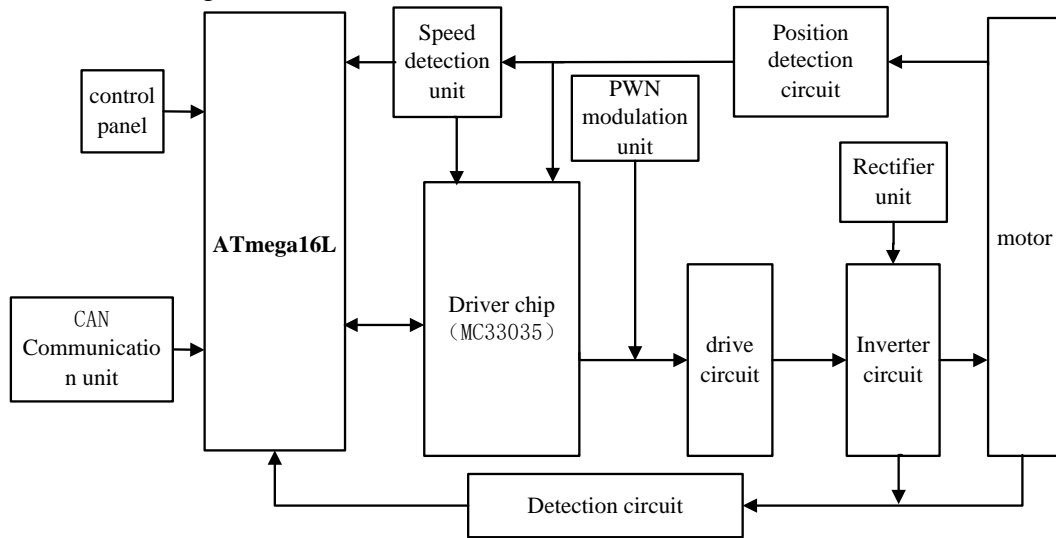


Figure 1: Control structure block diagram of voltage regulation system

3.1 Position detection circuit

The Hall sensor uses the principle of Hall Effect to output high and low level signals according to changes in the external magnetic field. In order to improve the real-time performance of the system and meet the needs of high-precision control, the voltage regulation control system of the mine electromagnetic starter overcurrent protection inspection device uses three latched Hall sensors to detect the position of the motor rotor, and the Hall sensors are fixed on the Hall disk. Its output characteristic curve and spatial distribution structure under different magnetic fields are shown in Figures 2 and 3. When the Hall element is placed in the n-pole (or s-pole), it will be turned on. After the magnetic field is removed, it will continue to be turned on. It will only be turned off when it is placed in the s-pole (or n-pole). Closed state until the next time the magnetic field changes. The Hall sensor senses changes in the external magnetic field and feeds back different signals to the control chip. The control chip calculates the rotor position of the motor and outputs different control signals to determine the turn-on sequence of the IGBT tubes. The drive motor continues to run as required until it receives a stop command.

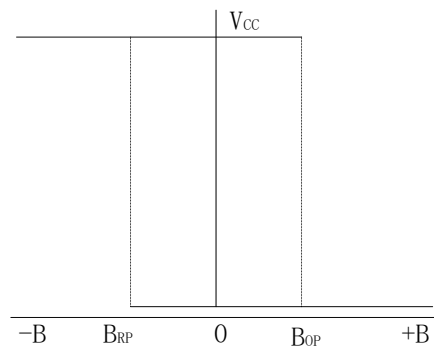


Figure 2: Output characteristics of Hall sensor

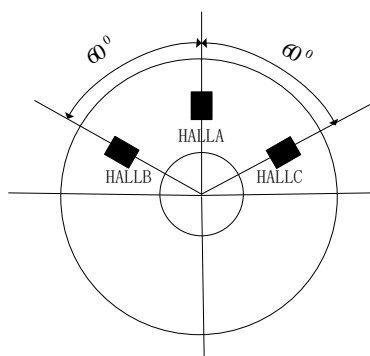


Figure 3: Spatial distribution of Hall sensor

3.2 Current detection

In order to ensure the safety of the control system. To avoid the motor winding current exceeding the current value borne by IGBT, the winding current must be detected in real time. The series voltage dividing resistance method has the advantages of low cost and simple structure, but the temperature drift of the resistance will affect the detection accuracy during the working time of the system. The Hall current sensor is made based on the principle of magnetic balance. It can accurately measure the current in the fluid by measuring the size of the Hall TV. It has the advantages of simple structure, high measurement accuracy, and strong anti-interference ability. Therefore, a high-precision Hall current sensor is used to detect the current of the winding in real time. The signal output by the current sensor is weak, and the signal is amplified by the operational amplifier, and then connected to the A/D conversion chip to convert the analog signal into a digital signal that the single-chip microcomputer can recognize and pass it to the ATmega16L single-chip microcomputer.

3.3 Software programming

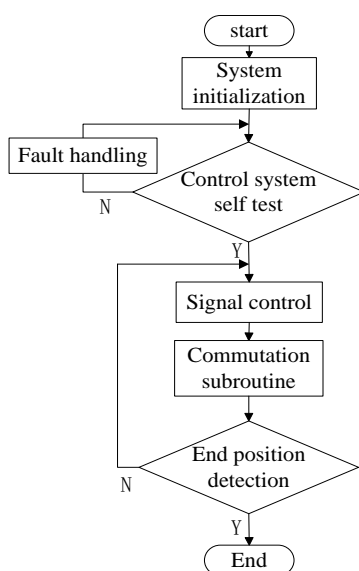


Figure 4: main program flow chart

The voltage regulation control system of the mine electromagnetic starter overcurrent protection inspection device adopts the modular design idea to compile and debug the voltage regulation control

system software program. First, the main program of the control system is designed to realize the initialization of the AVR single-chip microcomputer and the receiving and sending of control commands., System running status detection, feedback signal calculation and processing, motor braking, etc., and then design the CAN bus communication part program, including CAN communication hardware circuit initialization, SJA1000 controller reset, CAN message frame reception and analysis, data frame transmission, etc., Finally, each part of the program is jointly debugged as a whole, and the main program flow chart is shown in Figure 4.

4. Conclusions

With the development of the special action of "Mechanized substitution, robot operation, automatic reduction of people", higher requirements are put forward for the stability and automation level of coal mine electrical products and their inspection devices. The voltage regulation control system of the over-current protection inspection device of the electromagnetic starter in coal mine can adjust the speed of the motor according to the requirements of the control instruction, realize the smooth adjustment of the current of the inspection device, and have the functions of real-time detection of system faults and protection.

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