Journal of Electrotechnology, Electrical Engineering and Management (2022)
Clausius Scientific Press, Canada
DOI: 10.23977/jeeem.2022.050107
ISSN 2560-6697 Vol. 5 Num. 1

Practice verification and analysis of comprehensive relay protection device

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Keywords: relay protection, Power system, Integrated relay protection device, Maintenance calibration analysis

Abstract: This paper introduces the importance of comprehensive relay protection device, the key role it plays in the power system, the verification cycle and maintenance content of relay protection device, and improves the utilization efficiency of equipment and reduces the maintenance cost of equipment through effective maintenance means. Ensure the safe and economic operation of power system.

1. Introduction

Relay protection integrated automation system is an automation system that comprehensively uses the analog quantity, switching quantity, primary equipment state quantity and other information collected by the intelligent equipment of the whole power grid, automatically calculates and analyzes the information, makes more comprehensive use of these real-time information and adjusts the working state of relay protection, so as to ensure the safe and reliable operation of power grid.Relay protection is an important part of power system[1].

2. Importance of relay protection

When the power system is in an abnormal operation state, the relay protection device can send a signal or give an alarm in time, and notify the operator on duty to deal with it.

When an accident occurs in the power supply system, it can automatically remove the fault and limit the scope of the accident. It can be seen that relay protection and automatic device are of great significance to the stable operation of power grid[2]. It plays a key role in ensuring the safe and economic operation of power system and preventing the occurrence and expansion of accidents.

3. Necessity of maintenance of relay protection device

In order to ensure that the relay protection device can operate correctly in the case of power system failure, the relay protection device and its secondary circuit in operation should be verified and inspected regularly in time to ensure that the device is intact and functional, and the circuit wiring and setting value are correct.

4. Verifivation cycle of relay protection device

In order to ensure the requirements of selectivity, rapidity, sensitivity and reliability of relay protection devices, users with high requirements for power supply reliability and users of 60kV and above shall generally be verified once a year. The relay protection devices of 10kV users shall be calibrated every two years. For gas relay, inflation test shall be conducted once a year and internal inspection shall be conducted every three years[3]. If the relay protection device is modified or replaced due to maintenance or accident, these equipment shall be supplemented and verified later.

5. Basic requirements for inspection of relay protection devices

For the relay protection device in operation, the following inspection and verification shall be carried out:

- Check the mechanical part of the relay foundation.
- Test the electrical characteristics of the relay.
- Measure the insulation resistance of the secondary circuit.
- Check the whole set of actions of the protection device.
- Conduct secondary energization test for the protection device

During patrol inspection of relay protection device and electrical secondary side, patrol inspection of relay protection device, secondary circuit and mechanical part shall be carried out:

- Check whether the comprehensive protection device and relay housing are damaged or worn
- Check whether the equipment and devices have abnormal sound, heating, smoking and charred abnormal smell
- Check whether the pressing plate can be used normally, whether it is consistent with the requirements of operation, whether the setting value is correct, and whether various signal signs are normal
- Check whether the device is overheated and whether the regulated power supply voltage of the device is normal.
- Check whether the relay is stuck, displaced and tilted, burned, off shaft, off welding, etc
- Check whether the disk rotation of the induction relay is normal, whether the frequently charged relay nodes have large jitter and wear, and whether the coil and additional resistance are overheated

6. Maintenance and calibration of relay protection device in operation

In case of abnormal sound or phenomenon during the operation of relay protection device, it shall be reported to the competent department immediately and effective measures shall be taken.

When the action switch of relay protection device trips, after taking safety measures, check the specific situation of protection action and find out the cause. Before resuming power transmission, reset all signals, and make post event records and relay protection action records[4]. All work on the secondary circuit shall comply with the relevant provisions of the electrical safety work regulations, and the drawings consistent with the on-site equipment shall be used as the basis.

Generally, the maintenance personnel are only allowed to connect or disconnect the pressing plate, switch over the change-over switch and unload the fuse for the operation of the relay protection device.If the incoming line protection device regularly verified by the power supply department is involved, they shall contact the power supply department.

For the maintenance of secondary equipment, the relay protection, safety automatic device and secondary circuit wiring shall be regularly inspected according to the requirements of the regulations on the inspection of relay protection and power grid safety automatic device, so as to

ensure that the device is intact, the function is normal, and the circuit wiring and setting value are correct.

If the protection device fails between two calibrations, it can be found only after the protection device fails or waits for the next calibration[5]. If the power system fails during this period, the protection will not operate correctly. Abnormal protection device is a very serious problem in power system.

Therefore, the electrical secondary equipment also needs condition monitoring and implements the condition based maintenance mode.

7. Application of protection element principle in practical verification

Taking the comprehensive relay protection of motor as an example, this paper expounds the operation logic and standard process of some common protection elements in practical verification.

7.1 Quick break protection

The high value of quick break action current is used as the quick break setting value during motor starting, which is set according to the maximum starting current when avoiding the normal starting of the motor. The low value of quick break action current shall be set according to the two-phase short-circuit current at the motor outlet divided by a certain sensitivity coefficient under the minimum operation mode.

During the motor starting process, select “motor starting discrimination input” in the control word, and the motor will act with the high value of quick break current during the motor starting process. After the motor starts, in order to improve the sensitivity of the motor during normal operation, it will act according to the low value of quick break current. If “motor start discrimination exit” is selected in the control word, the motor will no longer judge the starting process, act according to the low value of quick break current, and put the over-current protection into operation all the time.

In case of internal fault, the motor is in load state and the current direction is from the bus to the motor, which meets the service conditions of directional elements. In case of bus fault or other motor fault, the directional element will cooperate with the over-current element to ensure no wrong action.

7.2 Over-current protection

The device is provided with a definite time over-current protection, which mainly provides locked rotor protection for the motor, and the action time is set according to the maximum allowable locked rotor time. The over-current protection will exit automatically when the motor is started, and will be put into operation automatically after starting.

When the power supply is interrupted for a short time or an external fault causes the extreme voltage of the motor to drop, the slip rate of the motor gradually increases and the rotor speed decreases. When the power supply is restored or the external fault is removed, the motor terminal voltage returns to normal and enters the self starting process. If the terminal current before self starting is greater than the minimum current of starting judgment, the starting judgment will not judge the self starting process. For some large generators or motors generally started by step-down, the starting current is still large, which often leads to the wrong action of over-current protection.

Therefore, when the current is greater than 1.2 times the rated current of the motor, the detection voltage rises abruptly, the over-current protection is withdrawn from the self starting operation, and it is automatically put into operation after starting. The self starting discrimination can be controlled

by the control word. When the self starting discrimination is selected to exit, the device does not distinguish the self starting and does not lock the over-current protection at the same time.

7.3 Zero sequence current protection

The grounding current of the motor depends on the grounding mode of the power supply system. In ungrounded or high resistance grounding systems, the fault current is only a few amperes, hundreds of amperes in medium resistance grounding systems, and greater in direct grounding systems. For systems with high grounding fault current level, if three phases are equipped with current transformers, the zero sequence current can be obtained from the sum of three-phase currents. In most cases, in order to test low grounding current, zero sequence current transformer is often needed to obtain zero sequence current. Therefore, the protection can be realized by two-phase current transformer plus zero sequence current transformer or three-phase current transformer.

7.4 Low voltage protection

In order to ensure safe production, for the motor that is not allowed to start automatically, after the power supply voltage disappears or decreases, the low-voltage protection acts on tripping and automatically disconnects the motor from the power grid. When the voltage of the measuring line is lower than the fixed value, when the switch or contactor is in the closed position and there is a falling edge, the low voltage protection acts. In order to prevent the motor from being cut off by mistake due to PT disconnection, this protection is provided with locking low-voltage protection in case of single-phase, two-phase or three-phase Pt disconnection.

7.5 F-C over-current blocking

For F-C (high voltage fuse contactor), if any fault current exceeds the breaking current of the contactor, the protection outlet is locked and the fault is removed by the fuse. When the capacitor fails to find the cut-off fault in time and the fault current is maintained all the time, if other protection actions of the device delay, other protection messages will still be sent, but in fact, the outlet will not trip.

The FC over-current locking function has the control word to select on / off. When the function is put into operation, the fuse contact of the external fuse is connected to the device. When the device is connected to the high level, the device sends a fuse trip alarm signal. When the FC over-current locking function is put into operation, whether to trip can be selected through the control word. When the function is withdrawn, it is only used as ordinary remote signaling.

7.6 Long start protection

The device measures the starting time of the motor: when the maximum phase current of the motor changes from zero to 10% of the rated current of the motor, start timing until the starting current drops to 120% of the rated current of the motor after the peak value, and the duration between becomes the starting time of the motor. Too long starting time of the motor will cause overheating of the rotor. When the actually measured starting time of the device exceeds the set allowable starting time, the protection acts on tripping, and the long starting protection can be switched on or off by the control word motor starting.

7.7 Over-heating protection

Overheating protection comprehensively considers the thermal effect caused by the positive sequence and negative sequence current of the motor, provides protection for overheating caused by various overload of the motor, and also serves as backup protection for motor short circuit, too long starting time and so on.

According to the principle that the motor can be started twice continuously, the heat accumulation of each start should not be greater than 50% of the trip value. Therefore, when the heat accumulation value reaches more than 50%, the closing and locking contact of the device acts, and the heat accumulation value (specific heat rate) can be found from the measured value of the operating condition of the device and can also be observed in the surface plate cycle display. After the overheating protection trips, the thermal memory function of the device starts, and the closing locking output contact remains until the heat accumulation value drops below 50%, and the overheating closing locking contact returns, which means that the motor can be restarted.

If it is required to start immediately in case of emergency, the device can be thermally reset, and the overheating locking can be switched on and off by the control word. In addition, the overheating warning function can be used to select whether the overheating trips by switching on and off the pressing plate. However, it should be noted that the overheating warning and locking functions are not controlled by the pressing plate.

7.8 Negative sequence current protection

Negative sequence current protection is mainly aimed at various non grounding asymmetric faults. For example, when a phase of the motor is broken, the size of the negative sequence component is different due to the load rate before the fault. When the load rate is greater than 0.7, the sound phase can cause overcurrent. Therefore, the conventional protection can not effectively protect the asymmetric fault. There are two implementation characteristics of action time characteristics, namely definite time limit and inverse time limit.

When the external circuit fails, the feedback negative sequence current of the motor may cause the wrong action of the negative sequence current protection. According to the different ratio of the current in case of asymmetric short circuit inside and outside the asynchronous motor area, when the negative sequence current is greater than 1.125 times the positive sequence current, the negative sequence current protection will be locked and started. When the negative sequence current is greater than 1.125 times of the positive sequence current, it represents an internal fault of the motor and automatically releases the locking. This ensures the reliability of the action, and the locking conditions can be switched on and off by the control word.

8. Specific embodiment of relay protection for accident analysis

According to the statistical data and practical experience analysis, when the manufacturer's manufacturing quality is poor, the secondary circuit maintenance is not timely, and there are technical defects in its own design, it is often the main reasons for the mis-operation of relay protection devices.

When an accident occurs or the relay protection equipment acts incorrectly, the accident analysis shall be carried out. The comprehensive relay protection device will provide the operation status and fault report of the system in the primary equipment before and after the fault. The current fault location algorithms of protection and fault recorder are generally divided into fault analysis method and traveling wave analysis method.

Based on the fuzzy analysis of the protection action information at both ends of the line and

other protection action information in the same section, combined with the level and experience of the maintenance personnel and the accurate calculation of the sampling data of protection and fault recording, the judgment can be made quickly and accurately to realize the auxiliary decision-making of relay protection for accident recovery.

9. Conclusion

Comprehensive relay protection devices and automation systems are of great significance to ensure the safe and stable operation of power grid. They not only meet the needs of power supply reliability, but also strengthen the overall efficiency of relay protection. However, at present, people still lack sufficient understanding of design, installation, setting, calibration and operation management. Some testers in commissioning departments still need to learn more about the performance and setting calibration methods of the device. The discussion of this paper hopes to provide some reference for the practical application of these electrical debugging personnel protection devices. In addition, some verification methods described in this paper are also applicable to other microcomputer integrated protection after appropriate modifications. It is hoped that with the joint efforts of practical operators and scientific researchers, the relay protection system can be further optimized, and the real-time information of the equipment can be fully used to further improve the reliability of the device.

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