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Research on Remote Monitoring System of Temperature and Humidity Based on GSM and ZigBee

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Abstract: This paper is about the temperature and humidity control system based on Short Messaging Service (GSM) and wireless networks (ZigBee technology). The system can be used in home network communication by software IAR Embedded Workbench as ZigBee development platform. After the user send short message to Short Messaging Service TC35 module, master microcontroller completes the communication between GSM module and ZigBee coordinator, then ZigBee coordinator control Internal family ZigBee terminal nodes according to the content sending by the single-chip computer. On the one hand, the ZigBee coordinator receives data collected by temperature and humidity sensor DHT11 and Short Messaging Service module sent to the user's phone in the form of short message via coding by the master microcontroller, on the other hand, the single-chip computer controls household appliances switch by the triode switch. Through debugging and experimental research of the hardware and software system, we concluded that the system can realize the remote monitoring of indoor temperature and humidity and remote control household appliances reliably, which laid a foundation of further implement on the intelligent of the household environment.

Keywords: Short Messaging Service Module, Remote Monitoring, ZigBee, Temperature and Humidity

1. Introduction

With the improvement of people's living standards, the demand of perceiving and regulating the indoor environment is growing. The main communication technology of remote monitoring system includes a network telephone, network, etc, who have a lot of shortcomings in anti-interference. This system uses Short Messaging Service (GSM). Users send control instructions and receive feedback information by mobile phone. Compared with other communication technology, Short Messaging Service (GSM) technology has strong ability of anti-interference and high reliability. This system uses the ZigBee wireless network technology to construct home communication network. ZigBee terminal module connects to external sensors and home appliance controller. The ZigBee coordinator helps implement home network communication. This paper uses ZigBee wireless network technology and GSM short message technology to complete the remote monitoring of indoor temperature and humidity and remote control of household appliances, which laid a foundation of further implement on the intelligent of the household environment.

2. The System Hardware Design

The remote monitoring system of temperature and humidity based on GSM and ZigBee consists of three major areas: short message module, main control center module and ZigBee wireless communication module. Master control center module is responsible for receiving and analyzing short message sent by the user’s mobile phone, then the contents parsed out can be transmitted to ZigBee coordinator. ZigBee coordinator controls ZigBee terminal nodes according to the content sending by the single chip. Indoor terminal node transmit the data collected by ZigBee coordinator to the master microcontroller. After encoded, the data should be sent to the user's phonere by Short Messaging Service module in the form of short message. The system composition block diagram is showed in figure 1.

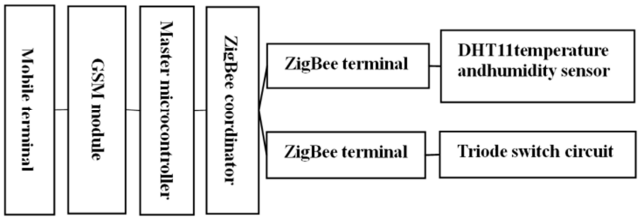

Figure 1. *The over all plan of monitoring system.*

Siemens TC35 module is be used as the GSM module, which is a GSM modem using AT commands format and to communicating with PC or master singlechip via RS232 serial port.

ZigBee is a short-range wireless communication technology, which collects from each terminal node on the network and communicates with GSM module through the master singlechip. Coordinator node be consisted of three parts: ① CC2430 minimum system; ② antenna circuit; ③ serial port communication circuit. Terminal node is used to communicate with coordinator, collecting data and meanwhile controlling household appliances switches.

DHT11 is a compound sensor to measure temperature and humidity, whose output signal is calibrated digital signal. DHT11 only has 4 pins, including the power, ground, data line, and empty leg. Temperature and humidity sensor interface circuit is shown in figure 2.

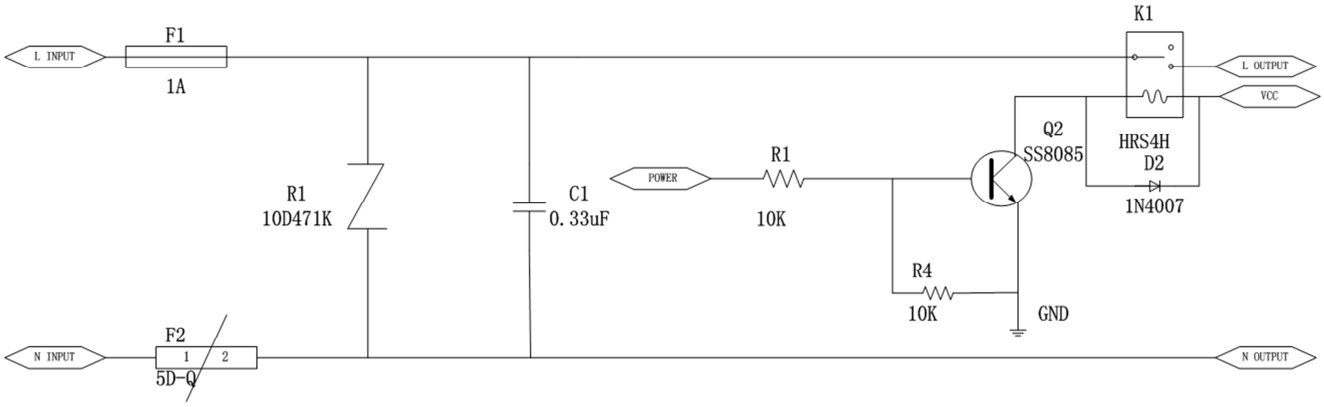

Figure 2. *Temperature and humidity sensor.*

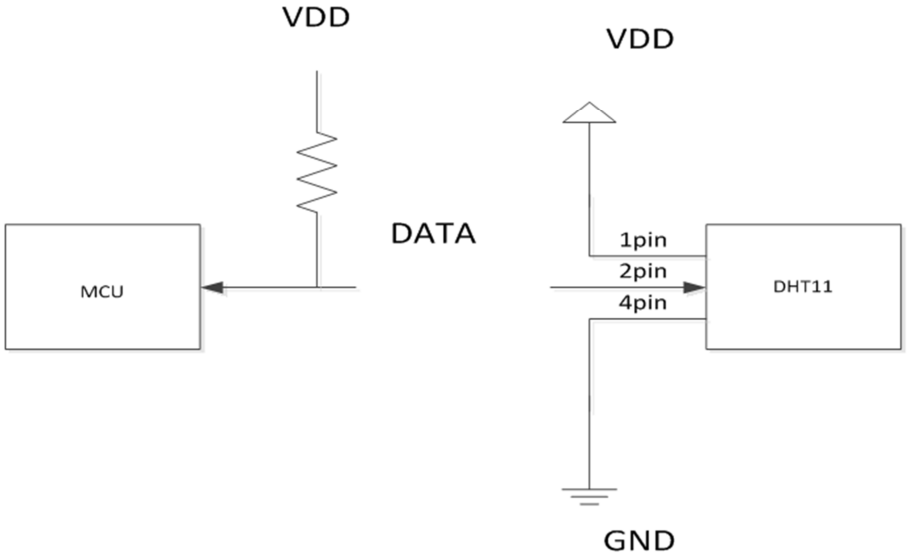

Figure 3. *The switch control circuit sensor interface circuit.*

Indoor electrical switch control circuit principle is shown in figure 3. In the figure, the L, N on the left side is 220 v ac input, the L, N on the right side is 220 v ac output. We control the level of the power switch port instead of controling electric equipment using the triode switch function. triode disconnects, the relay cuts off and electric equipment shuts down. When the power output high electricity, triode conducts, tentacles of relay conducts and electrical equipment opens.

3. The System Software Design

3.1. The Software Overall Design Scheme

In the System users send control instructions to GSM short message module through mobile phone. When GSM module receives the control command, the corresponding commands should be sent to the master microcontroller STC89C51, the master microcontroller parses the corresponding command,

then ZigBee coordinator receives the parse instructions. ZigBee coordinator sends the corresponding instruction to each ZigBee terminal nodes. Terminal nodes control electric switch or measure parameters that need to be monitored (temperature and humidity), finally the results can be sent to mobile phone. The system total process is shown in figure 4.

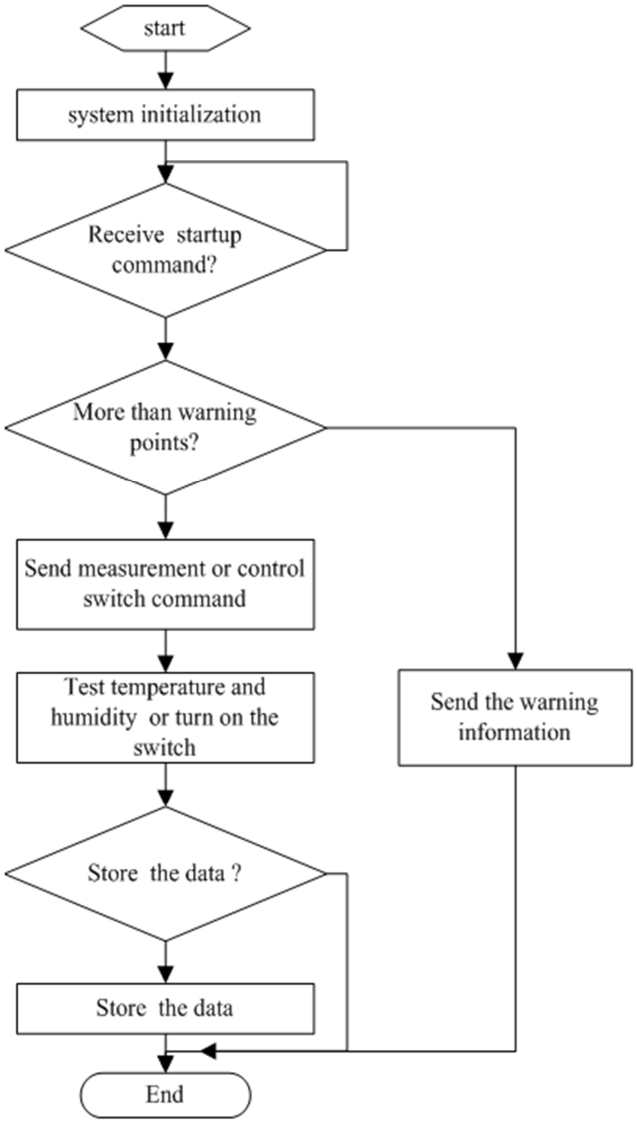

Figure 4. *The flow chart of the system.*

3.2. The GSM Module Software Design

The function of module is realize sending the temperature and humidity data to the users remotely in the form of short message. The design of GSM module software mainly includes the following two parts: 1, the GSM module initialization: (1) set up center address number (2) set text mode (3) text location Settings 2,the GSM module sends and receives messages. After powered on, the whole system initializates, serial of communication opens and codes inside the module, a text string generates, the information is send by corresponding AT command. Serial communication closes after sending information.

3.3. The ZigBee Module Software Design

The system uses the CC2430 chip of TI company, TI company provides a complete agreement in accordance with ZigBee protocol stack, that helps form the ZigBee network, the services and applications of the ZigBee agreement. Protocol stack is divided into four layers: the physical layer and MAC layer, network layer and application layer. Software design is mainly aimed at the application layer of the application of writing, calling the corresponding service to the operation of the underclass.

Coordinator for the wireless network also wants to ensure the normal operation of the network, data updating and the network maintenance, etc.

The terminal nodes as same as the coordinator node, need a corresponding initialization before use. After initialization, terminal nodes searches area network and sent the requests of join network to the coordinator. The Coordinator allows it to join the network. The terminal nodes acheive a temperature and humidity data immediately, send data to the coordinator and recycle into the next temperature and humidity collection. If the system sets low power, the terminal nodes can be done in a temperature and humidity data acquisition and send later into dormancy until the next again awakens when temperature and humidity data acquisition, and then enters the second data collection and send.

3.4. The Master Single Chip Microcomputer Software Design

Master microcontroller in the system completes communication between the GSM module and the ZigBee coordinator. Software design consider how to realize the communication with the GSM module and how to exchange data with ZigBee coordinator. According to the above, master Single Chip Microcomputer software design seperates the following two parts: 1, the software design of communication between the master Single Chip Microcomputer and TC35 module; 2, the software design of communication between the master Single Chip Microcomputer and ZigBee coordinator.

3.4.1. The Software Design of Communication Between the Master Single Chip Microcomputer and TC35 Module

In this system, the Single Chip Microcomputer communicates with ZigBee coordinator by simulate URAT with the interrupt method, because there is only one URAT on the singlechip used in communication with Short Messaging Service module. P3.5 of the master microcontroller is used as the simulation sender pin; P3.3 is used as the receiving pin; the format bits of the transmission data a are ten; eight bits in the middle is used to deposit information data.

The communication baud rate is set to 9600 BPS and the time required to transmit one bit data is about 0.1 ms. Crystal oscillator of Master microcontroller is 11.0592 MHz and the time required to transmit one bit data happens to be an

integer instruction cycle. Calculation process is as follows

$$S = \frac{1000000 / 9600}{12/11.0592} = 6$$

When there is data communication between the master microcontroller and the coordinator, the terminal subprogram starts working to complete the communication simulate URAT.

Simulate URAT communication program includes a URAT initialization program, the URAT dispatch interrupt routine, the URAT reception interrupt routine and receiving program.

3.4.2. The Software Design of Communication Between the Master Single Chip Microcomputer and ZigBee Coordinator

The master microcontroller connects with GSM module through the serial port and parses command message of GSM module sent to ZigBee coordinator. Meanwhile, it also needs to send the temperature and humidity transmitted by ZigBee coordinator to GSM module, the flow as shown in Figure 5.

4. Test and Result Analysis

4.1. A serial Port Test Program and Single Chip Microcomputer Programs Load Debugging Experiment

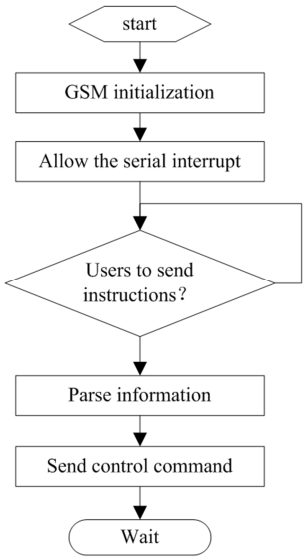

Figure 5. *Single Chip Microcomputer and GSM communication flow chart.*

First debugging TC35 module, the prepared SIM is inserted into card slot of TC35 and the TC35 is connected to the computer through the URAT. Then debugging software serially and dialling a number, if it is possible to get through, the test is successful. Loading the compiled program into the singlechip, running status of the program can be observed depending on the indicator light on development board.

4.2. ZigBee Module Serial Debugging Experiment

Experimental procedure: 1. Coordinator EB-Pro downloaded to the development board A is chosen as a coordinator to connect with the computer by USB cable; 2. End Device EB-Pro downloaded to the development board B is chosen as a terminal device to transmit data wirelessly to the coordinator and connect with the computer also by USB cable; 3. Electrify two development board, open the URAT debugging assistant, set communication parameters at 9600,8N1 and open the URAT, select the port number. The terminal will send data to the coordinator after successful networking. Result of ZigBee terminal experiment is shown in Figure 6. Result of ZigBee coordinator experiment is shown Figure 7.

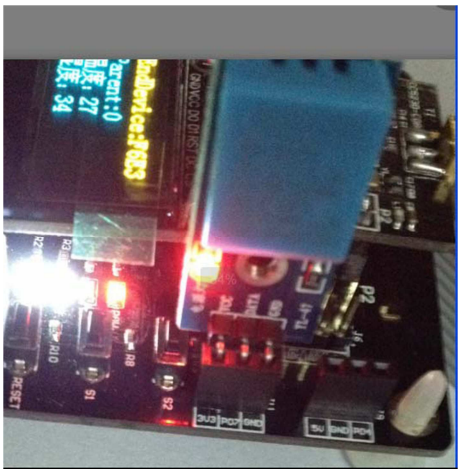

Figure 6. *ZigBee terminal experimental results.*

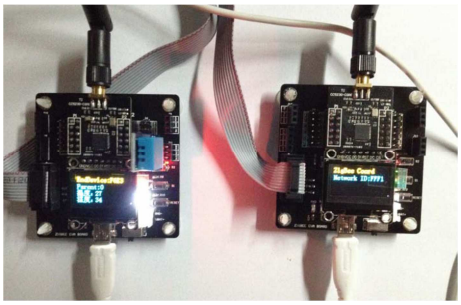

Figure 7. *ZigBee coordinator experimental results.*

4.3. The Mobile Testing System

Program debugged successfully should be downloaded to the coordinator, terminal nodes and the master microcontroller. Insert SIM card and power on. When the first indicator on the TC35 module, the serial begins to connect. When the second light flashes, TC35 module begins to register. The third light flash means registration done. Mobile phone demands ZigBee coordinator "adding nodes", then diode circuit and DHT11 sensor circuit come into the net, the corresponding light of terminal nodes flash, remote monitoring can be achieved. First of all, control the diode. After electric starting system, another user mobile phone send "k1" to SIM card as shown in figure 8, then open relay, led shines, as shown in figure 9. In the same way, after send control commands "k0" to the SIM card, relay and diode shut down.

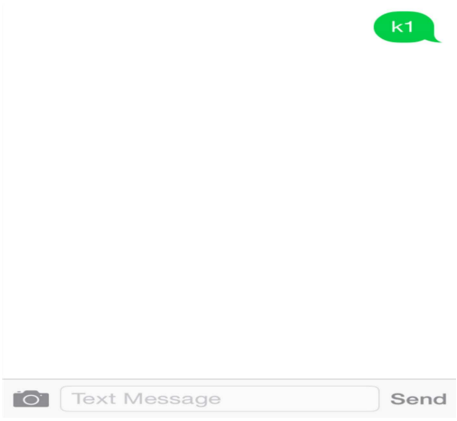

Figure 8. *Send command k1.*

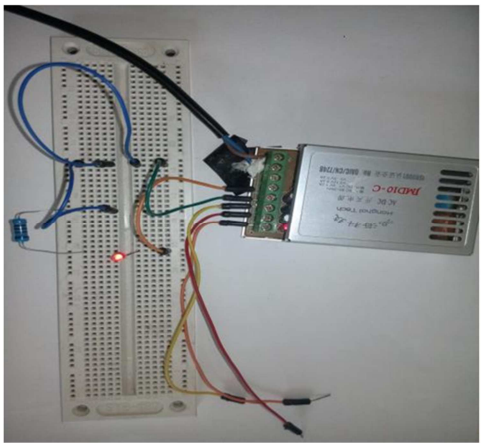

Figure 9. *Diode shine.*

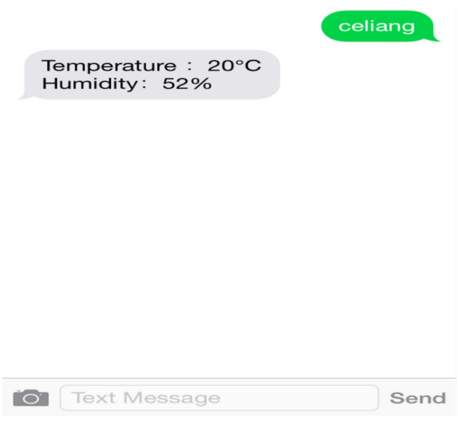

Figure 10. *Collect temperature and humidity.*

The indoor temperature and humidity collected by phone sending a short message should be sent back, as shown in Figure 10. After the test, mobile phone successfully collected indoor temperature and humidity and controlled the light of diode, meaning the system run successfully.

4.4. The Experiment Data Recording and Analysis

The indoor temperature and humidity collected by phone sending a short message and the indoor temperature and humidity measured by temperature and humidity meter should be recorded. The system measures per hour, totally six times. The indoor temperature and humidity collected by the system and the indoor temperature and humidity measured by temperature and humidity meter are shown in table 1.

Table 1. *Temperature and humidity collected by the system and by temperature and humidity meter.*

Measuring temperature and humidity of the time	Temperature of mobile phone reception (°C)	Relative humidity of mobile phone reception (RH %)	Temperature of temperature and humidity meter (°C)	Relative humidity of temperature and humidity meter (% RH)
8:00	24.5	63	24.7	64
9:00	25.3	62	25.6	63
10:00	26.0	61	26.4	60
11:00	27.1	56	27.6	57
12:00	28.6	55	29.0	54
13:00	29.9	50	30.4	49
Mean value	26.9	57.8	27.3	57.8

In conclusion, the temperature and humidity collected by this remote monitoring system of temperature and humidity based on GSM and ZigBee is consistent with the actual temperature and humidity. In terms of temperature monitoring, measurement results of this system compared with the actual temperature has absolute error of 1%. This result has great reference value.

5. Conclusion

Remote Monitoring System of Temperature and Humidity Based on GSM and ZigBee successfully implements communication between the indoor wireless sensor networks and mobile network., the indoor temperature and humidity remote monitoring and electric control. Compared with traditional cable data acquisition, the system is easy to form, saves space, needs low power consumption and convenient function extension, so it has a good application prospect.

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