

# Study on protection of coal mine underground anti leapfrog tripping method

Xiucan Guo<sup>1, a</sup>, Liwei Zhang<sup>1, b</sup>

<sup>1</sup>Xi'an University of Science and Technology, Xi'an, 710054, China

<sup>a</sup>guoxiucan@163.com, <sup>b</sup>zlwj132@sina.com

**Keywords:** Underground power supply; Grade trip; Digital; Differential protection

**Abstract:** The power supply situation of the coal mine is complex, there exists problems such as short route, unable to guarantee the overcurrent set value, it is easy to cause a short circuit, electric leakage, and then electric power system leapfrog to the ground, causing blackouts underground area, production cannot be carried out. And even worse, the concentration of gas may create security issues. Therefore, the author summarizes the advantages and disadvantages of each method through the analysis of various causes of tripping in coal mine power supply system aiming at the analysis and comparison of common tripping protection system method. The results show that the digital optical fiber differential protection can effectively prevent tripping phenomenon, it has a wide application prospect.

## Introduction

The safety of the coal mine power supply system is an important foundation for the continuous production, with the deepening of coal mining, the high voltage power supply equipments join unceasingly, the movement and operation mode of the power supply substation changes frequently [1], the importance of the safety of the underground power supply system is more prominent. At present, there are many hidden dangers and difficulties in the coal mine power supply system, such as lack of electric leakage protection function, cannot setting value of over-current protection, which brings the problems such as the underground power supply short circuit, electric leakage, seriously affect the safety of the underground workers. One of the most common problem is "leapfrog trip". Underground power supply system once happen leapfrog tripping problem, it will result in underground power supply stopped, directly affect the output of coal production, and it also lead to the problem of ventilation, then the downhole gas will gather, threat to personnel safety and damage to the mine seriously.

Nowadays, the coal mine power supply system always use the traditional relay protection devices, however, the underground power supply lines are complex, tripping problem can not be prevent, often causing widespread power cut. And when use the quick break over-current protection device as a protection circuit, unable to determine its over-current protection setting value and completely solve the problem of great trip because of underground lines are complex; when use the method based on Cascade atresia of communication to protect, it also unable to completely solve leapfrog trip. Along with the development of the optical fiber digital communication technology, its use in coal mining are also gradually increased, use the trip based on the digital optical fiber differential as protection device, using a point-to-point optical fiber communication technology for differential

protection, at the same time, using new data processing method of large volume and synchronous data acquisition technology of nanoseconds to thoroughly solve the problems of the above common trip, the method has reliable protection and increases the safety of underground index[2].

### **Analysis of leapfrog trip reasons**

(1)Between higher and lower switch relay protection device is not cooperate.At present,The high-voltage explosion-proof switch installed in many coal mines can not be matched with the high-voltage switch gear of the ground substation.What is more important is no guarantee of matching among relay protection devices. The time of short-circuit protection has to be less than 200ms for most domestic relay protection devices.During this protective time,the current equipment manufacturing technology is impossible to complete the high voltage explosion-proof switch efficient cooperated [6].With the extension of underground power supply line,the fixed value when setting value decreased step by step, small to a certain extent, there will be short of underground power supply line, and cause all the switch off, appear tripping fault[1].

(2)The quality problems of switch gear.A lot of small coal mines avoid large-scale equipment renewal because of funding problems,they has been used for less quality switch protection equipment,it long time lack of maintenance, although they reduce investment, but the process of coal mining become more dangerous.And most of the protection equipment lack of monitoring capacity,great error,response delay,the actual protection value contrary to apredetermined value, it's easy to cause the fault can not be excluded, even more serious is the misuse of the switch, it can cause the tripping problem happen in the power supply system,make the whole production stagnant.

(3)Selective difference of leakage protection device.The problem of fault line selection is the main cause of leakage protection: a)Grounding mode is complex:The grounding mode of power supply system mainly includes two kinds of methods: the stable grounding and the instantaneous grounding,two kinds of grounding methods, including direct grounding, arc grounding and other types, make the signal after the fault is very complex. b) The characteristics of the zero sequence current transformer are different, when the current transformer detects weak signal, strong signal or singular signal, it is prone to distortion, which can not identify the fault signal. c) There are a lot of harmonics in the grid connected to the power supply system,will also have a great impact on protection. d) The parameters of the power system itself will also have an impact on the protection, such as the balance of the power system, the length and distance of the line and the degree of compensation and so on.

(4)Over current protection operation after the loss of pressure release.In the power supply system of coal mine,after the device is powered off and then started,is easy to directly load startup, make the equipment heating and cause failure, so the high and low voltage switch power supply system will be equipped with the loss of pressure release.If the voltage flowing through the power system protection device is 85% higher than the rated voltage,the loss of pressure release will reliably pull action;If the voltage flowing through the power system protection device is 35% higher than the rated voltage,the loss of pressure release will continue to pull in state;If the voltage flowing through the power system protection device is less than 35% of the rated voltage,the loss of pressure release will be reliable off.It can be concluded that,when the operating voltage is between 35%~65% of rated voltage,protection device is in a non reliable working stage, while the loss of pressure release speed off action are mechanical, it cannot setting delay.Therefore,when short circuit fault occurs in

the power supply system of coal mine, voltage will continue to decline, once it has fallen below 65% of the rated voltage, may appear over-current protection is slower than the loss of pressure release action, because the over-current protection set the delay time, resulting in over-current protection device can not work, and causing the override trip problem in coal mine power supply system, more seriously there will be a large scale blackout in coal mine.

### Anti tripping protection system

**Protection Devices Based on Current Differential.** Protection based on current differential, the protection mode of traditional stage change into a differential protection in fact, used to deal with the problem of over-tripping. On the basis of Kirchhoff's Current Law, the current differential protection device is developed. Each line is connected by longitudinal way with cable, and the fault location is judged by the comparison of the current between the two ends of the line. If it is an internal fault, line cut-off, if it is an external fault, all power do not cut off .

As shown in Figure 1 below, when the line connection point M appeared short-circuit fault, then there will be two fault currents at both ends of the line L2, one is the value of current I4 close to zero; The other is the value of fault current I3 larger than normal. The switch QF3 protection device can determine the difference between the two ends of the current to determine whether the fault location in the internal circuit. And the current I1 and I2 at the line L1 will be affected by the M point fault, resulting in two current size increases, but the phase and amplitude will not change, the difference between the two ends of the current equal is about 0, it can determine the fault location In the external circuit, both the switching devices QF1 and QF2 do not trip, so there is no problem of overstepping. The current differential protection device is easy to be changed, and the fault location can be quickly determined and the corresponding power off operation. But it can only switch between the various lines of the anti-off-stage tripping device, for the bus failure it can not guarantee breaking, so the current differential protection can only stage-type line protection.

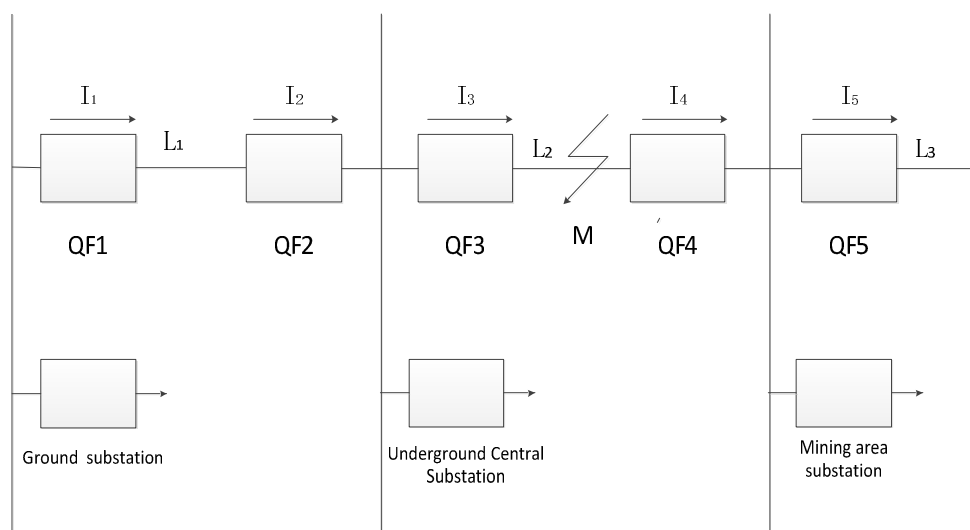


Fig 1 the diagram of Coal mine underground power supply system circuit

**The protection device based on communication cascade locking.** Based on the nature of anti tripping scheme of cascade atresia is the use of communication time range to all levels of vertical setting and avoid leapfrog switch sequence, at the same time using longitudinal differential lock communication cascade control in a certain period of time [3][4]. The protection device is connected

with each switch device through a communication line,when a fault occurs, each of the protective devices that monitor the fault current will be vertically transmitted,communication latency between switches is set to  $T_1$ (General set to 10~50ms),when the signal receiving time exceeds  $T_1$ , it is judged that the fault occurs at this level,rapid power cut off;If in the switch lock time  $T_2$  (generally set to 100 ~ 200ms) range, it can still able to monitor the fault signal,then immediately tripping protection, otherwise switch normal.

As shown in Figure 2 below,when the line connection point M appeared short-circuit fault,QF1-QF5 are both detect the fault signal,there is no power cut off during the communication waiting time  $T_1$ , and each switch transmits the blocking information to the upper-level switching device.It can be found that only QF5 does not receive blocking information during the waiting time,so cut off QF5 switch.For QF1-QF4,during the switch block time  $T_2$ , the fault line has been excluded, the system is normal,without disconnecting each switch to solve the problem of leapfrog tripping.Although the protection device can prevent the problem of over-tripping,but its transformation cumbersome,requirements real-time communication are relatively high,if the time between the switch communication delay, there may occur a leapfrog tripping problem.

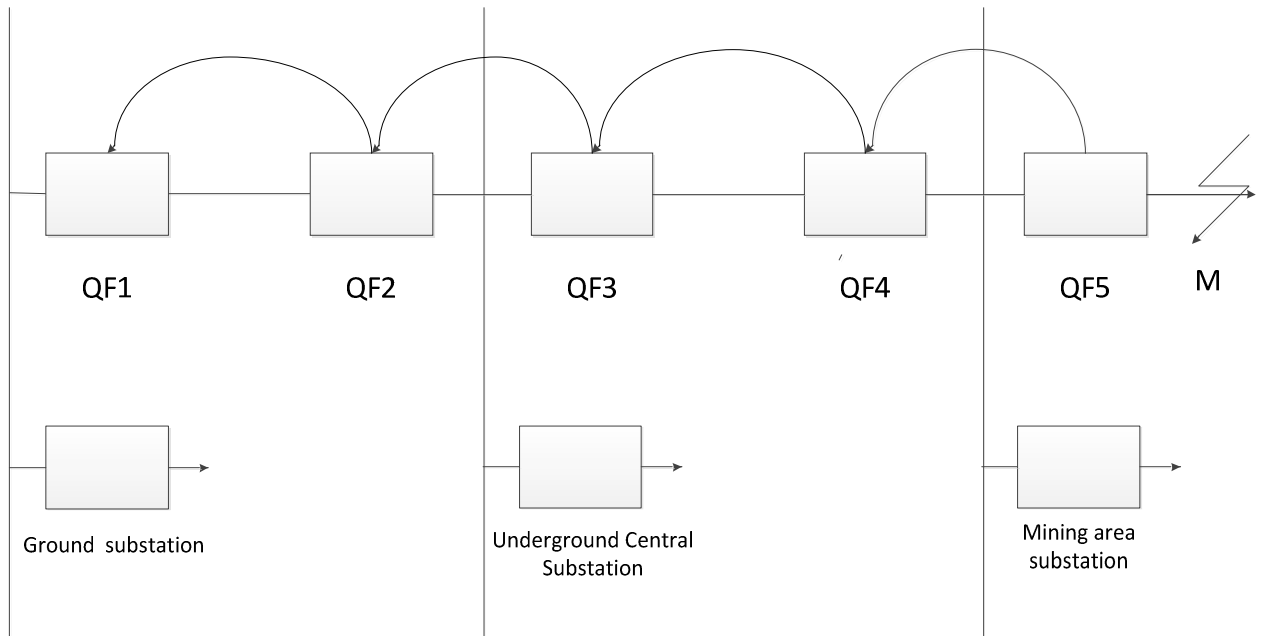


Fig 2 the diagram of Coal mine underground power supply system circuit

**Based on the digital optical fiber current differential protection device.**Optical fiber current differential protection is evolved on the above-mentioned current differential protection,it different from the 1) system scheme is that it use of digital integration and optical fiber technology.The basic protection principle is also based on the Kirchhoff current law,it can ideally make the protection unitized,and the principle is simple, not affected by changes in operating mode,and because the two sides of the protection device is not the link between the electrical and improve the reliability of the operation.At present, the current differential protection is widely used in the main transformer, line and bus of the power system, and its sensitivity is high, simple, reliable and fast. It can adapt to the power system vibration and non-phase running. It is unmatched by other system protection methods.Optical fiber current differential protection in the inheritance of the current differential protection of these advantages at the same time,with its reliable and stable optical fiber transmission channel to ensure that the transmission current amplitude and phase of the correct and reliable

transmission to the contralateral. And with the information technology, measurement, control technology and other advanced technologies and IEC61850 standards implementation, substation digital technology came into being, and this technology is applied to coal mine anti-leapfrog protection trip[5].

The system protection device selection of optical fiber current differential protection, can strengthen the leakage protection and line selection function, it can completely solve the problem of leapfrog tripping, and enhance underground safety. It uses a hierarchical acquisition, centralized control of the framework model, switch the acquisition, analysis will gradually completed. A variety of mine intelligent protection switch signal through the digital processing, and then point to point fiber-optic network communication interface to communicate, transmission to the integrated protection and control master and integrated protection metering device; Through the Ethernet integrated power supply system data to calculate and protect. The whole system consists of station control layer, spacer layer and process layer. The protection system block diagram shown in Figure 3.

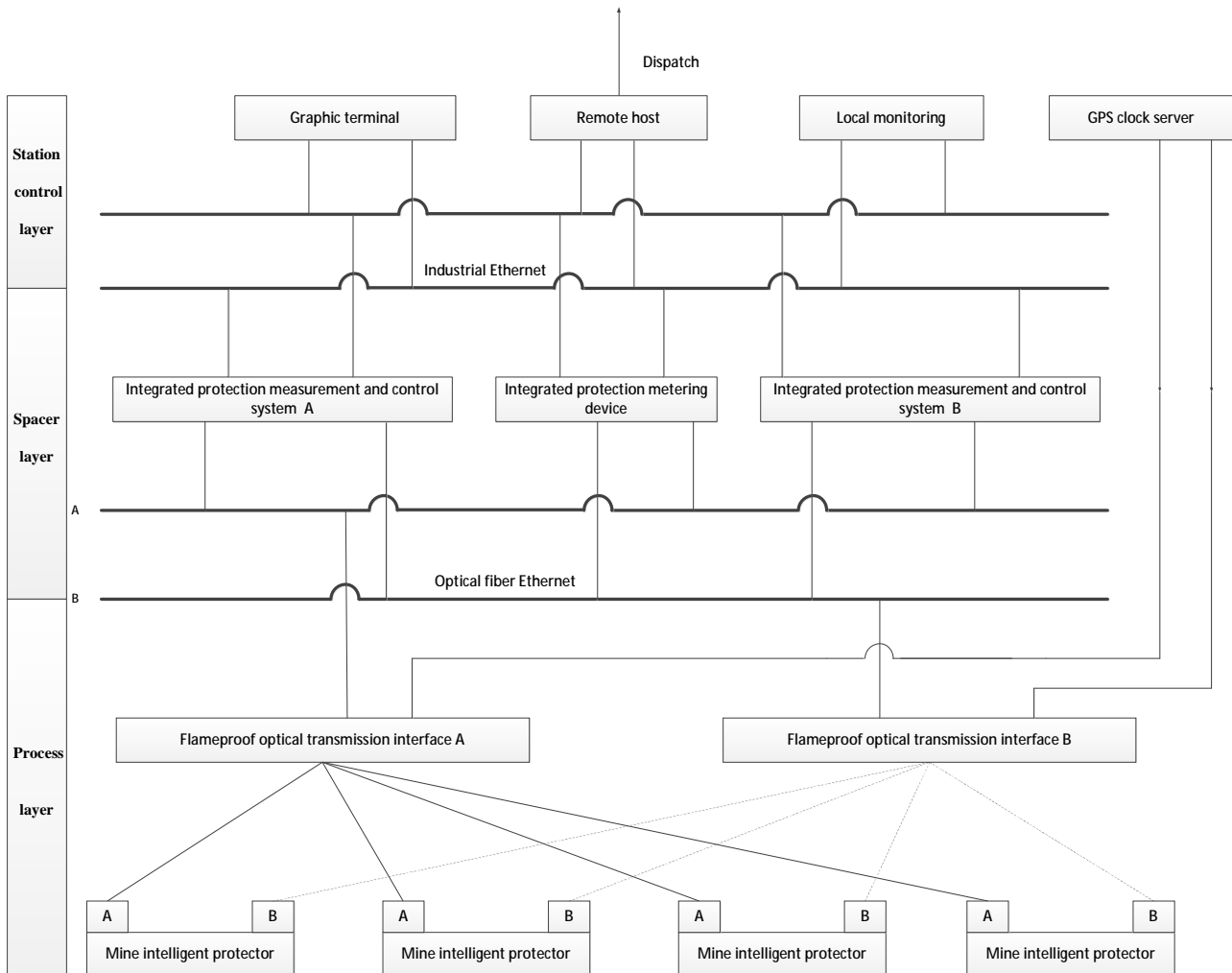


Fig 3 Block diagram of protection system

**Process layer.** The process layer mainly includes transformer, mine intelligent protector and so on, to carry out data acquisition and control of coal mine underground line role, through the optical fiber communication technology to transmit data to the upper. The bottom of the process layer protection

equipment using dual optical fiber technology, the upper layer of integrated protection metering device also uses dual technology, both ends of the corresponding connection, can greatly improve the communication reliability between the two layers

**Spacer layer.**The space layer mainly includes the industry ethernet,the integrated protection survey main engine and the integrated protection metering device,in order to enhance the stability of the system,the protection devices use dual configuration,corresponding to the transmission interface attributes of the process layer.To avoid the protection device can not trip fault occurs,and the line signal monitoring and control,and a single protection device can guarantee the safety of the entire power supply system of the relay.Through the receiving process to transfer the digital layer,integrated protection and control host can go through a variety of logic operations,judgments,to control the protection switch on and off.A variety of high-end protection devices can be closely connected to change the configuration,improve the diversity of system protection.

**Station control layer.**The station control layer mainly includes the local monitoring, the long-distance main engine control and the industry ethernet. And the gap between the communication is use of industrial Ethernet way,and you can use the protocol converter to some intelligent equipment for timely protection.

Through the above analysis,to completely solve the problem of common leapfrog trip,we can use the protection based on digital optical fiber differential,the system has a reliable protection,can uninterruptedly monitor the power supply system line fault, and timely control of the switch off, to avoid the phenomenon of unreasonable leapfrog trip and production stagnation, improve coal production efficiency and enhance the mine safety index.

## Conclusions

This paper gives a brief analysis of the causes of the leapfrog tripping problem in power supply system of coal mine, and summarizes the current common system protection devices.And described it's working principle, advantages and disadvantages of the system a.And emphatically described the working process and system structure of the digital optical fiber differential protection device,comparison other ways,it can completely solve the problem of leapfrog tripping, improve mine safety.

## References:

- [1]Liukai Yuan. Underground power supply system of tripping[J]. Shandong Coal Science and Technology,2016,09:127-128+130.
- [2]Zhangwen Chao.Study on Application of coal mine power supply anti override trip protection system[D].Liaoning Technical University,2011.
- [3]Pengguo Wen,Tangwen Hai. 6kV The protection of coal mine power system anti tripping solutions[J]. Coal mining machinery,2011,11:211-213.
- [4]Dingjing Bo. Research on the solution of coal mine power override trip problem[J]. Coal science and technology,2014,02:63-67.
- [5]Zhangen Feng. The design of anti tripping system of coal mine based on Intelligent Substation[J].

Mechanical engineering and automation,2016,01:186-187+190.

[6]Luanyong Chun,Liu Jian Wei. Cause analysis of underground power tripping in coal mine and discussion[J]. Industry and Mine Automation,2009,03:82-84.