Design of Hardware Circuit of Intelligent Monitoring and Control System in Modern Agricultural Greenhouse

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Abstract: In recent years, with the improvement of large-scale planting in rural areas, greenhouse cultivation technology has been developed rapidly, so intelligent monitoring and control of modern agricultural greenhouse is a hot topic. Based on the design requirements of modern greenhouse, the hardware circuit of greenhouse is designed by using STM32F103ZET6 main control chip. This study is of great significance for the establishment of scientific ecological environment of plants and the realization of high quality and high yield of crops.

1. Introduction

With the rapid development of science and technology, modern agriculture has gradually moved towards the development of control automation and planting specialization. It can create a scientific ecological environment suitable for crops by artificial methods and change the growth cycle of crops. Achieve high quality, high yield and low consumption of crops. In the process of technological innovation and development, greenhouse technology is a manifestation of modern agricultural planting. It is characterized by artificial establishment of ecological environment for plant growth, elimination of the influence of seasonal changes on crop growth, and getting rid of the dependence of crops on natural conditions in part or completely, so it is an important means for farmers to increase production and income.

The intelligent monitoring and control system of modern agricultural greenhouse is composed of hardware circuit and software programming. This study is based on the hardware design of the system. With the support of software design, the intelligent monitoring and control system of greenhouse is designed.

2. Design Requirements and Design Scheme of Intelligent Monitoring and Control System for Modern Agricultural Greenhouse

2.1. Design Requirements and Design Scheme of the System

(1).Real-time collection of temperature and humidity parameters in greenhouse and processing and display of collected data; (2). According to the requirements of plant growth environment conditions, the temperature and humidity values in the greenhouse are set by independent keys. When the greenhouse environment exceeds the set threshold parameters, the system will alarm and start the control system at the same time. Adjust the temperature and humidity, light intensity and CO2 concentration in the greenhouse to the specified parameter values;(3).The intelligent monitoring and control system of greenhouse should have high sensitivity, reliability and anti-interference ability;(4).Technical indicators require: Temperature range :-10~70℃, temperature accuracy :±0.4℃, humidity range :0~90%, humidity accuracy :±3% RH.

2.2. Design Scheme of the System

The system adopts the design scheme is shown in figure 1 Based on the requirement of design, The system uses STM32F103ZET6 as the main control chip in figure 1, In Figure 1,

STM32F103ZET6 is adopted as the main control chip, DS18B20 as the temperature acquisition sensor, BH1750 as the CO2 concentration detection sensor, DH11 as the humidity detection sensor and SGP30 as the light intensity detection sensor. After the environmental parameters detected by the sensor are fed back to the STM32F103ZET6 microcontroller for data processing, the environmental information of the greenhouse will be displayed on the ST7735 TFT LCD display in real time. At the same time, users can set the environmental parameters required in the greenhouse through the button circuit according to the growth conditions of plants [1].

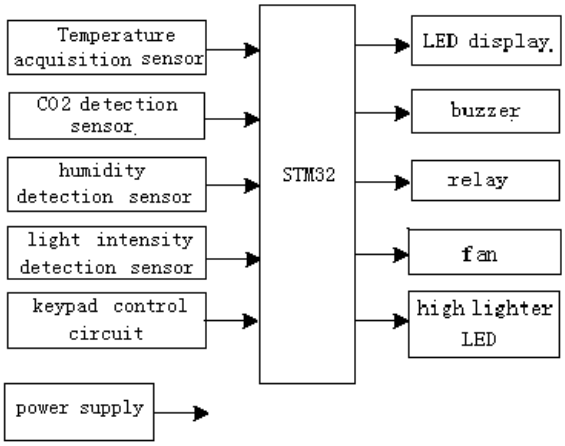

Figure 1. System design block diagram

3. Design of Main Hardware Circuit of the System

3.1. STM32F103ZET6 Minimum System

The minimum system of STM32F103ZET6 single chip microcomputer consists of the following parts: ① main control chip; ② reset circuit; ③ clock circuit; ④ power supply and download circuit. The STM32F103ZET6 pin is shown in figure 2[2].

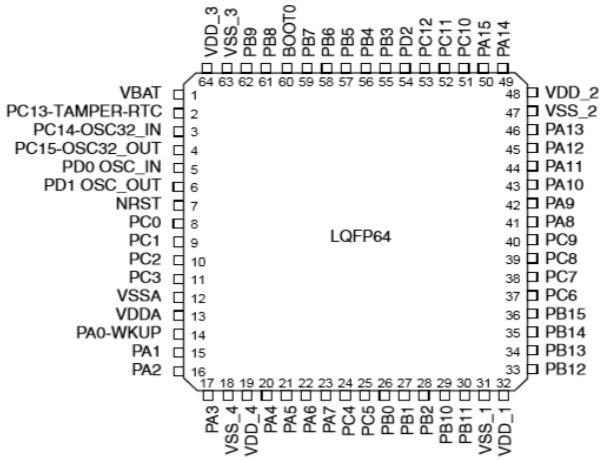

Figure 2. STM32F103ZET6 pin diagram

3.1.1. Introduction to STM32F103ZET6 Main Control Chip

STM32F103ZET6 is selected as the main control chip in this design. The features are as follows :(1). STM32F103ZET6 is a chip based on ARM Cortex-M3 core, It has the advantages of high performance, low cost and low power consumption;(2) The STM32F103ZET6 consists of 64 KB SRAM、512KB FLASH, two basic timers, four universal timers ,two advanced timers, two DMA direct memory (12 channels in total),three SPI serial peripheral interfaces, two IIC buses, five serial ports, a USB interface ,a CAN controller LAN, three 12-bit ADC modules, a 12-bit DAC module, a SPIO interface, One FSMC interface and 112 common I/O serial ports. From STM32F103ZET6 characteristics, it can be seen that its function is particularly powerful.

3.1.2. Clock Circuit

The clock signal is the control signal to coordinate the normal operation of each module in the single chip microcomputer, In the design of this system, Eight crystal oscillator circuits MHz the main frequency of the clock circuit, which is connected to the main control chip with ⑤pin (OSC_IN) and ⑥ pin (OSC_OUT), as shown in Figure3(a). The frequency of clock RTC is 32 KHz, It connects ③ and ④ pin to the main control chip, as shown in Figure 3(b)[3].

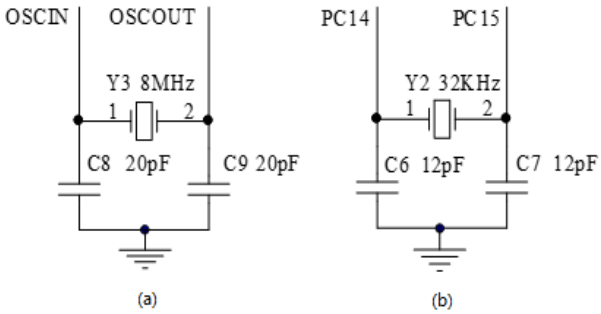

Figure 3. Clock circuit

3.2. Design of Temperature Sensor Acquisition Circuit

In the design of this system, DS18B20 sensor is used to detect the environmental temperature of greenhouses, and its packaging is shown in Figure 4. It has the following characteristics: (1) DS18B20 is an improved intelligent sensor, and its temperature measurement range is -20℃~100℃; (2) DS18B20 adopts "1-wire bus" to form multiple DS18B20 sensor networks to improve the detection efficiency of the system; (3) The "1-wire bus" can supply power by itself; (4) DS18B20 has more prominent advantages in temperature measurement, time conversion, transmission distance and resolution, etc.

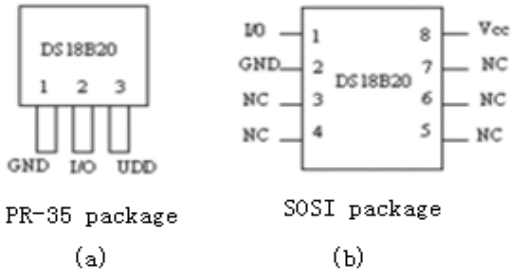

Figure 4. DS18B20 pin diagram

3.3. Design of Humidity Sensor (DHT11) Acquisition Circuit

DHT11 is a temperature and humidity composite sensor, which is composed of a resistor-type humidity sensing element and a NTC temperature measuring element. It uses special digital acquisition technology and temperature and humidity sensing technology, thus ensuring DHT1 has extremely high reliability and stability [4].

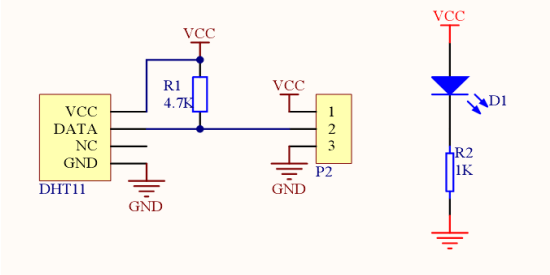

Figure 5. Temperature and humidity acquisition circuit

DHT11 sensor is used in this system to collect humidity DATA in the greenhouse and the collected DATA is sent to the STM32F103ZET6 main control chip for processing through the

DATA port. At the same time, the results are displayed through ST7735 TFT LCD, and the specific circuit is shown in Figure 5. It should be noted that : (1) when the length of the connection wire is shorter than 20 meters, 5K pull-up resistance is selected for the circuit; (2) When the length of connection wire is more than 20 meters, appropriate pull-up resistance should be used according to the actual situation.

3.4. Design of GY-30 Acquisition Module

The GY-30 acquisition module is shown in Figure 6.this module can detect various volatile organic compounds (TVOC) and H2; it is often used to monitor air quality in greenhouse. the circuit module is characterized by power supply voltage of 3-5V and built-in 16bitAD converter, which can directly output digital signals. It adopts IIC communication protocol and can be directly connected with MCU I/O, and its illumination range is 0-65535Lx.

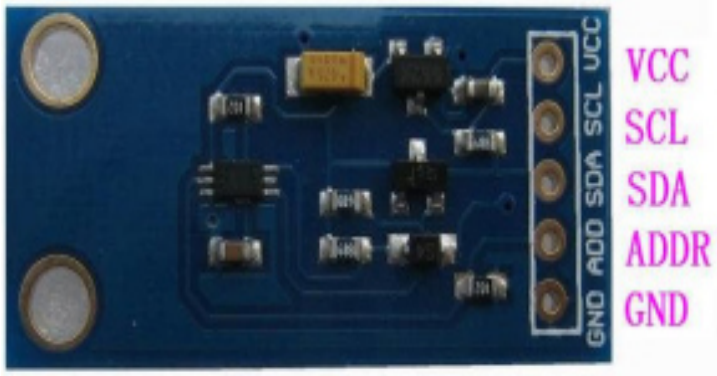

Figure 6. Physical picture of GY-30 sensor

3.5. Design of Relay Control Circuit

Relay is a kind of "automatic switch" which uses small current to control high current ".and it plays the role of automatic regulation, safety protection, conversion circuit and so on in the circuit.in the design of this system, four relay control circuits are used to control the temperature, humidity, CO2 concentration, light intensity and so on in the greenhouse [5].the specific circuit is shown in figure 7.

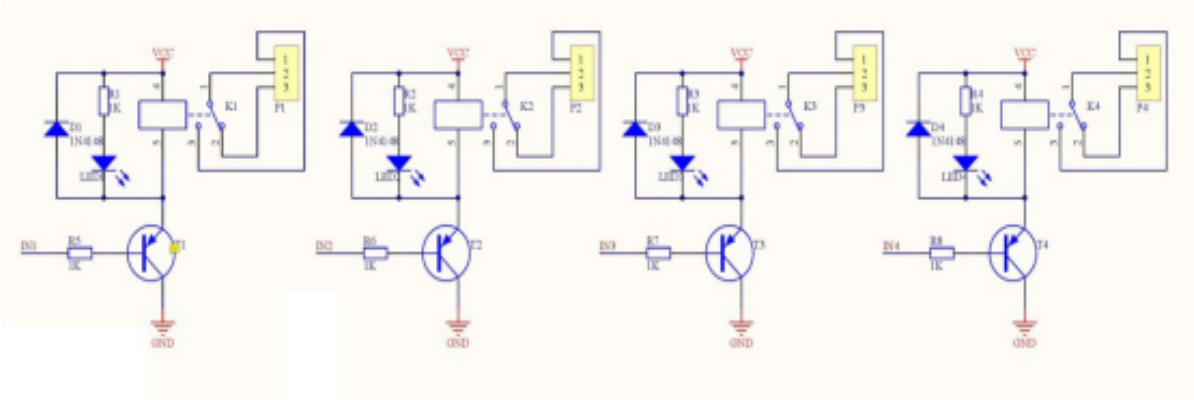

Figure 7. Relay control circuit

3.6. Design of LCD Display Circuit

In this design, THE ST7735 TFT LCD screen is selected as the status display of the system. With the support of hardware and software, the LCD screen can realize the following functions: ①. It supports mixed Chinese and English display; ②.support custom font color and background color, ③.support automatic line wrapping display; ④.supporting picture display; ⑤.supports rotating screen (set in TFT.h file of the program). In this design, the ST7735 TFT LCD display screen is used to display the environmental status of temperature, humidity, CO2 concentration, light intensity and so on in the greenhouse.

4. Design of System Software

Intelligent monitoring and control system of modern agricultural greenhouse is composed of hardware circuit and software programming. After the hardware circuit design of the system is completed, the software of the system needs to be designed. In this design, the main contents of the system software design are as follows: the design of the main program, the design of the environment parameter acquisition subroutine, the design of alarm subroutine, the design of the control button subroutine and the design of display driver subroutine, in which the main program is the main body of the whole STM32F103ZET6 main control chip. The main program design is to connect each independent subroutine module through programming to realize the overall functional requirements of the system.

5. System Assembly and Debugging

After the hardware unit circuit design is completed, cascading the designed hardware circuit, Using Altium Designer software to design circuit PCB boards, And install all components of the circuit on the PCB board, Download the program to STM32F103ZET6 MCU, After debugging the hardware and software of the system, The system achieves the following basic functions :(1) after power on, When the sensor detects that the environmental parameters in the greenhouse exceed the set threshold, The buzzer calls the alarm, LED red light flashes;(2) The temperature and humidity, light intensity and CO_2 concentration of greenhouse were collected, And through ST7735 LCD real-time display, As shown in Figure8, Through tests, The system achieves all the functions given by the design requirements.

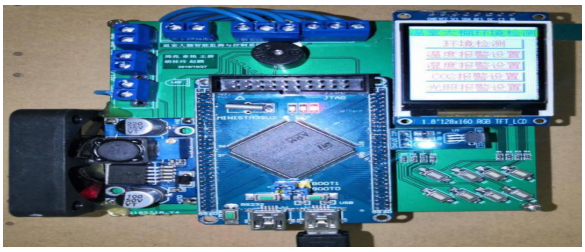

Figure 8. Physical picture of the system

6. Conclusion

Through the above discussion, we can see that based on the design requirements of the system, this study mainly discusses the hardware circuit design of the intelligent monitoring and control system of greenhouse. In the design process, the STM32F103ZET6 is used as the main control chip, the DS18B20 is digital temperature sensor, the DHT11 is humidity sensor, and the parameters of the environment state in the greenhouse are ST7735TFT LCD. With the support of system software programming, the intelligent monitoring and control of greenhouse is realized. The system can be used to adjust the ecological environment and growth cycle of crops, which is of great significance to achieve high quality, high yield and low consumption of crops.

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