STUDY ON LOW-VOLTAGE DISTRIBUTION FAULT ISOLATION TECHNOLOGY UNDER BIG DATA ANALYSIS

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Abstract: In order to effectively solve the problem of low voltage power distribution fault, large data analysis technology of low-voltage distribution fault isolation technology research, first of all, combined with clustering analysis method for common type of low voltage power distribution fault judgment, and for different fault types characteristics of power distribution fault isolation algorithm, the parameters evaluated targeted fault maintenance, thus effectively completed in low-voltage distribution under the condition of big data analysis research of fault isolation technology. Finally, the experimental results show that this technique is more practical than the traditional fault isolation technique.

1. Introduction
With the rapid development of China's industry, electric energy as an important form of energy supply has been widely used in our production and life. However, due to the complexity of the power distribution system, and the low-voltage power supply equipment is one of the most important contents, once the grounding system in the low-voltage power distribution equipment fails, it will bring very serious harm to our daily life, so we need to pay more attention to it and give practical and appropriate grounding fault protection[1]. The traditional low-voltage power distribution fault protection method is mainly tested by power distribution equipment. This method has certain danger. As the end of the whole power transportation process, the low-voltage power distribution line has the disadvantage of line length, which will have certain influence on the normal transportation of the power distribution line. Subsequently, a circuit distribution line isolation method is produced. The distribution path of this method is relatively complex and is vulnerable to external factors, including climate and geography. At the same time, the power distribution lines are directly connected with the user terminals, and the power supply and consumption of different users are also different[2]. This will also have an impact on the normal operation of low-voltage lines. For example, in low-voltage power supply and distribution lines, the occurrence of arc faults may be caused by aging of external insulation, poor contact and breakage of conductors. In recent years, the method of series isolation between loads has gradually attracted attention. The current of the protection circuit of this isolation method is usually smaller than that when the arc fault does not occur, which will not lead to the micro-circuit breaker. However, the parallel arc fault between the phase line and the neutral line will cause the line current to expand, and once out of control, it will have a serious impact on electrical equipment, causing equipment damage, paralysis, and even may cause safety accidents, posing a serious threat to the life safety of workers. Therefore, a fault isolation technology for low voltage distribution based on big data analysis is proposed. Experiments show that this method can effectively
isolate faults in low voltage distribution when distribution faults occur.

2. Low voltage distribution failure isolation technology research

2.1 Low-voltage distribution fault type judgment

Low voltage distribution equipment failure is mainly line failure or maintenance failure, mainly from the equipment, people and management analysis. Equipment factors and prevention: aging and deformation of low-voltage distribution equipment may occur after long-term use [3]. Due to the low voltage is rarely encountered power failure, the personnel do not understand the structure of the equipment, maintenance is not in place or even for a long time without maintenance, failure at a loss what to do. This kind of failure is often due to the load switch and its parts aging, deformation, such as "switch can not start normally; Operation panel out of control; Manual load switch cannot work and other problems. Since most auxiliary switches in the facility are arranged in the load switch, once the switch has problems, it cannot be repaired in a short period of time [4]. Structure deformation and distortion of low-voltage equipment after long use; The switch control panel cannot be opened and the spring loses its elasticity and cannot be reset; Aging of power supply line; The auxiliary switch fails to reset or automatically store energy. The equipment shall be maintained and repaired regularly, and the equipment or relay protection status shall be tested regularly. Repair and replace faulty equipment (backup important locations and non-conventional equipment for timely replacement).

![Three-phase equipment](image)

Figure 1 structure of low voltage power distribution grounding fault principle

The sensitivity of low-voltage protection apparatus is the main method to judge low-voltage distribution fault. It means that the protection apparatus can operate reliably when the slightest short-circuit fault occurs within the protection scope under the minimum operation mode of the system [5]. It directly determines the reliability of low-voltage protective appliances, and is an important index to reflect the effectiveness of distribution line safety measures. The sensitivity of low-voltage protection electricity mainly includes the sensitivity of fuse and the sensitivity of circuit breaker. In order to improve the sensitivity of judging distribution fault, the specific contents are as follows:

1. The rated current or setting current value of the protection appliance should be as small as possible under the condition that it is larger than the calculated current (or multiple of the requirement) of the circuit and can avoid short-time overload current.

2. Try to increase the single-phase short-circuit current at the end of the circuit protected by the circuit breaker under the minimum operation mode of the system, that is, reduce the phase line and neutral line of the circuit.

3. Low voltage circuit breaker with short time delay protection shall be used when using low voltage circuit breaker.

4. If the sensitivity of the low-voltage circuit breaker with short time delay protection cannot meet the requirements of the code, zero sequence current protection or residual current action protection shall be adopted.
2.2 Low-voltage distribution fault isolation algorithm

In order to effectively isolate the distribution fault, it is necessary to analyze the causes of low-voltage power supply and distribution grounding fault. The common fault causes are the short circuit between the phase line and the ground and the relevant conductors in the system, such as the short circuit between the phase line and the PE line, the phase line and the PEN line, and the phase line and the ground. The occurrence of grounding fault is of great harm, so it is necessary to implement effective grounding fault protection design to avoid the occurrence of hazardous accidents [6]. When the low-voltage distribution system is under fault protection, in this system, once the single-phase grounding fault occurs in the power supply and distribution system, the potential in the metal shell of the equipment can reach 50V. At this time, the equipment can be insulated with the monitoring device and the grounding fault device, and the range of the action current in the device can be guaranteed as follows:

\[ I_e R_e \leq 50V \]  \hspace{1cm} (1)

Where, \( I_e \) represents the single-phase grounding current; \( R_e \) represents the grounding resistance connected to the metal housing of the equipment. When two-phase grounding fault occurs in the power supply and distribution system, the power supply line shall be cut off in a relatively short time by using isolation technology [7]. There are two reasons for the two-phase grounding fault. One is that the IT grounding system has N lines. At this time, the isolated action current of the leakage switch should be:

\[ \sum \left| Z \right| \leq \frac{1}{2} U \varphi \]  \hspace{1cm} (2)

In the above two formulas, \( lop \) represents the current value of the leakage switch; \( Z \) represents the impedance mode of the fault circuit; \( \varphi \) represents the phase voltage. In low-voltage distribution fault isolation technology, low-voltage circuit breaker is usually used to cut off the supply line to protect the power supply and distribution system. However, when the circuit breaker adopted in the lower part of the system is difficult to fully meet the fault protection requirements, it will be necessary to complete the fault protection by installing leakage switch [8]. In the traditional system, since the PE line is not available, the PE line in the system shall be added in order to realize fault protection through the leakage switch. In this way, fault protection measures shall be taken. The design of the isolation parameter shall meet the following requirements:

\[ s I_a \leq U_o \]  \hspace{1cm} (3)

Type, \( s \) represents the earth fault loop impedance, unit for \( \Omega \); \( I_a \) represents the amount of current that automatically cuts off the fault circuit within A specified period of time, and the unit is A; \( U_o \) represents the voltage of the phase line to the ground in V. In the study of the maximum cut-off grounding fault circuit allowed to pass in the system, the circuit can be divided into two categories. One is the traditional fault protection circuit, and the time of the maximum fault circuit is 4-5s. The other is the isolation technology loop, the maximum fault loop time is 0.4s; According to the above data, there are two kinds of circuits. The response time of each type to the fault protection equipment is relatively short. The traditional fault protection circuit is about 5s, and the isolation technology circuit is about 0.4s. Therefore, only when the above mentioned fault circuit time requirements are fully met, the system's role and advantages can be fully played.

When analyzing the minimum value of low-voltage distribution fault protection, it can be studied by means of fuse. The rated current of the solution is divided into four stages, namely 4-10a, 12-16a, 40-63a and 80-200a. The corresponding circuit time is 4.5s, 5s and 6s, and the corresponding circuit time is 8.0s, 9s, 10s and 11s. Through the above data shows that when the ground fault protection through the fuse, due to the isolation technique system in the higher frequency of short-circuit fault cash attribute, and the fault type and easy to generate a larger current, low voltage power distribution fault isolation technology will play a role at this moment, when the current quantity is too large will cause circuit is cut off, achieve the goal of protecting circuit.
2.3 Realization of low-voltage distribution fault isolation

Isolation technology can reliably cut off the power supply in the case of single-phase fault. In the case of single-phase fault, the reliable cut off of the power supply is completed by short-circuit current, and the larger the short-circuit current is, the more favorable it will be to the protection device [9]. Under the premise of a certain power supply voltage, the size of the short-circuit current depends on the size of the fault circuit impedance, which is mainly composed of the system impedance (transformer impedance) and the fault circuit wire and grounding resistance. In this way, isolation technology can be adopted in the case of single-phase fault, which can reduce the fault circuit impedance and improve the reliability of the switch. Flexibility, that is to improve the switch protection characteristics to cut off power protection equipment.

When the protection device can be in the distribution system during the operation of leakage, the isolation technology can automatically cut off the leakage line to implement the protection of the entire line; Isolation technology can effectively reduce transformer impedance and suppress harmonic current by changing the junction group of voltage from y-y0 to x-y0 [10]. The isolation technology works in the non-working grounding state of the power supply, so there is neither neutral line N line nor protection line PE line in the power supply line of this grounding system. Therefore, the electrical equipment can only be three-phase symmetrical electrical equipment or single-phase electrical equipment whose rated voltage is line voltage. And, of course, if you need an N line, you can also fit an N line. But at the same time, it is necessary to set the over-current protection device on the N line, so as to cut off the power supply line in case of short circuit fault. Its working process is as follows:

![Figure 2 isolation technology workflow](image)

As can be seen from the above figure, when a single-phase short circuit occurs, the three-phase voltage remains unchanged. The three-phase electrical equipment can operate normally, and at the same time, the electrical equipment shell is not live, so there will be no electric shock accident. The metal shell of the electrical equipment is connected with the grounding body through a wire, and there is no electromagnetic interference between the electrical equipment. When single-phase grounding fault occurs in the low-voltage power supply and distribution system, the potential on the metal shell of the equipment can reach 50V, which can automatically cut off the fault circuit current to protect the electrical equipment from damage.

3. Analysis of experimental results

In the design of low-voltage power supply and distribution, the electrical grounding system must be carefully selected according to the environmental conditions, safety and reliability requirements and the electromagnetic interference requirements of the electrical equipment, and the grounding fault protection, so that the grounding system can effectively protect the safety of the electrical equipment and people. The traditional low voltage distribution fault usually USES low voltage circuit breaker to cut off the power supply line. It not only increases the risk of cutting off power for too long, but also
increases the difficulty of distribution circuit routing. Therefore, low-voltage distribution fault isolation technology is proposed. The traditional fault protection method and isolation technology are set as the control group and the experimental group respectively.

Table 1: Preliminary Test Items for Isolation Experiment

| project                                      | Check method                                           |
|----------------------------------------------|--------------------------------------------------------|
| Check whether the system power supply is normal | Check the supply voltage through the multimeter       |
| Connection wires are wrong                   | Connect the communication cable correctly as required |
| Power cord is loose                          | Compact power cord                                     |
| Solenoid valve damage                        | Replace the solenoid valve of the same model           |
| Communication line virtual connection, short circuit, open circuit | Find virtual connection, short circuit, open circuit point replacement, maintenance communication line |
| Wrong connection of power cord               | Connect the power cord correctly as required           |
| Fuse damage                                  | Replace the same type of fuse                          |

Check the two groups according to the above requirements, and after confirmation, connect the two groups of circuits to the power supply, and get the voltage-time curve as shown in the figure below.

![Fig.3 Contrast test results](image)

As can be seen from the above experimental results, in the case of single-phase grounding fault, the blocking voltage of the isolation technology can be up to 50V faster than the traditional fault protection method, and the circuit can be cut off quickly to protect the electrical equipment. Thus effectively solve the problem of distribution failure, fully meet the research requirements.

4. Conclusion
To meet the needs of the development of social economy in our country, low-voltage distribution lines are directly connected with the user key link, the fault type, operation environment and causes are very complicated, therefore, the low-voltage distribution line fault prevention and its maintenance and maintenance is a long-term and arduous task, low-voltage distribution of traditional fault protection response slow wire diameter, in order to solve this problem, low-voltage distribution fault isolation technology is put forward, after the experiment proved that this method is cocoa on fault loop current cut off, to protect electrical equipment damage, keeping a low voltage line safe operation of the high state, Can better serve the users.

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