Design of Comprehensive Protection Device for Mine Isolation Lighting Signal

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Abstract. In order to improve the safety and reliability of underground lighting circuit in coal mine, a comprehensive protection device for mine isolation lighting signal is designed based on the pir-50z intelligent protector. On the basis of the analysis of the status of coal in China's energy structure and mine production safety situation, the mode of lighting and the role of comprehensive protection device for mine isolation lighting signal and were studied, the detailed design of comprehensive protection device for mine isolation lighting signal hardware circuit and software program was carried out.

1. Introduction
With the continuous strengthening of the state's supervision of coal mine safety production and the rapid development of intelligent comprehensive mechanized coal mining technology, the situation of coal mine safety production in our country has been steadily improving, but the factors that endanger the safety production in our country still exist. Potential dangers of underground accidents cannot be completely eliminated, especially due to the increasing mining intensity and depth, the more complicated geological conditions, the continuous extension of power supply and distribution system and transportation system and other factors restrict the smooth development of underground production safety work. Therefore, it is of great significance to carry out the research on intelligent technology of electrical equipment in coal mines and to improve the reliability and safety of power supply and distribution system, transportation system, comprehensive mechanized mining system and auxiliary equipment, so as to ensure the smooth development of underground safe production work and protect the safety of underground workers and national property.

2. Lighting signal comprehensive protection device
Due to the limitation of the working environment in the coal mine, there is no natural light in the production process, so it is necessary to rely on artificial lighting for safe production. The existing underground lighting methods mainly include 127V power supply system and miner's lamp for workers. The 127V power supply system provides power for underground lamps (gas discharge lamp, LED light source, etc.) to realize lighting through integrated lighting signal protection device. The miner's lamp for workers realizes lighting through power supply of lithium battery, etc. The underground mining environment is complex. Whether the underground lighting conditions are in good condition directly affects the quality of coal mining, especially the safety of underground production and personnel. Therefore, the "Coal Mine Safety Regulations" clearly stipulates that underground lighting protection devices must have overload, short circuit and leakage protection functions. The mine flameproof lighting
signal comprehensive protection device is the power supply for 127V lighting and signal load under the coal mine, which meets the requirements of "coal mine safety regulations". The mine flameproof lighting signal comprehensive protection device is shown in Fig. 1.

![Fig. 1 The physical object of a mine flameproof integrated lighting signal protection device](image)

The model of mine flameproof lighting signal comprehensive protection device shall comply with the relevant provisions of MT/T 1123-2011 "Mine flameproof lighting signal comprehensive protection device" and MT154.2 -1996 "Coal mine electrical equipment product model compilation method and management method". Its composition and arrangement are as follows:

| Z | Z | – | – | M | – |
|---|---|---|---|---|---|
| W no contact, using contactor is omitted | Lighting | Rated voltage (V) | Rated capacity of transformer (kVA) | Design serial number (or management number) | Comprehensive protection device |
| B flameproof I flameproof and intrinsically safe | Device |

3. Control System Design

The electrical principle of mine flameproof lighting signal comprehensive protection device is shown in fig. 2, with intelligent protector as the core. It mainly includes fuses, transformers, contactors, sampling resistors, current transformers, voltage transformers, temperature sensors, electromagnetic relays, control buttons and communication interfaces. Fuses are selected according to the current and voltage of the main circuit of the mine flameproof lighting signal comprehensive protection device, and fuse under the condition of instantaneous short-circuit fault in the main circuit to protect the safety of the next level of devices [1]. The transformer is used to convert 1140V voltage of the main circuit into 127V voltage required by the lighting circuit, and is used for supplying power to the lighting circuit. The lower end of the transformer is used to control the on and off of the load. Current transformer, voltage transformer and temperature sensor are used to collect current, voltage and temperature signals and provide original data for intelligent protector. The electromagnetic relay amplifies the signal of the intelligent protector and is used for controlling the contactor. The control button converts external control commands into digital signals and sends them to the intelligent protector [2-3]. The communication interface is used to realize the networking between the mine flameproof lighting signal comprehensive protection device and the monitoring center of the superior, and realize remote monitoring and control.
3.1. Intelligent protector

PIR-50Z intelligent protector is the core of mine flameproof lighting signal comprehensive protection device, which is used to control button commands to be converted into control signals to control the switch-on and switch-off of contactors through electromagnetic relays. At the same time, parameters such as voltage, current, temperature and resistance of the device are collected and processed through calculation, so as to protect and alarm in case of failure, and data communication between the device and the upper monitoring center is realized [4]. PIR-50Z Intelligent Protector has a working voltage rating of 127V, rated frequency of 50Hz, and measurement accuracy of 5%. It has undervoltage, overvoltage, overload, short circuit, leakage lockout, leakage protection, temperature, gas and other protection functions, RS485 four-way communication function, calendar clock, fault memory and inquiry, and menu test function. The PIR-50Z intelligent protector is shown in Fig. 3.

3.2. Current Transformer

Current transformers are used to collect system current parameters and provide raw data for fault protection functions such as overload and short circuit. Since the magnetic circuit has a good linear relationship with the output of the hall element, the current enters from the control end of the Hall element. When a magnetic field is applied in the normal direction of the plane of the Hall element, the Hall electromotive force will generate in the vertical direction of the magnetic field or current, and the magnitude of the Hall electromotive force is proportional to the magnitude of the control current. Hall current sensors are often used in the isolation and conversion of complex signals such as DC, AC and pulse. The output signals of Hall current sensors can be directly received by AD module, digital signal processor (DSP), single chip microcomputer, PLC and secondary instruments. Compared with traditional current transformers, Hall current transformers have the advantages of strong anti-interference capability, strong overload capability, good linearity, high measurement accuracy, etc. In
this paper, hall current transformer is selected as the current measuring device of lighting protection device. the actual object of the transformer is shown in Fig. 3.

![Fig. 3 Current transformer](image)

3.3. Temperature Sensor

According to the system test range and accuracy requirements, DS18B20 is selected as the temperature measuring device of lighting protection device. As a common digital temperature sensor, DS18B20 has the advantages of high test precision, strong anti-interference ability, small volume, etc. The output signal is a digital signal and can be packaged in various forms such as screw thread type, stainless steel type, pipeline type, etc. DS18B20 digital temperature sensor measures temperature in the range of -55°C to +125°C, measuring accuracy is 0.5°C, minimum resolution is 0.0625°C, and power supply voltage is 3 ~ 5.5 VDC. The function operation of DS18B20 sensor is completed on the basis of sending commands. After power-on, the sensor is in an idle state, and the intelligent protector needs to send commands to complete temperature conversion.

3.4. Software Programming

Modular design idea is adopted in the software program design process of mine flameproof lighting signal comprehensive protection device, and the whole software program is divided into a plurality of subprograms such as a main program, an interrupt processing program, a fault processing program, a display program and the like [5-6]. The main program mainly carries out tasks such as system initialization and system self-checking. during the execution of the main program, the timer sends an interrupt at each sampling interval, executes an interrupt subroutine, judges whether the device is running, and returns to the main program if the operation is interrupted. the main program flow is shown in Fig. 4
4. Summary
PIR-50Z intelligent protector is used to control and protect the mine lighting circuit, which can realize the protection functions of under-voltage, over-voltage, overload, short circuit, leakage lockout, leakage protection, temperature, gas and other faults.

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