ZigBee Based Wireless Temperature Monitoring System of High-voltage Switchgear

Yingzi Chen

School of Automation Wuhan University of Technology Wuhan 430070,China

chenyingzis@163.com

Abstract. The high voltage switchgears are playing an important role in the electric power system, but in the long operation, the switch contact tends to become overheating because of its closed and narrow space. Obviously, it will cause the system to malfunction without timely resolution. What's worse, this situation probably result in fearful accidents which will pose a threat to people's lives. Therefore, according to the characteristics of high voltage switch cabinets, this paper designs a wireless temperature monitoring system for high voltage switches. Moreover, considering the problem of high voltage insulation, the ZigBee communication chip CC2530 and the digital temperature sensor DS18B20 which are used to realize the real-time and on-line temperature monitoring are selected to perform the functions of collecting temperature and transmitting information respectively. To some extend, this system improves the efficiency and accuracy of the monitoring, meanwhile, it saves human resources and can make the electric power system run safely and reliably.

1. Introduction

With the development of science and technology, the demand for power quality is becoming increasingly high. One of the causes of electric power system failure is the over-temperature of switch contact. Generally, high voltage switchgear has the functions of controlling and protecting the electric power system in power generation, transmission, distribution and power conversion, etc [1]. Besides, the high voltage circuit breaker is an important part of the whole switchgear. Under the harsh environment of high current and strong magnetic field, the actual operation with load changes and equipment aging deformation often causes heat to concentrate on the switch[2]. If not handled in time, it will directly affect industrial production and People's daily life, more seriously, it will result in safety accidents. Therefore, it is essential to use a reasonable on-line monitoring system to monitor the temperature of switchgear in real time in order to ensure the safe and reliable operation of the electric power system.

In practice, the voltage isolation must be carried out between the temperature acquisition device and the monitoring device, however the wireless monitoring precisely avoids this problem. In addition, other widely used temperature measurement methods are infrared temperature measurement and optical fiber sensor temperature measurement. The infrared temperature measurement technology is to measure the temperature of the equipment's surface by absorbing the infrared energy. This method has a high degree of safety, but requires close -range visual installation. Therefore, it is impossible to monitor the temperature of the nodes in the closed switchgear. The optical fiber sensor is used to convert the heat on the surface of the object to light signal, and then it can measure the temperature by measuring the light signal. The technology has high sensitivity, but it is not easy to install in the switch cabinets and will appear the phenomenon of creeping[3]. Each temperature measurement technique has its advantages

and disadvantages, due to the fact that the communication distance between the temperature measurement terminal and temperature information receiving terminal in the switchgear is not too far, an online temperature measurement method based on ZigBee wireless communication technology is selected to realize accurate and effective temperature monitoring in order to reduce the loss of electric energy.

2. General scheme of temperature measurement system

2.1. Brief introduction of ZigBee technology
Similar to Bluetooth, ZigBee is a new bidirectional wireless communication technology, which is used for data transmission between various electronic devices with short distance, low power consumption and low transmission rate. Because ZigBee network is built for industrial field automation control data transmission, it has the characteristics of safety, reliability, low cost and low power consumption.   Each node can not only be used as monitoring object itself, but also can automatically transfer data from other network nodes. The core technology of ZigBee is the ZigBee protocol stack, which uses the definition of IEEE 802.15.4 directly in the physical layer (PHY) and the media access control layer (MAC)[4].A ZigBee network consists of a single coordinator node, multiple routers and multiple terminal nodes. ZigBee supports three types of ad hoc wireless networks, namely star, tree and mesh topology.

2.2. Operational principle
As shown in figure 1, the temperature on-line monitoring system of high voltage switchgear is divided into three parts: temperature connecting module, data transfer module and monitoring host. The temperature connecting module includes temperature sensor, microprocessor, wireless communication module, etc. While the difference between the data transfer module and the temperature collecting module is that there is no temperature sensor. Moreover, the monitoring host mainly monitors and analyzes the temperature data from the data transfer module in real time.
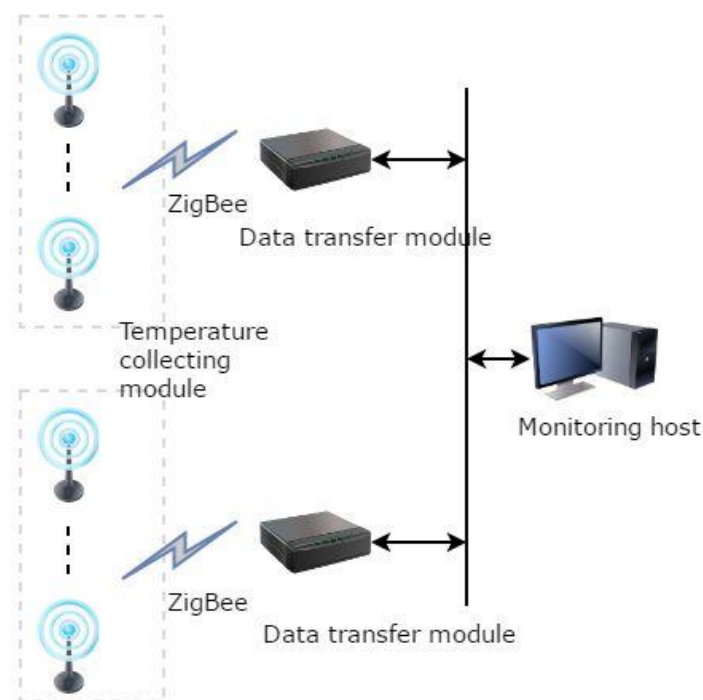

Figure 1. high voltage switchgear temperature monitoring system structure

    The KYN28A-12 which is one of the most common high voltage switchgears in China is used in this scheme, and its installation mode of circuit breaker is handcart type. Firstly, The temperature sensor installed in the high voltage switchgear measures the temperature of the node directly and converts the

temperature signal to the digital signal, which will be transmitted to the data transfer module through the ZigBee wireless network. After processing by the microprocessor, the temperature data will be uploaded to the monitoring host through RS-458 bus. Then, under the analyzing of monitoring host, if the temperature exceeds the allowable range, an alarm signal will be generated. It indicates that the node's temperature is abnormal. In addition, the ZigBee wireless network is established by the coordinator and router to form the transmission channel [5].

3. Hardware system design

3.1. Temperature connecting module
The core component of the active wireless high voltage switch temperature connecting terminal are the digital temperature sensor DS18B20 and ZigBee communication chip CC2530, as shown in figure 2.
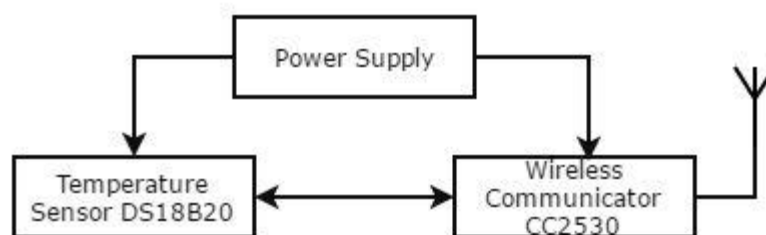

Figure 2.The structure diagram of temperature connecting module

Due to the harsh environment with a variety of strong interference information, to some extent, it will affect the measurement accuracy. Therefore, this paper selects the digital temperature sensor DS18B20 of DALLAS Semiconductor Company. This temperature sensor integrates all temperature sensing elements and conversion circuits in an integrated circuit shaped like a transistor [6].DS18B20 adopts three-wire structure, which reduces the complexity of peripheral circuit, so it has small volume, low power consumption, high precision and strong anti-disturbance ability. When connecting with microprocessor, only one port line is needed to realize the two-way communication between microprocessor and DS18B20.

CC2530 is a core chip in ZigBee wireless data transceiver. The chip has 32 / 64 / 128 / 256KB flash memory. Furthermore, different operation modes can be selected according to the actual situation of HV switchgear when comes to reduce power consumption. Besides, it has shorter switching time and less power consumption. Meanwhile, CC2530 has industry-leading RF transceiver performance and standard enhanced 8051CPU [7].

3.2. Data transfer module
The structure of the data transfer module is similar to that of the temperature connecting module, as shown in figure 3.
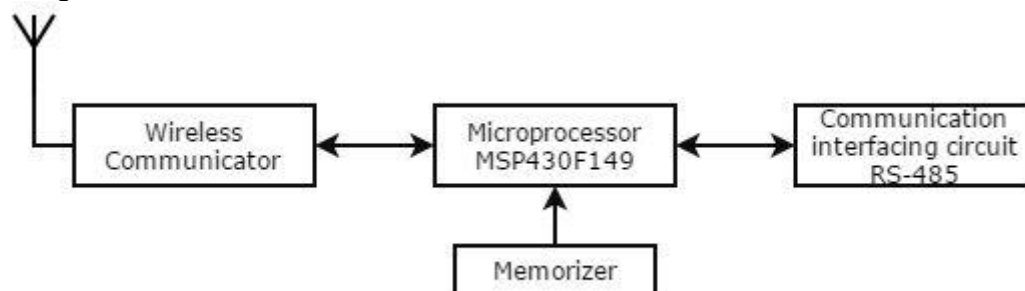

Figure 3. The structure diagram of data transfer module

Once the CC2530 receives the data and the corresponding address from the ZigBee temperature collecting terminal, the data will be stored in the register. Next, the microprocessor is informed to extract

the data and upload the data to the host computer through the RS-485 bus. In this paper, the 16-bit micro controller MSP430F149 of TI Company is used as microprocessor [8], which has the characteristics of low voltage and ultra-low power consumption. It takes less than 6μs to resume work in standby mode, and it integrates the SPI controller which can easily communicate with CC2530.

4. software system design

Temperature measurement node, data processing circuit, host computer control terminal and alarm all need the corresponding software to drive the hardware circuit. This paper mainly studies the software design of temperature measurement node.

After the measuring node is powered on and initialized, it starts to look for the ZigBee wireless network, and when it is confirmed to join the network, the ZigBee network address will be obtained. Most of the work of the temperature measurement node is in the state of low power consumption. Thus, the temperature sensor needs a timer to wake up. Actually, the temperature of the node is collected once every acquisition cycle and sent to the data transfer module. When it is confirmed that the transmission is successful, the system will collect another temperature in the next cycle. The flow chart is shown in figure 4.
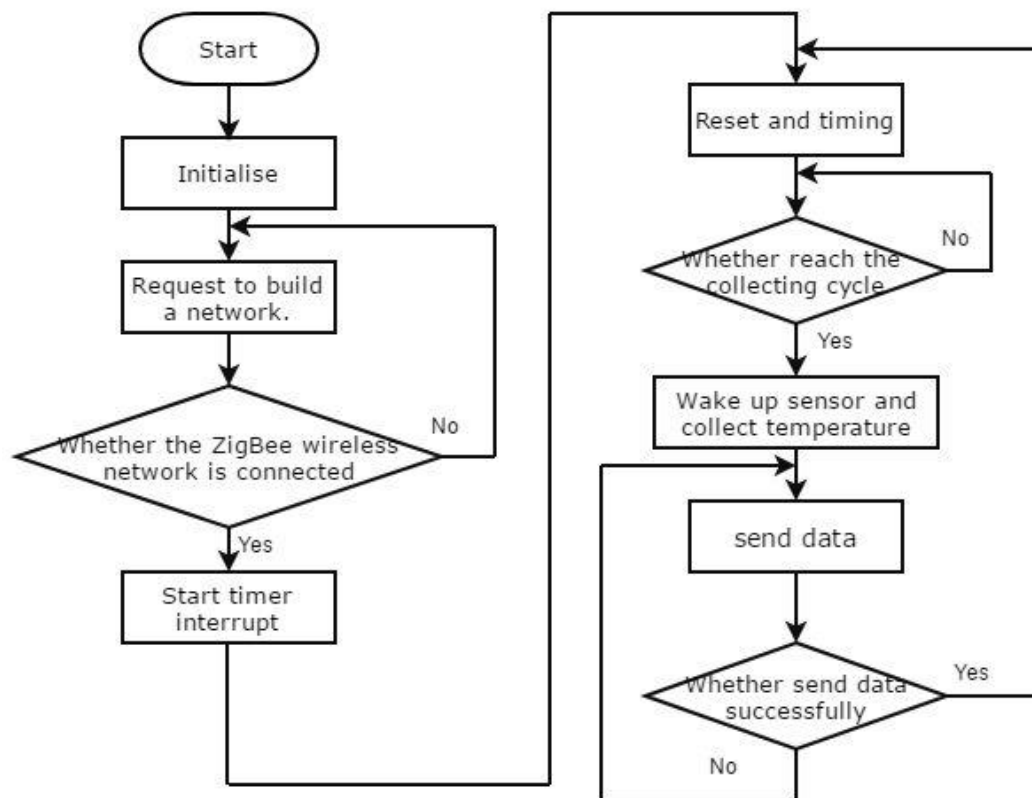

Figure 4. The flow chart Of temperature measurement node

5. conclusion

According to the application environment, a wireless temperature monitoring method based on ZigBee technology is proposed, and the key hardware and software of the system are designed and analyzed. Therefore, the following results can be obtained:

(1) When the set temperature alarm value is 40℃, an alarm signal will be generated if the temperature is higher than or equals to 40℃. It should be noted that the warning value should be set less than the maximum allowable temperature of the high-voltage switch in order to adjust the system promptly before the failure.

(2)   The display can clearly reflect the temperature of each contact and its changing trend. At the same time, the host automatically stores the temperature measurement data for reference and analysis.

(3)   The measuring accuracy of the whole system can reach ±0.4℃.

To put it briefly, the system can not only effectively solve the problem of high voltage insulation, but also can monitor the temperature of the contact in real time and online. Meanwhile, it has strong anti-interference ability, high precision and low power consumption, so, it is easy to realize in engineering.

References

[1]   Chen Qing, Ye Jiangming. 10 kV high voltage switchgear failure analysis and preventive measures [J]. Electrical Engineering and Electric, 2017 (04): 68-69.

[2]   Wang Lei. High-voltage switch cabinet fever causes and measures [J]. China's new technology and new products, 2011 (10): 143.

[3]   Xu Gaojun, Ma Hongzhong, Li Chaqunun, Li Kai, Xu Honghua, Ding Ning.Design of on-line monitoring system for active wireless temperature of high voltage switchgear [J]. Electric Instruments & Measurement, 2014,51 (22): 82-86.

[4]   Zhao Bingcheng. High Voltage Switchgear Online Monitoring System Development and Application [D]. Zhejiang University, 2011.

[5]   WANG Kui-ying, YU Yan-wei.Design of On-line Monitoring System for Temperature of High Voltage Switchgear [J]. Modern Electronics Technique, 2012,35 (15): 52-54 + 58.

[6]   Ding Daozhen ZigBee-based high-voltage switchgear contact temperature online monitoring system [D]. Jimei University, 2013.

[7]   Wang Zhenzhong.Design of ZIGBEE wireless data transmission module based on CC2530 chip [J]. China Equipment Engineering, 2017 (14): 133-134 (in Chinese).

[8]   QIU Yin-an, ZHOU Yong-mei, PENG San-cheng, MAN Jun-feng.MSP430F149 Single Chip Microcomputer and Its Application [J] .Journal of Zhuzhou Institute of Technology, 2004 (05): 31-33.