Analysis of hidden faults in power system relay protection

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Abstract: In modern power system, relay protection plays a vital role, it is the key link to ensure the safe and stable operation of power system. However, with the continuous development and complexity of the power system, the relay protection is facing many challenges and problems. Problems such as misoperation, leakage, unreasonable parameter setting and improper maintenance and operation often occur, which bring potential risks to the safety and reliability of the power system. Therefore, it is necessary to conduct in-depth analysis and optimization of power system relay protection to improve its reliability, sensitivity and management level, and ensure the safe and stable operation of the power system.

Key words: Power system; Relay protection; Hidden faults

I. Overview of power system relay protection

1. The definition and function of relay protection

Relay protection refers to when the power equipment or line in the power system fails, it can quickly and selectively remove the fault part to prevent the fault from expanding or spreading to the entire system, so as to ensure the safe and stable operation of the power system. Its core role is to quickly isolate the fault, reduce the scope of power outage, reduce accident losses, and create conditions for the recovery of the system after the failure. The realization of relay protection depends on a complex device system, including measuring element, logical judgment element and execution element. When the power system fails, the measuring element will detect the abnormal signal, the logical judgment element determines whether the action is needed according to the preset protection logic, and the executive element is responsible for executing the command to remove the fault, such as tripping and disconnecting the fault current. This series of actions must be fast and accurate to ensure the safety of the power system.

2. Classification and characteristics of relay protection

Relay protection can be divided according to different classification standards. According to the different protection objects, it can be divided into line protection, transformer protection, generator protection, etc.; According to the different protection principles, can be divided into overcurrent protection, distance protection, differential protection and so on. Each protection method has its specific application scenarios and advantages. For example, overcurrent protection is mainly used to detect overload and short circuit faults of lines or devices. The principle is that when the current exceeds a preset threshold, the protection device will act to cut off the fault current. This type of protection is simple and reliable, and is one of the most commonly used protections in power systems. The distance protection is by measuring the electrical distance from the fault point to the protection installation to determine whether to act, it is suitable for the protection of long-distance transmission lines, with high sensitivity and selectivity.

II. The problems of power system relay protection

1. the misoperation and leakage of relay protection equipment

Misoperation and leakage are two common problems of relay protection equipment. Misoperation refers to the wrong action of the protection device in normal operation or minor fault, resulting in the removal of non-fault equipment or lines, affecting the normal operation of the power system. Leakage refers to the failure of the protection device to act correctly in the event of a serious fault, resulting in failure to be isolated in time, which may lead to a bigger accident. The occurrence of misoperation and leakage is often closely related to the sensitivity of the protection device, anti-interference ability and parameter setting.

2. The parameter setting of relay protection is unreasonable

The parameter setting of relay protection is directly related to the performance and reliability of the protection system. Unreasonable parameter setting may cause the protection device can not be correctly judged when the fault occurs, thus delaying the time of fault isolation, and may even lead to the wrong operation or leakage of the protection device. In addition, with the change of the operating conditions and load state of the power system, the protection parameters also need to be adjusted and optimized accordingly to adapt to the new operating environment. However, in actual operation, due to various reasons, the adjustment of parameters is often not timely or accurate enough, which also brings potential risks to the relay protection system.

3. Improper maintenance and operation of relay protection

The maintenance and operation of relay protection is the key link to ensure its stable and reliable performance. However, in the actual operation, due to the influence of the maintenance personnel's skill level, working attitude and management system, there are often many problems in the maintenance and operation of relay protection. For example, maintenance personnel may fail to discover and deal with hidden dangers and faults of equipment in a timely manner, resulting in equipment performance degradation or failure; During operation, protection devices may fail to respond correctly or isolate faults in a timely manner due to reasons such as improper operation or poor monitoring. These problems not only affect the performance of the relay protection system, but also may pose a serious threat to the safe and stable operation of the entire power system.

III. The optimal path of power system relay protection

1. Improving the reliability and sensitivity of the relay protection equipment

In the power system relay protection, the reliability and sensitivity of the equipment are crucial indicators. The improvement of the two can not only enhance the performance of the protection system, but also effectively prevent the occurrence of hidden faults, so as to improve the safe and stable operation level of the whole power system.

To improve the reliability of relay protection equipment, the first thing is to carry out strict quality control and regular maintenance and overhaul of the equipment. In the selection of equipment, priority should be given to products that have been verified by long-term practice and have stable performance, and installation and commissioning should be carried out in strict accordance with relevant technical standards and specifications. In addition, regular preventive testing and condition monitoring of equipment, timely discovery and treatment of hidden dangers and defects of equipment, is also a key measure to ensure reliable operation of equipment. Taking a power grid company as an example, they adopted advanced online monitoring technology to carry out real-time status monitoring and data analysis of relay protection equipment. Through the continuous tracking and evaluation of the operating state of the equipment, the potential failure risk is found and warned in time, so as to realize the advance intervention and effective prevention of equipment failure. This not only greatly improves the reliability of the equipment, but also significantly reduces the probability of hidden failure.

Sensitivity is the response ability of relay protection equipment to fault signals, and its improvement is also of great significance. In practical applications, the key to improve the sensitivity is to optimize the protection algorithm and parameter Settings. By deeply studying the characteristics and rules of the fault signal and adopting a more accurate and sensitive protection algorithm, the fast and accurate identification of the fault signal can be realized. At the same time, according to the actual operation of the power system and equipment characteristics, reasonable adjustment and optimization of the protection parameters can also significantly improve the sensitivity of the equipment. Taking a large hydropower station as an example, they introduced intelligent algorithms into the relay protection system to carry out deep learning and pattern recognition of fault signals. By training a large number of fault samples, the protection system can accurately identify various complex fault signals and respond to them in the shortest time. This not only improves the sensitivity of the protection system, but also effectively avoids the occurrence of problems such as misoperation and leakage.

2. Parameter setting optimization and adaptive control of relay protection

In the operation process of the power system, the accurate action of the relay protection device is of great significance to ensure the stable operation of the power system. However, with the increasing complexity and scale of power system, parameter setting and adaptive control of relay protection have become an urgent problem to be solved. The following will deeply discuss the parameter setting optimization and adaptive control of relay protection, in order to provide theoretical support and practical guidance for improving the safety and stability of power system. ,

Parameter setting optimization is the basis of relay protection optimization. In the power system, the relay protection device needs to be adjusted in real time according to the running state of the power system to ensure that the fault current can be cut off quickly and accurately when the fault occurs, so as to protect the safety of the power system. This requires the parameters of the relay protection to be finely set. For example, in overcurrent protection, the starting current and time delay of overcurrent protection need to be reasonably set according to the short-circuit capacity, line length and fault type of the power system. By optimizing the parameter Settings, the sensitivity and selectivity of the relay protection can be improved, and the possibility of false operation and rejection can be reduced.

Adaptive control is an important means of relay protection optimization. With the rapid development of the power system, the operating state and fault characteristics of the power system are constantly changing. The traditional fixed parameter setting has been unable to meet the needs of modern power system. Therefore, the key to improve the performance of relay protection is to introduce adaptive control technology to enable the relay protection device to adjust itself according to the real-time running state of power system. For example, in the adaptive overcurrent protection, the starting current and time delay of the protection can be adjusted in real time to adapt to the changes of the power system by monitoring the current and voltage of the power system in real time. This adaptive control strategy can significantly improve the adaptability and reliability of relay protection. In addition to parameter setting optimization and adaptive control, it is also necessary to strengthen the maintenance and management of relay protection. Check and test the relay protection device regularly to ensure that it is in good working condition. At the same time, establish a sound relay protection management system, clear the responsibilities and authority of personnel at all levels, to ensure the correct action of relay protection.

3. Standardized maintenance and operation management of relay protection

In the power system, the importance of the relay protection device as the first line of defense to ensure the safe and stable operation of the power grid is self-evident. However, the existence of hidden faults often causes potential threats to the relay protection system. In order to effectively reduce the occurrence of these hidden faults, it is particularly important to standardize the maintenance and operation management of relay protection.

In order to realize the standardization of maintenance and operation management of relay protection, first of all, we need to establish a set of perfect maintenance system. This includes regular inspection, preventive test, fault diagnosis and repair and other links. Taking the power grid of a certain region as an example, they have formulated a strict inspection system, and carry out a comprehensive inspection of the relay protection devices of key substations at least once a month, including various aspects such as appearance, wiring, power supply and software version. During the inspection, if any anomalies or potential risks are found, an emergency response mechanism will be

immediately activated and a professional team will be organized to troubleshoot and repair them. In addition to the inspection system, the preventive test is also an important means to ensure the stable performance of the relay protection device. In a preventive test, the technician found that the operation time of a relay protection device exceeded the prescribed range. After in-depth analysis, they found the root of the problem -- it was caused by the aging of a component inside the protective device. Technicians immediately replaced the component and recalibrated the entire protective device to ensure its operating time was in line with standard requirements. Fault diagnosis and repair should not be ignored. When the relay protection device occurs abnormal or misoperation, it must be quickly fault diagnosis, find out the cause of the fault and repair. In a fault treatment, the technical personnel by comparing the protection action records before and after the fault, combined with the field inspection, accurately judge the misoperation caused by external interference. They quickly took the corresponding anti-interference measures, and reconfigured the protection device, and successfully eliminated the fault.

Conclusion: As the guardian of the power system, relay protection plays an irreplaceable role in maintaining the safe and stable operation of the system. Through the analysis of the problems existing in the power system relay protection, and put forward the optimization path, we can better cope with various potential risks and challenges. Improving the reliability and sensitivity of the relay protection equipment, optimizing the parameter setting and standardizing the maintenance and operation management will provide a solid guarantee for the safe and stable operation of the power system. It is believed that with the continuous progress of technology and the improvement of management level, the relaying protection of power system will usher in a better development prospect.

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