Research on intelligent inspection technology of distribution network based on RFID

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Abstract. As an important part of power system, the safe and stable operation of distribution network affects the power quality of the whole society and the reliability of power grid operation. As a technology widely used in Internet of things equipment, radio frequency identification (RFID) has the characteristics of non-contact reading and wide identification range, which is especially suitable for the working situation of patrol distribution network equipment. Based on radio frequency identification technology, non-contact two-way communication is carried out. According to the task transmitted from the workstation, the inspection results are recorded, and the field data is transmitted to the background management system through the wireless communication network. The intelligent purpose of the distribution network inspection system is realized, so as to improve the inspection efficiency and the reliability of the power grid operation.

1. Introduction
With the rapid development of China's society, the demand for electric energy and the reliability of power in various fields of society are increasing day by day, and the improvement of distribution network is related to the reliability and quality of power consumption. Therefore, it is necessary to build a strong intelligent distribution network to ensure the security and stability of power supply and consumption, improve the operation efficiency of the power grid and the reliability and economy of the overall operation of the power grid, so as to better serve the majority of users [1]. In our country, the traditional power distribution inspection mostly adopts regular inspection, that is to inspect the equipment at the specified inspection time [2]. However, with the increasing capacity of the power system, the further expansion of the scale of the power grid and the improvement of the complexity of the electrical equipment structure, the task of the inspection of the distribution network equipment is becoming more and more important. The regular planned inspection is difficult to reflect the operation status of the equipment in real time, which is not conducive to the prediction of the early symptoms of equipment failure and better evaluation of the equipment status. It is very inconvenient for the inspection personnel to keep the traditional inspection records.

With the popularization of Internet of things technology and the development of computer network technology, more and more advanced technologies or concepts are applied to the power equipment inspection business. At present, radio frequency identification (RFID) technology is widely used in power inspection. This technology can identify the electronic tag without contact, and then achieve the
2. The technical principle of RFID

RFID radio frequency identification (RFID) is generally known as electronic tag technology. It can realize the specific target and data information within the standard radio frequency range in a non-contact way, and use wireless technology to read, write and exchange. The working principle of RFID system is essentially electromagnetic theory technology [3]. When the system works, the data information between the electronic tag and the reader can realize the two-way transmission of data through radio frequency identification technology, and then realize the exchange of data information. When the RFID tag enters the range of RFID reader's RF signal, the induction coil generates induced current, activates the tag's internal storage and antenna, and transmits the RF signal of specific frequency. The reader receives and decodes the radio frequency signal containing the equipment information, and hands the information to the single chip microcomputer for processing [4, 5, 6]. The software part plays two roles: terminal operation and background management. Through the collection, integration and calculation of data information, the sharing of data resources is realized.

The most prominent feature of RFID technology is non-contact reading and the reading distance can be from several centimeters to tens of meters, it can identify high-speed objects, resist harsh environment, has strong confidentiality, can read multiple identification objects at the same time, etc. [7, 8], thus improving the traditional way of manual inspection records of inspection personnel, as well as the problem that paper records are not easy to save, it can accurately, safely and quickly identify distribution network equipment Carry out patrol inspection to improve work efficiency.

3. Composition of distribution network intelligent inspection system

A typical RFID system consists of two parts: hardware and software. Among them, RFID tag and RFID reader are the main hardware support of RFID technology. The software part effectively controls and manages the effective communication and transmission of data information between the electronic tag and the reader, and reasonably manages, analyzes and processes the collected data information [9].

3.1. Hardware structure of RFID system

The intelligent inspection system is composed of on-site power distribution equipment and electronic tags, portable inspection terminal personal digital assistant (PDA) reader and database server, these things are as shown in Figure 1.

![Figure 1. Hardware structure of RFID system.](image-url)
1) PDA of handheld inspection terminal

Based on RFID radio frequency identification technology, it can realize non-contact automatic intelligent identification between PDA and power distribution equipment information. PDA downloads the task from the workstation to patrol the designated equipment of the designated unit, and records the inspection results, and then transmits the field data to the background management system through the wireless communication network [10]. Through automatic identification of distribution network equipment objects and real-time extraction of relevant data information, it has the advantages of high data acquisition accuracy. Through automatic identification of distribution network equipment objects and real-time extraction of relevant data information, it has the advantages of high data acquisition accuracy, strong real-time performance, strong anti-interference ability, convenient operation and portability [11].

2) Electronic label identification

The electronic tag is used to store the detailed data information and historical verification information of the equipment. The PDA inspection record terminal uses the electronic tag of the equipment within the scope of RFID identification on site. The current generated by electromagnetic induction makes the chip on the RFID tag act to send a response signal back to the PDA [12, 13, 14, 15, 16], so as to complete the inspection task and extract the relevant data information, and record the inspection events and equipment defects. In the inspection task, the RFID identification code value carried by the task is transmitted to the PDA through automatic confirmation, so as to ensure the accuracy of the collection object, the position of the inspection personnel and the accuracy and reliability of the data.

3) Database server

The database is responsible for customer management and data collation. The inspection data is transmitted to the data center deployed in the master station through PDA return or wireless communication network. At the same time, the database server is responsible for storing the basic data and parameter information of power equipment as well as the query and statistics of electronic tag information as well as user management, help and other information [17], so as to realize the guidance, identification and judgment, event recording of automatic inspection work of power distribution equipment, and complete the equipment account information collection, equipment defect query, operation and maintenance mode management and many other functions. In addition, managers can also query the operation information of distribution network equipment through the system or mobile phone terminal as required.

3.2. RFID system software structure

The software system is developed on the basis of hardware configuration and open interface of mobile intelligent equipment, and the enterprise level equipment inspection database is established [18], which enables a large number of patrol data to be archived and maintained uniformly, as well as data communication, query, report and protection. The intelligent inspection system needs to have the following characteristics:

1) Data collection

The data collection module is installed in the PDA of the handheld terminal, which is used to collect the data such as the reading of the electronic tag and the running status of the equipment. Before the inspection, the inspectors need to download the inspection tasks issued by the company to the handheld PDA terminal, and carry out the inspection according to the specific inspection tasks. The inspectors can carry out the patrol operation according to the task reminder or the operation status of the equipment itself. If the equipment defects are found, the defects will be recorded and managed, and uploaded to the background management system at the same time.

2) Data management

The data management module is installed in the computer background management system. It can receive, classify, store and query the collected patrol data, generate relevant reports, and make statistics on the abnormal equipment or transfer it to the inspection management system to generate the equipment defect table. Through RFID tag identification, the system can automatically and quickly complete...
equipment matching, and support intelligent default value [19]. When collecting equipment operation parameters, the system can display the last inspection results, better reflect the trend of equipment operation status, help to find potential equipment faults, and automatically write the latest evaluation results into the electronic tag. The module also has the function of database protection, which can customize the location, items, cycle and route of inspection.

3) Data query

The query module is installed in the network application server of the information management system. Any machine on the network can query the operation patrol data through the network application server, and make statistics and generate relevant reports according to the needs. The system uses open-source visualization products, which can be visualized in the form of tables, spectrograms, histograms, pie charts, line charts, etc., providing a friendly and interactive user experience, and automatically generating inspection record reports.

4. Composition of distribution network intelligent inspection system

When going out for inspection, the inspectors can read the electronic tag through the handheld device terminal to obtain the relevant information of the equipment, take photos of the equipment according to the situation, and record the operation of the equipment and the implementation of the task. If the fault is found, the fault type, equipment number and other information will be sent to the background management system combined with the current PDA.

4.1. Basic process of inspection system

When the inspection personnel arrive at the inspection destination, log in the PDA of the handheld terminal and start the inspection of the equipment, after the first electronic tag is scanned successfully, the PDA of the handheld terminal automatically records the time, which is convenient for the management personnel to supervise the inspection personnel in place, and undertakes the functions of task download, task execution, RFID identification, data collection, task upload, etc. RFID identification is the basis, data collection is the purpose, and data management is the support.

The patrol personnel log in to the terminal system to download the inspection task book, view the inspection task, and inspect the equipment according to the specific work deployment. After completing the equipment inspection task, the collected data will be automatically uploaded to the system. At this time, the system will automatically detect whether all inspection items have been recorded, whether the patrol data of the equipment exists, and how many devices are not inspected at the inspection point And how many inspection points are not inspected in this task, the corresponding prompt and record are given, which effectively avoids the phenomenon of wrong inspection and missed inspection. This is done in turn until all the equipment inspection of the inspection point is completed. When the next inspection point is reached, the patrol inspection is carried out according to the above until all patrol tasks are completed. The flow chart of distribution network intelligent inspection system based on RFID technology is shown in Figure 2.
Figure 2. Flow chart of distribution network intelligent inspection system.

4.2. Digital intelligent management of inspection system

The inspection information of distribution equipment includes basic equipment information, inspection personnel and inspection records, technical parameters of equipment, equipment inspection time, history of fault occurrence, etc. These information constitute a huge equipment information database. After the inspection work is completed, the inspection data is uploaded to the back-end server through the wireless network, and the system will combine the latest equipment status data obtained from other systems for multi information fusion analysis and diagnosis, and provide advanced applications, such as state assessment, fault diagnosis and risk assessment.

The digital intelligent inspection system can classify and manage the database, and make statistics, summary and analysis of all kinds of historical data stored in the database, and display the frequency and object of a certain fault in a certain period of time by using various graphical reports. Thus, it provides suggestions for accurately judging the operation status of power plant equipment and decision-making for equipment operation and maintenance. It can make managers make countermeasures by forecasting and analyzing these data information, so as to achieve the purpose of pre control and reduce the occurrence of accidents. After the patrol personnel download the inspection task, the PDA of the handheld terminal will automatically synchronize the evaluation results of the latest equipment status, and write the latest status into the storage space of the RFID tag user area, so that the inspection personnel can intuitively understand the latest operation status of the equipment. This can reduce the workload of inspection personnel as much as possible, improve the management ability of the company, and realize the digital intelligent level of equipment information management of power companies. It has practical significance to improve the inspection efficiency and operation and maintenance level of distribution network equipment. After the patrol personnel download the inspection task, the PDA of the handheld terminal will automatically synchronize the evaluation results of the latest equipment status, and write the latest status into the storage space of the RFID tag user area, so that the inspection
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5. Application of RFID intelligent inspection system
With the continuous promotion and deepening of information construction of power Grid Company, the business integration and information sharing of all aspects of smart grid also put forward higher requirements for information service function. At the same time, the integrated platform also needs to expand and enhance the support for spatial information of grid resources. Combined with the development of information technology and the operation and maintenance characteristics of power equipment, the following points will play an important role in the research of intelligent inspection system.

1) Based on the standardization and development of technical standards, a variety of identification technologies can be used with each other. For example, using visual identification technology in barcode recognition technology can collect the required data more accurately and efficiently. With the development of computer network technology, the intelligent inspection system will be integrated in the distribution equipment management system to realize the exchange and utilization of data information.

2) In the current distribution network operation environment, combined with RFID technology and Geographic Information System (GIS) technology widely used in the Internet of things technology, a power grid GIS platform is established to provide all-round grid geographic information with high precision and in line with the objective power grid resource distribution and attribute characteristics [20]. Through the high-performance interface and professional data center platform, the geographic information data is coupled to the existing power production management system and intelligent distribution inspection system. The inspection plan is made in the production management system and synchronized from the background to the intelligent power distribution inspection system, which is issued to the inspection personnel, and the inspection personnel download the geographic information and inspection content in the power distribution inspection system to the handheld terminal. The inspection site RFID and handheld GIS terminal are used to locate the inspection equipment and determine the inspection personnel in place, so as to fundamentally eliminate the missing inspection and false inspection of the inspection personnel.

3) Aiming at the life cycle management and operation management of power equipment, a new generation of intelligent inspection system is constructed based on the concept of Internet of things technology. Comprehensively improve the openness, reliability, security and maintainability of the system, and realize the modern management of fine division of labor and fine service quality, so as to promote the application of Internet of things in smart grid and intelligent inspection system.

6. Conclusion
With the continuous update and development of intelligent inspection technology of distribution network, people's experience in power supply reliability, power quality and service quality has been improved, and great social benefits have been achieved. Through the intelligent planning of inspection route, it can avoid the situation that the inspection is not in place and not standardized, reduces the workload of the inspection personnel, and improves the work efficiency of the distribution network inspection work. At the same time, through the intelligent inspection database system, the auxiliary analysis of the inspection work is carried out, and the accident equipment is predicted, which effectively reduces the occurrence rate of failure, shortens the power outage maintenance time, reduces the loss, takes the Great economic benefits have been obtained. In addition, RFID technology can also combine with other Internet of things technology to further improve the inspection ability and information intelligence degree of the intelligent inspection system.
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