Design of Environment Monitoring System Based on Wireless Sensor Network

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Abstract *–This system applies the technology of wireless sensor network and adopts the control function of Single Chip Micyoco (SCM). This system designed uses the SHT11 temperature and humidity sensors as detection elements, and the real-time measurement data is transmitted through a wireless transceiver module. Through building up practical system and commissioning test, it concludes that this system can realize the wireless remote monitoring of greenhouse and automatic alarm to ensure that the temperature and humidity would remain in the best condition for plant growth.*

Keywords *–temperature and humidity sensor, wireless transmission, monitor.*

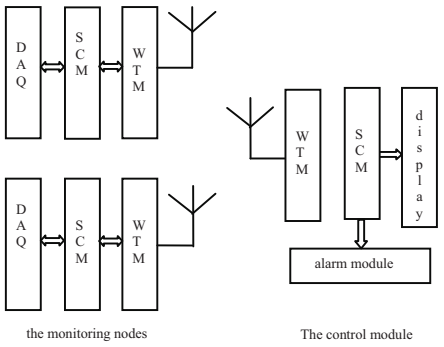
I. INTRODUCTION

Nowadays, to solve the problem of farmers and improve the income of the farmers is a big challenge of our country. In recent years, our country continue to take measures to develop the rural economy and to support, help the rural development. To construct the greenhouses and to product the anti-season vegetables is one of the measures to increase the income of farmers. The detection and control of them plays a very important role to improve plant survival rate, accelerate the growth process , reduce the mortality rate and increase yield. At present, the monitoring and control system of the greenhouse can be divided into wireless monitoring system and cable monitoring system. In recent years wireless sensor network[1,2] is a new technology which can automatically apperceive, collect and process information of monitored objects, and transmit the information to the observer.Wireless sensor network is composed of a large number of small sensor nodes arranged in the monitoring region, and the information transmitting system is formed through wireless communication[3] . This design armed at the specific environment in the greenhouse applies the wireless sensor network technology to realize the wireless monitoring system.

II. THE OVERALL DESIGN OF THE SYSTEM

The system sets some monitoring nodes in the greenhouse, and the monitored data would be transmitted to the control module through temperature and humidity detectors and real-time acquisition device distributing in the greenhouse. According to the temperature and humidity monitored, the operator can take corresponding measures to make the temperature and humidity retain the best growing environment for the crops.

This system mainly consists of receiving, control, alarm module and a plurality of remote monitoring, transmitting modules. Fig.1 shows the block diagram of the system design. At the same time, the control module would compare the received data with the presented data. The system would alarm if the received data exceed the presented range.



DAQ: data acquisition WTM: wireless transceiver module

Fig.1. Block diagram of system design

In rural areas, many farmers will built the greenhouses not far from his home for convenient management. Therefore, using short-distance wireless sensing systems can basically meet the design requirements. At present, the mature short-distance wireless data network technology has the following kinds: Bluetooth, Wi-Fi, UWB technology and ZigBee technology. But the above technology is more complex, and the development cost is higher, development cycle is long. So these are not suitable for application in rural areas. Considering this, this system uses Single Chip Micyoco (SCM) and the wireless radio frequency(RF) transceiver NRF24L01 with built-in PCB antenna to meet the design requirements. There are a plurality of monitoring nodes in the system design for the multi-point monitoring. Each monitoring node has processing module, and each monitoring node has a separate address. The monitoring node is composed of power supply module, processing module, sensor module and wireless communication module [4]. This is

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the key to the practical application that how to set up and distribute the monitoring nodes according to the monitored environment.

The sensor module in the front of the monitoring points is responsible for collecting the monitored physical quantity and turning them into signal (analog quantity or digital quantity) which can be recognized by processor. The processing module is responsible for the control operation of entire monitoring node, and realizes the task management and energy consumption management. This design uses SCM STC90L52AD as the processor of the monitoring node. The SCM controls the NRF24L01 to transmit the address of the monitoring node and the temperature and humidity data of the recent detection when the NRF24L01 in the node receives the local address transmitted from the control module. The SCM controls the sensor SHT11 to carry on cyclic detecting for temperature and humidity of the monitoring node when the NRF24L01 in the node fails to receive the local address. The hardware structure design of the monitoring node is shown in Fig. 2.

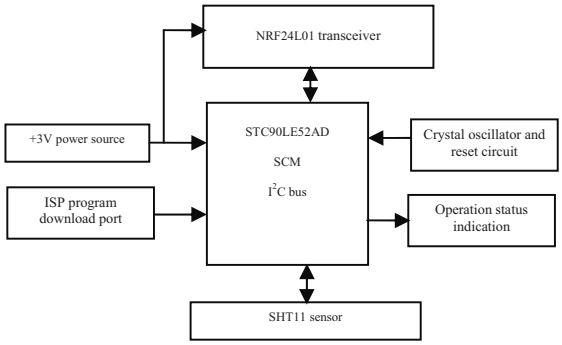

Fig. 2 . Block diagram of hardware design of the monitoring node

The control module is composed of power supply module, processing module, wireless communication module and display, alarm module. Fig. 3 shows the Block diagram of hardware design of the control module. In the control module, this design adds MC14489 chip as the driver of digital tubes. This will not only save I/O ports, but also improve the drive current, speed up the running speed of the control system. The hardware structure design of the control module is shown as Figure 3. SCM extracts the address signal from the buffer and transmits the address to the monitoring nodes through the NRF24L01. NRF24L01 is set in reception status state after transmitting address to receive the address of the monitoring node and the temperature and humidity data. In this design we uses 5 digital tubes to display. After the NRF24L01 receiving data successfully, the digital tubes display the address of the monitoring node first and then display the temperature and humidity data. When the first digital tube displays "C", the display of the following digital tubes is the temperature data received. And When the first digital tube displays "F", the display of the following digital tubes is the humidity data received.

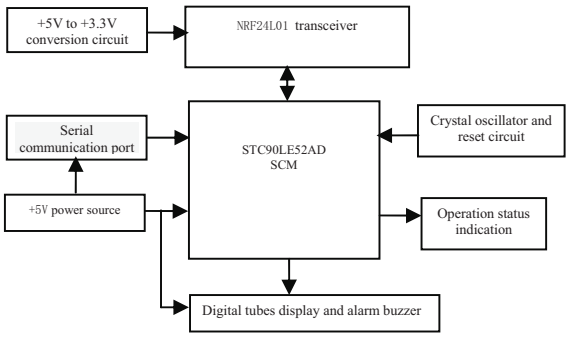

Fig. 3. Block diagram of hardware design of the control module

III. THE HARDWARE DESIGN OF THE SYSTEM

A. The power circuit design

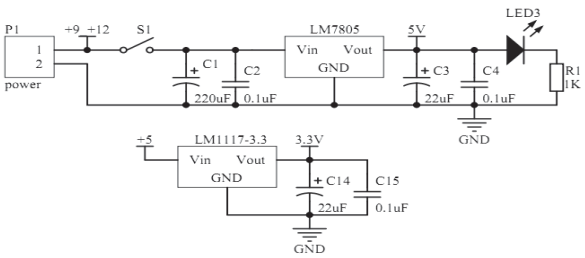

Fig.4. The power supply circuit of the system

The circuit of +5V to +3.3V is the power supply for wireless transmitting-receiving module and detecting unit. The circuit of +5V is the power supply for SCM and display, alarm module (see Fig.4).

B. The monitoring node circuit design

The monitoring node circuit is shown in Fig. 5. The P1.0 pin of SCM is connected with the buzzer in the circuit. Once the temperature or humidity exceeds a preset data, the light emitting diodes(LED)would be lighted and extinguished circularly, and the buzzer would alarm to remind the greenhouse workers to take corresponding measures. The P2.5,P2.6 and P2.7 pins of SCM are connected with the temperature and humidity sensor SHT11. The SHT11 will send the collected data to SCM to process through the I^2C bus. SCM sends the collected data from the sensor to the wireless transmitting module through the P3.2, P2.0, P2.1, P2.2, P2.3 and P2.4 pins. The SHT11 used in this design is a new intelligent temperature and humidity sensor based on CMOSens technology. The temperature and humidity sensors, signal amplifying and conditioning, A/D converting, two-wire serial interface are integrated in a SHT11chip. It has ultrafast response

speed, strong anti-interference ability and high cost performance. [5]

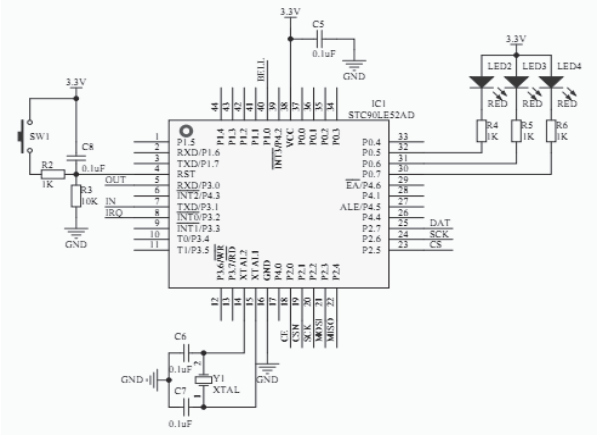

Fig. 5. SCM connection circuit diagram of the monitoring nodes

C. *The control module circuit design*

In the circuit of control module SCM controls the receiving and sending signal, processing the received data, and sending the temperature and humidity signal to the display module, and controls the alarm circuit. SCM connection circuit diagram of the control module is shown in Fig. 6.

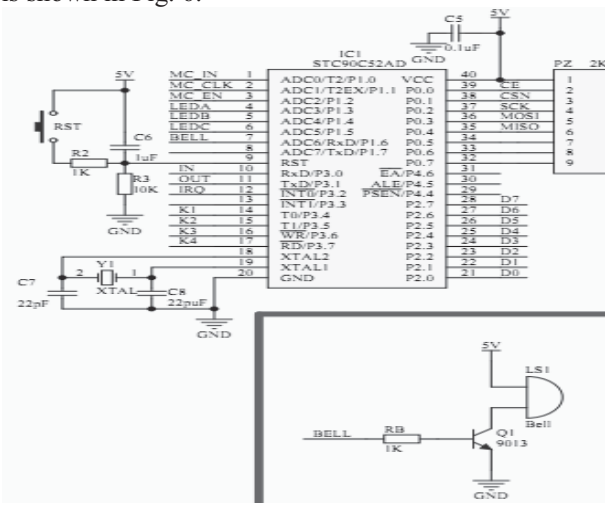

Fig. 6. SCM connection circuit diagram of the control module

In this circuit the P0 port of SCM is connected with pull-up resistors and connected with the wireless transceiver NRF24L01. The 3 ~ 7 pins of NRF24L01 are respectively connected with the P0.0 ~ P0.4 pins of SCM, and the 8 pin(IRQ) is connected with the P3.2 of SCM. The P1.0~ P1.2 pins of SCM are connected with IC2MC14489 chip as digital tube driving circuit. The P3.4 ~ P3.7 pins of SCM are connected with 4 buttons(K1, K2, K3, K4) to preset the temperature and humidity range. Among them, K1 is the function selection key, K2 and K3 are the plus and minus keys. After the completion of presetting, press K4 to determine the set value. The P3.0 ~ P3.1 pins are connected with MAX232 as program download port. The control module transmits the address signal by NRF24L01 and the NRF24L01 of the monitoring nodes receive this address signal. Then SCM of each monitoring node reads the address signal and matches it with local address. If the matching is successful, SCM will transmit the temperature and humidity data of the recent detection together with its own address to the control module by NRF24L01. [6] Considering that the signal transmission distance of NRF24L01 is only 60 ~ 100m which can not meet the design requirements, this design uses NRF24L01 with a built-in PCB antenna. The experimental data show that the transmitting distance of this system can reach about 400m if without large obstacles in outdoor. So this system can basically meet the design need.

D. *The I2C bus design*

I2C bus is a serial extended bus widely used between the chips at present. The bus achieves full duplex synchronous data transmission by using two lines . One is the data line SDA and the other one is the clock line SCL. For SCM without I2C, we can combine the common I/O ports with software simulating the timing sequence of I2C serial bus interface to complete the interface function of I2C serial bus. This design uses the form of software simulating for data transmission. [7] When receiving a complete data byte sent by SHT11, SCM would send this data to the wireless transceiver module and would not receive the next dada byte at once. At this time, the SCM could pull the SCL line to be low electrical level. Until the data transmission is completed and SCM is ready to receive the next byte, the SCM would release the SCL line to be high electrical level in order to continue the data transmission between the SHT11 and SCM. [8]

IV. THE SOFTWARE DESIGN OF THE SYSTEM

A. *The subroutine design of monitoring node circuit*

The main function of the subroutine of monitoring node circuit include that:1.To initialize the SCM; 2. To control SHT11 to detect temperature and humidity; 3. To judge whether the temperature and humidity exceeds the preset value. To set the corresponding flag be "1" if the temperature and humidity exceeds the preset value. Otherwise set "0"; 4. To control the wireless module to transmit the temperature and the humidity and sign information if the flag is "1"; 5. To receive the address information transmitted from the control module through the interrupt and to determine whether the address is valid. To transmit the temperature and humidity values if the address is valid.

B. The receiving and transmitting control program design of NRF24L01 in the monitoring node

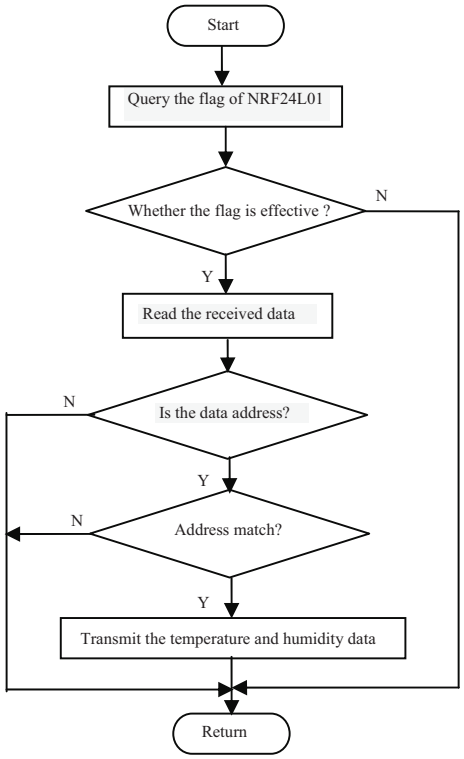

Fig.7. Receiving and transmitting control program flow chart of NRF24L01 in the monitoring nodes

C. The control module function subroutine design

The main function of the control module include that:1. To read the key value and judge the function of the key; 2. To control the wireless module to transmit the node address. To wait and receive the data transmitted from the monitoring node; 3. To control the digital tubes to display the received data;4. To determine whether the temperature and humidity data received exceeds the prescribed range. To alarm if transfinite.

The control module uses active mode to read the temperature and humidity data of each monitoring node circularly. The SCM of control module first controls the wireless module to transmit the address of monitoring node, then sets the wireless module to be receiving state and wait the respond data from the monitoring node. In this design we uses the timing function of SCM to eliminate this condition that the monitoring nodes may not be able to respond due to hardware failure. If the SCM has not received the respond data during the preset effective time, the SCM would ignore this monitoring node and read data of the next node. The receiving and transmitting control program flow chart of the control module is shown in Fig. 8.

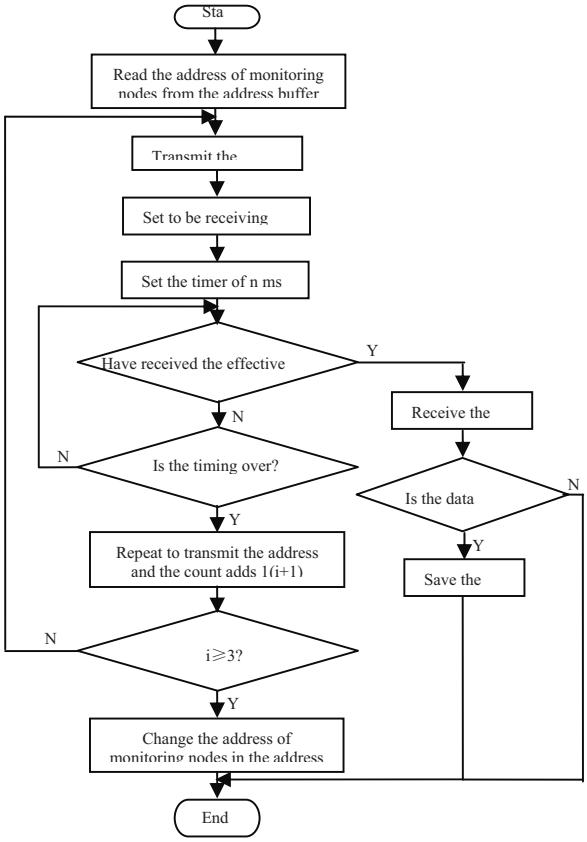

Fig.8. Receiving and transmitting control program flow chart of the control module

V. CONCLUSION

This system design is based on wireless sensor network. This system realizes multi-point temperature and humidity monitoring of the greenhouse through the remote control of SCM and transmits the data to the control center through the wireless receiving-transmitting system. After building up practical system and commissioning test, it can be proved that this system can realize the wireless remote monitoring of greenhouse and automatic alarm to ensure that the temperature and humidity would remain in the best condition for plant growth. This design is an application of wireless sensor network technology in the design of the automatic monitoring and control system which is feasible and efficient. This design has a certain practical significance to the development of monitoring system for the agricultural greenhouse environment in our country.

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