Application of Directional Transmission Data Technology for Transmission Lines

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Abstract. The transmission line is realized by boosting the electric energy from the generator with a transformer and then connecting it to the transmission line through the circuit breaker and other control equipment. Structure, transmission lines are divided into overhead transmission lines and cable lines. At present, the real-time state acquistion of overhead transmission line mainly depends on the online monitoring device installed by itself. After the equipment obtains the monitoring information, it will send the relevant information to the remote monitoring system through the network formed by the network. However, the length of the working time of the online monitoring device is limited by the battery, so improving the power utilization rate of the transmission line monitoring device can significantly extend the working time of the device. This paper proposes a directional transmission data technology which can solve the problems of high energy consumption and poor signal transmission quality of monitoring devices, and effectively extend the network lifetime.

1. Introduction
In recent years, the rapid development of sensors, wireless communication, hardware embedded and technology at home and abroad has promoted the continuous upgrading of wireless sensors, the increasingly perfect hardware configuration and software functions, able to meet more scene requirements, and widely used in various industrial production[1]. Sensors are installed on the towers of overhead transmission lines to monitor the connection and galloping of the lines with various functions. However, in practical work, because the sensor is installed on an independent tower, the conventional power supply method is not applicable. At the same time, because of the simple structure, the sensor generally uses battery power supply[2-3].

2. Characteristics of overhead transmission lines
In the power system, transmission can be divided into overhead transmission line and underground transmission line according to the structural form. The overhead transmission line is erected on the ground, and the power line insulated by insulator and air is mainly composed of conductor, overhead ground wire, insulator string, tower, grounding device and other parts[4]. Compared with underground transmission lines, overhead lines have the advantages of low construction cost, short construction period and easy maintenance. Therefore, the overhead line transmission is the main transmission mode used in the development of power industry[5]. Generally speaking, the transmission line refers to the overhead transmission line. Through overhead lines, power stations, substations and load points in different areas are connected to transmit or exchange electric energy, forming a power network or distribution network of various voltage levels.
However, because the working environment of the overhead transmission line is in nature, many severe environmental weather (such as thunderstorm, icing, etc.) and external force damage to the line will cause various effects on the tower body or line of the overhead transmission line, which may cause tower body corrosion, flash on the edge of some lines, or even cause line disconnection, which may cause long-term power interruption for users, affecting the normal operation of social economy.

In recent years, more and more attention has been paid to the protection of overhead transmission lines, and various monitoring equipment has been installed to monitor the operation of overhead transmission lines. However, the operation of the device requires a continuous and stable power supply. Although the device is equipped with batteries or solar power devices, energy consumption is still the bottleneck affecting the wide application of various devices.

3. Monitoring information transmission of overhead transmission lines

Overhead transmission line inspection is the basic means to master the operation status of the line and evaluate the equipment status, which is a very important link in the operation and maintenance of the transmission line. The patrol inspection and inspection of the line are mainly carried out by the special line inspector[6-8]. According to the different purposes and properties of the patrol inspection, the patrol inspection can be divided into normal patrol, special patrol, night patrol, fault patrol and pole landing patrol. The inspection includes UAV inspection and staff on-site inspection.

The manual inspection is to inspect the overhead transmission line according to a certain period, including the inspection of the line body and auxiliary equipment, as well as the observation of the line protection area, so as to understand the operation status of the line, timely find out the defects of relevant equipment and various problems threatening the operation safety.

UAV patrol generally uses UAV to carry out line icing observation, line foreign matter observation, mountain fire detection and other operation projects. UAV Air Patrol has the characteristics of less time-consuming, low risk and high efficiency. However, UAV generally requires the operator to operate remotely nearby, and the pictures taken by UAV need to be checked again manually.

In order to overcome the shortcomings of manual inspection and UAV inspection, at present, the sensor devices with specific functions are used in the overhead transmission lines to monitor the environment, temperature, leakage current, icing, wind deflection, sag, galloping, insulator pollution, tower tilt and other line conditions in the overhead transmission lines in real time, and then the relevant data are analyzed after being transmitted to the background of the online monitoring system. And give an early warning of the abnormal condition of the line. Using the on-line monitoring device to monitor the status of each line can effectively guarantee the safe and economic operation of the overhead transmission line, and provide a certain reference for the status maintenance of the overhead transmission line.

Due to the wide distribution of overhead transmission lines, the current overhead transmission line monitoring devices on each tower need to install operator's telephone card for data transmission, which will increase part of the operating cost and management difficulty; on the other hand, the online monitoring device is generally far away from the communication operator's base station, and the energy consumption rate from the device to the base station transmission information device is very fast. High energy consumption of monitoring device leads to frequent battery replacement, which increases work content and management difficulty.

4. Information routing method of overhead transmission line based on directional antenna

Overhead transmission lines usually have very obvious geographical characteristics, such as the direction, span, substation location, the terrain and crossing of the lines, and the climatic conditions of the lines are very similar. This provides a certain basis for monitoring information transmission of overhead transmission lines.

Because overhead transmission lines usually have strong directionality in the field, that is, the connection of two poles and towers is linear, and the connection of poles and towers from the far end to the near end shows a certain linear relationship, while the wireless signal sent by the online
monitoring device propagates to all directions, without directionality, which will increase the transmission energy consumption of the device invisibly. At the same time, due to the existing electromagnetic interference problems: During the operation of power equipment, a strong magnetic field environment will be generated, which will bring obvious electromagnetic interference to the data collection work and reduce the efficiency and quality of the actual collection.

If the device uses directional antenna to transmit wireless signal, under the same distance condition, the device can effectively reduce energy consumption, improve energy consumption utilization rate, and extend node lifetime.

Directional antenna is a kind of antenna that transmits and receives electromagnetic wave in one or several specific directions, and transmits and receives electromagnetic wave in other directions is zero or very small. The purpose of using the directional transmitting antenna is to increase the effective utilization of the radiation power and increase the security; the main purpose of using the directional receiving antenna is to enhance the signal strength and increase the anti-interference ability.

In view of the characteristics of overhead transmission lines, in order to solve the problems of high energy consumption and poor signal transmission quality of monitoring devices, the application of directional antenna on each monitoring device of overhead transmission lines can significantly reduce the energy consumption of monitoring devices, at the same time, balance the energy consumption of power supply of devices, extend the working time of the network as a whole, reduce the use of telephone cards of telecommunication operators, and improve the management. Reduce costs and difficulty.

At present, the industry generally believes that the online system should be divided into three layers, namely, the perception layer, the network layer and the application layer. The functions of the three levels are power information collection, power information transmission and power information processing application. The transmission line intelligent monitoring system adopts the power Internet of things architecture, which is divided into three layers (see Figure 1)

**Figure 1.** Schematic diagram of layered structure of overhead transmission line

The perception layer is the perception of the material world, that is, the collection of power information. Through sensors, information acquisition equipment and other technical means. Realize the information collection of environmental information, line information, tower status and other aspects of the transmission line.

The network layer realizes the transmission and control of information. In view of the requirements of power grid for network security, reliability and real-time, network transmission mainly relies on the realization of power wireless private network, and realizes information transmission and control by
means of public telecommunication network after encryption processing in the special environment without conditions.

Application layer is the processing and application of information, including the platform, middleware and various business applications that provide basic services for applications. Realize the intelligent monitoring, analysis and decision-making, on-site monitoring, intelligent line patrol, intelligent early warning, line detection and other business functions of the transmission line.

Transmission line information routing based on directional antenna mainly works in the network layer, that is to complete the networking of each node.

First of all, the device needs to know the position and direction of each other's nodes, which is the basis of the application of directional antenna. Generally, poles and towers are in the field of vision, and the direction is easy to correct. On the other hand, the device itself can also be used to adjust the direction, and GPS or other positioning technology can be used to obtain the position information of adjacent towers, so as to calculate the relative direction between the nodes of the device and automatically correct the receiving and transmitting direction of the antenna.

The device realizes route selection, loop avoidance and route reconfiguration in the network layer, and at the same time establishes its own route table and solves the maintenance problem of route table. The next hop node is determined according to the routing table, so as to reduce the error probability of the route, improve the stability of the network, reduce the network delay and improve the performance of the working network.

Figure 2 is the schematic diagram of information transmission of overhead transmission line. It can be seen from the figure that the connection of poles and towers of overhead transmission line is basically linear, which provides a certain basis for the application of directional antenna in structure. After the monitoring information of the device is sent out, it is transmitted by hop, and finally transmitted to the monitoring system through the substation or base station.

![Figure 2. Information transmission diagram of overhead transmission line](image)

A routing method for monitoring information of overhead transmission line based on directional antenna, the general workflow is as follows, as shown below:

The node sensor of the device acquires the physical quantities to be monitored such as wind speed and current;

The device node data unit encapsulates the acquired information and encapsulates the attribute information such as the location and time of the monitoring point;

The device node determines the next hop device node by querying the routing table;

After determining the next hop device node, adjust the position and direction of the directional antenna according to the node position of the next hop device;

According to the distance from the next hop device node, adjust the transmission power to reduce energy consumption and send the information;

The next hop device node receives the information, fuses and encapsulates the monitoring information of the device node;

The next hop node starts the next round of forwarding route and finally forwards it to the monitoring system.
Figure 3 is the information forwarding diagram of overhead transmission line based on directional antenna. It can be seen from the figure that monitoring node a encapsulates the monitoring information after obtaining the relevant monitoring information[8]. By querying its own routing table, the encapsulated information is forwarded to the next monitoring node in the routing table. Similarly, after receiving the information, the next node encapsulates again after information fusion with this node And then forward the next hop route to the monitoring system.

![Directional Antenna Forwarding Route](image)

**Figure 3.** Directional antenna forwarding route

After we applied the information transmission method of overhead transmission line based on directional antenna to the network, we compared it with the common network. Figure 4 shows the network lifetime. Through comparison, it can be seen that the energy consumption of device nodes in the new method is about 2200 rounds, about 30% longer than the common network. Figure 5 shows the stable working time of the network. From the figure, we can see that the new method. the average working time of the surface is about 20% longer than that of the common method.

![Number of Dead Nodes with Rounds](image)

**Figure 4.** Number of dead nodes with rounds

![Network Stable Period](image)

**Figure 5.** Network stable period

5. Conclusion
When the information transmission method of overhead transmission line based on directional antenna is applied to the transmission of monitoring information of transmission line, it can obviously reduce the transmission power of antenna, improve the survival time and stable working time of the whole monitoring network, guarantee the stable transmission of monitoring information and facilitate the stable work of communication network.

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