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Research on status information monitoring of power equipment based on Internet of Things

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Abstract

Power equipment is an inseparable and important part of the power system, and its operation largely determines the operation of the power grid. With the continuous promotion of the application of the Internet of Things technology in the power field, the monitoring of the status information of power equipment based on the Internet of Things has high research value. In order to explore the monitoring method of power equipment status information based on the Internet of Things, this article combines work practice to analyze the data information, tasks, and technical methods of power equipment status monitoring, conducts detailed research on primary equipment and secondary equipment, and formulates the power equipment status information monitoring strategy and method based on the Internet of things.

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Keywords: The Internet of Things; Power equipment; Condition monitoring

1. Introduction

With the rapid development of the power system and the concept of "Three Types and Two Grids" proposed by the State Grid Corporation of China, the stability of the power system operation becomes more important [1]. At the moment of steady development in our country, the demand for power loads is also increasing. It is particularly important to use the Internet of Things technology to strengthen the reliability of power grid equipment. Under the smart grid, the state maintenance of power equipment has changed the traditional mode of maintenance based on time periods. Instead, it uses the Internet and smart technology to realize real-time status monitoring of power equipment, and evaluate the operating status of the equipment based on power equipment operating data, experimental data, etc., and provide a decision-making basis for power equipment maintenance. In recent years, with the rapid development of the Internet of Things, the Internet of Things technology has been increasingly used in the construction of smart grids, especially in the maintenance of substations, which has brought great effects.

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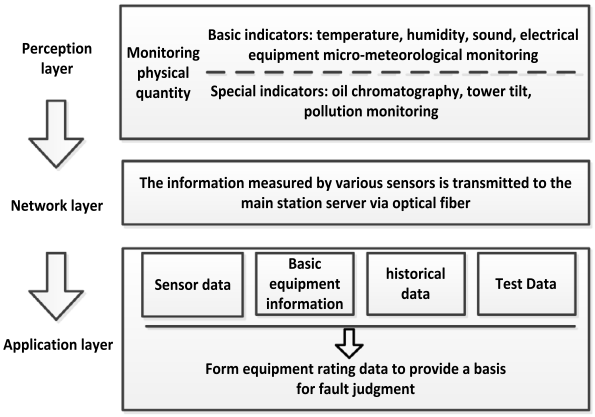

Fig. 1. Power equipment status information monitoring based on Internet of Things technology.

2. Status information monitoring of power equipment

2.1. Status monitoring data information and tasks

In the past power equipment maintenance process, it was found that equipment on a certain range of transmission lines rarely experienced a large number of failures at the same time. The deterioration of equipment generally needs to go through a gradual process, and with the help of detection equipment to monitor the status change data of the power equipment, the changes in the monitoring data can reflect the operating status of the power equipment well, and find problems and repair them in time [2]. In the monitoring of power equipment status information, generally the data information that needs to be recorded includes physical quantities such as voltage, current, brightness, vibration, temperature, and sound, as well as chemical analysis of gas and oil. In power equipment status detection, each data parameter has a corresponding role, and each data information reflects one aspect of the power equipment. The main tasks of power equipment status information monitoring based on the Internet of Things technology include the following aspects [3], the schematic diagram is shown in Fig. 1.

- It collects and organizes the real-time parameters of the operation of power equipment, and establishes a data file of the state of the power equipment;
- Based on the collected data information, it is used to judge the operation status of the power equipment, whether there is a fault, whether it is in an abnormal state, whether there is a hidden trouble of the fault, etc., and judge the nature and severity of the fault of the power equipment according to the parameter comparison;
- It is based on power equipment maintenance standards and combined with monitoring data to classify the operation status of power equipment to provide a basis for equipment maintenance decision-making.

2.2. The internet of things technology used

The Internet of Things is in the 21st century when electronic information is developing rapidly, and it has become one of the signs that the world has entered the information age. The Internet of Things is the combination of electronic information technology with people's daily life, and the combination of information and data with communication networks, forming a close connection between things [4]. Through intelligent perception systems, recognition technology and computer communication experience, various forms of transformation and convenience have been brought to people's lives. The information technology of the Internet of Things has penetrated into all aspects of people's lives. The Internet of Things is now known as the third wave of electronic information technology after computers and the Internet. The Internet of Things is mainly to upgrade and innovate people's experience, and rely on the innovation of the Internet of Things to improve the user experience of various industries. The Internet of Things can analyze and monitor industry information data through intelligent identification, positioning, tracking, and monitoring, realize the connection between objects and the network, and manage and monitor through the perception layer and transmission layer. At present, the Internet of things has penetrated into all walks of

life, bringing great convenience to our daily life, but there is a huge competition in the continuous promotion and application of Internet of things technology, which brings various forms of transformation and upgrading for industrial development, and promotes the development and progress of the industry.

In the monitoring of the status information of power equipment, the key technologies of the Internet of Things mainly used include the following aspects: the first is radio frequency identification technology, which is generally used in Ultra High Frequency (UHF), Micro Wave (MW), etc. in unmanned inspection scenarios of transmission lines; The second is nanotechnology, mainly used in sensor equipment, Radio Frequency Identification (RFID) equipment, etc., to meet the requirements of small size, low power consumption, and high performance of power monitoring equipment, and realize the arrangement of multiple sensors in a small location; The third is a wireless sensor network, through the combination of wired and wireless, to achieve the collection and transmission of power equipment status data in different scenarios and different environments; The fourth is Machine to Machine (M2M) technology, which realizes the communication between machines and machines under certain program settings, and realizes the interconnection and intercommunication between people, machines, and mobile terminals; The fifth is cloud computing and data security technology. Cloud computing technology organizes, allocates and uses the resources in the system according to the power equipment status detection requirements to achieve the optimization of equipment detection efficiency, while information security technology ensures the safe operation of power equipment status detection network system. The sixth is data fusion technology, mainly to realize the simple processing of a large number of sensors and their data in the power system, reduce broadband waste, and organize data information that is more in line with user needs.

3. Primary equipment status information monitoring

3.1. Features and methods of primary equipment status information monitoring

A state maintenance can effectively improve the monitoring effect of electrical equipment, and can eliminate problems and safety hazards in electrical equipment in a timely manner, which has a very good role in promoting the construction and development of my country's power grid [5]. The primary equipment condition maintenance mainly relies on its own diagnostic skills, and the diagnostic functions are improved through the Internet of Things, infrared sensing devices, and smart sensing devices, and the operation effect is more significant. As an auxiliary system, it assists related content during the operation of the equipment state according to the sensor, and the monitoring and inspection functions are enhanced. In the process of an equipment operation, an equipment maintenance can analyze the historical data of the system, and provide timely feedback on the problems existing in the diagnosis, maintenance, and maintenance process, which effectively improves the reliability, effectiveness and comprehensiveness of primary equipment operation state evaluation of electrical system.

The primary equipment status maintenance items mainly include the online diagnosis status of power equipment and equipment, equipment management data, equipment operation and maintenance status, live monitoring status, fault recording status, and preventive test data, etc.; the influencing factors mainly include: electricity market information, equipment operation data, equipment information, etc. These maintenance items can effectively reduce the workload of relevant personnel in the process of monitoring the primary equipment of power transmission and distribution, strengthen the maintenance of the maintenance work, and give full play to the economic characteristics of the maintenance, and solve the problems of difficult and high loss of primary equipment maintenance from many aspects.

3.2. Data monitoring of generators and transformers

The generator is one of the most important equipment in the power system. Generally, for the current power system in my country, the generator equipment structure is relatively closed. Traditional detection generally adopts the mode of time period, and in the context of smart grid construction, infrared imaging technology, ultrasonic sensors, etc. can be used to monitor its operating status in real time. Among them, infrared imaging technology has the advantages of strong practicability, high efficiency, sensitive and reliable inspection. Through the analysis of the temperature field of the operating equipment and the study of the thermal spectrum image, the possible failures of the equipment, the nature of the failure, and the time of the failure can be put forward. For the condition of no failure but abnormal temperature, timely warning and measures can be taken to prevent the occurrence of the

failure. Through infrared imaging and ultrasonic sensing, the inside of the generator can be visualized, thereby improving the quality of its online real-time monitoring. In addition, considering the mechanical principle of the generator equipment, ultrasonic sensors can also be used to monitor the parameter values of the air gap between the rotor and the stator, or a speed sensor can be installed on the equipment to collect vibration information during work, so as to realize the state information monitoring.

As far as the transformer is concerned, its load capacity, temperature, sound, oil level and other index parameters can be monitored to find the problem in time and solve it in time. During the operation of the transformer, the partial discharge and local overheating caused by the transformer are generally dissipated by oil. Insulating oil will be thermally decomposed during work, producing gases or hydrocarbons such as CO, H_2, CO_2, C_2H_2, etc. Then the gas is extracted from the insulating oil for chromatographic analysis to detect the contents of various gases and compare the standard parameter values to know the operating status of the transformer. In addition, vibration sensors can also be used to monitor transformer winding deformation, and current sensors can be used to monitor transformer cores. Not only that, electrical and ultrasonic methods can also be used to monitor discharge faults in transformer operation in real time. In practice, several probes can be set to work at the same time, which can effectively improve the detection effect.

3.3. Status information monitoring of transmission lines and buses

In the smart grid, compared with generators, transformers, switchgear and other equipment, there is a big difference in the implementation of status information monitoring of transmission lines. Transmission lines have fixed lines, and involve long physical distances and large geographic areas. They also have to withstand the interference of uncontrollable conditions such as thunder and lightning, trees, and small animals in various harsh weather conditions, which poses challenges for real-time monitoring. The integration of the Internet of Things technology has solved this problem well. Real-time status monitoring of the transmission line can be achieved by installing a large number of sensors on the transmission line towers, transmission lines, etc., or performing regular drone line inspections. In the transmission line detection, various types of sensors transmit the collected data information to the central detection system through the network layer, and then the system server analyzes and compares the data, and finally obtains the operating status of the transmission line. Generally, considering the characteristics of the transmission line, its real-time operation status detection generally adopts detection methods such as micro-climate environment detection, wire wind deviation online detection, wire temperature detection, icing detection, and tower tilt detection.

The bus is an extremely important component in the substation. Generally, the bus is not prone to failure during normal operation. The actual detected failure rate is relatively low, but once a failure occurs, its destructiveness is very serious and the consequences are extremely serious. According to the analysis of current fault types, the probability of artificial fault is high. Therefore, the state detection mainly focuses on the pollution and insulation of grounding switch, grounding wire and bus equipment. The state detection method can adopt the wireless mobile or rotary camera technology in the Internet of things.

3.4. Data monitoring of high-voltage circuit breakers and isolating switches

High-voltage circuit breakers and isolating switches are important equipment to protect the safe and stable operation of the power system. At present, there are three types of high-voltage circuit breakers in my country's power system: oil circuit breakers, vacuum circuit breakers, and Sulfur hexafluoride (SF6) circuit breakers. Each type of circuit breaker has different types of faults in actual work, so its corresponding detection methods It should also be targeted. In the status information monitoring of high-voltage circuit breakers, it is necessary to focus on real-time status information monitoring of the switch contacts, including internal and external burns, external damage, and surface contamination of the switch. Vacuum circuit breakers need to combine its performance principles to monitor the vacuum degree of the vacuum interrupter in real time; oil circuit breakers monitor the tightness; SF6 circuit breakers mainly monitor the moisture content in their SF6 gas. The status information monitoring of high-voltage circuit breakers generally adopts infrared monitoring technology and movable probes in the Internet of Things technology.

The monitoring of disconnector is relatively simple, it mainly focuses on the common faults such as rusting of components, poor operation of operating mechanism, abnormal heating of contact and so on. The technology of infrared temperature measurement, X-ray, movable probe and so on can be used to monitor the status information of disconnector.

4. Status information monitoring of secondary equipment

4.1. The characteristics and methods of secondary equipment status information monitoring

In the context of the integration of smart grid and Internet of Things technology, secondary equipment, as auxiliary equipment of the primary equipment of the power system, plays an important role in stabilizing the safety of the power system. At the same time, its own safety needs to be monitored in real time. In the smart grid system, the secondary equipment not only provides monitoring, regulation, control, and protection for the primary equipment, but also has certain self-monitoring functions. Therefore, the status information monitoring of the secondary equipment can give full play to the advantages of the Internet of Things, and realize the status information monitoring of the secondary equipment in a systematic and unitized mode. Regarding the self-monitoring function of the secondary device itself and its own communication function, it can rely on the network layer of the Internet of Things to realize the interconnection between the devices through the communication function, so as to obtain the operating status information of the secondary device.

4.2. Secondary circuit information monitoring

The status detection of the secondary circuit is generally completed by the secondary circuit monitoring system in conventional substations, and its functions mainly include whether the insulation of the secondary system is good or not, fault alarms, etc. With the rapid development of smart grids, the protection devices in the grid have shown a trend of microcomputerization and intelligence. The secondary circuit is composed of multiple relays, and the relay points in the circuit are very many and scattered, which poses a problem for the relay status information monitoring. Not only that, a large number of microelectronic components, integrated circuits, etc., bring obvious electromagnetic interference to secondary equipment. From a practical point of view, the monitoring of the status information of the secondary loop is mainly aimed at determining the fault point. Generally, the injection method is used to inject a specific frequency current into the secondary circuit, and then find the fault point through real-time monitoring, so as to effectively determine the fault point of the secondary equipment and perform rapid repair. Although the secondary equipment has various restrictions such as susceptibility to interference, high reliability and high precision requirements, with the development of the Internet of Things technology and the maturity of the centralized control station monitoring technology, the condition monitoring of power secondary equipment can achieve good results both in technology and economy.

4.3. Monitoring of operating environment information of power equipment

The external environment is one of the important external factors that affect the safe and stable operation of power equipment. Power equipment failures caused by the external environment cause great damage to the power system, especially the external conditions with harsh weather conditions and complex geographic environments, which have a great impact on the operation of the power grid, such as breeze vibration, wire icing, and wind deviation of insulator strings. In addition, outdoor transformers, circuit breakers, etc. are also highly sensitive to temperature, and too high temperatures can easily cause faults. Therefore, real-time status information monitoring of the external environment of power equipment is required. In the fusion construction of smart grid and the Internet of Things, the method of online monitoring of the meteorological environment of the wire is usually adopted. Various sensors are installed on the transmission line to collect environmental data information (Parameters such as temperature, relative humidity, wind speed, wind direction, air pressure, rainfall, light radiation, etc.), in real time and perform analysis and processing to realize the online monitoring of the operating environment of power equipment.

To sum up, in the construction of smart grid, the introduction of Internet of Things technology has greatly improved the level of online monitoring of the power grid. Compared with traditional offline monitoring technology,

online monitoring is more intelligent and real-time, free from periodic restrictions, and its analysis of power equipment is also more automated and intelligent, which can improve the efficiency and reliability of condition monitoring. Under the Internet of Things technology, power equipment monitoring makes full use of the advantages of the Internet of Things technology. There are a large number of sensors to form the perception layer, and then through the data communication at the network layer, data analysis and feedback are completed in the detection system center to realize the status monitoring of the power equipment.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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