The voltage sag of coal mine power supply and its influence on the reliability of safety monitoring system

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Abstract. Through the investigation and test of the interference of AC power supply in coal mine, it is found that when the high-power equipment is started or stopped, the obvious voltage drop phenomenon is often caused on the power network, which affects the reliable work of the safety monitoring system connected to the power network. This paper tests the situation of voltage drop on site, and analyzes and verifies the influence of this kind of voltage drop on the stable operation of the monitoring system. When the voltage drops, the equipment may restart, which seriously threatens the normal production safety. Finally, in order to ensure the safe and stable operation of the monitoring system, this paper puts forward some suggestions on the design of uninterrupted power box.

Keywords: Voltage sag, Coal mine, Safety monitoring system, power box

1. Introduction
The application of electricity to the mining industry is a distinctive area of both mining and electrical engineering. Power Quality is defined as "any occurrence manifested in current, voltage, or frequency deviations that results in damage, upset or failure of end-use equipments. It is common experience that electric power of poor quality has detrimental effects on health of different equipment and systems [1]. At the same time, mining complexes are often remotely located, where power is weak and unpredictable. Application in Coal Mine Power Network, more and more power electronic devices, such as non-linear device used in the power system, causes grid voltage and current distortion, brings out voltage transient phenomenon [2, 3]. In case of any typical underground mines starting a big motor such as is used on winders, crushers, haulers, pumps etc. particularly on weak systems, results in a large voltage drop [4]. FACTS for cost-effective improvement of power feeding of large mining complexes, Loads such as mine hoists, mining shovels, crushers, etc for mining are demanding and also sensitive to dips and fluctuations in feeding voltage, thereby depending on secure, high quality power supply [5].

Voltage sag: In IEEE standard, voltage sag is defined as: the effective value of power frequency voltage at a certain point in the power supply system suddenly drops to 10% - 90% of the rated value, and then returns to normal after a short duration of 1ms- 1min. Voltage sag and instantaneous interruption have been considered as the most serious dynamic power quality problems that affect the normal and safe operation of many electrical equipment. Voltage sag will affect the normal operation of electrical equipment, and also cause the error of control equipment and signal transmission. Deep mine operations increasingly depend on sophisticated electronic controllers and automated processing. This requires
higher levels of power quality for the electrical power utilized in its operations. With the wide usage of sensitive electronic equipment in mineral process, voltage dips lasting for only a few tenths of a second, may cause production stops resulting in considerable associated costs [6]. Especially in the coal mine, it will affect the normal work of the safety monitoring system connected to the AC power line and other communication and control systems. The instability of the power supply voltage may interfere with the signal acquisition of the safety monitoring system and cause data error, or restart the safety monitoring system [7, 8]. For coal mine power system voltage dips cause blackouts phenomenon, the paper design the under-voltage protection device, it solves an adverse impact to control device in power supply system of coal mine safety production when the grid voltage drop[9]. The voltage sag improvement options need to be evaluated in a systematic manner, in this context, standardization will have an important role to play for voltage sag mitigation. The intent of standards is to provide specifications for equipment that will lead to improved selection criteria for subcomponents and improvements in equipment design [10].

This paper will analyze and discuss the voltage drop and interruption phenomenon and the power supply working characteristics of the safety monitoring and monitoring system.

2. Analysis of coal mine voltage drop characteristics

In the process of the research, some typical coal mines are selected to test the electromagnetic interference. The following survey data are from Lijiata coal mine in Inner Mongolia and Pingdingshan Coal Mine in Henan.

HIOKI 3197 power quality analyzer is used to test.

The underground power grid has been monitored for a period of time, and the typical values are shown in the figure below. Figure 2 shows the input power 660VAC of the power box in the coal mine safety monitoring system near the dig working face. Figure 3 is the graph of 127VAC input power of power box in the coal mine safety monitoring system near the working face when the pump motor is switched. Figure 4 is the graph of 127VAC input power of power box in the coal mine safety monitoring system near the working face when the power supply line is switched.

From the monitoring to the analysis of voltage change data, first of all, the voltage sag in coal mine is frequent; Secondly, the amplitude of voltage drop is larger, especially on the low voltage 127V used for communication control equipment, which can reach nearly 30%; Moreover, the voltage gap on the low-voltage line lasts for several seconds.
Figure 2. 660VAC input of monitoring system power box near dig working face.

Figure 3. 127VAC input of monitoring system power box near dig working face.
3. Influence of power supply drop on monitoring system

According to the requirements, the power box of the monitoring system is equipped with batteries. After the AC power supply is cut off, the standby battery must be put into operation immediately. In order to extend the battery life as much as possible, most equipment adopts two power supply modes: the battery supplied by the equipment is used when there is no external power supply; Switch to external power supply immediately when external power is connected. In this way, a set of special circuits are needed to detect whether there is external circuit access, and at the same time, a set of circuits is needed to control the power switch. But this switch has a switching time. The switching time is not shorter, the better. On the premise of satisfying the application demand, proper and slow switching can benefit from other aspects, such as reducing loss, reducing transient impact, improving reliability, etc., so as to avoid the load may cause operation abnormality due to instantaneous power failure. When the power supply is normal, the power battery is basically in standby state, and there are two methods: cold backup and hot backup. When hot backup is adopted, the battery is in floating charge state and does not bear the load. The safety monitoring system requires that it cannot stop working, and only hot backup operation method can be adopted.

In order to understand the impact of monitoring voltage drop on the normal operation of coal mine safety monitoring system, a test is designed to verify. Because the safety monitoring system relies on the power box to convert the underground AC power into DC power, we only need to do the voltage drop test on the power box. The layout and connection diagram of the test is shown in Figure 5. The power failure simulator generates a voltage drop, which is input to the tested power box and fed back to the monitoring end of the power failure simulator for confirmation. When the voltage drops, the DC voltage output is monitored in the power box. The tested equipment is a certain type of mine power box, with input of 110-220 VAC and output of 20 VDC. The ucs500n of EM test company is used in the power failure simulator, as shown in Figure 6. The output of the monitoring power box is a voltmeter. During the test, it was found that the battery of the power box did not start in time, and the output DC voltage fell to 0.16v, as shown in Figure 7.

![Figure 4. 127VAC input of monitoring system power box near the coal mining tunnel.](image)
Power failure simulator

Testing equipment - power box

Measuring assembly

voltmeter

**Figure 5.** Connection diagram of voltage drop test.

**Figure 6.** Test layout.  
**Figure 7.** Voltmeter data.

This kind of problem is often found in the application, and this result is also reproduced in the laboratory. This is due to the output voltage drop caused by too long switching time of the power box, which will cause the power failure and restart of the security monitoring system connected behind, which can not meet the requirements of relevant standards.

### 4. Design countermeasures for power box of safety monitoring system

The AC input of different voltage levels of the flameproof and intrinsically safe UPS enters the corresponding input terminal of the isolation transformer through the fuse. The output of the isolation transformer is connected to the AC / DC converter, and the AC / DC outputs a stable DC voltage, which charges the standby battery through the charging circuit to store electric energy; On the other hand, the stable power output is obtained through the voltage stabilizing link. When the AC power is cut off, the electric energy stored in the battery is discharged through the voltage stabilizing link to maintain the stable power output and realize the uninterrupted power supply function. The external interruption mode is used to monitor the working state of mine AC power. When it is found that the mine AC power cannot be supplied normally, the circuit is switched to start the battery power supply, so as to ensure the continuous work of the safety monitoring system. When the low voltage fault occurs, the monitoring chip can quickly detect the fault, and the protection locking circuit is in the low voltage μ Turn off the external power supply and open the battery power supply circuit in S-level time to achieve the purpose of uninterrupted power supply.
5. Conclusion

1) According to the survey and test data, voltage sag occurs frequently in coal mine; The voltage drop is large, especially for the low voltage 127V of communication control equipment, which can reach nearly 30%; The voltage drop on the low voltage line lasts for several seconds.

2) The power box of coal mine safety monitoring system is verified. At present, some power boxes can not achieve uninterrupted power supply, and the switching time is too long when the voltage drops.

3) Finally, some suggestions are put forward to improve the design of the power box.

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