Design of Greenhouse Environment Monitoring System Based on Wireless Sensor Network

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***Abstract*—As an important agricultural infrastructure, greenhouse plays an important role in the development of modern agriculture to supply proper environment for plants. The wireless sensor network has the advantages of simple structure, high efficiency, low cost, safety and reliability compared with the existing wired monitoring technology. This paper describes a design of greenhouse environment monitoring system based on wireless sensor network, the system integrates detection, wireless communication, alarm, display, control and other functions into one, using temperature and humidity sensor SHT11 and light intensity sensor BH1750 for data monitoring, using CC2530 as microprocessor, man-machine interface is realized by using LabVIEW software. The system is mobile and flexible, strong expansibility, low cost, low power consumption, flexible operation, the experiment proved that the system measurement accuracy, control stable operation. It can satisfy the demand of the greenhouse monitoring.**

Keywords-wireless sensor network; greenhouse environment; CC2530; LabVIEW

I. INTRODUCTION

The growing environment of crops is the most important factor that affects the growth and yield of plants. Therefore, it is very important to build a suitable growing environment for crops. The development direction of modern agriculture is digital, precise and intelligent [1]. However, at present, most of the agricultural information monitoring system in our country adopts the wired way for data transmission and control which has the problem of complicated wiring, high installation cost and high maintenance cost [2]. Therefore, the research of greenhouse environment monitoring system based on wireless sensor network has great practical significance.

II. SYSTEM OVERALL STRUCTURE

The greenhouse environment monitoring is mainly composed of the monitoring center, the coordinator, the control execution structure, and the terminal node. The overall structure of the system is shown in Figure 1.

Each function terminal node transmits environment information by ZigBee wireless transmission technology to the coordinator, then the coordinator via a serial port in the form of cable transmission to the monitoring center [3].The LabVIEW software is used to display interface of the host computer, and display the environmental information of the greenhouse. When the environment inside the greenhouse is not within the hope scope, the user can click on the corresponding electrical equipment switch button on the interface to adjust the greenhouse environment data.

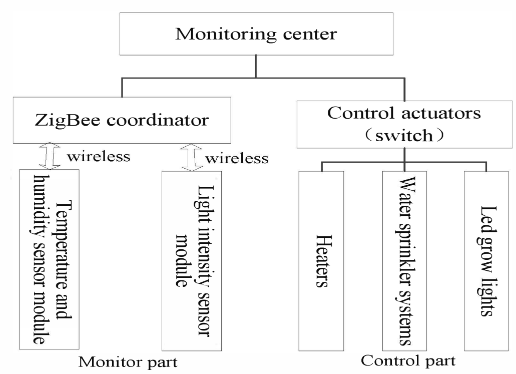

Figure 1. System block diagram.

III. HARDWARE STRUCTURES

A. Coordinator Design

As Figure 2, CC2530 peripheral hardware circuit design as circuit principle diagram.

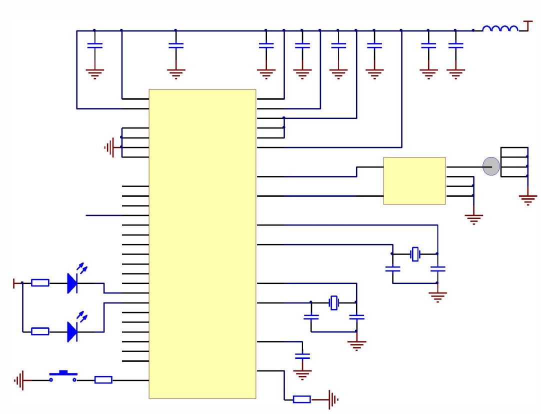

Figure 2. CC2530 peripheral hardware circuit design.

The network coordinator hardware architecture is shown in Figure 3. The core hardware of wireless local area network chooses TI Company's CC2530 chip. The RF part of the CC2530 chip is responsible for networking, while the internal integration enhanced 8051 core is responsible for controlling the RF, external devices and running ZigBee [4].

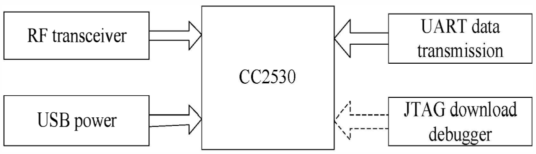

Figure 3. Coordinator hardware structure.

When using, through the IAR software, the ZigBee protocol stack coordinator program downloaded in the coordinator CC2530 module, wireless networking and data transmission functions are realized. When downloading the program, using DEBUGGER emulator to connect the JTAG interface, and using USB for power supply, the communication port between coordinator and RS-232 serial port [5].

B. Terminal Node Design

The terminal device includes sensor part and controller part, which is responsible for data acquisition and transformation of environmental factors.

The sensor to measure the air temperature and humidity in the greenhouse is the SHT11 sensor. The SHT11 chip is connected to the input port of the CC2530 through the DATA bidirectional serial data line and the SCK serial clock input. Part of the circuit diagram of the SHT11 sensor is shown in Figure 4.

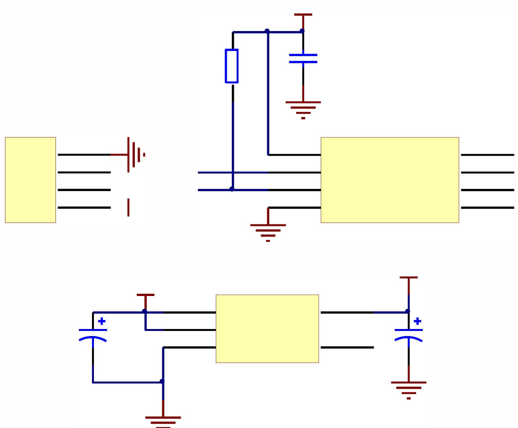

Figure 4. SHT11 sensor application circuit design.

The light control of greenhouse is mainly to increase the light intensity. When the general illumination intensity decreased to 1000Lux, light should be filled [6]. According to the requirements of light intensity in greenhouse, the illumination sensor model is BH1750. Its high resolution can be used to detect a wide range of light intensity changes (1Lux-65535Lux) [7]. BHT1750 illumination sensor ADDR port grounding, and the other end of the clock SCL and data segment SDA two serial ports connect to CC2530. Part of the circuit diagram of the BH1750 is shown in Figure 5.

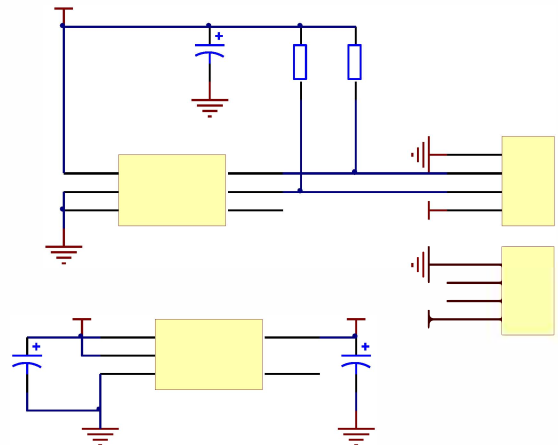

Figure 5. BH1750 sensor application circuit design.

IV. SOFTWARE DESIGN

A. Design of Wireless LAN Software

The development of ZigBee wireless network protocol stack in Z-stack environment, using the IAR software program that includes the bottom terminal device driver design, adding to the protocol stack for temperature and illumination intensity detection, and for interaction data with PC, using ZigBee protocol stack network, and realizing data transmission and acquisition.

The way of this system is to build the network automatically, and the terminal nodes are automatically added to the network. Coordinator node and terminal node Networking software flow chart shown in Figure 6.

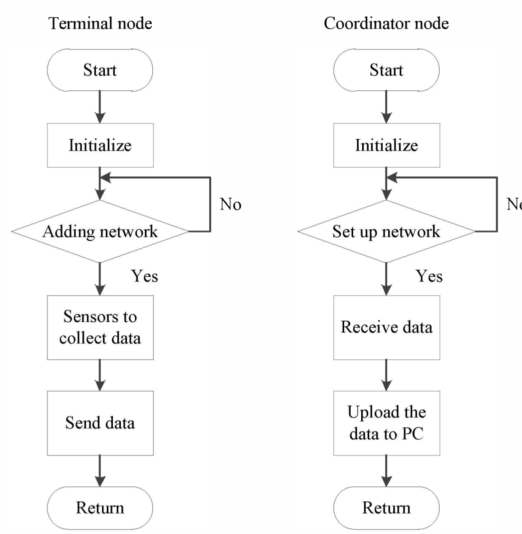

Figure 6. Terminal node and coordinator node software process.

The main work of the terminal node software design is hardware initialization, data acquisition and processing, and wireless transmission. The main work of the coordinator software design is the hardware initialization, the establishment of the network, the wireless communication with the terminal nodes and the serial communication with the controller. Both the terminal node and coordinator programs are based on the ZigBee protocol stack. The corresponding function of the program is added to the application layer of the protocol stack, modify the other layers of code, you can complete the corresponding function.

B. Design of PC Software

PC program written using LabVIEW software, realizes the man-machine interface display data. LabVIEW provides 5 serial communication nodes, respectively, to achieve the initial set of serial port, serial port to write, read the serial port, serial port input serial number, serial port interrupt [8]. Before the serial communication between the PC and the wireless acquisition module, we must first configure the serial port, so that the parameters of the PC serial port are consistent with the serial parameters of the wireless transceiver module. The LabVIEW software flow chart is shown in Fig. 7.

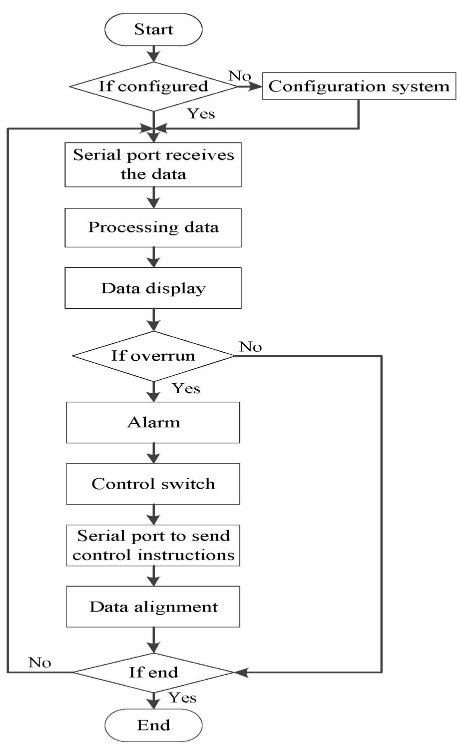

Figure 7. LabVIEW software flow chart.

V. SYSTEM TEST AND DATA ANALYSIS

A. Data Acquisition Test

In the laboratory, we collected and measured the 10 groups of temperature and humidity data, and data were collected by the sensors, and measured by the temperature and humidity meter, comparing the data results show in Table I and Table II. Hearter and humidifier were used to gradually rise the temperature and humidity.

TABLE I. COMPARISON OF TEMPERATURE DATA

Serial number	***Sensor acquisition temperature (℃)***	***Measured temperature(℃)***	***Error value(℃)***
1	14.7	14.8	-0.1
2	15.3	15.5	-0.2
3	16.1	16.3	-0.2
4	17.4	17.5	-0.1
5	18.3	18.4	-0.1
6	19.6	19.7	-0.1
7	20.6	20.7	-0.1
8	21.1	21.3	-0.2
9	21.8	21.9	-0.1
10	22.1	22.5	-0.4

TABLE II. COMPARISON OF HUMIDITY DATA

Serial number	***Sensor acquisition humidity (%RH)***	***Measured humidity(%RH)***	***Error value(%RH)***
1	20.1	18.9	1.2
2	27.6	26.7	0.9
3	30.9	30.5	0.4
4	34.3	33.9	0.4
5	36.7	36.2	0.5
6	40.6	39.9	0.7
7	47.8	46.6	1.2
8	51.0	50.5	0.5
9	57.7	57.1	0.6
10	60.8	59.9	0.9

The accuracy of the temperature and humidity meter used in the experiment is ±0.3℃ (temperature), ±2%RH (humidity). The result can be seen from the comparison, the temperature got from sensor is lower than the temperature got from humidity meter. The minimum error value is -0.1℃, the maximum error is -0.4℃. The humidity got from sensor is higher than from humidity meter. The minimum error value is 0.4%RH, the maximum error is 1.2%RH. Above data shows that the temperature and humidity got from the designed acquisition circuit is accurate. The error is in a reasonable range, it can be illustrated that the data collected by temperature and humidity sensor is accurate and reliable.

Light intensity collected 10 sets of data, data such as Table III. During the experiment, the distance between the full spectrum LED lamp and the light intensity measuring device is reduced to increase the light intensity

TABLE III. COMPARISON OF INTENSITY DATA

Serial number	*Sensor intensity (Lux)*	*Measured intensity (Lux)*	*Error value (Lux)*	*Relative error (%)*
1	98	96	2	2.08
2	211	205	6	2.93
3	518	507	11	2.17
4	1002	997	5	0.50
5	2526	2492	34	1.36
6	4906	4891	15	0.31
7	7971	7896	75	0.95
8	11532	11295	237	2.10
9	27394	27260	134	0.49
10	49015	47980	1035	2.16

The measurement accuracy of the digital integrated illuminometer is 4%.The results show that the average error of the 10 sets of data is 1.51%.The minimum error is 0.31% the maximum error is 2.93%. From the above data shows that the Illumination measurement data got from the designed acquisition circuit is accurate. The error is in a reasonable range, it can be said that the use of light sensor data collected is accurate and reliable.

B. *System Monitoring Function Test*

The parameter configuration interface of the system is shown in Fig. 8. Click on the system configuration, set the baud rate to 38400bps, set the communication port to COM6. In the parameter setting area, according to the specific needs of different crops, the environmental range of the crop is set.

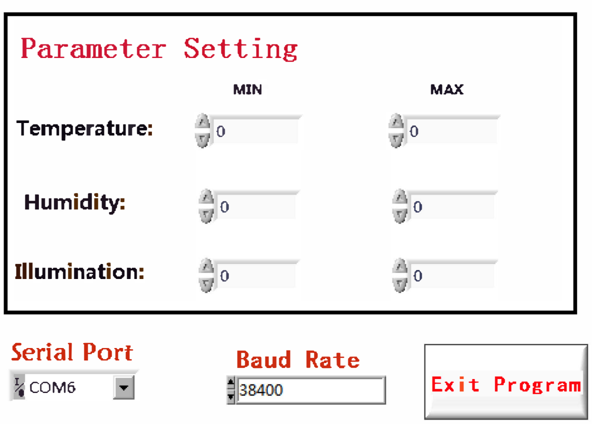

Figure 8. System configuration interface.

The data monitoring interface of greenhouse environment is shown in Fig. 9. The interface is the host computer interface, the temperature and humidity, light intensity data is real-time displayed. When the detected value exceeds the lower limit, the lower limit lamp triggered. When the detected value exceeds the upper limit, the upper limit lamp triggered. The user can also control the relevant control button on the interface to control the relevant electrical equipment light.

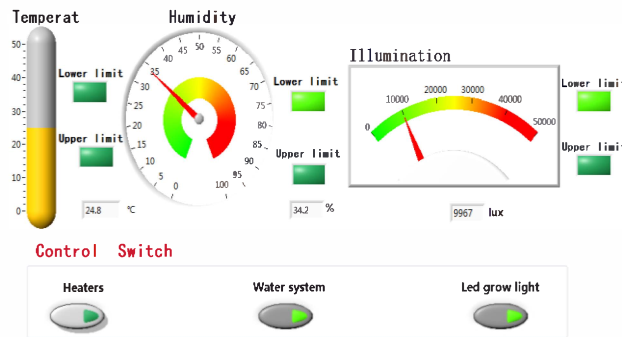

Figure 9. Greenhouse environmental data monitoring interface.

VI. SUMMARY

This paper introduces a design of greenhouse environment monitoring system based on Wireless Sensor Network. The system is based on ZigBee sensor network technology, wireless transmission of information, to solve the problem of complex wiring. The experimental results show that the system can quickly organize network, and accurately receive and send data .Using LabVIEW to write the front panel software which can set real-time display, switch control, data storage and other functions as a whole. The experimental results show that the test data is of high precision. The switching control is stable, reliable, easy to operate online and suitable for greenhouse using.

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