Design of Formaldehyde Monitoring System in Wireless Network

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Abstract. The monitoring of indoor formaldehyde and other harmful gases has attracted more and more attention. In this paper, the wireless sensor technology was introduced into the monitoring of formaldehyde gas. The realization of the hardware and software design of wireless sensor nodes, the design of the real-time monitoring software of the host computer, the development of the communication protocol, and finally achieve the goal of the successful operation of indoor formaldehyde concentration monitoring network. The formaldehyde monitoring system mainly consisted of the formaldehyde concentration collection system, the data of the wireless transceiver system and the host computer monitoring system. The system can effectively complete the data acquisition and processing, and can be real-time monitoring of the site.

1 Introduction

With the development of society, people pay more and more attention to the influence of the living environment on their health. However, in the process of home decoration, it is inevitable to produce chemical pollution to the indoor air, especially the formaldehyde gas. In the environment of formaldehyde gas concentrations exceeding the standard can cause a variety of chronic respiratory diseases, serious or even cause leukemia or more serious disease [1][2][3]. The release of formaldehyde gas in the home space is also a slow dynamic process, is often affected by heat, humidity and ventilation. Therefore, to building a more perfect monitoring system to the implementation of accurate, dynamic, multi-point detection of formaldehyde gas is very necessary in the home environment for improving the quality of indoor air environment. In this paper, the ZigBee wireless sensor technology was introduced into the monitoring of formaldehyde gas; the hardware and software design of wireless sensor node was completed; Indoor formaldehyde concentration monitoring network was successfully established. System can effectively complete the data acquisition and processing work, and can be real-time monitoring of the site.

2 System Design

At present, the typical short-range wireless communication technology mainly includes the following: Bluetooth technology, WiFi technology, infrared data transmission technology, ZigBee technology, etc[4]. These communication technologies have a standard communication protocol, strict communication format, Their advantages and disadvantages were shown in Table 1.

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Table 1 Comparison of various communication methods

Communication category	ZigBee	Bluetooth	WiFi	Custom communication
Transmission distance	50-300m	10m	50m	100m
Network scalability	Automatic extension	No extension	No extension	Artificial extension
Complexity	Simple	Complex	Very complex	Simple
Transmission speed	250Kbps	1Mbps	1-11Mbps	1Mbps
Transmission band	868Mhz~2.4Ghz	2.4Ghz	2.4Ghz	2.4Ghz
Network node number	65000	8	50	6 (Artificial extension)
Networking time	30ms	10s	3s	200ms
Equipment cost	Low	Low	High	Low
Integration degree and reliability	Low	Low	Commonly	Low
Maintenance cost	Low	Commonly	High	Low

As an emerging wireless network technology, ZigBee technology has the characteristics of low power consumption, low cost, short time delay, large network capacity, high reliability and high security, which is widely used in the networking industry chain M2M industry, such as the smart grid, smart transportation, smart home, finance, mobile POS terminal, supply chain automation, industrial automation, intelligent building, fire protection, public security, environmental protection, meteorology, digital medical, remote sensing exploration, agriculture, forestry, water, coal, petrochemical, and other fields[5][6]. ZigBee devices can easily form a star network, tree network and mesh network. Each ZigBee device is assigned a 64 bit IEEE address, and can be used for communication in the network. Terminal and coordinator to establish a connection between the equipment after the network, the device will be a 16 bit network of short address, and can use the 16 bit short address in the construction of the wireless network for communication. This design used the star network topology; there were two types of ZigBee devices in the network for the coordinator node and several terminal nodes. The terminal node was responsible for collecting the sensor signal, and the wireless transmission was carried out. Coordinator node was responsible for receiving data and sending in terminal equipment. Terminal equipment was responsible for the control of command and data processing. The structure of the whole system is shown in Fig 1.

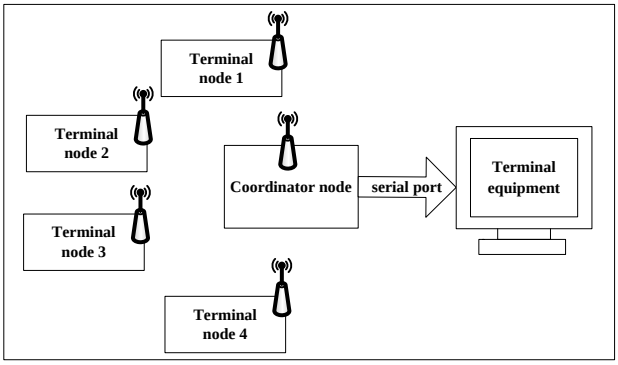


Fig 1 The structure of the system design

3 System Hardware Design

Hardware system consisted of terminal equipment, terminal node and coordinator node. The hardware structure of the terminal node and the coordinator node were shown in Fig 2 a)and b) respectively.

(1) Micro controller module：It was the control center of formaldehyde detector. The signal source was collected through the AD module, and the signal source was measured and controlled by the wireless sensor.

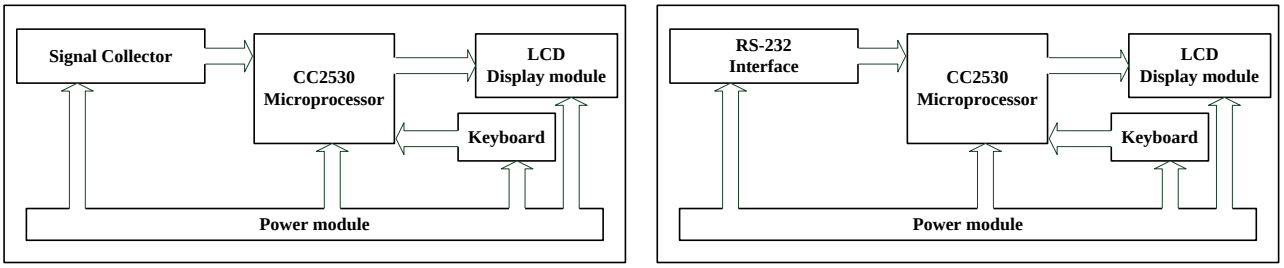
(2) Sensor module：It was the test core component of the formaldehyde detector. Its internal circuit will produce linear detection signal source, according to the external environment of formaldehyde concentration.

(3) Power module: It provided the power supply for each module of formaldehyde detector.

(4) RS232 module: It provided an interface for the formaldehyde detector and the PC terminal host computer, which was used to realize the real-time monitoring of the concentration of formaldehyde.

(5) Display module: It was one of the output devices of the formaldehyde detector, which shown the information of the part of the measurement and the preparation of the formaldehyde detector.

(6) Keyboard module: It was one of the input devices of formaldehyde detector, which can be used to implement the binding between ZigBee devices and some other functions.



a) b)

Fig 2 a) The hardware structure diagram of terminal equipment

b) The hardware structure diagram of coordinator node

MQ138 type gas sensor was used in formaldehyde sensor module for wide range of detection range, fast response recovery, high sensitivity and long-term stability of the work, etc. Internal sampling system of the MQ138 will produce a current signal when it was absorbed by the air sample. The current signal was converted to a voltage signal through a resistor as the concentration of formaldehyde. The voltage signal was transmitted directly to the AD converter, which was converted to digital signal and processed accordingly. CC2530 chip supported up to 14 bit analog-to-digital conversion, the effective number of up to 12. The output of the sensor can be directly connected to the I/O pin of the CC2530 chip. The sensitivity of the sensor can be adjusted by adjusting the resistance value of the potentiometer, and the gas alarm detection can be realized by detecting the port level.

4 System Software Design

The main task of the system software design was to realize the networking of wireless network, the work control of the sensor and the wireless receiving and dispatching of the data. The development environment used in this system was IAR Embedded Workbench for MCS-51 7.51A, the protocol stack was ZStack-CC2530-2.2.0.

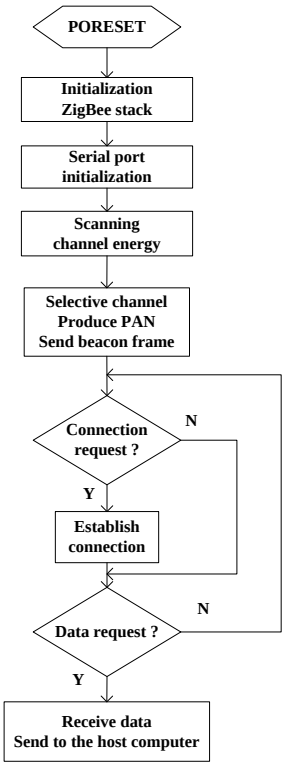


Fig 3The flow chart of coordinator program

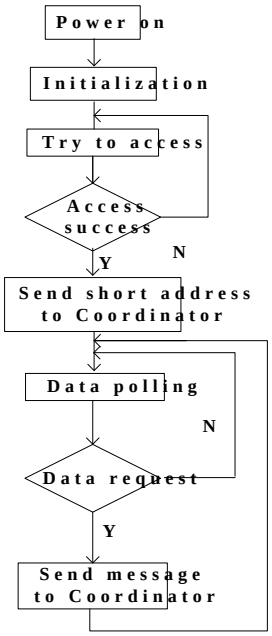


Fig 4 The flow chart of sensor node program

(1) The coordinator node software design. When the coordinator received the information, the program can identify the network address of the sensor or the data collected by the sensor by judging the identifier of the data. If the network address of the sensor was received, the network address was in the address list and then sent to the host computer through the serial port communication, and the host computer was processed by the host computer. If the sensor was the value of the collection, the signal through the identifier to determine and from the serial port to the host computer to facilitate the numerical monitoring. The network address of the device was composed of two parts: a physical address and an application layer address. At the start of the program to compile time set physical address, each device in the network must be assigned a unique physical address. The flow chart of coordinator program was shown in Fig 3.

(2) The software design of sensor node. After the sensor node was powered up, the system is initialized first, then the channel was selected and added to the existing wireless network. The terminal node device was in a dormant state waiting coordinator data request. When a data request was received by the coordinator, the data was collected and sent to the coordinator node. If the data request was not received, the data requested continues to listen to the channel. The flow chart of sensor node program was shown in Fig 4.

(3) PC software design. In the system, the formaldehyde concentration values returned by different sensor nodes can be displayed on the PC in real time, and when the formaldehyde concentration exceeded the preset value, the alarm prompt was issued on the PC. The software can record and store the detected data, and it was convenient for the user to inquire about the formaldehyde concentration of a certain node in a certain period of time. The host computer software of the system used the Visual.Basic.6.0 development tool. Serial control connected to the ACCESS database. Visual programming can be convenient observation and modify the effect on the process of running the program.

5 Conclusion

In this paper, ZigBee technology was used to build the system of wireless sensor network software and hardware platform. Through the selection of the ZigBee module and the design of the signal acquisition circuit module, the basic requirements of the system were realized. The upper computer

monitoring and management system was set up, which can get the data of the field in real time through the host computer. Through the test in the actual environment, the system meted the requirements of wireless formaldehyde detection.

Acknowledgments

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