Research on A New On-line Monitoring System of Transmission Line Icing Based on RF433 Technology

Wang Zheng*, Chen Fei, Peng Chong, Wu Taiwu, Huang Qian and Yang Xi

CSG EHV Power Transmission Company Guiyang Bureau, Guiyang, China

*wangzheng@ehv.csg.cn
*Corresponding author’s e-mail: 1839682709@qq.com

Abstract. In view of the disadvantages of the current transmission line icing online monitoring terminal data transmission through wire and large power consumption, this paper uses RF433, WIFI and low-power design technology, realize the low-power wireless transmission function of each sensor data, and through the communication protocol between the front-end wireless sensor and the main controller, achieve the purpose of improving the efficiency of the sensor. Finally, the terminal efficiency designed in this paper is verified by actual test. After 72 hours of test, the packet loss rate of each sensor is 0%, which indicates that the system can run stably. At the same time, the maximum power consumption of the main control board in one day is 0.11W, which is far lower than the power consumption of the online monitoring terminal of the cable icing over 1W. In this paper, the design of low-power wireless icing monitoring system for transmission lines can correctly guide the work of anti-icing and anti-icing, which is of great significance for the safe operation of transmission lines.

1. Introduction

With the rapid development of science and technology in my country and a large amount of investment in power grid engineering infrastructure, more and more transmission lines will be constructed and operated. At the same time, due to the complexity of the topography in Southwest my country, there are relatively many local microclimate events, especially the winter icing still poses a greater threat to the healthy operation of the line [1-2]. Since the ice disaster in 2008, a large number of wired ice-coating online monitoring terminals have been installed on the line to operate, but after years of engineering practice analysis, there are still many problems with the ice-coating monitoring device, such as the wind blowing and the disconnection of the equipment connection cable. Hang down, even disconnection occurs. Therefore, it is of great significance to use wireless communication technologies such as RF433 and WIFI to develop a new type of ice-coated online monitoring terminal and establish a unified communication protocol to overcome the shortcomings of existing wired monitoring devices.

Wireless sensor network was first proposed in 1999 in China, and it has been widely used in all walks of life [3-5], however, the research on the online monitoring device of transmission line based on RF433 and WIFI communication by various domestic production technology manufacturers and research institutions is not perfect. The difficult problems in this monitoring mode are the research into low-power front-end wireless sensor technology and data monitoring terminal wireless transmission technology. Research and the communication protocol between the front-end wireless sensor and the main controller have not been really in-depth research.
Therefore, this paper applies radio frequency technology (RF433) and wireless WIFI technology to the online monitoring system of transmission lines. Through the research of front-end sensor wireless low-power technology and data monitoring terminal wireless transmission technology, the wireless connection between front-end sensor and monitoring terminal is realized. Improve the stability of system operation and form a unified communication protocol to achieve better interchangeability and flexibility between devices. Moreover, the development of wireless sensors reduces the hidden dangers of line safety caused by wired connection, and makes local sensor failures not affect other components, so as to improve the reliability of online monitoring devices, and finally achieve that the online monitoring system of transmission lines can correctly guide line monitoring work. The purpose of ensuring the safe operation of the line.

2. Research on low-power front-end wireless sensor technology

2.1. Low-power sensor power supply and image collection

In this paper, the research of low-power front-end wireless sensor technology can effectively make up for the shortcomings and deficiencies of current front-end sensors in wired collection, data transmission, and installation applications. The working principle of the low-power front-end wireless sensor designed in this article is as follows Fig. 1.

Among them, the energy harvesting module uses BQ25504 devices to achieve programmable maximum power point tracking sampling and optimize solar energy efficiency; the synchronous boost module uses the MAX17224 DC-DC boost converter that only needs micro-watts of power to start working. It has ultra-low quiescent current performance and its energy conversion efficiency can reach 95%; the micro-controller module uses the STM32L15x ultra-low leakage process, and uses the device's low-power operating mode; the wireless transmission module adopts the CC1310 chip, which can ensure the battery life through its extremely low active RF and MCU current and low power consumption mode current consumption; the DC-DC module charging chip adopts LTC3652, which is achieved by obtaining the open circuit voltage of the solar cell Maximum power point tracking (MPPT) of solar cells to improve solar conversion efficiency; the DC-DC control unit adopts the digital potentiometer MCP4100. The MCP41000 forms a variable resistance through the output of the chip pins, which reduces the output voltage of the solar cell, improves the voltage conversion efficiency, and reduces the system power consumption.

For the low-power data monitoring terminal of the video surveillance system, the RF module is periodically woken up, and the power-on/off command is sent through the RF module to enable the camera system to turn on/off the WIFI power supply and the camera power supply, so that the data monitoring terminal and the camera establish a link through WIFI, and the camera system working. After data collection and transmission are completed, the camera system RF module and WIFI module enter the sleep state.

![Fig. 1 Working principle of icing on-line monitoring terminal](image-url)
2.2. Data wireless transmission technology realization
This article sets the main control to send instructions to non-image sensors every 10 minutes, and send instructions to image sensors every 1 hour. The image sensor collects data every hour and transmits data to the main control via WIFI wireless communication, tension/tilt sensors, and weather sensors. The wire temperature inclination sensor collects data every 10 minutes and transmits it to the main control receiving end through RF433 wireless communication. The specific work flow is designed as follows:

![Implementation process of data wireless transmission Technology](image)

2.3. Power supply system design
The power supply system of the ice-coating online monitoring system designed in this paper mainly uses sunlight to obtain energy. Through a controllable DC-DC circuit, the solar output voltage is controlled to effectively improve the efficiency of solar energy. Since solar cells have different maximum power point voltages under different temperatures and sunlight, if the traditional DC-DC circuit is used, the maximum power point of solar cells under different weather conditions cannot be tracked, so that solar cells cannot be used to generate electricity. Therefore, for the design of the power supply system in this article, firstly, the single-chip microcomputer is used to obtain the operating temperature of the solar cell through the temperature sensor; secondly, the output voltage of the solar cell is collected through the voltage acquisition circuit; finally, the DC-DC is controlled by the software algorithm to capture the maximum value of the solar cell Power point to charge the rechargeable lithium battery. In order to achieve the maximum power output of the solar cell under different temperature light.

3. Research on Formulation of Communication Protocol
The communication protocol established in this article is about the master-slave wireless communication protocol, and the communication method (one-to-many, polling communication) between single master and multiple slaves is established. At the same time, the slave-master data communication takes the master as the main body, and the slave as the slave, and performs data interaction in Mod-bus mode.

Define all the peripheral information address table in the slave, which is used to store the data collected by the slave peripherals and the working status of the peripherals. The master is distinguished by the address of the slave, and read all the addresses from the corresponding address of the slave in turn. For the required data information, configure the parameters of the slave in the same way, and the peripheral device information address is designed as follows Tab.1.

This paper provides the following parameters for device data and address transmission: if the data address range is 0x0000~0x006F, then read and write this type of parameter; if the data address range...
is 0x0100~0x0200, then read this type of parameter; if the data address range is 0xC8~0xFF, the data will be cleared after reading this parameter.

| Data A | Data B | Address bit | ... | Data N | Data N | Status bit |
|--------|--------|-------------|-----|--------|--------|------------|
| Address 1 | Address 2 | Address ... | Address N | Address N+1 | Address N+2 |

4. **Practical application analysis**

In order to verify the effectiveness of the new low-power transmission line icing on-line monitoring terminal designed in this article, this article first tests the data transmission packet loss rate of each sensor: place the main controller and each sensor at a distance of 100m, and the image sensor collects data, and the data packets collected by the image sensor are transmitted to the main control via WIFI wireless communication. The data packets collected by other various sensors are transmitted to the main control through RF433 wireless communication, and the data packet loss of each sensor is tested. Table 2 shows the test results of the data transmission packet loss rate of each sensor. After 72 hours of testing, the packet loss rate of each sensor is 0%, which shows that the system can operate stably and is suitable for monitoring line-related parameters.

**Tab.2 Results of packet loss rate of data transmission**

| Sensor name         | Transmission distance (m) | Transmission rate (kbps) | Test duration (h) | Transfer data volume | Packet loss rate |
|---------------------|--------------------------|--------------------------|-------------------|----------------------|-----------------|
| Image               | 100                      | 100                      | 72                | 2880                 | 0%              |
| Pull                | 100                      | 10                       | 72                | 1404                 | 0%              |
| Meteorological      | 100                      | 10                       | 72                | 1584                 | 0%              |
| Inclination         | 100                      | 10                       | 72                | 1296                 | 0%              |

This article secondly tested the power consumption of the main control board. Five main control boards were used as test objects to record their energy consumption within one hour. Table 3 shows the statistical results of the main control board energy consumption. According to the experimental data, the highest power consumption is 4.5438mWh for the fourth test experiment. At this time, the overall static working power consumption of the device is 4.5438*24=0.11 W per day, which is far lower than the current situation that the existing wired ice coating online monitoring terminal consumes more than 1W per day.

**Tab.3 Statistical results of energy consumption of main control board**

| Numbering | Capacity (mAh) | Power consumption (mWh) |
|-----------|----------------|-------------------------|
| 01        | 1.9273         | 4.5029                  |
| 02        | 1.6733         | 3.9001                  |
| 03        | 1.7751         | 4.1261                  |
| 04        | 1.9487         | 4.5438                  |
| 05        | 1.8279         | 4.2548                  |

5. **Conclusion**

This paper uses RF433 and WIFI to improve the existing wired ice-coating online monitoring terminal to realize wireless transmission of sensor data, and to solve the defect of excessive energy consumption of the existing online monitoring equipment through the research of front-end sensor wireless low power consumption technology. At the same time, through the formulation of the
communication protocol between the front-end wireless sensor and the main controller, the products are standardized, so that the products of various manufacturers are universal, thereby improving the efficiency of work and operation and maintenance. Finally, through actual tests, the packet loss rate of each sensor is 0%, and the main control power consumption is 0.11 W per day, which reduces the energy consumption of existing equipment to a certain extent.

Acknowledgments
This work funded by the Science and Technology Project Fund of China Southern Power Grid Co., Ltd. (Research on online monitoring devices for transmission lines based on RF433 and WIFI communication).

References
[1] Wang B., Wu X., Hu X., et al. (2015) Research of Transmission Lines Icing Weight Estimation Based on NWP Model. Water Resources and Power., 33:169-171.
[2] Yang L., Hao Y., Li W., et al. (2010) Relationships Among Transmission Line Icing, Conductor Temperature and Local Meteorology Using Grey Relational Analysis. High Voltage Engineering., 36:775-781.
[3] Tian X., He J., Guo M., et al. (2018) Mobile charging and data collection strategy in wireless sensor networks. Chinese Journal of Scientific Instrument., 39:216-224.
[4] Chen R., Ni M., Xu C., et al. (2019) Communication performance analysis of wireless sensor network for railway environmental monitoring. Telecommunications Science., 35:76-83.
[5] Wei R., Li S., Zhang Y., et al. (2019) Energy efficiency and route optimization strategy for rechargeable wireless sensor networks in power grid construction environment. Electrical Measurement & Instrumentation., 56 :31-36.