International Journal of Control and Automation
Vol.8, No.11 (2015), pp.105-112
http://dx.doi.org/10.14257/ijca.2015.8.11.11

Design of Greenhouse Environment Parameter Measurement System Based on GPRS

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Abstract

Combining characteristics of the greenhouse and the problems existing in the process of environment parameter measurement, an environment parameter intelligent measurement system based on GPRS has been put forward and the hardware circuit and the software design of the system have been completed. The system is mainly composed of a parameter measuring terminal, GPRS network and a monitoring host. The parameter measuring terminal with the core of single chip microcomputer can obtain environment parameters on the scene through a high precision sensor, and then, it sends the data through the GPRS module based on wireless network to the monitoring center, and the monitoring host will receive data that will be real-time displayed. The system has the characteristics of good expansibility, low cost and high accuracy so that it can meet the requirements of wireless acquisition of remote data and has broad prospects of application and a good promotional value.

Keywords: *Greenhouse, Parameter Measurement System, GPRS*

1. Introduction

With the development of agricultural technologies in our country and the continuous improvement of people's living standard, greenhouses have been widely applied to such fields as vegetable cultivation, floriculture and poultry farming and provided necessary environment conditions for animal and plant growth. Taking Shandong Shouguang as an example, the cultivated area of vegetable greenhouses in this area every year has reached 800,000 mu, the annual output of various types of vegetables has exceeded 4 billion kilograms, and the products have been sold throughout the country. However, the growth of different crops needs different temperature and humidity environment, and once the environment of greenhouses is out of control, there will be reduction even no yield of crops that will cause losses for farmers. Therefore, the measurement of environment parameters is a necessary task in the planting process [1-3]. The traditional measurement of environment parameters is completed mainly relying on experience-based judgment of technical personnel or artificial checking of field instruments. This method needs high labor intensity and has low work efficiency, and it is against with the current trend of the development of facility agriculture. Although parts of greenhouses use the automatic integrated system based on sensor technology, this system adopts the method of wire design with complex wiring, and any carelessness will break signal wires, which have caused inconvenience for agricultural civilization. In recent years, the development of Internet of things technology has brought new opportunities for high-tech agriculture, and wireless network can omit the complex wiring, save space, and meet the requirements of data transmission [5].

In view of the above factors, in this paper, a design scheme of an intelligent environment monitoring system based on GPRS technology has been put forward. This system integrates sensor technology, computer technology, network technology

ISSN: 2005-4297 IJCA

and intelligent control into one and it can obtain real-time information such as temperature, humidity and illumination of greenhouses and send it to the managerial personnel of farmer households. With the aid of the system, farmer households can get real-time grasp of and control all growth data of greenhouses, which has provided important safeguards to promote the increasing of both production and income of agricultural products.

2. Overview of GPRS

The full name of GPRS is General Packet Radio Service, which is a kind of packet radio switching technology that is developed by increasing GPRS gateway node (GGSN: Gateway GPRS Support Node) and GPRS service node (SGSN: Serving GPRS Support Node) on the basis of GSM system and can provide end-to-end data service with the characteristics of fast speed and low price. GPRS network is usually made up of four parts: MS (Mobile Station), BBS (Base Station System), GPRS service node SGSN and GPRS gateway node GGSN [6-8]. GPRS data link is shown in figure 1. In this system, MS is the measuring terminal of the lower computer.

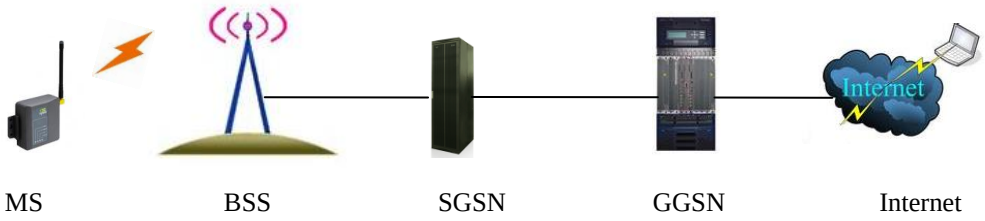

Figure 1. Data Link Map of GPRS

Compared with GSM system, GPRS has the following advantages:

(1) The transmission speed is fast. At present, the transmission speed of GSM is about 9.6Kbs, while the speed of GPRS can reach 56Kbps, and theoretically, the fastest speed can reach 171.2Kbps.

(2) It is charged in accordance with flow, so the charge mode is reasonable. The charging of GPRS is based on flow without considering communication time. If users are online, it is only charged during data transmission, and without data transmission, users have no need to pay.

(3) The speed of network access is fast. Users can be real-time online after they login the network, and when the network is activated, packet switching can be completed in a second to provide instant links and improve the efficiency of data transmission.

(4) The utilization of radio resources is high. For a single user, he or she can occupy multiple channels at the same time, while the same channel also can be shared by multiple users, which have greatly improved the resource utilization.

(5) GPRS supports TCP/IP protocol. GPRS has a wide coverage range that can support TCP/IP protocol in the lower layer and realize the seamless connection with Internet.

Hence, as an advanced wireless network mode, GPRS can quickly and easily build distributed, collecting-distributing and open network that can gain wide application in such fields as industrial control, data acquisition and wireless meter reading.

3. Design of the Whole System

The composition and structure of the greenhouse environment parameter measurement system based on GPRS is as shown in Figure 2. The system is composed of 3 parts of the measuring terminal of the lower computer, GPRS data transmission network and the monitoring host of the upper computer and in a system, multiple measuring terminals can be configured according to the quantity of greenhouses. The measuring terminal of the lower computer is composed of the display, sensor, microprocessor and GPRS module to realize the functions of data acquisition, processing and display, and it is responsible for receiving the message from the monitoring host of the upper computer and transferring the data according to instructions. First of all, the measuring terminal of the lower computer extracts temperature, humidity and illumination data detected by the sensor and send the data through RS232 serial port to GPRS communication module, and GPRS module uses antenna sending the data to GPRS network. After GPRS module that is connected with the host of the monitoring center receives the signal, the signal will be sent to the computer through a serial port for analysis, display and storage. The inquiry commands and control commands of the monitoring host also can be sent to the intelligent measuring terminal through GPRS network and operate the control equipment. Through GPRS network, the system host and its multiple slaves can form an organic whole to coordinate and complete greenhouses' function of parameter measurement.

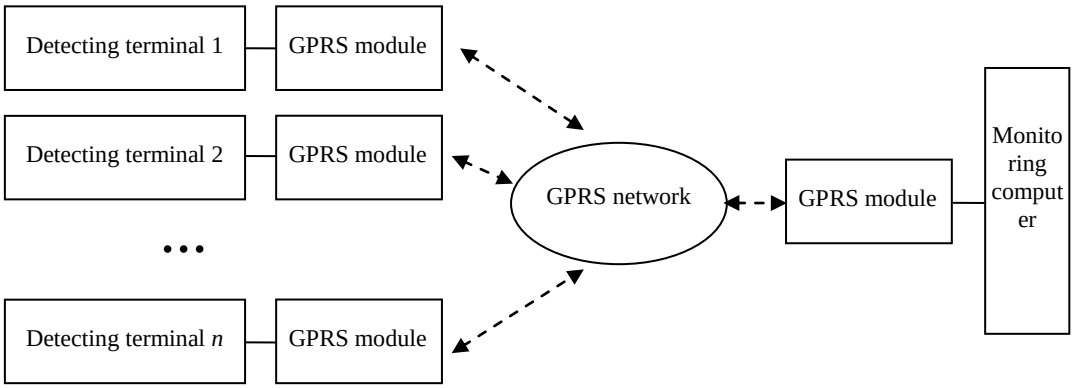

Figure 2. Schematic Diagram of Detection System Based on GPRS

In the hardware design of the whole measurement system, the key hardware structure is the measuring terminal of the lower computer. And the framework of every terminal is shown in Figure 3.

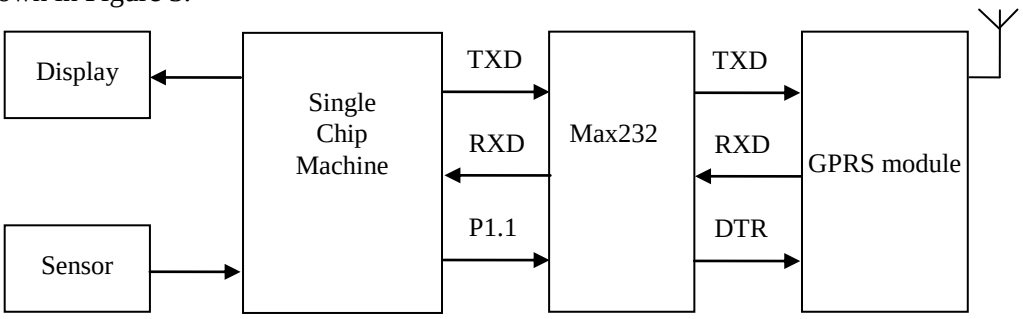

Figure 3. Structure Diagram of Detection Terminal

3.1. Single Chip Microcomputer

The field controller adopts STC89C52 single chip microcomputer produced by Shenzhen Hongjing Technology Company as the processor, which is an enhanced high-performance CMOS microprocessor with an 8K bytes of programmable memory inside and 512 bytes of RAM integrated on the chip, and the instruction code and mount structure can be fully compatible with the traditional 8051. STC89C52 single chip microcomputer has 3 16-bit timers and falling interrupting or low level trigger circuits with 4 interruptions and the function of separate watchdog. The chip integrates general 8-bit central processing unit and ISP Flash storage unit, and during the process of program downloading, the special programmer or emulator is not needed, and the user program can be directly downloaded in the chip through a serial port, which has provided a cost-effective solution to the development of many control systems.

3.2. GPRS Module

The wireless communication module chosen in this system is MC35 produced by SIEMENS. This module has the supply voltage of 3.3-4.8V and the maximum working current of 2A, and it contains all functions of TC35 with the characteristics of small volume, light weight, easy integration and low power consumption. In the practical design, the I/O port of the single chip microcomputer can be DTR signal of MC35 after MAX232 level switch. The single chip microcomputer can directly read the collected data, and then pack the data and send it to MC35 module through a serial port according to the format prescribed by the agreement so as to send the data to the monitoring center. Similarly, the command from the monitoring center also can be reversely transmitted to the terminal. The characteristics of MC35 module are as follows:

(1) Support EGSM900 and GSM1800;
(2) Support numbers, voices, short messages and faxes;
(3) Provide a toolkit applied by SIM;
(4) Be certificated by R&TTE;
(5) SMS has various patterns of MT/MO/CB/PDU.

3.3. Temperature and Humidity Sensor

This system chooses SHT11 as the sensor, which is a temperature and humidity integrated sensor with 12C bus single chip full-calibration digital signal output produced by Swiss Sensirion Company. The sensor's output resolution of the humidity value is 14 digits and the output resolution of the temperature value is 12 digits, and they can be set as 12 digits and 8 digits according to the programming. The sensor adopts unique CMOSens TM technology and has the characteristics of digital output, commissioning free, calibration free, peripheral circuit free and full exchange. With small size and low power consumption, it is 550μA during measurement, 28μA on average, 3μA during dormancy, and using battery supply can make it long-term stable operation. When SHT11 is measuring relative humidity, the accuracy can reach ±3.5%（20 to 80% RH）, the measuring range is from -40℃ to +120℃, and the accuracy is ±0.5℃, which can fully meet the requirements of actual measurement. The connection between SHT11 and the single chip microcomputer is shown in Figure 4.

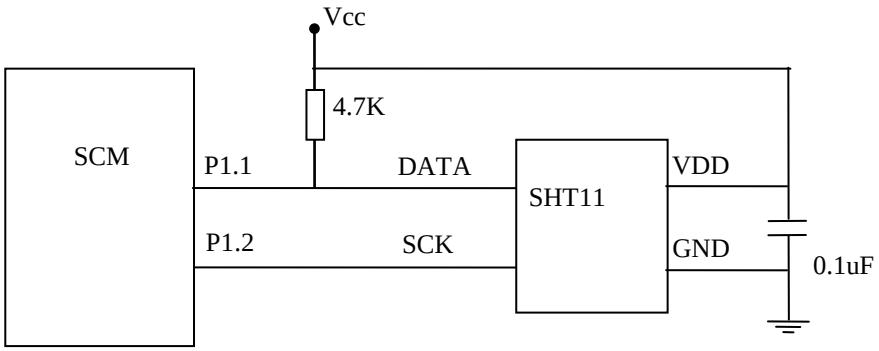

Figure 4. Interface Circuit of SHT11 and SCM

3.4. Illumination Sensor

The model of the illumination sensor chosen by the system is BH1750FVI, which is a digital integrated sensor with serial interfaces produced by Japan's RHOM Joint-stock Company with the luminosity range of 1-65535lx and has been widely used in such fields as mobile phones, digital cameras and photosensitive controllers. There's a built-in high sensitivity photosensitive diode in BH1750FVI, and when there's light, the produced electrical signal will directly output a digital signal through the built-in 16-bit analog-digital converter and eliminate the following A/D switching circuit and complex calculations. The circuit between BH1750FVI and the single chip microcomputer is shown in Figure 5.

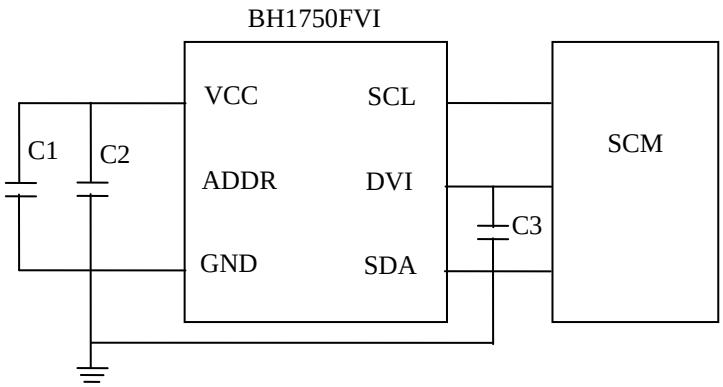

Figure 5. Interface Circuit of BH1750FVI and SCM

4. Software Design of the System

The software design of the system mainly includes: the data acquisition program of the lower computer, the data management program of the upper computer, and the data transmission program.

4.1. Software of the Lower Computer

The program of the single chip microcomputer adopts C51 language and is compiled based on Keil platform and it has fulfilled the acquisition of environment parameter data,

the data display and send. After the measuring terminal of the lower computer is started, firstly, it is the initialization, then it is the acquisition of temperature, humidity and illumination information according to the instruction requirements; and then, it transmits the collected data through TC35, and the single chip microcomputer sends AT command to TC35 through a serial port to control it. And the flow chart is shown in Figure 6.

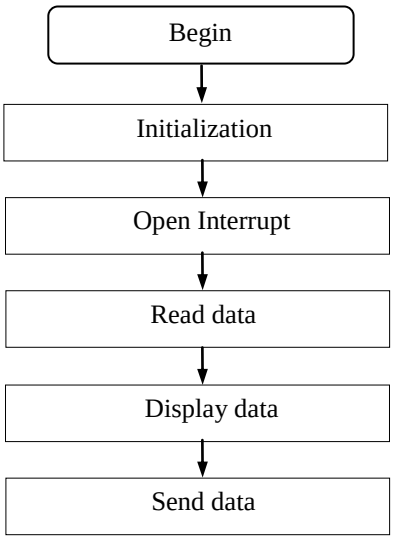

Figure 6. Main Flowchart of Slave Machine

4.2. Data Management Program of the Upper Computer

In order to improve the efficiency of programming, the design process of the upper computer program is under the help of MSComm control to complete and fulfill the communication with the lower computer, the processing, storage and display of the upload data on the lower computer, and the data curve analysis. Through serial ports, MSComm control sends and receives data and has provided the basic function of serial communication. TeeChart control can make all kinds of charts and combine the collected temperature and humidity data with the data curve together to realize the dynamic and real-time display of data in the form of curve. The structure is shown in Figure 7.

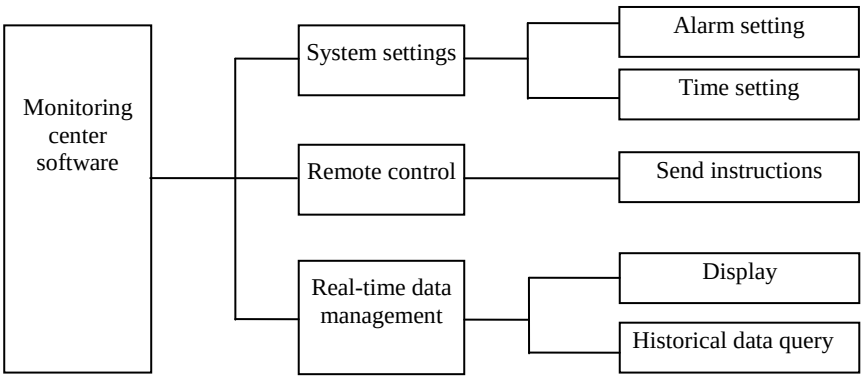

Figure 7. Data Management Software on PC

4.3. Data Transmission Program

The single chip microcomputer realizes the control to TC35 and the receiving and sending text messages through sending commands. Through the serial port of the single chip microcomputer, send commands to TC35, complete the initialization of the module, set SMSP and the sending mode to send and receive data. Among them, the agreement of the communication between the host and the slave has the following rules:

1) The baud rate of the host and all slaves should be set as 9600 bps;

2) The initial states of both the host and the slaves should be set as the serial interrupt mode.

3) The format of the data sent by the host is: [start character], [the address code of the slave], [command word], [data], and [check].

When the slave receives the command sent by the host, it should check whether the address belongs to itself. If the address is correct, the slave will reply to the host and perform the corresponding command; otherwise it will not respond to the host.

4) After the slave receives the command, the format of the response is [start character], [the address code of the slave], [command word], [data], and [check].

5. Experimental Results and Analysis

In order to verify the performance of the greenhouse environment parameter measurement system, in the laboratory under normal atmospheric pressure, we have respectively adopted standard temperature and humidity source to conduct contrast experiments to the system. The experimental results are shown in the figure 8, in which the solid line is the actual value, and the chain line is the measured value. Assume that the measured value is N', the real value is N, then:

The absolute error is expressed as:

$$\varepsilon = | N - N' | \tag{1}$$

The relative error is:

$$\Delta=\varepsilon/N\times100\% \quad \Delta = \frac{\varepsilon}{N}\times100\% \tag{2}$$

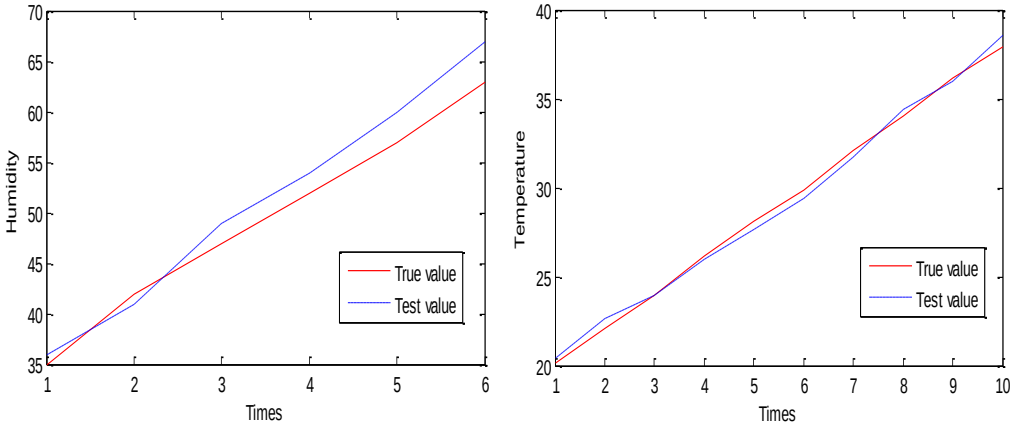

Figure 8. The Experimental Results of Temperature and Humidity

From the measurement experiment results, we can know that the system can measure temperature and humidity information steadily, the relative error of the measurement is

controlled within ±5%, and the performance is stable and reliable so that it can meet the requirements of the field measurement.

6. Conclusions

This paper has designed a greenhouse environment parameter measurement system based on GPRS wireless network transmission. This system can integrate sensor technology, microprocessor technology, wireless communication technology and intelligent control technology into one, measure the temperature and humidity parameters in greenhouses, and coordinate with the subsequent controller to realize automatic control of greenhouses. The system adopts GPRS communication mode, so it not only doesn't need to build a communication network, but also doesn't produce network maintenance costs with low operation cost. The experimental results show that the system has stable operation, accurate measurement data, strong anti-interference ability and important promotional value.

Acknowledgments

This work has been supported by National Natural Science Foundation of China (Grant No. 61403283), Shandong Provincial Natural Science Foundation (No. ZR2013FQ036), the Spark Program of China (No. 2013XH06034), the Spark Program of Shandong Province (No. 2013XH06034) and Technology Development Plan of Weifang City (No. 201301015).

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