

Design of Temperature Monitoring System for Air Cooled Radiators Based on LoRa

Yanyan Shi

College of Automation Engineering, Shanghai University of Electric Power, Shanghai 200090, China

Abstract: Air cooling technology is widely used in the north. When the winter temperature in the north is too low, the cooling radiator is prone to freezing, leading to the inability of air cooling units to operate normally and causing huge economic losses. In response to the above issues, this article designs a monitoring system for air cooled radiators based on LORA communication, based on Internet of Things technology. Analyze the A-type tower structure and heat dissipation principle of the air-cooled condenser, reasonably select the temperature measurement point position, and achieve temperature data transmission through LoRa communication and Ethernet communication technology. The monitoring software is programmed in C # language, which can visually display the temperature distribution information of the air-cooled condenser and store data in real time. The experimental results indicate that the system has certain guiding significance for preventing the freezing phenomenon of air cooled condensers and optimizing operation.

Keywords: Air condenser, LORA module, Monitoring system, Anti freezing, Wireless temperature measurement.

1. Introduction

With the current increase in installed capacity of air cooling systems, some problems have also been exposed during the operation of air cooling units. For example, as an important component of the air cooling system, when the temperature in the northern winter is too low, the water flowing inside the tube bundle is prone to freezing during the heat dissipation process, leading to the abnormal operation of the air cooling unit and even causing shutdown accidents, resulting in huge economic losses.

The scale of the air-cooled condenser system is huge, and the on-site situation is complex. Traditional wired temperature measurement methods such as thermocouples and thermal resistors are used, which have many problems such as complex wiring and power supply, difficult installation, low measurement accuracy, high cost, and difficult maintenance. It is difficult to flexibly monitor the temperature field of the air-cooled condenser on a large scale. In response to the above issues, in order to effectively prevent freezing phenomenon, a monitoring system for air-cooled condensers based on LoRa wireless communication has been designed and developed.

2. Overall System Scheme Design

The monitoring system for air cooled condensers based on LoRa communication mainly consists of data collection nodes, data aggregation nodes, gateway nodes, and monitoring interfaces. The system diagram is shown in Figure 1. The data collection nodes mainly collect information such as temperature, wind speed, and direction of the A-type tower of the air cooled island through sensors. After processing, the data is sent to the aggregation node in a short distance through the LoRa wireless transmission device. The data aggregation node and collection node form a network, receive node data within the area, organize the data, and transmit it to the gateway node. After receiving the data sent by the LoRa aggregation node, the gateway node uploads it to the upper computer through TCP/IP protocol. Simultaneously expanding the RS485 interface, it can be connected to the DCS system of the power plant through the ModBus protocol. The upper computer displays the temperature field information of the A-type tower of the air condenser in real-time, and perform antifreeze warning based on the temperature threshold set by the staff for easy detection by the staff.

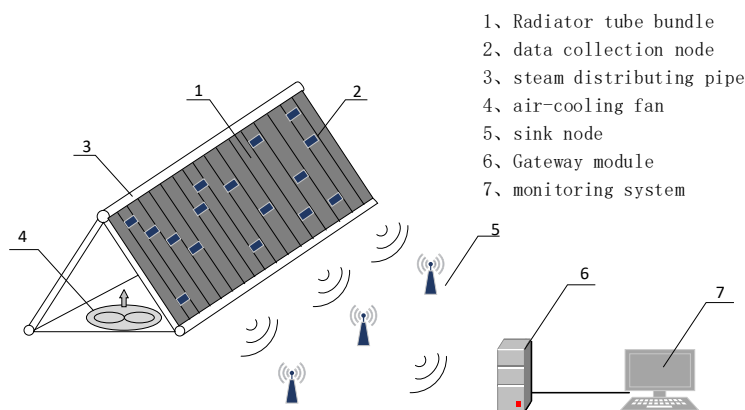


Figure 1. System Overall Design Block Diagram

3. Hardware Design

The hardware of this system is divided into three parts: data

collection node, data aggregation node, and gateway node.

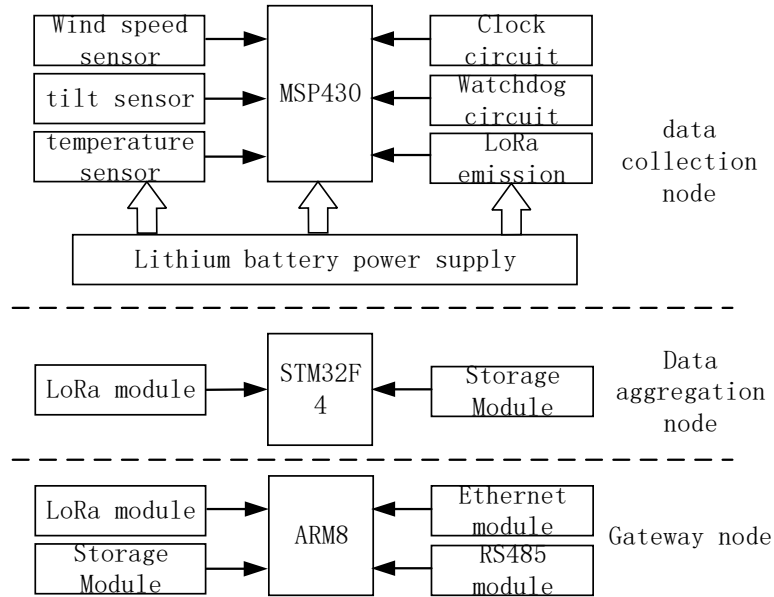


Figure 2. Hardware structure diagram

The circuit design of the data acquisition node consists of STM32L0 microcontroller, SX1278LoRa module, STS35 Dis temperature sensor, power supply module, and external storage circuit. The data collection node uploads the collected temperature information wirelessly to the gateway node through LoRa. The system adopts a 5V lithium battery power supply. Based on the transmission characteristics of LoRa, in order to avoid data upload conflicts, a defined communication protocol is used, combined with LoRa's CAD detection mode, to ensure the safety and reliability of data transmission.

The data aggregation node consists of an STM32F4 microcontroller, a LoRa module, and a storage module. The data is collected at several points to receive temperature data from the collection node, processed by the program, and uploaded to the gateway node. The aggregation node is equipped with a storage module, which can store data when there is a failure during data upload and wait for it to be uploaded again.

The gateway node is the information hub between the wireless sensor network and the upper computer. Through the gateway node, the data information of each data collection node in the wireless sensor network will be uploaded to the system application layer through the RS-232 standard interface.

3.1. Temperature measurement

The design of temperature collection circuit needs to consider factors such as cost, measurement accuracy, and structural volume. As a temperature monitoring sensor for the heat dissipation fins of air-cooled condensers, measurement accuracy is one of the most important considerations. It also needs to make constraints on the volume at the temperature measurement nodes to facilitate on-site measurement and installation. This system uses the STS35 Dis temperature sensor, which is a surface mounted high-precision digital sensor with small size, low power consumption, a range of -

55~125 °C, and an accuracy of ± 0.1 °C, meeting the system requirements. It adopts an I2C interface, with fast conversion speed and high resolution. The circuit design is simple, and connecting to MSP430 only requires two pins, saving IO resources. The circuit diagram is shown in Figure 3.

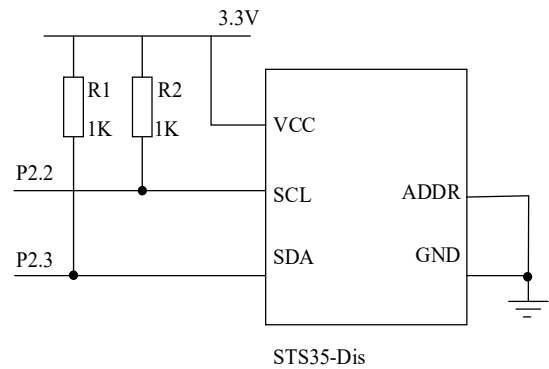


Figure 3. Temperature measurement circuit

3.2. Measuring point layout

Due to the large heat dissipation area of air-cooled radiators, the flow characteristics of high-temperature hot steam inside the condenser are both random and uneven, which leads to uneven distribution of the surface temperature field of air-cooled condensers. This means that in practical application scenarios, targeted node layout strategies must be adopted to achieve real-time monitoring of the condenser temperature field. Here, a method combining uniform and centralized distribution of points is adopted. This method not only considers the uniform distribution of monitoring points, but also focuses on the centralized layout of monitoring points to ensure the comprehensiveness and accuracy of monitoring. The specific layout is shown in Figure 4.

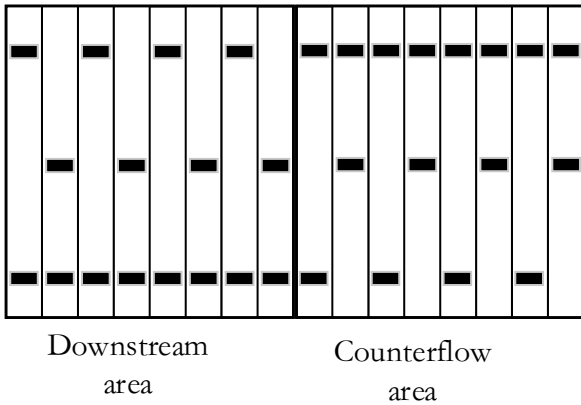


Figure 4. Layout diagram

3.3. LoRa wireless transmission

There are currently various commonly used wireless communication methods, compared to WiFi, Bluetooth, etc.

LoRa is a long-distance wireless transmission technology based on spread spectrum technology, widely used in various low-frequency wide area communication technologies. It is known for its simple and efficient characteristics, which enable long-distance communication and have very low power consumption. This system uses the SX1278 series RF chip, which operates in the frequency band of 443MHz in China. The SPI data interface is selected, and the communication distance can reach 8KM. Here, a star shaped wireless networking structure is selected. The star shaped networking structure is simple, and the failure of a single node will not affect the entire system, making it convenient for monitoring and management. The specific circuit is shown in Figure 5.

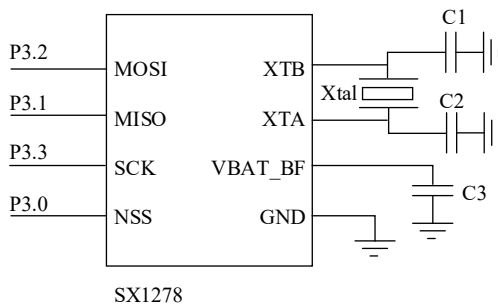


Figure 5. LoRa wireless transmission circuit

4. Software Design

The software design of the air cooling temperature measurement system mainly includes the software design of temperature measurement nodes, gateway nodes, and monitoring interfaces.

4.1. Design of temperature measurement node software

Before the temperature measurement node starts collecting data, it checks whether the sampling circuit is connected, and during sampling, the IO port will be set to high level, while when not sampling, it will be set to low level, effectively reducing power consumption. Meanwhile, through DMA multi-channel sampling technology, temperature and voltage signals can be continuously collected, and the collected ADC values can be stored in registers in a certain order. These signals are then processed through an array to obtain more

accurate results. The specific process is shown in Figure 6.

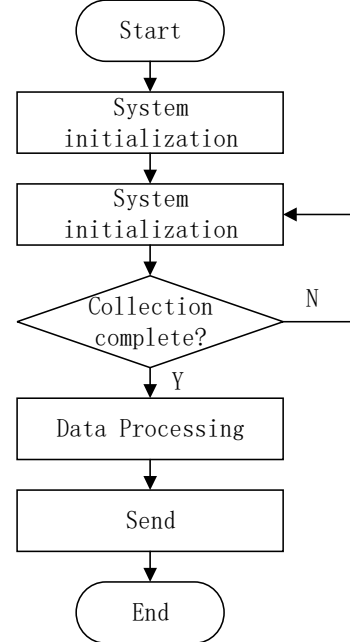


Figure 6. Collection node program flowchart

4.2. Design of temperature measurement node software

The main function of the gateway node is to process data from the temperature measurement node and communicate with the monitoring host. It will process and provide feedback on the data reported by the temperature measurement node, and report the data and parameter configuration to the host. The host will regularly query the number and status of nodes reported by the gateway, and update data and databases in real-time. According to the instructions sent by the host, the gateway node will provide corresponding response data. The main program of the gateway node includes node reporting data processing and host communication, and the flowchart is shown in Figure 7.

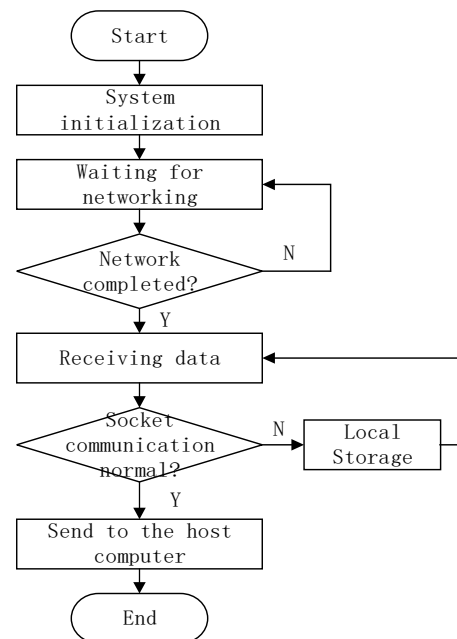


Figure 7. Gateway program flowchart

4.3. Upper computer software design

The upper computer is written in C # language, including

system management, monitoring interface, data communication, record query and other modules. The system

structure diagram is shown in Figure 8.

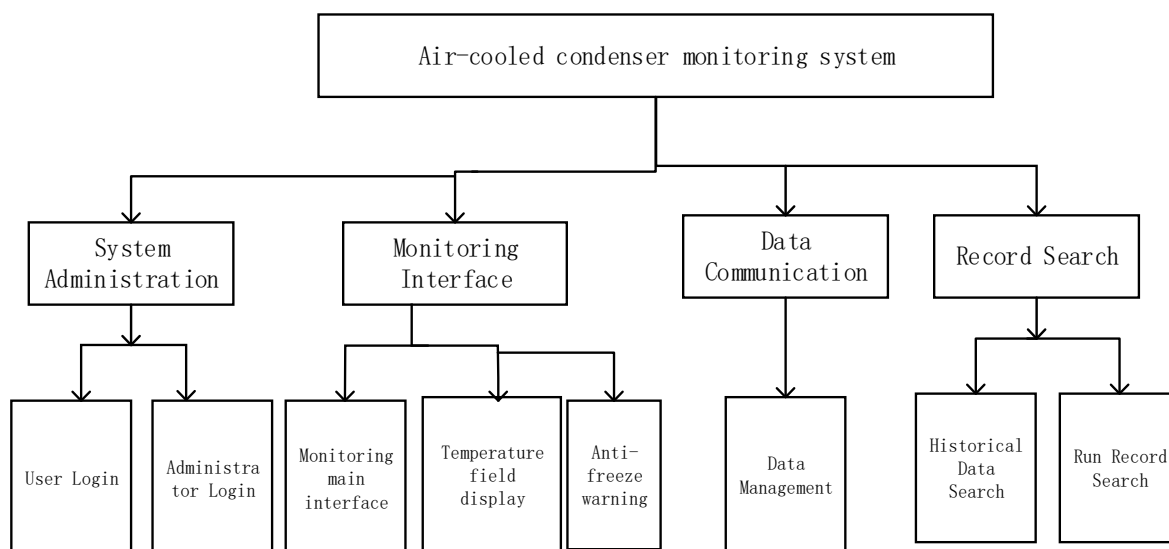


Figure 8. Upper computer system diagram

The monitoring host has the ability to send command requests to the gateway and process the data after receiving the response data from the gateway. It will parse the data frame command type and store temperature and voltage data in the database. In addition, it will also compare the stored data with the preset temperature difference and voltage alarm parameters. If the threshold is exceeded, the corresponding alarm information will be displayed on the monitoring interface. Through this method, the monitoring host can effectively manage and process data, and respond to abnormal situations in a timely manner. The monitoring host can display different node numbers, temperatures, and voltages. Node ID and address information can be obtained based on data frames. Store these in a database for easy investigation of duration records.

5. Conclusion

The LoRa wireless temperature measurement system designed in this article is different from traditional wired temperature measurement methods, and introduces IoT technology to achieve human-machine interaction. Using high-precision sensors to collect temperature data, it is convenient for staff to understand the temperature situation of the air-cooled radiator through the data.

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