

Design of Greenhouse Monitoring System

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Abstract

The greenhouse monitoring system in modern agricultural production can effectively control various environmental factors in the greenhouse so as to change the greenhouse environment to create suitable growth conditions for crops. This design adopted 51 single chip microcomputer as the core, using DHT11 digital temperature and humidity sensor and light sensor respectively to acquire the temperature and humidity and light in the greenhouse which were uploaded to the single chip microcomputer to be judged whether exceeding the threshold. If those data exceed the threshold, MCU sends signal to control relay control circuit working so as to control actuators for heating, cooling, and so on. The simulation results show that the design can real-time monitor and automatically adjust the environmental factors in the greenhouse, and display the data through the display to provide the best environment for the growth of crops.

Keywords

Greenhouse; Monitoring system; Single chip microcomputer; DHT11; Light sensor.

1. Introduction

With the rapid development of science and technology, the application of science and technology in agriculture has become more and more extensive. An important part of modern agricultural production is to monitor and control some important environmental parameters. Greenhouse control technology mainly adjusts various environmental parameters in the greenhouse, provides the best environment for the growth of crops, and avoids the impact on environmental changes throughout the year and bad weather on crop growth. Traditional greenhouses are inspected and managed manually, which have disadvantages such as low measurement accuracy, time-consuming, waste of labor, and inability to monitor in real time, which makes it difficult to achieve the expected results. Modern greenhouses have a relatively high degree of automation. Sensors collect signals and use a single-chip microcomputer as the control core. The measurement accuracy is high, social labor is not wasted, and the environmental parameters in the greenhouse can be monitored in real time.

In this design, single-chip microcomputer is selected as the control core, and sensors with relatively low measurement error and high cost performance are selected to form a greenhouse monitoring system that can automatically adjust the temperature, humidity and light intensity of the greenhouse. This design reduces the workload of the operator on the one hand, and reduces the measurement error on the other hand, creating a suitable environment for the growth of crops, so that the crops produced in the greenhouse can reach the goal of high yield and high quality. Such a low-cost, highly functional greenhouse monitoring system can be widely promoted in the country, and the greenhouse monitoring system is automated to achieve high-quality and high-yield production of crops, which greatly improves agricultural labor productivity.

2. Scheme Design

This system uses MCU as the control core, and uses DHT11 temperature and humidity sensor and TSL2561 illuminance sensor to realize real-time information collection, and upload the collected data to the single-chip microcomputer, and the single-chip microcomputer will judge. If the set safety value is exceeded, the single-chip microcomputer sends out control signal to control the relay control circuit to perform operations such as heating, cooling and changing the light intensity, so as to realize the automatic monitoring of the greenhouse.

2.1. System Function

Functions to be realized by this system:

- Real-time detection and display of temperature, humidity and light. The temperature, humidity and illuminance data in the greenhouse are detected by the DHT11 sensor and the TSL2561 sensor respectively, and the measured data are uploaded to the single-chip microcomputer. Display temperature and humidity values and light intensity through LGM12641BS1R.
- Setting of the environmental safety value of the greenhouse. The keyboard circuit realizes the safe value setting of the temperature, humidity and light in the greenhouse.
- The temperature, humidity and light intensity in the greenhouse are automatically adjusted. The sensor sends the measured data to the single-chip microcomputer, and the single-chip microcomputer makes a judgment. When the data exceeds the safe value, the single-chip microcomputer outputs a control signal to control the operation of the relay control circuit and adjust the environmental parameters.

2.2. System Hardware Circuit Structure Diagram

The hardware is mainly based on 51 single-chip microcomputer. DHT11 temperature and humidity sensor and TSL2561 light intensity sensor collect temperature, humidity and light data, and display the measured data on the LGM12641BS1R display. The overall block diagram of the hardware circuit of this system is shown as in Figure 1.

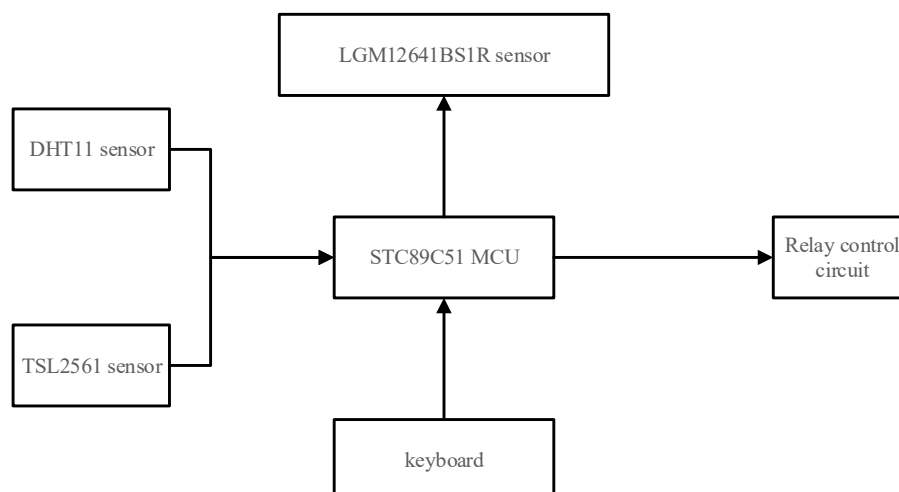


Figure 1. General block diagram of the hardware circuit

2.3. Software Module

The software system of this design includes: main program module, temperature and humidity control module, illuminance control module, LGM12641BS1R display module and relay control module. Through the signal acquisition module, the data of various environmental factors in the greenhouse can be collected and uploaded to the single-chip microcomputer. The display

module can display the environmental parameters in the greenhouse in real time, and the control execution circuit can perform operations such as heating and cooling. Through the synergy of the above-mentioned modules, the monitoring of various environmental factors in the greenhouse can be realized.

3. Hardware Circuit

3.1. The Smallest Single-chip Microcomputer System

The minimum system of the single-chip microcomputer consists of two circuits, reset circuit and clock circuit. The specific conditions of these two circuit are as follows: (1) Clock circuit. The clock circuit is mainly used to maintain the stable operation of the single-chip microcomputer. The commonly used clock circuit has two methods: one is the internal clock mode, and the other is the external clock mode. This system uses the internal clock mode. (2) Reset circuit. In order to prevent the system program from failing to run normally, this system needs to set a reset circuit to restart the program. The button used in this design is reset manually. This circuit is shown as in Figure 2.

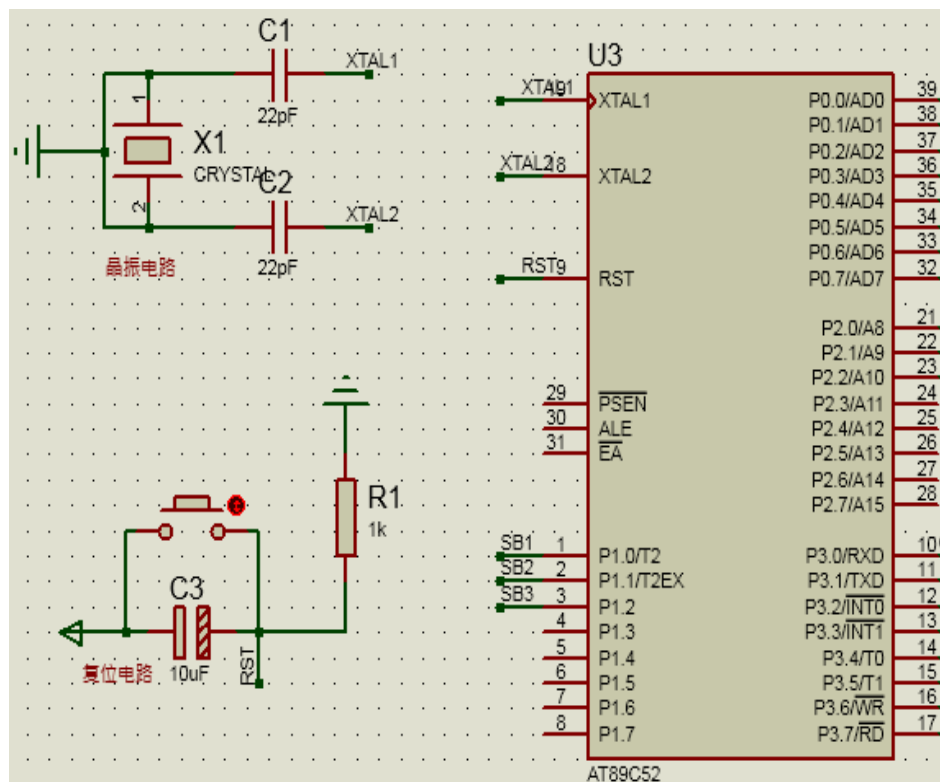


Figure 2. The minimum system circuit diagram of the single-chip microcomputer

3.2. Temperature and Humidity Detection Circuit

The temperature and humidity detection circuit mainly collects the temperature and humidity parameters in the greenhouse through the DHT11 sensor, and uploads the collected data to the single-chip microcomputer. The second pin of the DHT11 sensor is connected to the data port of the single-chip microcomputer through DATA technology to send and receive data. In order to stabilize the measurement data, this design needs to add a 5K pull-up resistor. The first pin of the sensor is connected to the power supply terminal of the single-chip microcomputer, and the fourth pin of the sensor is connected to the ground terminal of the single-chip microcomputer. The third foot of the sensor is placed in suspension. After the sensor is powered

on, please wait for 1 second during this period to make it stable without sending any instructions. This circuit design is shown as in Figure 3.

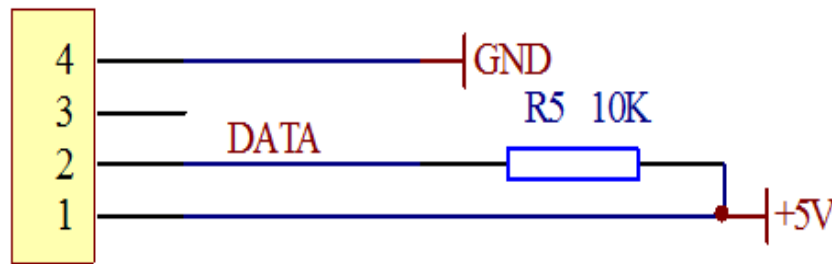


Figure 3. Temperature and humidity acquisition circuit

3.3. Illumination Detection Circuit

The illuminance detection circuit mainly collects the illuminance parameters in the greenhouse through the TSL2561 illuminance sensor, and uploads the collected data to the single-chip microcomputer. If the illuminance is outside the set safe value range, the single-chip microcomputer sends out a signal to control the operation of the relay control circuit, and perform operations such as reducing or increasing the illuminance. This circuit is shown as in Figure 4.

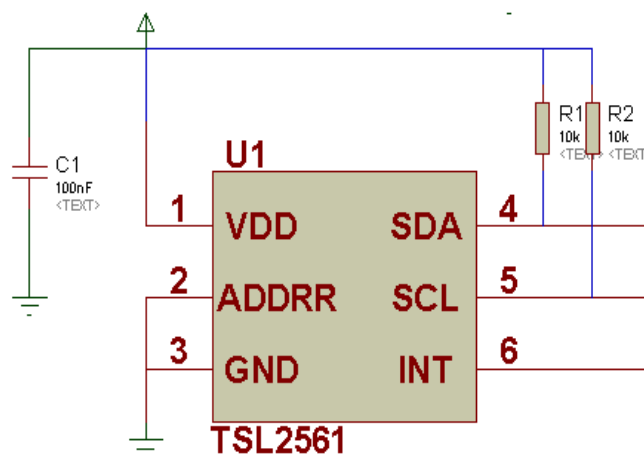


Figure 4. Illumination measurement circuit

3.4. Display Circuit

LGM12641BS1R is a dot matrix LCD that can display Chinese characters. It is set by the program to display two lines, and the two lines are used to display temperature, humidity and light. There are 3 values after the Chinese character setting, the first value is the measured value, and the last two are the highest and lowest set values. Real-time monitoring of temperature, humidity and light parameters in the greenhouse can be realized according to the values displayed on the LCD. The display circuit is shown in Figure 5.

Main technical parameters of LGM12641BS1R:

Display capacity: 16×2 characters;

Chip working voltage: 4.5-5.5V;

Working current: 2.0mA (5.0V);

The best working voltage of the module: 5.0V;

Character size: 2.95×4.35(W×H)mm.

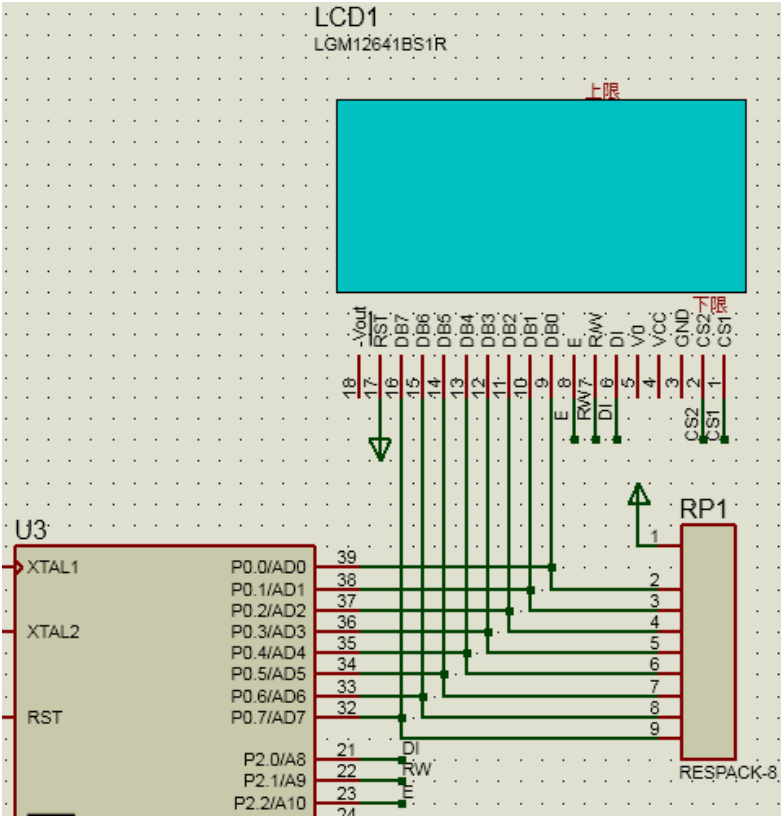


Figure 5. LGM12641BS1R display circuit

3.5. Keyboard Circuit

The keyboard scanning circuit originally designed adopts a simple low-level scanning mode. The keyboard circuit is shown in Figure 6. The keyboard has three keys. SB2 is the key to set the safe value of temperature and humidity, SB1 is the key to increase, and SB3 is the key to decrease. The key to set the safety value can control the safety value of the two parameters of temperature and humidity. Press once to set the highest value of the temperature safety value, and press it again to set the lowest value of the temperature safety value. The same is true for the safety of humidity and light intensity. The value is set in the same way. The increase or decrease of the key position means that each time the key is pressed, the number of values increases or decreases by one value.

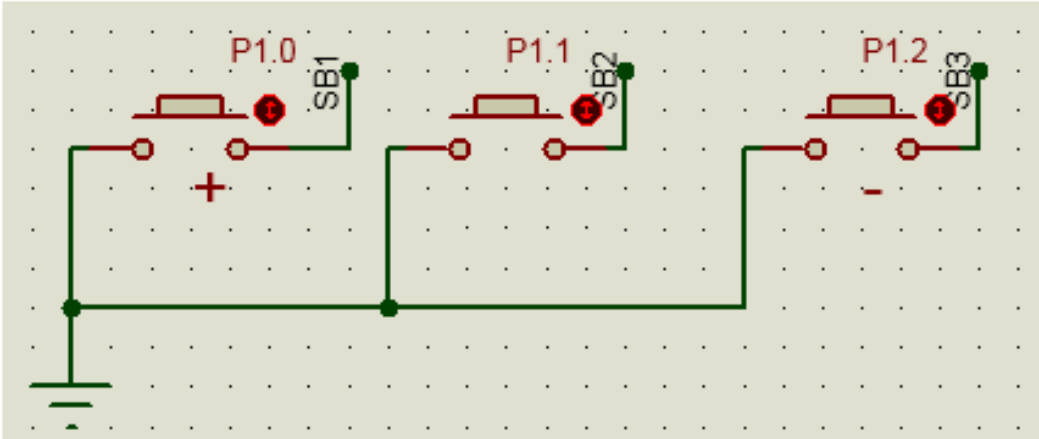


Figure 6. Keyboard circuit diagram

3.6. Relay Control Circuit

The data collected by the sensor is sent to the single-chip microcomputer, and the single-chip microcomputer judges the data. When the measured value exceeds the safe value, the single-chip microcomputer sends out a control signal to drive the relay. But the single chip microcomputer is a weak current device, the weak signal sent out is amplified by the triode, so as to drive the relay action, and then the corresponding actuator can work. When the measured value of temperature exceeds the set safe value, the single-chip microcomputer outputs a high level, the relay is closed, the actuator works, and operations such as cooling and heating are realized. In the same way, humidity parameters and illuminance parameters are also controlled in the same way. If the current measured value is within the set safe value, the single-chip microcomputer outputs low level and the relay does not act. The relay control circuit originally designed is shown in Figure 7.

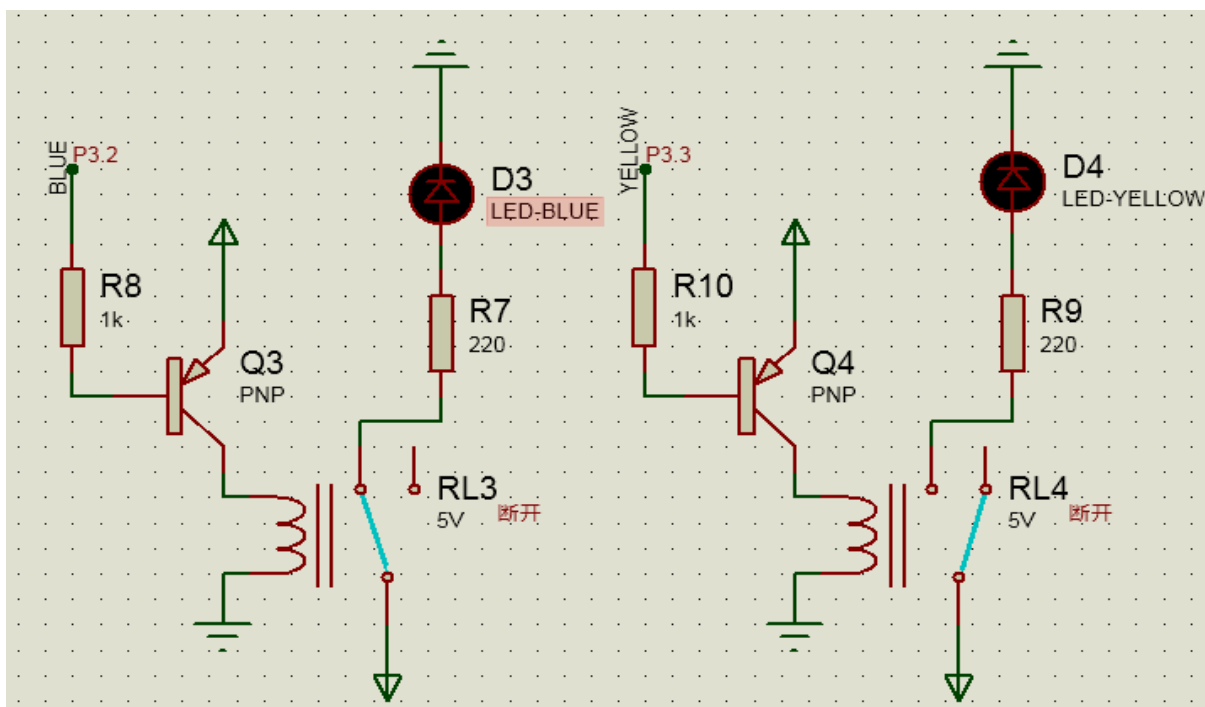


Figure 7. Relay control circuit diagram

4. Software Design

Combining the needs analysis of this subject, first establish a flow chart of the overall framework of the program, divide the entire design into multiple modules, require each module to achieve its own function, and finally integrate the various sub-module systems to form an overall General procedure. The main program first initializes the entire system, and then the sensor collects data and sends it to the single-chip microcomputer, and the single-chip microcomputer judges the data. If the threshold is exceeded, the microcontroller will send a signal to control the relay to execute the circuit, and the execution circuit will make the corresponding operation. The main flow chart of this system is shown as in Figure 8.

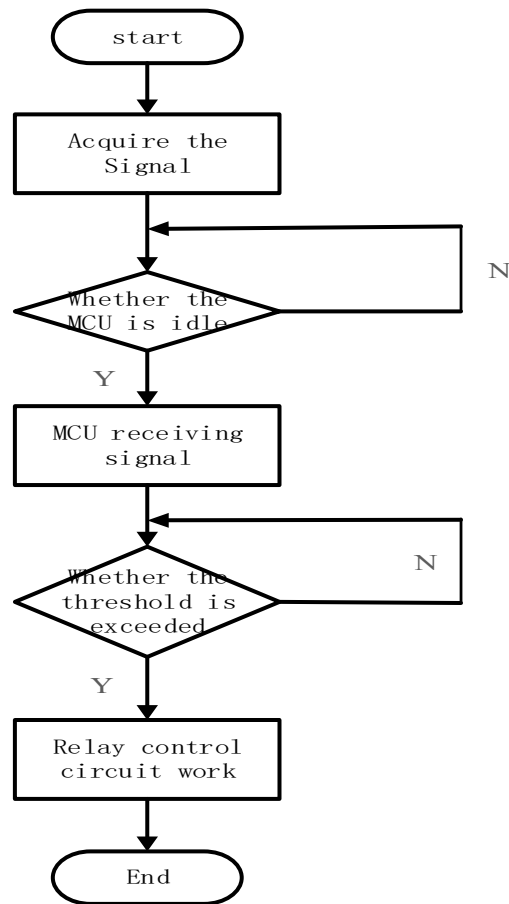


Figure 8. System main flow chart

5. Simulation Results

The debugging and simulation of this design are carried out on the Proteus software. This simulation experiment mainly monitors and simulates three environmental factors: temperature, humidity and light in the greenhouse. The simulation experiment of each environmental factor is carried out under two conditions of normal value and abnormal value.

5.1. Temperature and Humidity Simulation Results

This system mainly controls the temperature, humidity and light intensity in the greenhouse. When the temperature in the greenhouse exceeds the upper limit and lower limit of the safe value, the relays Q3 and Q4 act separately to control the corresponding actuators to adjust the temperature in the greenhouse to reach the normal value range. Similarly, when the humidity in the greenhouse exceeds the upper and lower limits of the safe value, the relays Q2 and Q1 act separately to control the operation of the corresponding actuators and adjust the humidity in the greenhouse to reach the normal value range.

When the measured values of temperature and humidity in the greenhouse in Figure 9 are all within the set safe value, the relay does not act.

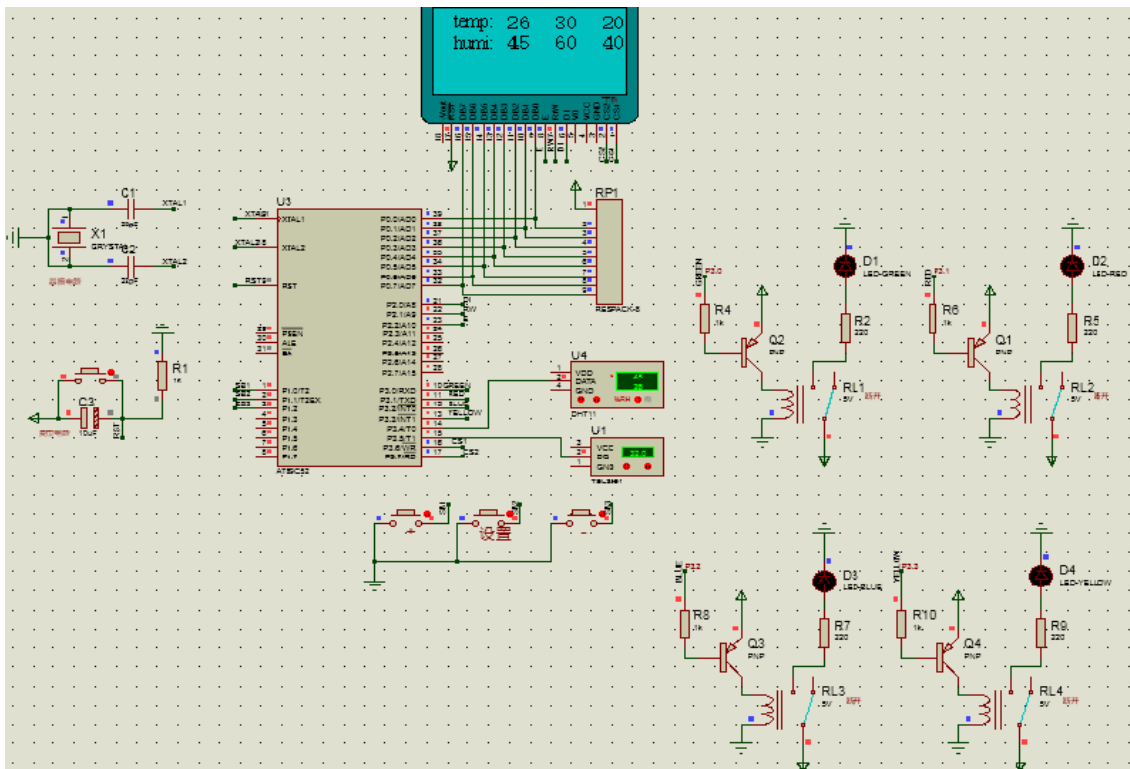


Figure 9. Simulation results of temperature and humidity within safe values

In Figure 10, the measured temperature is higher than the upper limit of the set safe value, and the humidity is within the safe value. At this time, the relay Q3 is activated, the switch is closed, the blue light D3 is on, and the cooling actuator works to reduce the temperature in the greenhouse.

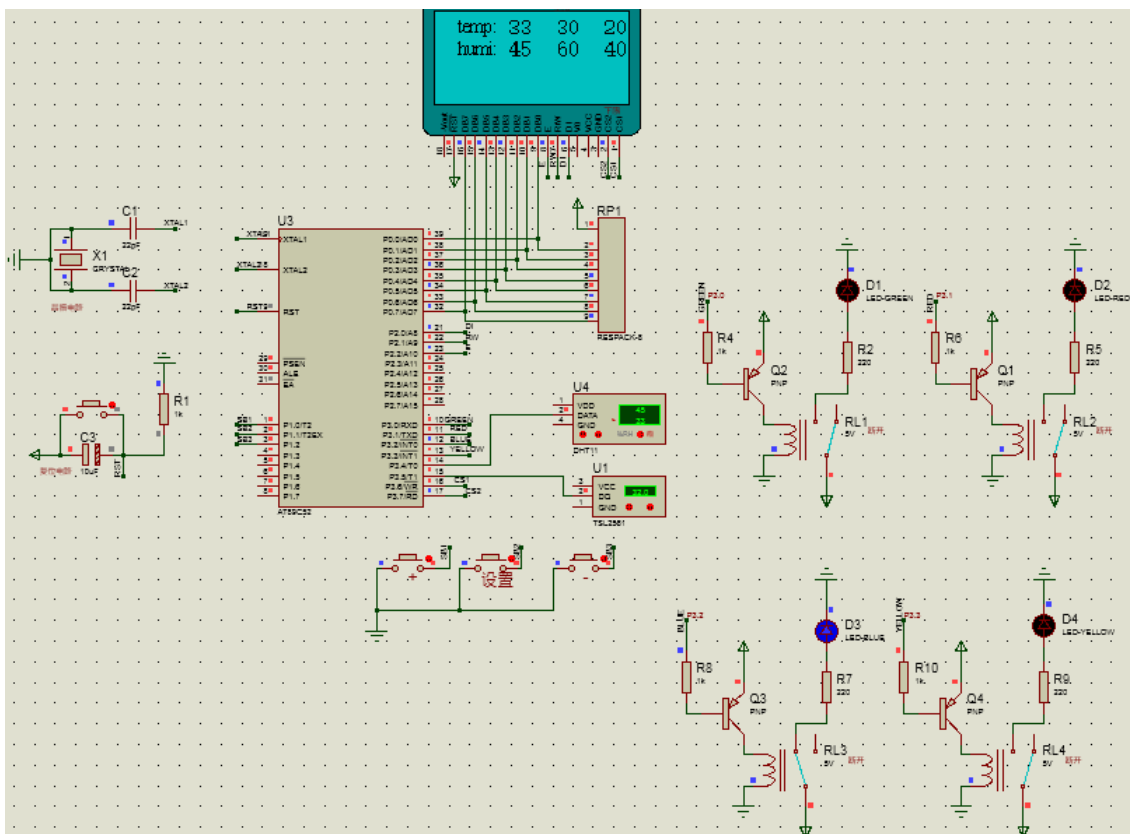


Figure 10. Simulation results of temperature exceeding a safe value

In Figure 11, the measured temperature is lower than the lower limit of the set safe value, and the humidity is within the safe value. At this time, the relay Q4 is activated, the switch is closed, the yellow light D4 is on, and the heating actuator works to increase the temperature in the greenhouse.

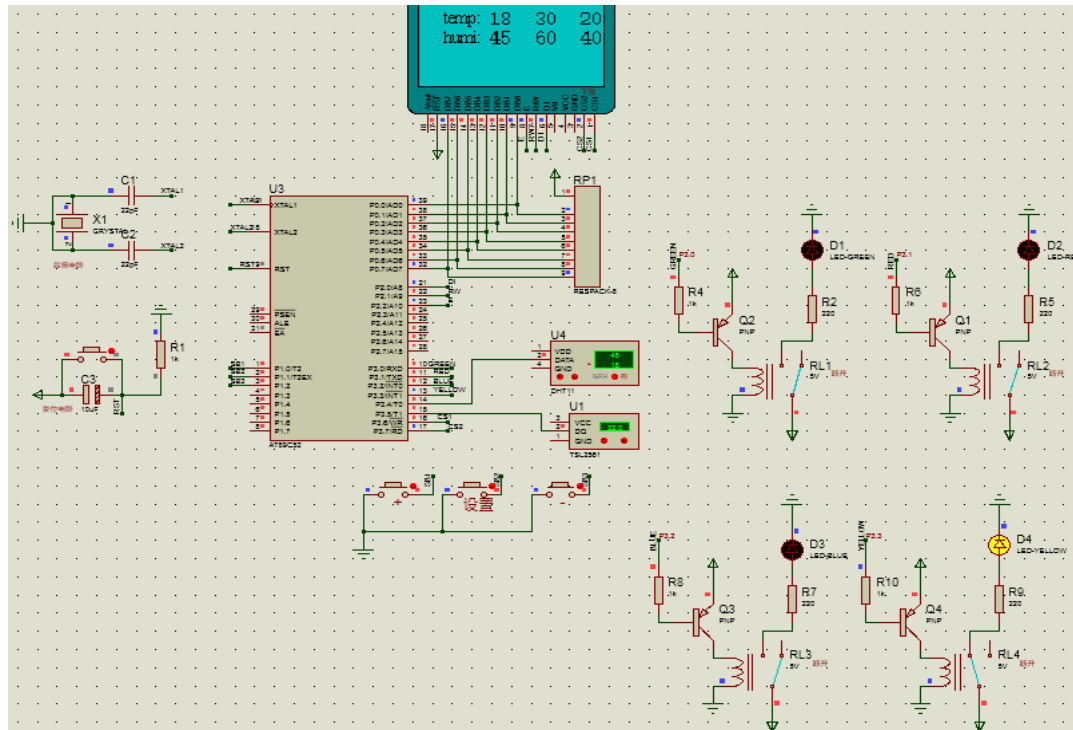


Figure 11. Simulation results of temperature lower than safe value

In Figure 12, the measured humidity value is higher than the upper limit of the set safe value, and the temperature is within the safe value. At this time, the relay Q2 is activated, the switch is closed, the green light D1 is on, and the drying actuator works to reduce the humidity in the greenhouse.

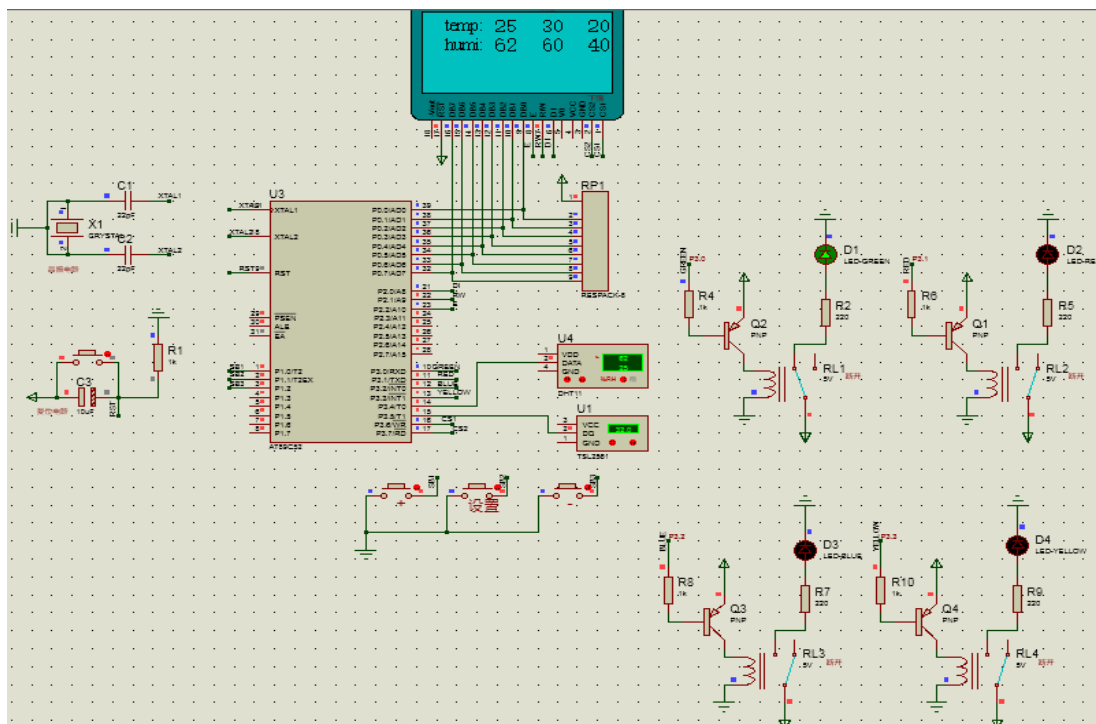


Figure 12. Simulation results of humidity exceeding a safe value

In Figure 13, the measured humidity value is lower than the lower limit of the set safe value, and the temperature is within the safe value. At this time, the relay Q1 is activated, the switch is closed, the red light D2 is on, and the humidification actuator works to increase the humidity in the greenhouse.

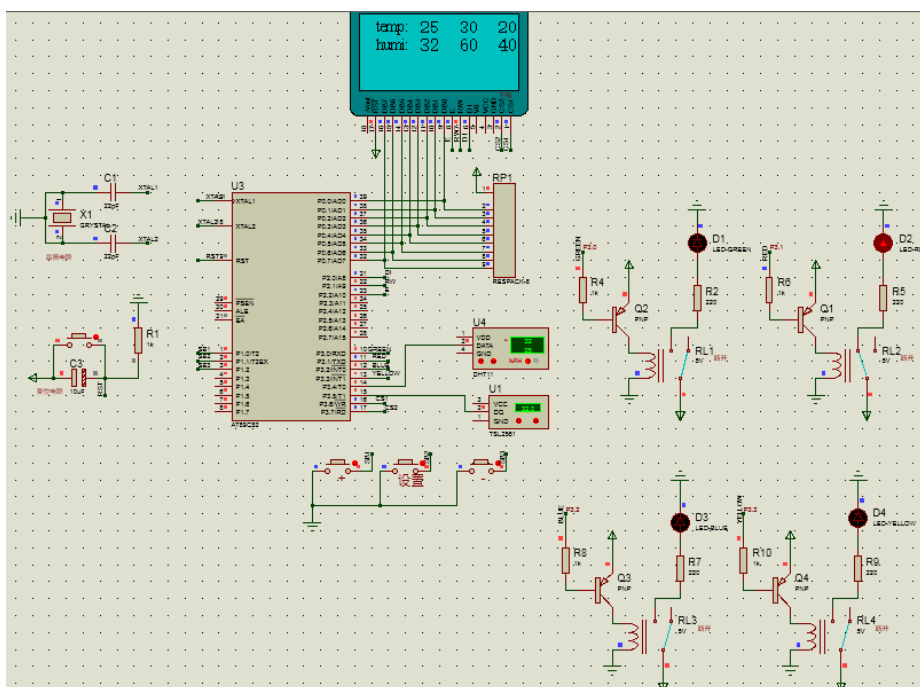


Figure 13. Simulation results of humidity lower than safe value

5.2. Illumination Simulation Results

The light intensity in the greenhouse is also an important parameter for crop growth. When the illuminance in the greenhouse exceeds the upper and lower limit of the safety value, the relays Q3 and Q4 act separately to control the corresponding actuators to adjust the illuminance in the greenhouse to reach the safe value range.

In Figure 14, the measured value of illuminance is within a safe value, and the relay does not operate.

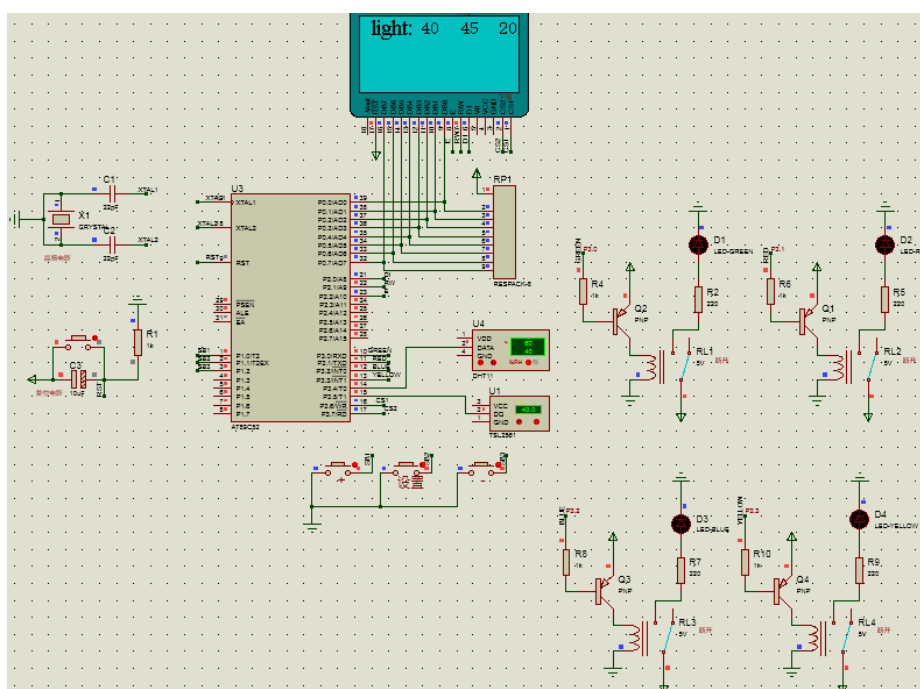


Figure 14. Simulation results when the illumination is at a safe value

In Figure 15, the measured value of the illuminance is higher than the upper limit of the set safety value, the relay Q3 is activated, the switch is closed, the blue light D3 is on, the shading actuator works, and the illuminance in the greenhouse is reduced.

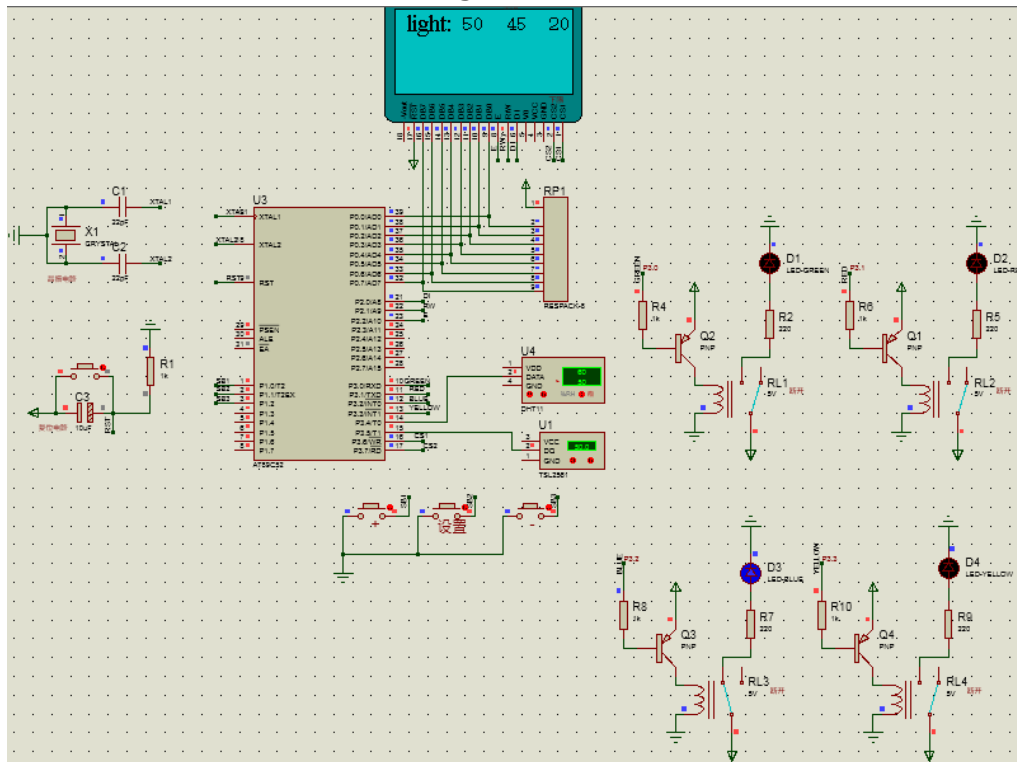


Figure 15. Simulation results of illuminance exceeding a safe value

In Figure 16, the measured value of the illuminance is lower than the lower limit of the set safety value, the relay Q4 is activated, the switch is closed, the yellow light D4 is on, and the illumination actuator works to increase the illuminance in the greenhouse.

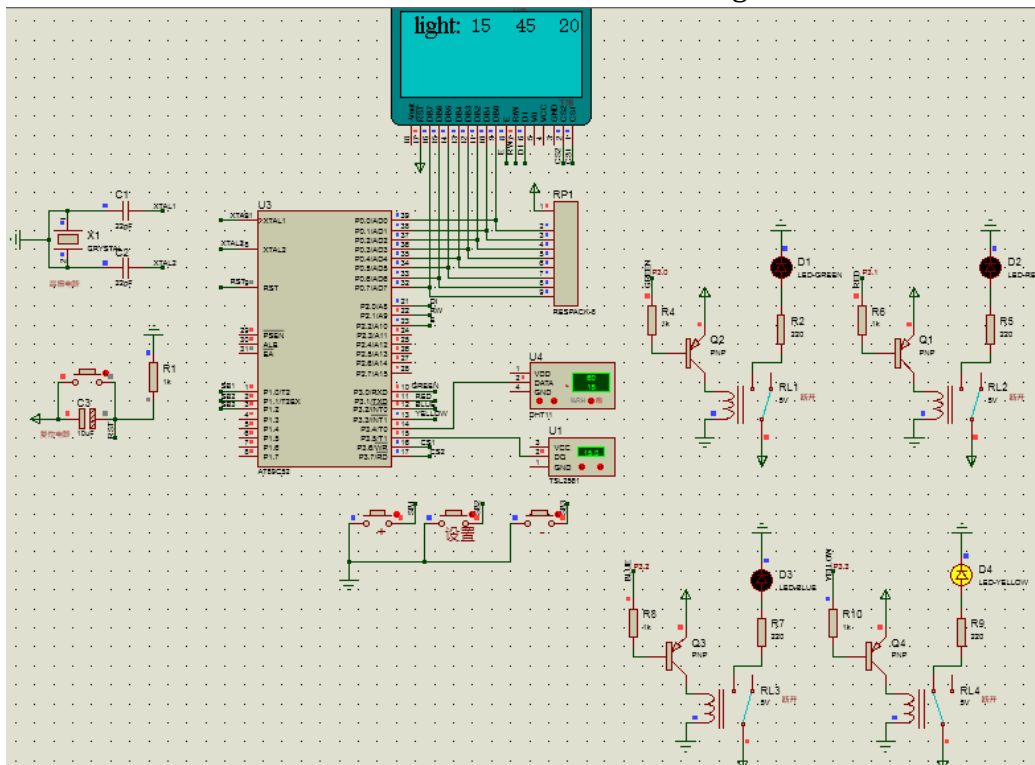


Figure 16. Simulation results of illuminance lower than safe value

The above simulation results show that the system design can perfectly monitor the three parameters of temperature, humidity and light in the greenhouse. The greenhouse monitoring system designed in this paper realizes the automatic adjustment of the three parameters of temperature, humidity and light in the greenhouse system to a large extent. On the one hand, the use of digital sensors improves the accuracy of signal acquisition. In addition, the digital signal acquisition system is adopted, the circuit structure is relatively simple, and the measurement result is less affected by the circuit itself, which reduces the error to a certain extent.

6. Conclusion

This system uses a single-chip microcomputer as the control core of the system, a sensor as a data acquisition element, and uses software programming for simulation. The simulation results show that the design has basically fulfilled the requirements of the system design.

However, due to our limited level, there are also some shortcomings in this design. For example, due to the limitation of the measuring device, the setting and control range of the temperature and humidity safety value is relatively small, and the mutual influence between the parameters is not taken into consideration, because the mutual influence and the algorithm are too complicated, otherwise the system the scope of application should be wider.

References

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