Real-time online monitoring and protection control system for automobile generator based on artificial intelligence

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Abstract. This paper mainly introduces the shortcomings of the traditional automobile generator control system and the improvement of the defects of the traditional automobile generator control system. This article is divided into seven chapters to describe the design background, design ideas, implementation plans and test results of the intelligent detection and protection system for automotive generators. The first chapter mainly introduces the domestic and international research on the intelligent detection and protection system of automobile generators and the design significance of the intelligent detection and protection system of automobile generators. The second chapter briefly describes the overall design ideas and plans of the intelligent detection and protection system for automobile generators, and proposes the general design direction of the overall system. The third chapter puts forward the hardware implementation scheme of the intelligent detection and protection system of automobile generators. The fourth chapter mainly summarizes the design ideas and design methods of the main software of the system. The fifth chapter mainly sets the parameters of the intelligent detection and protection system of the automobile generator, and reduces the error to the allowable range. The sixth chapter is mainly about the experience and summary of this research topic.

1. Introduction
At present, automobile fault detection is the primary link in the maintenance of automotive electrical systems, and in the automotive power system, the generator also bears the main power output. Therefore, the protection and detection of the car generator has become the top priority of the maintenance of the car power system [1]. Therefore, the research and implementation of intelligent detection and protection system for automobile generators is of great significance for future automotive intelligent control [2-4].

In order to simplify the maintenance process and reduce the accident caused by electrical faults, a scheme of real-time monitoring system with intelligent feedback system is proposed, which uses sensor sampling to display the parameters of three-phase AC motor online and real-time and quickly and accurately when the fault occurs. Ground faults are removed and displayed to minimize locomotive damage.

2. Overview of the overall system design
The system uses DL-PT202G voltage transformer as the three-phase AC motor voltage sampling sensor, and uses the code wheel and the motor speed measuring module based on the wide voltage comparator LM393 to measure the motor speed. The protection circuit uses a JQC-3F (T73) 5VDC type relay as a protection device. The display alarm circuit consists of a liquid crystal display LCD1604, an LED light emitting diode and an active buzzer. The voltage regulation control module intends to use STC12C5A60S2 as the main control core chip of the voltage regulation circuit and digitally process the sampled motor, voltage, current and speed parameters and send it to the main controller through
asynchronous serial communication. The core control chip of the main control circuit uses the PIC18F2580 microcontroller, and the sampled value is processed by the PIC18F2580 microcontroller and the corresponding execution command is issued to the corresponding controlled component. Because the system needs to simulate the generator and the special characteristics of the three-phase relative symmetry of the load, the A2212 brushless DC motor is used to simulate the three-phase AC motor, and the three-phase symmetry requirement of the load is realized by a simple electronic load circuit. The framework of the intelligent detection and protection system of automobile generator is shown in Figure 1.

3. Main hardware design

The hardware circuit of this design is mainly divided into sensor conditioning circuit, protection circuit, analog voltage regulation control module, terminal main control module and electronic load circuit module. The following is the introduction of the main module of intelligent detection and protection system of automobile generator.

3.1. Sensing conditioning circuit

3.1.1. Voltage Sampling Circuit

The voltage sampling conditioning circuit uses the DL-PT202G voltage transformer as the three-phase AC motor voltage sampling sensor, and then converts the AC voltage into a DC voltage of 0~5V that can be detected by the MCU through rectification, filtering and voltage regulation [5]. The voltage sampling conditioning circuit is shown in Figure 2.

![Figure 1 Block diagram of intelligent detection and protection system for automobile generator](image)

![Figure 2 Voltage sampling conditioning circuit](image)
3.1.2. **Current Sampling Circuit**

The current sampling circuit will cause a small voltage drop in the main circuit through the 0.01Ω cement resistor. Then the signal is amplified by using the IN282 current sampling and amplifying special chip. The chip can amplify the voltage by about 50 times. Due to the change of the current through the cement resistor, the changed micro-voltage is obtained, and the changed micro-voltage is amplified to the AD sampling circuit of the single-chip microcomputer to realize the indirect taking of the system current by the single-chip microcomputer. The current sampling conditioning circuit is shown in Figure 3 below.

![Figure 3 current sampling conditioning circuit](image)

3.1.3. **Speed sensing circuit**

The speed sensing circuit is a jump that can generate 0~5V high and low level during the rotation of the code wheel by the photoelectric gate, and then the characteristic of the LM393 voltage comparator makes the output square wave signal more stable and obtain an accurate digital signal. Then the digital signal is sent to the single chip microcomputer, and the single chip computer calculates the square motor frequency to calculate the current motor speed to perform corresponding response action. The speed sensing circuit is shown in Figure 4.

![Figure 4 speed sensing circuit](image)

3.2. **Protection circuit**

The protection circuit is composed of JQC-3F (T73) 5VDC type relay as the main device. The relay can provide isolation and drive protection between the control loop and the single chip in the high voltage and high power occasion. It can be under the condition of 125V AC voltage. Withstands 10A of current and can withstand 7A at 240V AC, it can meet the needs of this graduation project. The protection circuit is shown in Figure 5.
3.3. Electronic load circuit

The electronic load circuit converts the three-phase AC voltage into a DC voltage through a three-phase full-bridge rectifier circuit and a filter circuit. The three-phase current can be balanced by adjusting a load through a simple load circuit [6-8]. The electronic load circuit is shown in Figure 6.

Figure 6 Electronic load circuit

4. System software design and analysis

4.1. Protection Control Algorithm Strategy Overview

The control requirements of the intelligent detection and protection system of the automobile generator need to control and protect the voltage, current and speed of the system [9-10]. In order to make the protection response the fastest, the system compares the sampled value with the threshold value by integrating the various factors, and when the sampled value is the same as the threshold value 50 times, the terminal controller issues an alarm command.

4.2. PIC Configuration Bit Settings Description

Since the terminal controller uses the PIC18F2580 microcontroller as the core control chip, and the PIC18F series MCU defines the configuration method of the relevant configuration bits when it is manufactured by Microchip, the internal code of the microcontroller can be configured through the software code configuration bit, such as the crystal clock, Watchdog, JTAG, power-down detection and code protection. It can be configured through the interface in the MPLAB IDE integrated development
environment in the PIC microcontroller. Only the correct configuration bits can drive the PIC microcontroller to work.

4.3. Main program design
The serial sampling terminal is mainly designed for the STC12C5A60S2 single-chip microcomputer in the analog voltage regulator. The main program of the analog voltage regulator is AD sampling configuration, matrix button design, AT24C02 power-down storage design and asynchronous serial communication software design. The main program flow chart of the serial sampling end is shown in Figure 7.

![Figure 7 Analog voltage regulator main program flow chart](image)

The terminal controller is mainly composed of PIC18F2580 MCU. Since the terminal controller only has an asynchronous serial communication interface pin, the operation of the terminal controller is only responsible for processing the signal of the analog voltage regulator, and controlling the display and issuing control commands. Figure 8 shows the main program flow chart of the terminal controller.

![Figure 8 terminal controller main program flow chart](image)

4.4. Average filter algorithm design
Because of the fluctuation of the circuit voltage, the sampling voltage is greatly deviated. Based on this problem, an idea of using software to perform the average filtering is proposed. The general process framework is to accumulate the sampled data through a cyclic sub-function, and the accumulated sampling data. The average filtered voltage is obtained by the calculation of the average value, by which the error due to system fluctuations is greatly reduced. Figure 9 is a flow chart of the average value filtering algorithm.
5. System parameter setting and results

The sampling value of the intelligent detection and protection system of the vehicle generator and the protection threshold of the system parameters have passed the actual test, which is within the ideal controllable error range. The system transmits data at a speed of 9600 bps, which can basically achieve fast data transmission and complete the basic requirements of system control.

The online monitoring protection control system requires protection alarm control for the set system voltage, current and speed. The system voltage, current and speed protection alarms have been completed through physical construction. And on this basis, add human-computer interaction display and parameter power-down memory storage.

5.1. System Overcurrent Protection Parameter Tuning

According to the requirements of the intelligent detection and protection system of the automobile generator, when the load is short-circuited or over-current, if the over-current is greater than or equal to 1.2 times the set value, the control circuit will automatically turn off the output of the generator to ensure the generator and the electric equipment. Not burned. Table 1 shows the system overcurrent protection parameter setting.

| Overcurrent setting | Overcurrent protection value | Overcurrent action value | Error |
|---------------------|-----------------------------|--------------------------|-------|
| 2.20A               | 2.64A                       | 2.60A                    | 0.04  |
| 1.50A               | 1.80A                       | 1.65A                    | 0.15  |
| 1.10A               | 1.32A                       | 1.10A                    | 0.22  |
| 0.80A               | 0.96A                       | 0.88A                    | 0.08  |

5.2. System Overvoltage Protection Parameter Tuning

The automotive generator intelligent detection and protection system needs to automatically cut off the output and alarm when the output voltage is out of control and the voltage suddenly rises. Table 2 shows the tuning of the system overvoltage protection parameters.

| Speed threshold | Action value | Error |
|-----------------|--------------|-------|
| 100r/s          | 105r/s       | 5     |
| 200r/s          | 210r/s       | 10    |
| 300r/s          | 296r/s       | 4     |
| 400r/s          | 385r/s       | 15    |
5.3. Test results
Through the test of the parameters of voltage, current and speed of the intelligent detection and protection system of the automobile generator, it is found that the over-current protection action value of the intelligent detection and protection system of the generator will operate at about 1.2 times of the set value of the over-current protection of the system, and the error average is 0.15. The left and right floating of the generator intelligent detection and protection system will operate within 0.2 error range of its set value; since the speed is collected by indirect measurement, the low speed alarm action value will be around 13 Error.

6. Conclusion
The main core part of the design is divided into two parts, namely the analog voltage regulation module and the terminal control module. The analog voltage regulation module is mainly composed of STC12C5A60S2, which is mainly responsible for the sampling of the system voltage, current and speed, the control of the protection alarm circuit, the setting of the protection threshold and the power-down memory storage of each system parameter. The terminal control module is mainly composed of PIC18F2580 MCU, which is mainly responsible for the processing of sampling parameters, the control strategy of protection parameter actions and the real-time display of parameters. The analog voltage regulation module and the terminal control module implement data transmission through an asynchronous serial communication interface.

After the actual test, the system displays and protects the parameters of the intelligent detection and protection system of the automobile generator under normal conditions. The parameter monitoring display and protection actions are all within the required range. The entire vehicle generator intelligent detection and protection system can achieve stable work and complete the research requirements of this topic.

However, the intelligent detection and protection system for automobile generators is still an important research topic in the field of new energy vehicles. Today's intelligent control technology for automobile generators still has a long way to go. When people experience the convenient and comfortable built-in environment of automobiles. There will be protection provided by intelligent control technology at all times. The maturity and perfection of the intelligent control technology of automobile generators will have a major breakthrough today in the theme of energy-saving and low-carbon.

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