Fault diagnosis technology of relay protection secondary circuit in Intelligent Substation

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Abstract
With the development of communication technology, the cable of interactive information in traditional substation is gradually replaced by optical fiber. The interaction of information is achieved by network communication. This transmission method will cause problems such as opacity of information transmission and difficulty in finding defects. On this basis, many researchers have proposed a large number of related technologies and research to improve the reliability of relay protection secondary circuit and quickly locate faults to improve maintenance efficiency. This paper summarizes on-line monitoring technology and fault diagnosis technology, and briefly discusses its development significance.

Keywords
Intelligent substation; relay protection; secondary circuit; on-line monitoring; fault diagnosis.

1. Introduction
In today's smart substation, the information transmission cable between the equipment has been replaced by optical fiber, and the communication network has also replaced the traditional secondary circuit, in which the traditional electrical signal is replaced by optical fiber digital, and the secondary equipment has been networked[1], Virtual circuit and digital signal replace the traditional voltage and current signal into the form of information transmission between devices in intelligent substation.

Based on the openness and sharing of intelligent substation information transmission; The relay protection of power system has the advantages of high safety, strong performance, automatic control and so on. According to different types of requirements, different fault diagnosis models can be established to carry out on-line monitoring and fault diagnosis positioning of relay protection in intelligent substation from different aspects. Based on CNKI China journal full text database, this paper sets "fault diagnosis of secondary circuit in Smart Substation" as the theme and "core journal" as the scope, carries out fuzzy matching search, collects 25 relevant documents in recent years, and writes a review report.

2. Secondary circuit system of substation relay protection

2.1. Brief introduction of relay protection secondary circuit
The function of relay protection is to monitor the power system in real time, so that it can deal with the fault or abnormal situation in time, and send out the alarm signal. Relay protection circuit is mainly composed of three kinds of circuits: control circuit, regulation circuit and relay protection and automatic device circuit. The control circuit is composed of circuit breaker and isolating switch, which is aimed at the opening and closing operation of primary equipment.
Regulation loop refers to the automatic device with regulation function. The specific function is to dynamically adjust the working state of the equipment according to the changes of the parameters of the primary equipment. The circuit of relay protection and automatic device mainly analyzes the abnormality and fault of the primary equipment during operation, and independently sends the tripping instruction, so that the existing equipment can be removed by itself, and the relevant circuit breaker can be put into operation after the fault is removed, so that the power can be re supplied.

2.2. Types of online monitoring information

(1) Operation information. The operation information of the secondary device includes self-test information, fault information, input information, and switch information. Self check information mainly includes channel light intensity, operating temperature and power supply voltage of the device; The information of switching value and sampling value is represented by the measured current, differential current and input value of each branch.

(2) Alarm information. All kinds of abnormal operation state information of secondary device protection equipment is alarm information, including abnormal alarm of switching value and sampling value and abnormal alarm of device. When these alarm signals appear in the secondary circuit, the online monitoring system can quickly determine the type of fault and locate it, so that the operation and inspection personnel can quickly eliminate the fault and reduce the loss.

(3) Action information. The action information of protection is the action information, which includes the element information of protection action, the phase information of protection action, the time information of protection action and the logic information of protection action.

2.3. Detection method of secondary circuit of power system relay protection

In the literature [3] and [7], it is mentioned that the common method of power system relay protection secondary circuit detection is multimeter detection. The connection of current circuit can be monitored by using multimeter, but for the actual situation, this method can not effectively judge the polarity of current transformer. This method relies too much on experience, and there may be omissions in the actual detection.

On this basis, the secondary circuit detection method using external power supply method can greatly improve the detection accuracy; The application of this method can greatly improve the work efficiency of testing personnel. Between the high-voltage equipment put into operation, the common method to simulate the common faults is to set the short-circuit point and construct the closed circuit by external power supply. In this way, the voltage and current waveforms of the secondary circuit can be obtained in time and detected by analyzing the waveforms. When it is determined that there is no open circuit in the secondary side, the staff can analyze the current and current changes after applying AC power to the high voltage side. After analyzing the wiring condition of secondary circuit, inspectors need to check the polarity of current transformer and voltage transformer in time, and also complete the detection of bus differential protection direction, high frequency protection direction and longitudinal differential protection direction on this basis.

3. On line fault monitoring of relay protection secondary circuit

3.1. Establish fault system diagnosis model

According to the requirement of on-line monitoring of relay protection state, a fault system model of intelligent substation is proposed in reference [1]. The state information of the whole relay protection system is integrated and analyzed online and automatically by using the system characteristics of intelligent substation, and the key relay protection states hidden
among the state information are identified, and further determine the fault point or fault range \[8\]. The fault information model has the following functions: (1) it should include all the state information and the operation mode information that restricts the relationship between the state information; (2) The model can obtain the functional relationship based on the state information of the connection relationship inherent in the primary system \[12\]; (3) The model can obtain the functional relationship between the state information of the logical connection of the secondary system; (4) The model needs to obtain the functional relationship between the state information of the protection principle and the business characteristics of the relay protection; (5) The model should have the ability of fault location combined with fault information.

### 3.2. On line monitoring system of Intelligent Substation

Literature \[2\], \[3\], \[10\] describes the intelligent substation online monitoring system to analyze and obtain real-time information to achieve online condition monitoring and fault diagnosis of secondary circuit. The system includes the main station system and the station end system. The network message is used to record the information collected by the analysis device. The station device is mainly responsible for collecting, configuring, preprocessing and filtering information. The device quickly judges the communication network fault, collects relevant information, and transmits it to the master station system of the dispatching end in the form of file. The master station system preliminarily judges the abnormal information transmitted by the station end device, and feeds back it on the interface. Its fault diagnosis mainly relies on SV / goose link diagnosis, AC circuit double AD sampling method, and protection action fault diagnosis \[15\].

SV link refers to the transmission link used to transmit information in the working system of intelligent substation. The information transmission between systems is realized by the SV signal recognized by the transmission system. In the specified time, if the receiving device does not receive effective SV and goose information, an early warning will occur.

The main faults of AC circuit include node disconnection, phase voltage drop of circuit disconnection phase, normal phase voltage of other two phases, abnormal indication of multimeter, etc. Double AD sampling method is used to compare the detection data of two channels to realize synchronous comparison of various data. Through comparative analysis of monitoring data, the data parameters are judged to be floating within the normal parameter range \[16\].

The fault diagnosis of protection action is to take the detection state of the device as the judgment index, follow the consistency principle, ensure the consistency of the protection time difference and action of the protection device, judge whether the protection action sent by the protection device is correct by comparing the analog quantity and verifying the switch quantity, and ensure the operation time of the protection device.

### 3.3. Visual display of secondary circuit

All IED devices in smart substation are modeled according to IEC61850 standard, and the configuration information of Smart Substation is integrated into SCD. The secondary loop information in SCD includes goose, SV publish / subscribe control block configuration, do internal short address, physical port description, virtual terminal cyclic redundancy check and version information \[18\]. The process layer network composed of secondary equipment in SCD is separated to realize the visualization of secondary circuit of intelligent substation. The connection information of virtual terminal and physical optical fiber of process layer network is obtained, and then the modeling elements are displayed on the software interface. Relying on secondary circuit visualization, it can quickly locate the fault location, and then directly locate the actual fault location \[18\].

The visualization of secondary circuit is mainly composed of the following two parts:
(1) The first part: modeling the connection of IED and virtual terminal and physical optical fiber in secondary circuit with graphic elements.
(2) The second part: associate the dynamic primitives in the secondary loop visualization interface with the corresponding MMS alarm signals.

4. Conclusion

Nowadays, intelligent substation is a kind of substation with digitalized information, networked communication platform and standardized information sharing. This trend provides favorable conditions for the development and application of equipment condition monitoring technology of relay protection secondary circuit. There are also corresponding solutions to various hidden faults in the secondary circuit. Through reading a large number of literatures, we can learn that the stable operation of the intelligent substation can be guaranteed by establishing fault system model, intelligent substation online monitoring system, secondary circuit visualization and other technologies. Compared with the traditional manual periodic maintenance, the intelligent substation can be maintained in a stable manner. These technologies can greatly reduce the probability of failure, through early warning to reduce the loss caused by failure, but also greatly reduce the workload of staff, improve work efficiency. Comprehensive analysis shows that in the actual operation process of intelligent substation, it is necessary to develop on-line monitoring and fault diagnosis and location technology of relay protection secondary circuit.

References


