Design of Embedded Line Galloping Monitoring System Based on Wireless Communication Technology

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Abstract: In order to meet the requirements of multi-measurement nodes and high temperature resistance, this project draws extensive experience from relevant industries based on the relevant requirements. A bus temperature measurement system based on two-bus technology is developed. The system is based on two buses and combines OFDM technology to modulate signals on carriers with different frequencies. Through parallel transmission, the original signal is demodulated using differential coherent demodulation. The simulation results show that the system can effectively deal with channel signal interference.

1. Introduction

With the gradual development of the construction of our power grid, transmission lines in some areas have complex terrain and volatile climates. They are prone to rain, snow and strong winds in winter, causing galloping disasters in the lines. In recent years, due to global climate change, extreme weather has occurred frequently. The possibility and severity of grid galloping disasters have greatly increased[1-2].

Once the line galloping occurs, it will easily lead to terrible consequences such as line tripping, disconnection, tower shaking, or even collapse, which seriously threatens the normal operation of the power grid. Line galloping acceleration sensor monitoring system is based on the use of acceleration sensors to capture the acceleration data information of the transmission line, and the acceleration data is obtained by quadratic integration to obtain line galloping frequency, amplitude and other information. It is not affected by weather and light, and can realize line galloping Continuous monitoring[3].

The traditional line galloping acceleration monitoring system is to install and fix the acceleration sensor on the transmission line[4]. The data view is mainly by regularly removing the monitoring device from the transmission line to retrieve the data, or based on short distance such as Bluetooth and Zigbee. Wireless communication technology sends data out, but the transmission distance, speed, and power consumption have limitations[5-6]. In order to solve the above problems and better realize the monitoring of line galloping, this paper designs an embedded line galloping monitoring system based on wireless LoRa module.

The system can effectively improve the inconvenience of data reception under the premise of ensuring that the acceleration data of the transmission line is monitored[7]. At the same time, the system is based on the wireless LoRa module for wireless data communication, which has the advantages of
fast transmission rate, long transmission distance, and low power consumption. As the control core of the system, STM32 ensures the stability and reliability of the system's work. The low-power design concept ensures the endurance of the system.

2. Overall system design
The overall design framework of the embedded galloping monitoring system based on wireless communication technology is shown in Figure 1. The system consists of two parts: the lower computer and the upper computer. The lower computer is responsible for the collection and transmission of dancing data. The line galloping monitoring device of the lower computer is mainly composed of a signal acquisition module, a signal conditioning module, a main control module, a wireless communication module, and a power supply module. The upper computer is mainly responsible for the receiving and processing of dancing data.

![Test control system](image)

Figure 1. The overall framework of the test system

3. System hardware design

3.1. Design of signal acquisition module and signal conditioning module
The signal acquisition part is composed of two parts: acceleration sensor and gyroscope. The gyroscope is responsible for collecting the angle of the transmission line swing, and the acceleration sensor is responsible for collecting the acceleration values of the three directions of the transmission line swing.

The system uses the 832M1-0200 piezoelectric acceleration sensor produced by the American MEAS company, which is based on the piezoelectric effect of piezoelectric ceramics (with stable piezoelectric ceramic crystals inside). For the acceleration measurement, it has the characteristics of high sensitivity, wide frequency response range, good dynamic characteristics, strong anti-interference ability, low power consumption, etc., which is very suitable for measuring the swing acceleration of transmission lines. The main relevant parameters are shown in the following table, and the physical diagram and pin diagram are shown in Figure 2.
Table 1. The main technical parameters of 832M1-0200

| Technical parameter name | Parameter value |
|--------------------------|-----------------|
| Measured axis            | X, Y, Z         |
| Range                    | ±500g           |
| Sensitivity              | 2.5mv/g         |
| Frequency Range          | 2~6000Hz        |
| Impact limit             | 5000g           |

Figure 2. Acceleration sensor physical map and pin map

3.2. Wireless communication module design

The system adopts WH-L101-L-P-H10 wireless communication module produced by Youren Networking Company. This module supports point-to-point communication, the transmission distance is as far as 5KM, the working frequency range is between 398MHz and 525MHz, the receiving sensitivity is high, the data transmission is stable, and the anti-interference ability is strong. The physical diagram is shown in the figure 3 below.

After the data collected by the sensor undergoes data conditioning and analog-to-digital conversion, the main control chip sends the control signal. The STM32 chip sends data to the wireless LoRa module by means of a serial communication protocol. The wireless LoRa module then sends the data wirelessly to the data receiving end. The communication circuit design is shown below.

Figure 3. Communication module circuit

3.3. Power module design

The galloping monitoring device needs to be installed on the transmission line for a long time, so its endurance must be guaranteed. In the power supply design, in order to make the system's power endurance stronger, proceed from two aspects.

On the one hand, the system uses a 7000mA high-capacity lithium battery. Based on the sp6205 voltage regulator chip, the battery is divided into two stable current sources D1 and D2. D1 always has
current output. D2 is controlled by the main control chip whether to output current. The related circuit diagram is shown below. On the other hand, solar panels are designed to charge the battery of the system, which further increases its endurance.

![Power supply circuit diagram](image)

**Figure 4. Power supply circuit diagram**

### 4. System software design

The lower computer software of the system is built based on μC/OS-Ⅱ operating system. The μC/OS-Ⅱ operating system can be regarded as the interface between the hardware system and the application program. Its main function is to schedule and manage computer resources, including task scheduling, memory management, message mechanism, exception handling, etc.

When designing system software, it is based on the multi-task scheduling mechanism of μC/OS-Ⅱ operating system. According to the actual needs of the test system, a system task and three user tasks are designed. System tasks are idle tasks with the lowest priority. The three user tasks are the initial task, the low-power operating mode task, and the normal operating mode task. The system workflow is shown in Figure 5.

![System workflow](image)

**Figure 5. System workflow**

When the system starts to work, after the initial task creates other user tasks, the system first enters the low-power working mode task. D1 is powered on and D2 is powered off. D1 is responsible for powering the main control chip and gyroscope. In the signal acquisition part, only the gyroscope is powered on and the ADC's task is a single-channel detection task. The angular acceleration information of the line dancing collected by the gyroscope is sent to the ADC after signal conditioning. The ADC converts the analog voltage signal into a digital signal, and then sends it to the main control chip. The
main control chip compares the angular acceleration value with a preset threshold. If the angular acceleration value does not reach the threshold, it proves that there is no danger of galloping, but it is still necessary to continue to maintain the threshold judgment of the angular acceleration value.

If the value of angular velocity reaches the threshold, it means that line galloping has the possibility of occurrence. The system jumps from a low-power working mode task to a normal working mode task. The main control chip controls D1 and D2 to be powered on at the same time. D2 is responsible for powering the acceleration sensor and the wireless LoRa module. At this time, the task of ADC is a multi-channel detection task. After the three-axis acceleration signal undergoes signal conditioning and digital-to-analog conversion, it is sent to the wireless LoRa module by the main control chip through serial protocol communication. The wireless LoRa module is responsible for sending acceleration data to the data receiving end. When the angular acceleration value is less than the threshold value again, the system re-enters the task of low power consumption working mode. The working process of the wireless LoRa module is shown in Figure 6.

After system hardware design and software design, the final true shape of the line galloping monitoring device is shown below in Figure 7. The main control circuit PCB board is installed in a housing or the like, and the housing is fixed to the transmission line that needs to be monitored by screws and other fasteners. When installing, please pay attention to make the solar panel face up.

![Diagram](image1)

**Figure 6. Work flow of LoRa module**

![Image](image2)

**Figure 7. The actual appearance of line galloping monitoring device**
5. Data receiver design and host computer design

The data receiver is responsible for receiving the data from the data acquisition end, and the selection of its communication module and STM32 chip is consistent with the data acquisition end. It is based on the point-to-point transparent transmission mode of the wireless LoRa module for data communication, and is controlled based on the STM32 design.

The host computer is designed based on the LabView software development platform. LabView is a special measurement and control software in the field of test control. The host computer designed and developed by this system has friendly interface, intuitive and simple operation, and vivid image. Figure 8 is the upper computer operation interface diagram. It has the functions of parameter setting, data collection, storage, and retrieval. And can process the data of multiple monitoring nodes at the same time.

![Figure 8. Software operation interface](image)

6. Conclusion

Aiming at the galloping disaster of transmission lines, this paper designs an acceleration sensor galloping monitoring system that can continuously monitor galloping conditions. The data acquisition module of the system consists of a gyroscope sensor and an acceleration sensor, which can realize the data acquisition of the angular acceleration of a certain node of the transmission line and the three axial accelerations. The wireless LoRa module is controlled by the STM32 chip to send data, and the data receiving end receives data and displays it on the LabVIEW host computer.

This system has long wireless transmission distance, stable work, real-time reliability, and good endurance, which can realize the function of monitoring the galloping of transmission lines.

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