Design of monitoring system for redundant communication power supply based on ZigBee

Shujuan Zhang, Wanli Ma, Mengxi Yu, Feng Zhang and Junwei Chen

State Grid information and communication company of Shanxi electric power company

*E-mail: zhanglixia@sx.sgcc.com.cn

Abstract. Aiming at the problems of poor maintenance effect and large measurement error of traditional communication power supply monitoring system, a redundant communication power supply monitoring system based on ZigBee is designed. The sensor and power supply cable are installed, the battery working state parameters are collected and cleaned, compressed and fused. The MSP430F149 single chip microcomputer is used to realize the high-speed processing of field information and optimize the configuration of hardware structure. The software maintenance process of the complete redundant communication power supply monitoring system is designed. The logic editing technology is used to correct, adjust and improve the system software. The mathematical model of hardware maintenance is established. The most reasonable monitoring and measurement of redundant communication power supply is calculated by ZigBee method to realize the effective monitoring of communication power supply. The experimental results show that the hardware operation effect of the design system is good, and the measurement error can be effectively reduced.

1. Introduction

The traditional redundant communication power monitoring technology and management means can not meet the needs of the new situation [1]. Too many peripheral expansion modules lead to complex circuit, and the chip function is relatively single, which will have a certain impact on the stability and reliability of the system [2]. In view of the above shortcomings, this paper proposes a redundant communication power supply monitoring system based on ZigBee, in order to provide reference for the design of subsequent communication power monitoring system.

2. Monitoring system of redundant communication power supply

2.1. hardware structure optimization of redundant communication power supply monitoring system

In order to adapt to the characteristics of power supply equipment of communication base station and improve the robustness of the system, a hierarchical monitoring method is adopted in the hardware structure design of redundant communication power supply monitoring system. MSP430F149 software is used to optimize the hardware structure and operation function. The system processor is controlled by 16 bit ultra-low power single chip microcomputer, and has five low power consumption modes [3]. In the system, because the output voltage of power supply is composed of multiple voltage sensors, excessive voltage information will lead to data redundancy, and the collected data must be preprocessed. Based on this, the system structure framework is as Figure 1.
Based on the above system framework, the hardware module of the monitoring and recognition system is further designed. The system structure includes three parts: video capture, core control and intelligent visual recognition. The ZigBee protocol stack and other chips are embedded into a single chip, and the wireless communication technology is used to realize the safe transmission of university network information. ZigBee wireless communication technology, using CC2530 chip, integrates multiple sensors in RF front-end, wirelessly transmits monitoring information collected by sensors to sink nodes, realizes unified fusion processing between nodes, and standardizes the hardware structure of power monitoring system as Figure 2.

The structure in Fig. 2 includes a terminal awareness module, a handover module and a client module. In addition to data acquisition and control, the system can also dynamically expand the monitoring function through master-slave control mode. In order to ensure the real-time monitoring, the sensor automatic information upload and acquisition mechanism is adopted to complete the power consumption parameter acquisition, power consumption control and data transmission of PAN regulator, including AD sampling, sending power consumption control signal, and writing debugging. The MCU of the terminal device enters the waiting state after initialization[4]. After receiving the data, determine whether the target address is the ID of the terminal device, and then process according to the received instructions.

2.2. Operation algorithm of redundant communication power supply monitoring software
Based on the hardware configuration structure of redundant communication power supply monitoring system, the mathematical model of system equipment maintenance is further established, and the related variables in the mathematical model are optimized[5]. Genetic algorithm is used to optimize the
maintenance system, and the expected results are achieved. Suppose that the number of maintenance cycles of the system is \( n \) in the whole life cycle, and the interval of each cycle is \( T_i (i = 1, 2, \ldots, n) \). When \( N-1 \) level system maintenance, it is pointed out that the relationship between system reliability and failure rate is as follows:

\[
K(t) = \exp (N-1) \left( \sum_{T_i} h_i(t) \right)^R
\]  

(1)

In the above algorithm, \( R \) is the interval time of the system maintenance cycle, \( h_i(t) \) is the reliability of the system equipment in the system maintenance cycle, and \( K(t) \) is the preventive maintenance time when the system reliability reaches the predetermined \( L \) threshold. Then the threshold \( K \) is calculated as follows:

\[
K = K(t) \exp \left( \sum_{T_i} b_{N-1} (L + \alpha T_{N-1}) \right)
\]  

(2)

The growth factor of system failure rate is \( b_{N-1} \) and the decline factor of life cycle is \( \alpha \). During the maintenance period from \( i-1 \) to \( i \), according to the above assumptions, the maintenance consumption algorithm of the system is as follows:

\[
C_T(i) = K C_r(i) \sum_{T_i} h_i(t) + K C_p + K C_d(i)
\]  

(3)

Where \( C_T \) is the maintenance coefficient of the system, \( C_p \) is the highest value of one-time maintenance of the system, \( C_r \) is the lowest value of the first maintenance period, and \( C_d \) is the system outage index. Because the system equipment cannot carry out endless maintenance in the actual operation process, it is necessary to set a upper limit for the upper limit of system maintenance cycle and set it to \( n^* \). According to the basic system characteristics of communication power monitoring system, the lower limit of system reliability is 0.5. The basic system operation coefficient of power monitoring system is:

\[
\min F_c = \frac{C_T(i) + n^*}{\sum_{C} b_{N-1} \left[ C_r \sum_{T_i} h_i(t) + C_p + C_d(i) \right] N_n K_k}
\]  

(4)

By solving the mathematical model with genetic algorithm, the minimum maintenance cost within the given reliability range is calculated, and the reliability \( K_k \) and maintenance times \( N_n \) are taken as the output results of the mathematical model to realize the system maintenance of the communication power supply monitoring system.

2.3. Implementation of redundant communication power supply monitoring

The monitoring station is an important part of the whole monitoring system. The system connects the monitoring station upward to collect and transmit various monitoring data collected by the monitoring station. The direct communication control unit is connected to each monitoring station to receive various data. After data processing, the data will be sent to the monitoring station\(^6\). The monitoring center in the upper monitoring system can monitor and communicate with each monitoring station in real time. The monitoring process of redundant communication power supply system is as Figure 3.
In addition to data collection, the main tasks of IoT sensing include data cleaning, compression, aggregation and fusion[7]. Thus, the effective transmission and subsequent processing of data after preprocessing are realized.

Aiming at the change rule and spatiotemporal correlation of sensing data, a method of sensor node data cleaning based on probability statistics is proposed[8]. Gaussian distribution is used to obtain the probability model of distribution, and the outliers are obtained by calculating the observed values under the probability distribution mode, and then the data is cleaned up.

3. Analysis of experimental results

In order to verify the operation effect of the monitoring system, the standard tracking index based on 64 point data is carried out. Standard data sets are used to standardize the original screening points, and the filtering calculation is carried out to achieve the purpose of subsequent screening. The experimental parameters of average precision and success frequency can be calculated as Table 1.

| Parameter          | Numerical value |
|--------------------|-----------------|
| Number of computers| 3               |
| Processor          | 8.2GHz          |
| Memory             | 64GB            |
| Database           | SQLserver       |
| The server         | Dual disk array |
| Communication rate | 120Mbps         |
| Monitoring point   | 78000           |

According to the above parameters, under the same experimental environment, the actual monitoring effect of traditional monitoring system and the monitoring system of redundant communication power supply based on ZigBee proposed in this paper are compared and recorded in the interference environment. The hardware performance comparison of the two systems under signal interference is as Table 2.

| Interference frequency /Hz | Traditional system | The system of this paper |
|-----------------------------|--------------------|--------------------------|
| 10                          | 72%                | 92%                      |
| 20                          | 71%                | 90%                      |
| 30                          | 68%                | 89%                      |
| 50                          | 62%                | 87%                      |
| 70                          | 57%                | 83%                      |
| 100                         | 40%                | 80%                      |
| 110                         | 32%                | 79%                      |
It can be seen from table 2 that in the same experimental environment, compared with the traditional system has obvious advantages, the hardware operation effect of this design system is better. The abnormal power parameters of software operation in the application process of the traditional system and the system in this paper are further compared as Table 3.

| Running time(h) | Traditional system | The system of this paper |
|----------------|--------------------|--------------------------|
| 3              | 5.2kw              | 0.0kw                    |
| 6              | 6.4kw              | 0.2Kw                    |
| 9              | 7.5Kw              | 0.6kw                    |
| 12             | 8.3kw              | 1.0kw                    |
| 15             | 9.38kw             | 1.0kw                    |
| 18             | 10.4kw             | 1.2kw                    |
| 21             | 11.2kw             | 1.2kw                    |
| 24             | 12.3kw             | 1.2kw                    |

It can be seen from table 3, the abnormal power of the redundant communication power supply monitoring system based on ZigBee is significantly lower in the operation process, effectively prevent the abnormal operation of power supply, protect the whole system, reduce the measurement error caused by sensors, environment and other factors.

4. Conclusion
This paper presents a monitoring system for redundant communication power supply based on ZigBee. The system collects the operation information of all kinds of power equipment through sensors and transmits the data to the main control room through the regional control unit for power monitoring. Through the experimental analysis, the hardware operation effect of the design system is good, which can effectively reduce the measurement error.

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