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Study on a Measurement and Control System for Greenhouse

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We develop a distributed and multi-span measurement and control system for greenhouse based on CAN bus using communication technology and embedded technology. The information of environmental factors (temperature, moisture, illumination) is collected, processed, transmitted and controlled. This paper presents the design flow charts of hardware circuits and software. Experiment shows that the measurement and control system for greenhouse can meet the goal of environmental monitoring and is worthy of popularization.

1. Introduction

The major part of China belongs to continental monsoon climate and the winter and summer monsoon winds blow in opposite direction. The winter is cold and dry, while the summer is hot and raining. The four seasons are distinct, which is unfavourable for crop group. Moreover, north and south China have very different climate. Due to low temperature, many months are not suitable for agricultural production in North China. Technologies are indispensable for developing modern agriculture.

At present facility agriculture plays an important role in China and the popularization of facility agriculture can promote modernization of agriculture, while increasing agricultural yield and peasants' income (Chen, 2014). Greenhouse is a crucial part of facility agriculture. To meet people's need and to keep pace with the trend of agricultural technology, artificial intelligence has been introduced into greenhouse. This new technology enjoys a huge development potential.

The greenhouses referred in this study are conventional greenhouses in China as well as the intelligent greenhouses from foreign countries. The measurement and control system for greenhouse proposed integrates sensor, intelligent control, single-chip microcomputer and communication technologies.

2. Overall design

2.1 Working principle

The measurement and control system for greenhouse consists of 3 parts: sensors, controller and environmental control system. Sensors are used for collecting parameters of the greenhouse environment and converting them into digital signals as input into the microcontroller. Environmental control system is used for controlling the parameters of the greenhouse environment. The controller presents the logic of the entire control mechanism with the flexible programming of the interaction between the input of sensor data and output of environmental control system.

Therefore, the control based on different rules is achieved. Below is the closed-loop circuit of the control system (Fig. 1).

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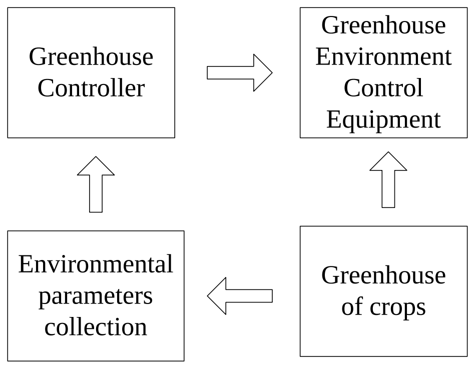

Figure 1: Working principle of the system

2.2 Hardware design

The block diagram of hardware design is shown in Fig. 2. The hardware mainly includes sensor circuit, microcontroller, input/output (I/O) module, power supply processing module, CAN bus interface and USB interface. Data collection module is responsible for collecting parameters of the greenhouse environment using sensors and front-end data processing. The sensors used are divided into two types: sensors with analogue output or digital output. The analogue signals are directly transmitted to the controller via a built-in A/D converter of the chip. The controller processes the data, makes judgment following the preset control logic, and finally outputs the control signals with the opening or closure of corresponding output equipments. I/O module consists of relays, photoelectric isolation and greenhouse equipments(Guo et al., 2013). The power supply module provides SV and 3.3V power supply. Human-machine interaction module realizes menu operation and parameter configuration. CAN interface and USB interface provide connections between a single greenhouse and the upper computer for multi-span, integrated management.

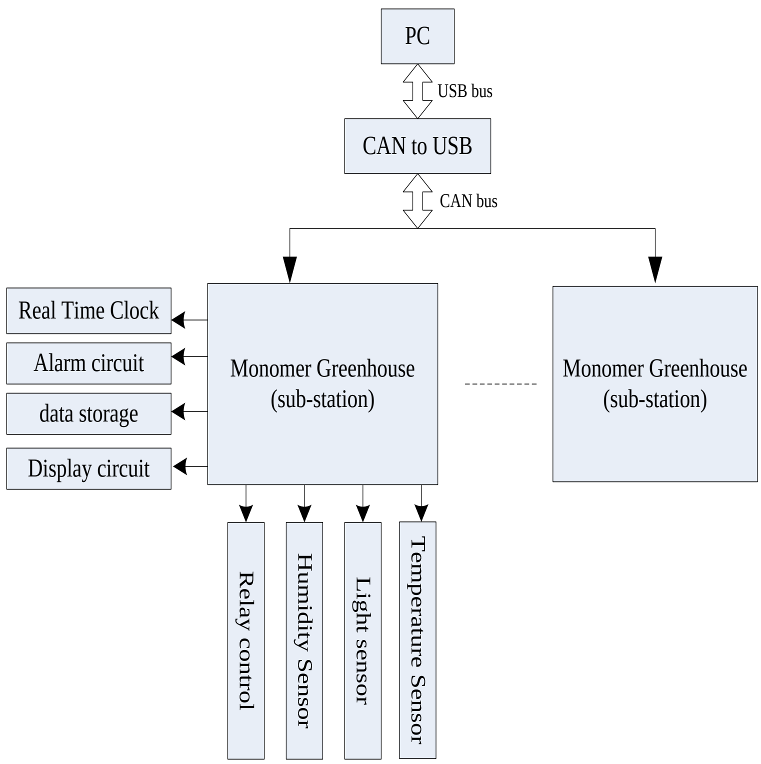

Figure 2: Block diagram of hardware design

2.3 Software design

Software design includes the design of control system software for a single greenhouse, CAN bus transmission, USB data transmission and upper computer management software. Control system software for a single greenhouse has the following modules: system configuration, alarming configuration, stage control, historical data, expert database and growth stage logic control. By choosing the operating mode, configuring expert database, dividing the control stages and connecting with equipments, a flexible programming is possible between the control logic and executing devices. Therefore, logic control is realized for the equipments at each growth stage and then for the entire crop growth process (Tan, 2015). The software for upper computer management is written using C# programming language, an object-oriented programming language, to enhance auxiliary management function of the greenhouse control system. CAN bus protocol is responsible for data transmission between the greenhouses and for multi-span management by the upper computer via the USB communication protocol. The design of the software for single greenhouse control system is shown in Fig. 3

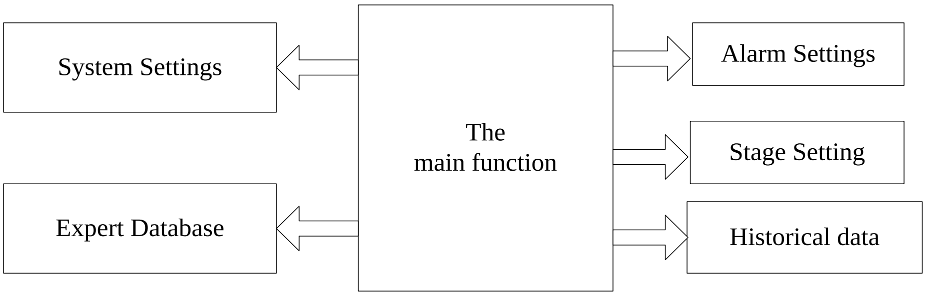

Figure 3: Function block diagram of single greenhouse control software

3. Hardware design

3.1 S3C6410 controller

S3C6410 controller is a 16/32-bit RSIC microprocessor developed by Samsung based on ARM11 processor core. This controller is featured by high price performance, low power consumption and ease of development and the ability to enhance the peripherals. S3C6410 controller is used in the single greenhouse control system. Its high-capacity memory and diversity of peripheral interfaces make it easier for functional update and for meeting the control requirement.

3.2 Sensor interface design

3.2.1 DS18B20 and single-chip microcomputer interface design

There are two types of interface circuit connections for DS18B20 and single-chip microcomputer. One is connection of power supply to VDD, with grounding of GND and connection of I/O interface of single-chip microcomputer to DQ pins. The other is the use of parasite power for power supply, with grounding of VDD and GND and connection of DQ pins to I/O interface of single-chip microcomputer. Regardless of the mode of connection, when the DS18B20 sensor is writing memory and performs A/D conversion of the temperature data (Hu and Liang, 2014). The temperature sensor circuit is shown in Fig. 4.

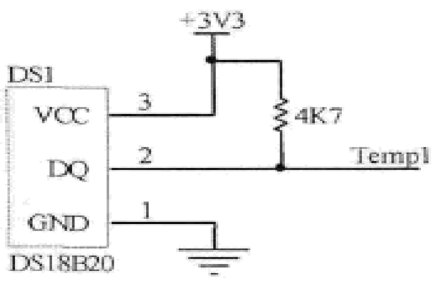

Figure 4: Temperature sensor circuit for DS18B20

3.2.2 Design of air moisture sensor circuit

HIH-4000 Series Humidity Sensors (Honeywell) are used.HIH-4000 Series Humidity Sensors have high output voltage and linearity. Therefore, no external conditioning circuits for signal amplification and non-linear correction are designed. The sensors are already capable of processing weak signals. VDD is connected to the 5V power supply, with GND grounded and OUT as the output terminal that outputs 0.8V-3.9V analog voltage signals. The corresponding relative humidity is 0% RH-100% RH. In our design(Yin and Zhao, 2014), OUT terminal is directly connected to the PC 4-pin convert on the single-chip microcomputer for A/D conversion. The air humidity sensor circuit is shown in Fig. 5.

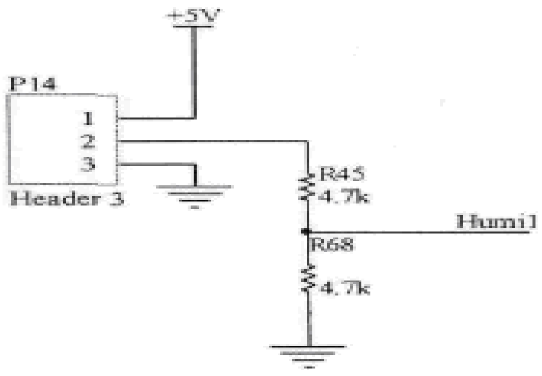

Figure 5: Air humidity sensor circuit

3.2.3 Design of light intensity sensor circuit

BH1750FVI light intensity sensor is connected to I2C bus. When the 12C bus is idle, SDA and SCL are at high electrical level. When SCL is at high electrical level, a falling edge of SDA can be used to initialize a start condition, while a rising edge of SDA can be used to initialize a stop condition. As shown in Fig. 6, both start and stop conditions are issued by the master device. After the start condition ends, the first byte is a 7-bit address value, according to which the slave device is chosen. The 8th bit determines the type of operation: reading or writing data.

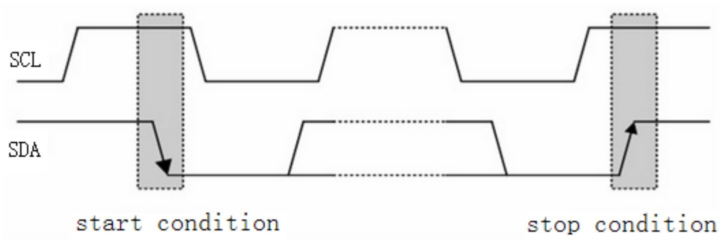

Figure 6: Sequence diagram of I2C

4. Software design

4.1 Software for single greenhouse control system

The block diagram of the master program is shown in Fig.7. After power-up, the operating mode and the relevant equipments are initialized. All equipments are shut down by the relay of the output control circuit, and the master program is run. Master program is the core of software design and crucial for the whole software architecture. After the subprogram is started, the following functions are implemented successively: service program, modification of the environmental parameter configurations, processing program, data monitoring, crystal liquid display and CAN bus communication.

4.2 Software design for DS18B20 temperature sensor

The uniline communication of DS18B20 temperature sensor is realized in a time-sharing manner and the time interval is strictly controlled. That means the writing and reading of time sequences are very important. All operations in DS18B20 temperature sensor should obey this protocol. The communication protocol is as follows: initialize the sensor (emit reset pulses), deliver the instruction of memory operation, process the data.

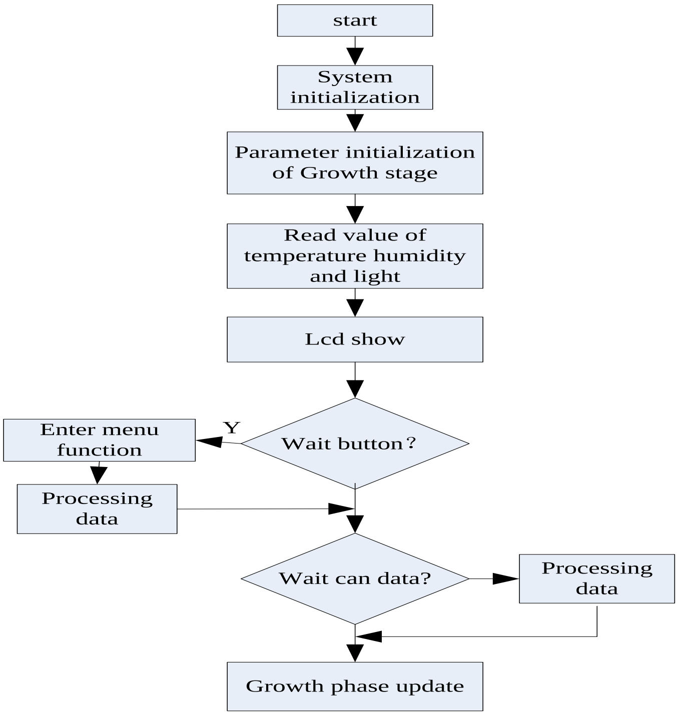

Figure 7: Block diagram of the master program

4.3 Software design for BH1750FVI light intensity sensor

The high-precision mode (llx) is chosen for the BH1750FVI light intensity sensor. According to the instructions of data manual, an instruction demanding high-precision mode is first sent. After waiting for 180ms, the results of light intensity measurements are read from the sensor. The flow chart of receive program is shown in Fig. 8.

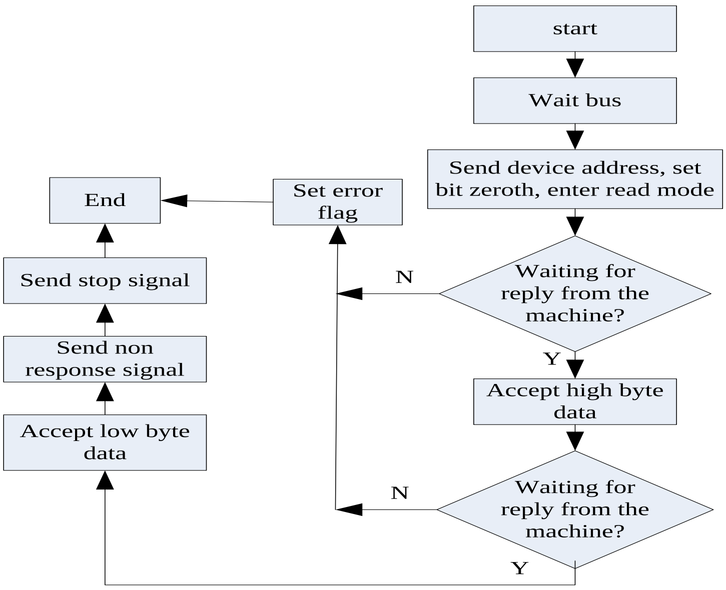

Figure 8: Flow chart of software design for light intensity collection

5. System testing

After debugging, the measurement and control system was installed to the greenhouse. All modules operated well with good software/hardware coordination. Some parameters were measured using the proposed system for a whole day, with the results shown in Table 1. Since no light was supplemented in the greenhouse during experiment, the light intensity control data are not provided.

Table 1: Parameter measurements of the greenhouse

Time of test	Temperature indoor (°C)	Humidity indoor (%)	Outdoor temperature (°C)	Outdoor humidity (%)
00:25	17.4	75	17.5	62
01:12	17.7	75	17.1	62
03:01	17.6	73	16.1	63
05:08	16.8	74	15.1	69
07:41	16.6	73	15.8	78
09:26	18.7	75	17.1	62
11:28	20.4	74	19.4	46
13:42	22.0	74	21.9	31
15:16	22.9	73	22.6	19
17:19	20.7	74	21.6	28
19:29	19.2	76	20.2	38
21:37	17.9	77	18.4	49
23:00	16.8	78	17.1	59

Experiment shows that the measurement and control system can work well in the greenhouse environment. The greenhouse parameters changed mildly, which means that the greenhouse environment is properly controlled and suitable conditions are provided for crop growth.

6. Conclusion

The intelligent measurement and control system designed for greenhouse is capable of monitoring and controlling the blowers, sun screens, heating and humidifying devices as well as sky windows/side windows. The parameters of the greenhouse environment, including temperature, humidity and light intensity, are controlled within the desired range. Experiment has indicated that this system is high in technology content and low in cost, representing a breakthrough in automatic and intelligent control of greenhouses in China.

Reference

Chen J., 2014, The Greenhouse Control System Based on Embedded WinCE, Yinshan Academic Journal, Vol. 28, No. 1, pp. 44-47.

Guo L.S., Xu X.N., Su L., 2013, Research on the Control System for Intelligent Greenhouse, Journal of Changsha University, Vol. 27, No. 2, pp36-38, doi: 10.3969/j.issn.1008-4681.2013.02.015.

Hu H., Liang L.Z., 2014, Design of the Greenhouse Multi-point Temperature Gathering Based on Zigbee and ARM, Jiangsu Agricultural Sciences, Vol. 42, no.7, pp.414-419, doi: 10.3969/j.issn.1002-1302.2014.07.143.

Jiang D.G., 2014, GPRS-Based Designing Temperature and Humidity Monitoring System of Greenhouse, Hubei Agricultural Sciences, Vol. 53, No. 9, pp. 2153-2155, doi: 10.3969/j.issn.0439-8114.2014.09.050.

Tan C.B., 2015, Research on Application of environment of greenhouse monitoring system based on ZigBee Technology, Electronic Test, No. 4, pp. 86-89, doi: 10.3969/j.issn.1000-8519.2015.04.043

Yin G., Zhao L., 2014, All intelligent greenhouse monitoring system design, Electronic Design Engineering, Vol. 22, No. 1, pp. 64-67, doi: 10.3969/j.issn.1674-6236.2014.01.021.