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## Study on background monitoring system of intelligent transformer substation based on IOT

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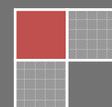
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### ABSTRACT

With the development and application of science and technology, the monitoring system of transformer substation faces higher requirements. Currently, most of the monitors, warning devices and other safety auxiliary facilities installed at transformer substations are independent of each other without unified management. In addition, the data mainly coming from on-the-spot monitoring and collection of staff will be then brought back for analysis. Therefore, the existing faults found in the monitoring and management of transformer substation equipment and rapid investigation of transformer substations cannot be timely and quickly resolved. In order to guarantee the safety, the staff can not visit particular areas to collect data, thus there are blind areas existing in monitoring system of transformer substation. The construction of background monitoring system of intelligent transformer substation based on the research, development and application of the technologies of IOT can realize real-time transmission of the remote data of intelligent monitoring of transformer substation and auxiliary control system, including video information, all kinds of remote control command operating production equipment, report of creation and processing of emergency, thus making the background monitoring of transformer substation more convenient to appropriately solve the problems existing in traditional mode. The real-time transmission of monitoring data to make the data convenient for the operation and inspection of staff. The application of wireless sensors, positioning system, radio frequency identification and other technologies of IOT in transformer substations realizes the accurately, and timely located monitoring of transformer substation, thus establishing an intelligent management platform of monitoring system.

### KEYWORDS

Technologies of IOT; Transformer substation; Monitoring system; Wireless sensor network.



## INTRODUCTION

Currently, the management of transformer substation in China mainly depends on artificial on-the-spot survey, inspection and maintenance. Even the safety inspection of power equipment also mainly depends on regular, multiple on-the-spot inspections of staff. Therefore, the personal skill and experience of staff carrying out on-the-spot inspections are crucial because the transformer substation will maintain an abnormal operation state if the faults can not be quickly and well solved. The inspection results depend on the personal skill of on-the-spot inspectors. Besides, the solution of practical problems relies on the on-the-spot data and the problems provided by on-the-spot inspectors, then the solution of the problem can be proceeded. Because the systems do not cooperate with each other, it is difficult for the background monitoring system to manage and operate them<sup>[1]</sup>. However, the technology of IOT can be applied in transformer substations to establish an intelligent background monitoring system which uses a variety of sensors to collect the real-time data of on-the-spot temperature, humidity and instruments and equipment. The collected data will be sent back to the background monitoring platform through a sensor network. The management of the functions of auxiliary facilities including image and video monitoring, safety alarm device, daylight devices and ventilation facilities can realize the purpose of real-time monitoring and timely solve the hidden faults existing in transformer substations, thus ensuring the normal operation of the transformer substation. Full implementation of the background monitoring system of intelligent transformer substation can realize the functions including intelligent detection, intelligent judgment, intelligent processing, and intelligent management.

### INTRODUCTION OF THE TECHNOLOGY OF THE IOT

#### Overview of the IOT

The concept of IOT firstly derived from the logistics domain, mainly based on radio frequency identification technology and sensor network technology. The IOT is a network covering thousands of material objects with the help of existing technologies. The core and basis of the "technology of IOT" is still the "internet technology", namely that it is a kind of extending and expanding network technology based on the internet technology. Every object in the IOT has its exclusive ID which can be identified, read and queried, thus providing more rich and colorful help and management for all kinds of enterprises and household lives.

Since the start of the technology of IOT in our country, a relatively complete industrial chain has formed and is applied in many fields. At present, the IOT mainly reads the information of the target objects of information collection through radio frequency identification technology (RFID), global positioning system (GPS), sensors, laser scanning and other information identifiers and transmitters<sup>[2]</sup>, and it conducts integrating transmission to achieve rapid object tracking, monitoring, managing, and other operations.

#### Key technology of IOT

The sensor technology and network communication technology in the IOT are developing rapidly. Either the research staff or users all hope to further improve the life quality and the mode of enterprise management, create an intelligent world, fully improve the utilization rate of energy and people's living standards, and construct a harmonious urban traffic environment with the help of the IOT.

The technology of IOT can mainly be divided into three aspects including comprehensive perception, reliable transmission, and intelligent control. The comprehensive perception layer mainly refers to carry out real-time and dynamic perception on monitoring objectives whenever and wherever possible through RFID, sensors, two-dimension code, and other related sensor equipment. The collected data will be immediately transmitted through Ethernet, wireless networks and mobile network<sup>[3]</sup>. The monitors will manage and operate according to the previous data, thus realizing the "communications" between people and objects. The relevant working model is shown in Figure 1.

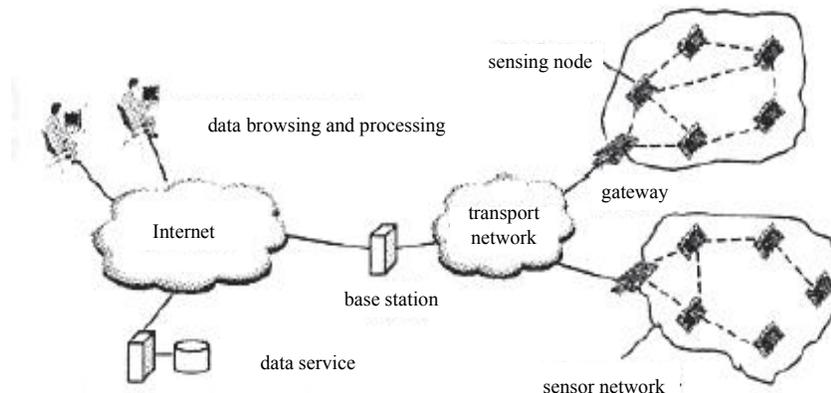


Figure 1 : Basic working model of the IOT

The IOT is made up of all kinds of technologies, involving in numerous fields. Its technological advantages endow it with vast application domain. As for the transportation field, the application of the technologies of IOT, including sensors, data analysis and processing, global positioning system (GPS) in modern transportation can create an intelligent traffic environment. The IOT mainly involves in the following technologies as shown in TABLE 1 below.

**TABLE 1 : Key technologies of IOT**

<b>Sensor layer</b>	<b>radio-frequency technique, ZigBee technology, location technique, sensor, two-dimension code technique</b>
Transport layer	Internet, WSN technique, mobile communication technique
Application layer	artificial intelligence technology, middleware, M2M technique, data mining

The construction of background monitoring system of intelligent transformer substation is one of the main application of IOT. Sensor equipment is installed in the transformer substation for the real-time monitoring of transformer substation state, including temperature, humidity, work efficiency and security. Then, the collected data will be transmitted to data processing center through the network layer for processing and analysis, so as to collect effective information such as the working state of the equipment in transformer substation and whether there are faults existing in equipment. The right decisions will be made on the basis of those information.

**THE APPLICATION OF IOT IN INTELLIGENT TRANSFORMER SUBSTATION**

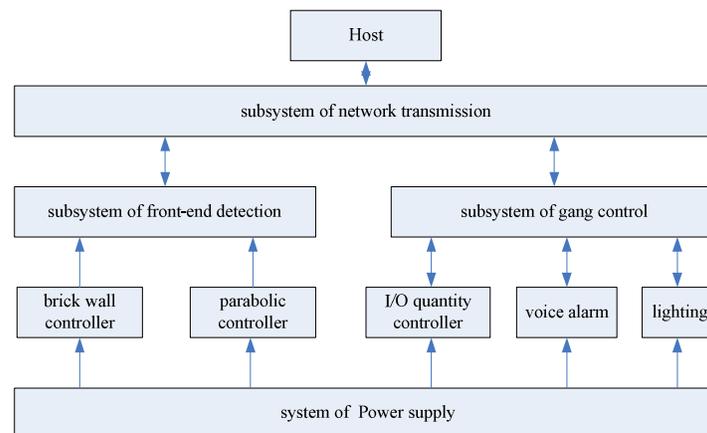
To ensure the normal operation of transformer substation under any environment, it is important to construct a safe and reliable transformer substation which can realize normal operation of power grid under harsh environment, provide service for enterprises and daily lives and provide guarantee for the fast maintenance of power grid. The IOT can be applied in the construction of intelligent monitoring system of transformer substation. Equipments with advantages of being reliable, highly integrated, energy saving and good performance were installed to fully realize and construct an background monitoring system of intelligent transformer substation which regards the high-speed, secure network communication platform as the basis of information transmission.

**The application of IOT in auxiliary system**

Currently, the auxiliary equipment within the transformer substation are independent of each other. In other words, the information of the equipment cannot connect with each other. Therefore, as for the background monitoring of transformer substation, the system is not good monitoring system. However, the application of the technology of IOT can greatly improve the background monitoring system. The application of IOT in auxiliary system includes the following aspects:

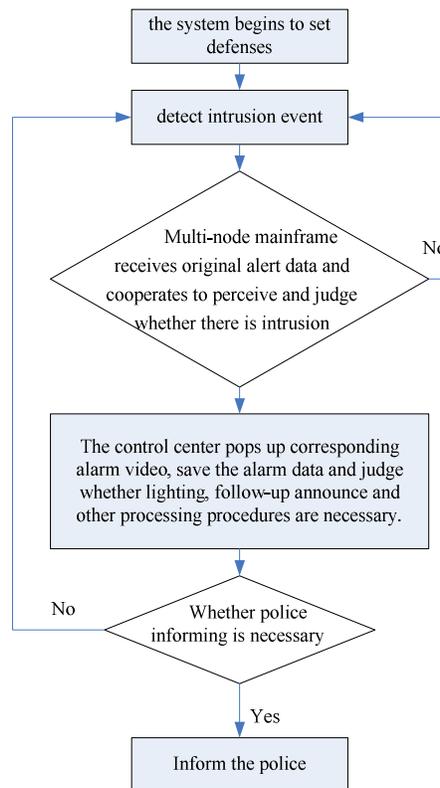
**(1)The subsystem of image monitoring and security guarding**

Due to the shortages existing in the traditional substation construction, the background monitoring system is not complete and is inconvenient for control. Therefore, a variety of sensor nodes (such as: temperature sensors, pressure sensors, etc.) are used for substation monitoring and real-time acquisition of the on-the-spot status of transformer substation. The monitoring system of intelligent transformer substation based on sensor network has many advantages: the transformer substation can be constructed under any environment, besides the intelligent equipment testing and data collecting and analyzing can automatically ensure the effectiveness of data<sup>[4]</sup>, and put forward better and more efficient solution for practical problems. The integration platform block diagram of the background image monitoring system of transformer substation based on the technology of IOT is as shown in Figure 2.



**Figure 2 : The integration platform block diagram of the background image monitoring system**

As long as abnormal intrusion behavior triggers the alarm, the system will immediately respond to it. In addition, the main controller of transformer substation also will send audio signal to on-the-spot audio equipment, then the alarm will be triggered, and the workers also can issue on-the-spot warning through radio. The working process of intelligent alarm system is shown in Figure 3.



**Figure 3 : Intelligent alarm system**

## (2) Water supply and drainage subsystem

Monitor the state of the water supply and drainage equipment, the quantity of water use and displacement, the pollutants, the water level of sewage pool and the water tank, and control the working state of drainage devices. Conduct real-time monitoring on ponding status and timely solve it, realize the automatic discharge of water. Start the camera to carry out on-the-spot monitoring, remotely inquiry status of water quality, ensure the safe and reliable operation of the system, sound alarm in time as long as emergency occurs, remind attendants to take emergency measures.

## (3) Subsystem of intelligent monitoring and supervision

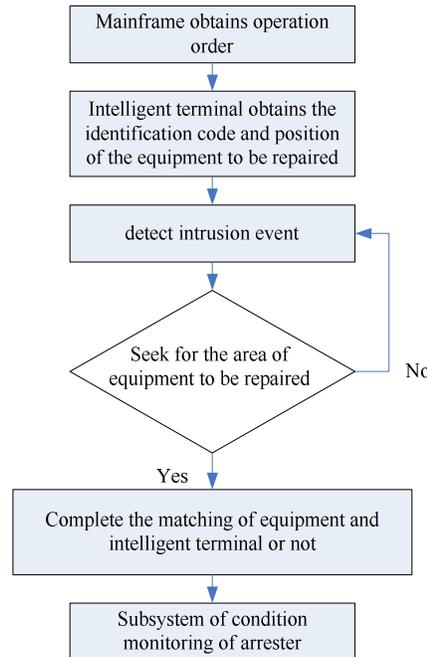
The monitoring system of intelligent transformer substation based on the technology of IOT is mainly composed of sensor nodes, hand-held intelligent terminal devices as well as the mainframe hosting background monitoring and control, and other important parts. The intelligent sensor nodes are mainly installed at important and large substation equipment as the electronic tags, storage of electric data acquisition and processing<sup>[5]</sup>. The intelligent sensor has the sensory ability of perceiving vibration, temperature, humidity and other environmental information. Each monitoring area is assigned with certain number of monitoring devices (including sensors and camera monitor), and only the cards having been identified can read out the real-time information of each related area.

The intelligent terminal inputs corresponding operation state according to the previously stored Chinese prompts, and at the same time automatically collects the running environment parameters of equipment, display the basic information of devices including serial number, date of commissioning, maintenance plan. Figure 4 shows the flow chart of the working process of intelligent monitoring.

## (4) Subsystem of condition monitoring of arrester

Leakage current sensor and voltage monitoring sensor jointly serve as the front-end data acquiring equipment of arrester monitoring system, collecting and recording each time point of data collecting. The voltage monitoring sensor is mainly used for data collection. The collected phase information will be then sent to mainframe through sensor network after analyzing and processing. The reference phase of leakage current can be judged from the collected data. If the collected phase information is sent to all current sensor nodes of direct repeats, then it can be used to calculate the impedance value. The background monitoring mainframe of transformer substation obtains the total leakage current through analyzing data of

arrester, thus realizing the real-time online monitoring of arrester under safe mode with networking. As we all know, the probability of occurring indoor lightning stroke is quite small, thus it is necessary to build buildings to protect certain equipment or implement some protection circuits to prevent the current sensor from stopping working due to the influence of thunder and lightning.



**Figure 4 : The flow chart of the working process of intelligent monitoring**

#### **(5) Subsystem of SF6 leakage monitoring**

The SF6 sensor is mainly responsible for detecting the content of SF6 in the air, and the oxygen sensor is mainly responsible for detecting the content of oxygen. Install multiple SF6 sensors and oxygen sensors for real-time monitoring and collecting data. After analyzing and processing the collected data<sup>[6]</sup>, the leakage status of SF6 can be judged from the analysis results. Then, the monitoring platform of IOT determine the operation of ventilator, and it also can activate some alertors (such as opto-acoustic alertor), thus providing double guarantee for the normal operation of system.

#### **The intelligent status monitoring system of transformer substation**

The background monitoring system of intelligent transformer substation based on the IOT mainly collects data through a variety of sensor nodes and sends the data through communication network. Then it carries out a series operation and fault analysis on the working status and safety maintenance of transformer substation, and judges whether there are faults existing based on the data collected by front-end equipment. After analyzing, the background system makes right decision and orders related ancillary equipment to deal with the faults and maintain the equipment. To realize the intelligent function of transformer substation, it is still necessary to solve the following key problems:

(1) A large number of sensor nodes are applied in the monitoring system of transformer substation, but the life cycle of these sensor nodes needs to be taken into consideration<sup>[7]</sup>. If the life cycle of the sensor node is too short, it then need to be updated frequently, which not only will produce electronic waste, but also may affect other normal monitoring systems of transformer substation. Therefore it is vitally important to design sensor nodes with longer life cycle.

(2) A large number of sensor nodes and other equipment are installed in the monitoring system of transformer substation based on the technology of IOT. If the system still uses previous network communication protocol, it will become complex. Thus, it is necessary to form a kind of network transmission protocol which is suitable for communication within certain range. And in this way, the equipment in the transformer substation can be intelligentized, thus realizing intelligent control.

Reasonable environmental solutions can be put forward on the basis of intelligent monitoring of the environment, temperature and humidity of transformer substation, thus fully saving power resources. Once intelligent monitoring system finds that the water level of transformer substation exceeds or water leakage occurs, the alarm will be triggered, thus reducing the risk of serious water leakage and accident expanding to the minimum extent. Taking the advantage of high integration of data of multi sensors, the intelligent invasion preventing can be achieved without the help of experiences. Once the warning line is touched, the warning devices will be triggered, which having possesses a relatively high reliability of preventing equipment damage<sup>[8]</sup>.

Besides, make full use of the existing structure system of IOT, realize the intelligent identification and authentication of inspection and maintenance, so as to prevent faulty operation; carry out inspection within the transformer

substation to avoid blind area of inspection; carry out real-time temperature inspection and real-time arrester inspection on various equipment in the transformer substation to improve the control effect.

### CONCLUSION

The wide application of the technology of IOT has realized the exchange and integration between people and things. The target monitoring objectives can be timely recognized, positioned and tracked through monitoring all kinds of equipment, which also is conducive to better management and control of operation and use of equipment. Built the sensor network under the help of related technologies, so as to realize real-time monitoring of various factors affecting the status of transformer substation as far as possible. Estimate the operation and working status of transformer substation, realize automation of management and control. Because the environment of some areas in the transformer substation is relatively dangerous, there will be potential risks during testing, operating, and maintaining. Therefore the maintenance worker need to keep real-time communication with the staff in the transformer substation. Adopt camera monitoring to ensure their safety and prevent the occurrence of accidents<sup>[8]</sup>. The application of the technology of IOT not only ensures the normal operation of transformer substation, but also will further improve the detection technology of the equipment.

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