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A Temperature Control System Design Based on 51 SCM

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Abstract

Temperature control is quite extensive in their daily lives and industrial applications, and past temperature control is done by hand and not enough attention, in fact, temperature needs to be monitored in many places in order to prevent accidents. To solve this problem, a temperature control system based on 51 Single Chip Microcomputer (SCM) is designed in the paper. Combining with SCM AT89C51, temperature sensor is used to collect temperature, the collected temperature values are transferred to the LED display to shows. Then cooling or heating is automatically operated by the fan or an electric wire in order to achieve a constant temperature. The experimental results show that the system can perform real-time monitoring of temperature and reach the goal of effectively controlling temperature.

***Keywords**: 51 SCM; temperature control; temperature sensor; AT89C51; Temperature acquisition*

1. Introduction

Temperature control system is widely used in various fields of social life, such as household appliances, automobiles, materials, and power electronics and so on. The performance indicators of commonly control circuit vary depending on the application and performance required [1-5]. In industrial enterprises, how to improve operating performance of temperature control target has been problems to be resolved by the control of personnel and field technicians [6- 9]. Such control object have big inertia, lag seriously and there are many uncertainties, so it is difficult to establish a precise mathematical model, which resulting in poor performance of the control system, or even unstable control and out of control. Thermostat circuit of traditional relay is simple and practical, but because of the relay frequently, may be due to poor contact and affect the normal work. Control field also uses a lot of traditional PID control, but PID control object model is difficult to establish [10-13], and when the disturbance factors are not clear, the parameter adjustment inconvenience remains widespread problem.

To solve these problems, we designed a temperature control system based on 51 SCM that uses digital temperature sensor DS18B20, which internal integration of the A / D converter so that the circuit structure is more simple, but also reduces the accuracy loss of the temperature measurement conversion, so that temperature measurement is more accurate. Digital temperature sensor DS18B20 can communicate with the SCM with only one pin, greatly reducing the wiring trouble, which makes the device more expansible. Because of DS18B20 chip miniaturization, more can connected to the main circuit via a single hop data lines, so DS18B20 digital temperature sensor can be made as probe to probe into a small place, which increasing usability.

2. Overall Design

Temperature data is directly measured by temperature sensor chip, following the upper and lower limit of temperature is controlled by SCM process [14-17]. An external circuit

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generates is used to display and control heating and down to meet the design requirements.

Consider using a temperature sensor, combined with the SCM circuit design, using a DS18B20 temperature sensor directly read the measured temperature value, after conversion, in order to complete the design requirements. Temperature control process is shown in Figure 1.

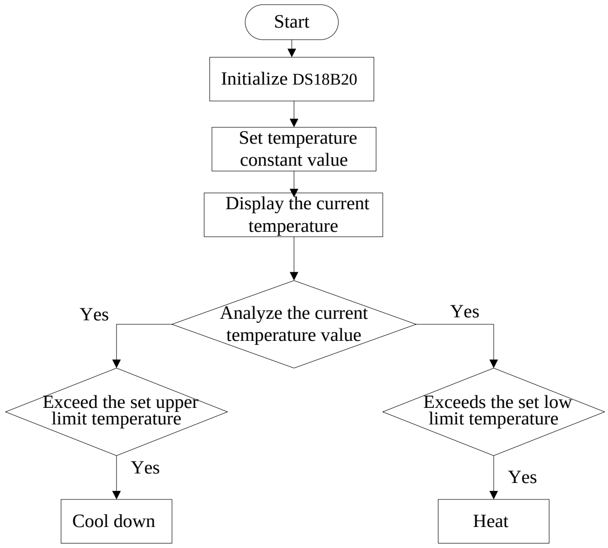

Figure 1. Overall Process of Temperature Control

The overall circuit design block diagram of the system is shown in Figure.2, which consists of five parts: SCM AT89C51 control section; DS18B20 temperature sensor acquisition section; 3 bits LED digital display section; key regulating circuit section; diode alarm section.

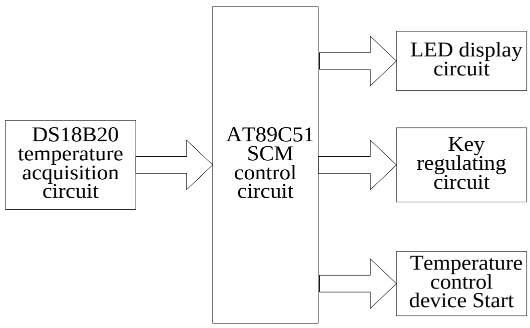

Figure 2. Thermometer Circuit Design Scheme

The entire design is divided into the following sections: control section, the display section, temperature acquisition part, and key control section.

Control section. SCM AT89C51 run under the action of program control and peripheral simple combination circuit, control upper and lower limit of temperature, display it on the LED and control heating and cooling equipment to maintain the temperature.

The display section. Display circuit use 3 bit and 7 steals common anode LED digital tube, sending the number of ports from P0, P1 port scanning. There are two parts of show circuits, the first is to show the current temperature detected by the temperature sensor DS18B20, and the second is to set a constant temperature.

The temperature acquisition section. Measured temperature is directly collected by the smart temperature sensors DS18B20.

Key control section. Control and regulate by the four buttons for adjusting the constant limit temperature, play a preset regulatory role.

3. Hardware Design

3.1. Temperature Sensor Design

The paper uses a digital temperature sensor DS18B20 temperature to detect temperature. Package and pin of DS18B20 is shown in Figure 3.

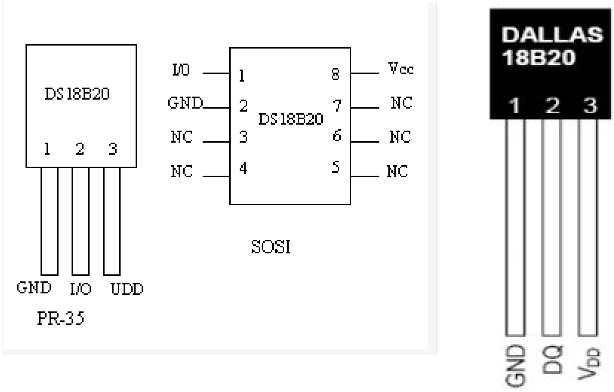

Figure 3. Package and Pin of DS18B20

Internal structure. Internal structure of DS18B20 is mainly composed of four parts: 64 lithography ROM, temperature sensors, nonvolatile temperature alarm triggers TH and TL, configuration registers [18-19].64-bit serial number of Lithography ROM is lithography good before factory, which can be seen as the address sequence code of DS18B20. Arrangement of 64-bit lithography ROM is: Start 8 (28H) is the type of label product, then the 48-bit is the DS18B20 own serial number. The last 8-bit is cyclic redundancy check code (CRC = X8 + X5 + X4 + 1) of the first 56-bit.The role of lithography ROM is to make every DS18B20 be different, so that you can achieve purpose of multiple DS18B20 are articulated on a bus, that is, you have to do is to configure the register. According to DS18B20 communication protocol, the host controlling DS18B20 to convert temperature must complete three steps: DS18B20 have to reset before each access, send a ROM command after reset successful, and finally send the RAM command, in order to carry out a predetermined operation for DS18B20. Reset requires the main CPU 500 to data line down microseconds and then released [20-21]. DS18B20 wait about 16 to 60 microseconds after receiving a signal, then issue a low pulse for 60 to 240 microseconds, the main CPU receives this signal indicates a successful reset.

Temperature measurement principle of DS18B20. Each DSl8B20 piece in its ROM is there its unique 48-bit serial number, written in the on-chip ROM before factory. Host must use read ROM (33H) order to read out the serial number of DSl8B20 before entering the operating procedures.

Internal device of temperature measurement principle of DS18B20 is shown in Figure 4. Oscillation frequency of low temperature coefficient crystal is little affected by temperature, which is used to generate a fixed frequency Pulse signal and sent it to the subtraction counter 1.High temperature coefficient crystal varies with temperature significantly change its oscillation frequency, signals generated as a pulse input of down counter 2, further implies gate count, when the count gate open, DS18B20 count for the clock pulse generated by low temperature coefficient oscillator, then complete temperature measurement. Count door open time is determined by the high temperature coefficient of the oscillator, before each measurement, first, the base corresponding to -55 ℃ is placed in subtraction counter 1 and a temperature register, the subtraction counter 1 and the temperature register is preset in a base value corresponding to -55 ℃.Pulse signal generated by low temperature coefficient oscillator is subtraction counted by subtraction counter 1, when the preset value of subtraction counter 1 is reduced to 0, value of the temperature register will be incremented, the preset value of subtraction counter 1 will be re-loaded, subtraction counter 1 restart to count Pulse signal generated by low temperature coefficient oscillator, and so on until the subtraction counter 2 to 0, stop accumulating temperature register value and the temperature register value is the measured temperature. The slope accumulator is used to compensate and correct the nonlinear during temperature measuring, the output is used to correct the preset value of subtraction counter, repeat the process as long as the count has not closed the door to, until the temperature register value reaches the temperature measured.

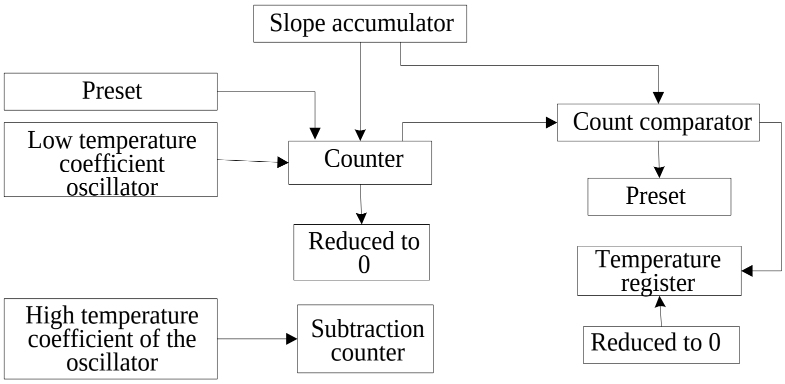

Figure 4. Internal Device of Temperature Measurement Principle

Temperature acquisition process of DS18B20. Because line communication of DS18B20 is sharing completed, which has strict slots concept, so the read and write timing is very important, the system's various operations on DS18B20 must be carried out according to protocol. Operating protocol is: initialize DS18B20 (send reset pulse) → send ROM function command send memory operation command → process data. Temperature acquisition process is shown in Figure 5.

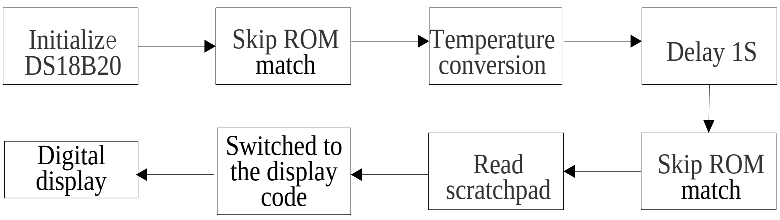

Figure 5. Temperature Acquisition Process

3.2. SCM Interface Design

DS18B20 uses the power supply. 1 pin of DS18B20 grounds, 2 pin as the signal line, 3 pin connects to power. When DS18B20 write memory operation and temperature A / D conversion operation, there must be a strong pull-up on the bus, pull-on time up to 10μs. SCM pin is shown in Figure 6.

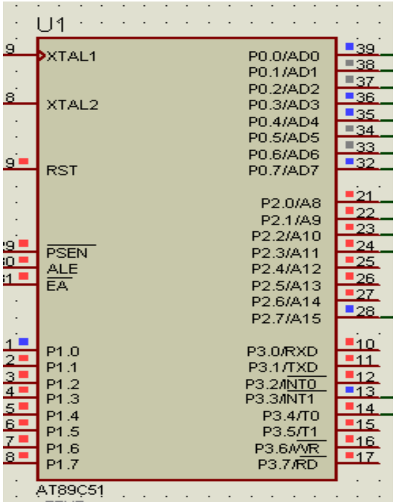

Figure 6. SCM Pin

3.3. Hardware Design

Display circuit. Display circuit uses 7-segment common cathode LED scan circuitry, P0.0 to P0.7 eight ports of SCM are connected to eight pins of digital tube and the 9th pin is to connected to ground to display the temperature value of the current detected with an accuracy of 0.1, which is shown in Figure 7. To save output port of SCM and easy to program, the design also has a set of digital tube connected by P2.0 to P2.7, in addition to different interfaces and other are same.

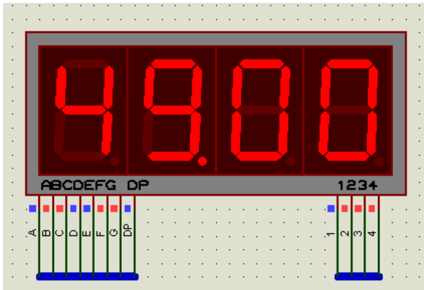

Figure 7. Circuit of Display the Limiting Temperature

DS18B20 temperature sensor circuit. Temperature acquisition use digital temperature sensor DS18B20 and by QD connection to P3.0 mouth of SCM. DS18B20 temperature sensor circuit pin is shown in Figure8.

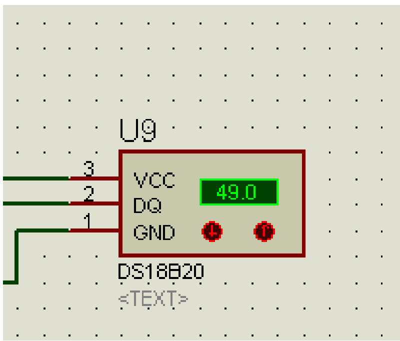

Figure 8. Emperature Sensor Circuit Pin

Key circuit. Key circuit is shown in Figure 9. The K2, K3, K4 three buttons control the upper and lower limit temperature. P3.1 interface is connected to K4 key. P3.2 interface is accessed to K3 key. P3.3 interface is accessed to K2 key. K2 key is used to reduce the upper and lower limit value of temperature. K3 key is used to increase the upper and lower limit temperature increase. K4 key is a switch key of temperature controlling.

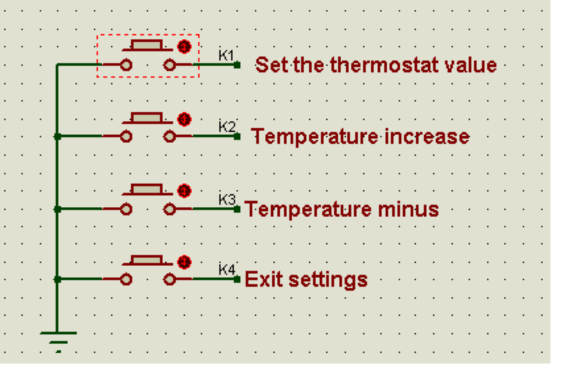

Figure 9. Key Circuit

Crystal control circuit. Crystal uses 12MHZ standard crystal. Connect to SCM XTAL1, XTAL2, crystal control circuit is shown in Figure10.

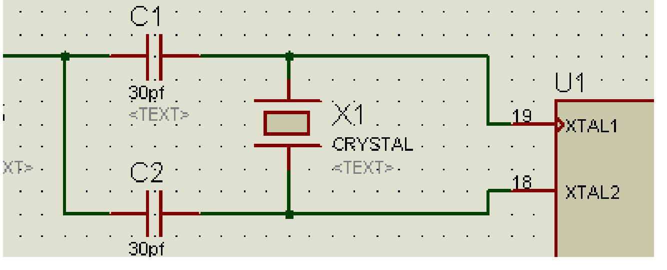

Figure 10. Crystal Control Circuit

The reset circuit. Reset circuit uses the way of manual reset, press the K1 key to reset the device which is directly connected to RESET SCM pin. Reset circuit is shown in Figure11.

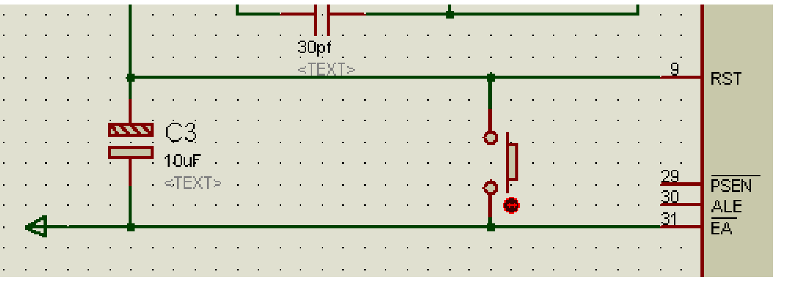

Figure 11. Reset Circuit

Temperature control device. Temperature control device is shown in Figure12, use a fan and an electric wire to control temperature, directly to the SCM pins P33 and P34.

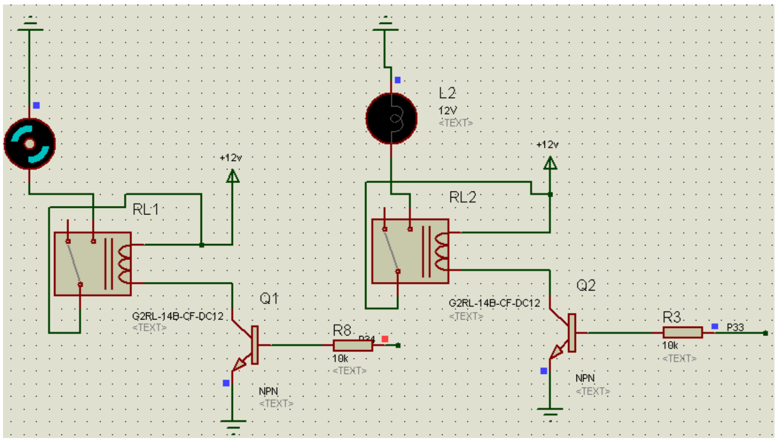

Figure 12. Temperature Control Device

4. Software System Design

To complete the function, an application system must first have better hardware as a guarantee. It also must be supported by appropriately design of software, many the work which is done by the hardware can be programmed by software instead.

The software of device designed in this paper includes the main program, the read temperature subroutine, and the answer to reset subroutine, the write subroutine and related DS18B20 program.

The main program. The main function of the main program is responsible for real-time display of temperature, read and process the current temperature measured by DS18B20, the temperature measurement once every 1s. Such a test can measure the temperature in less than 1s, the program flow is shown in Figure 13. Through calling reading temperature subroutine, the integer part and the fractional part stored in the internal memory is separately stored in two different units, then calling the display subroutine to display.

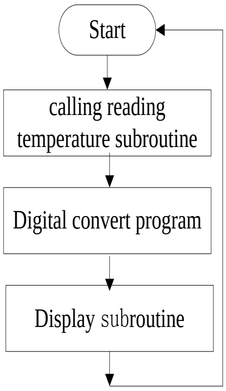

Figure 13.The Main Program Flow

Read temperature subroutine. The main function of read temperature subroutine is that read out 9 bytes in the RAM, need to check the CRC when reading out. If check is wrong, the temperature data is not overwritten, the program flow is shown in Figure 14. Each command of DS18B20 particularly demands for the timing, so it is necessary in accordance with the required timing to achieve the desired purpose, at the same time, note that reading came in is the high after the low, a total of 12 digits, decimal is 4 bit, integer is 7 bit and there is a sign bit.

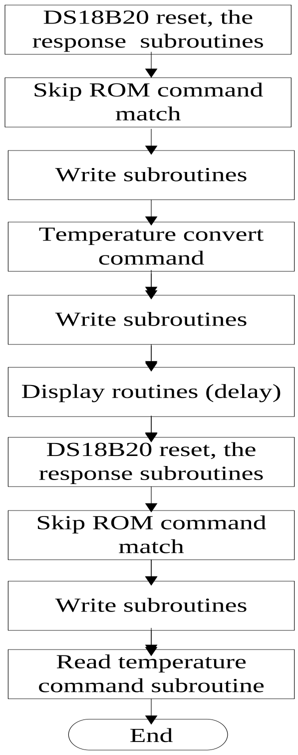

Figure 14. Read Temperature Subroutine Flow

The write subroutine. Write subroutine flow is shown in Figure 15.

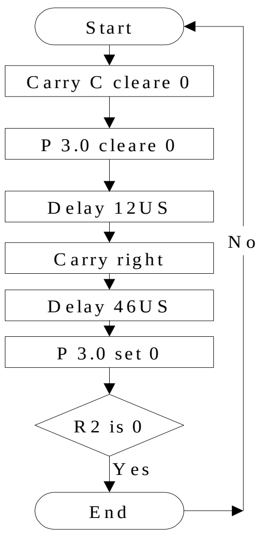

Figure 15. Write Subroutine Flow

Threshold adjustment subroutine. Threshold adjustment subroutine flow is shown in Figure 16.

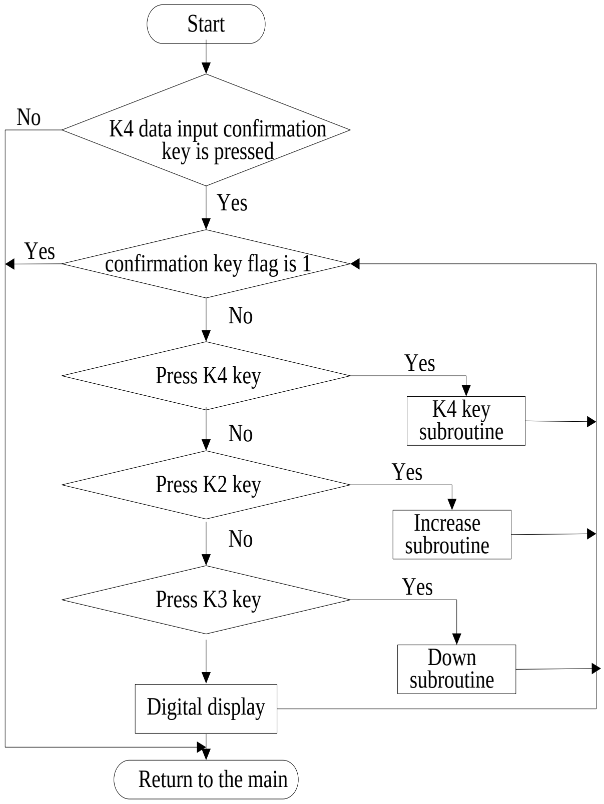

Figure 16. Threshold Adjustment Subroutine Flow

5. Simulation Experiment

In this experiment, the constant temperature value is set to 45 ℃, jump up and down temperature of 3 ℃, design accuracy is 0.1. When the temperature is below the set limit temperature 3 ℃, that is 42 ℃ and below, the heating device is activated, it needs external heating. When the temperature rises to a constant temperature, stop heating, maintaining the temperature. When the temperature is higher than the set temperature 3 ℃ and above,that is 48 ℃ and above, the time needed to take measures to cool down the external cooling device activated. When the temperature drops to a constant temperature, stop cooling. Temperature is between the upper and low limit temperature, the actuator does not perform.

5.1. Set Constant Temperature

Manually set the thermostat temperature is 45 ℃, the cooling device fan operation is stopped, and the electric wire heating device does not work, that is, in a gray state, which is shown in Figure 17, set by K1 key.

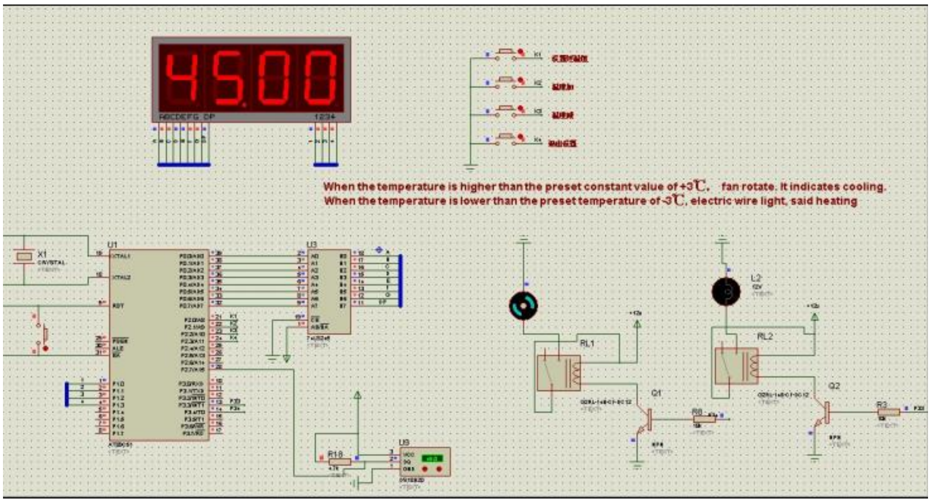

Figure 17. Set Constant Temperature

5.2. High Temperature Test

When the room temperature rises above the constant temperature 3 ℃, when the temperature sensor detects a temperature of 49 ℃, already higher than the preset temperature, the cooling device fan starts work, that the fan starts to rotate, which are shown in Figure 18 (1) (2), for environment to cool until the temperature dropped to 45 ℃, the fan stops, maintain a constant temperature.

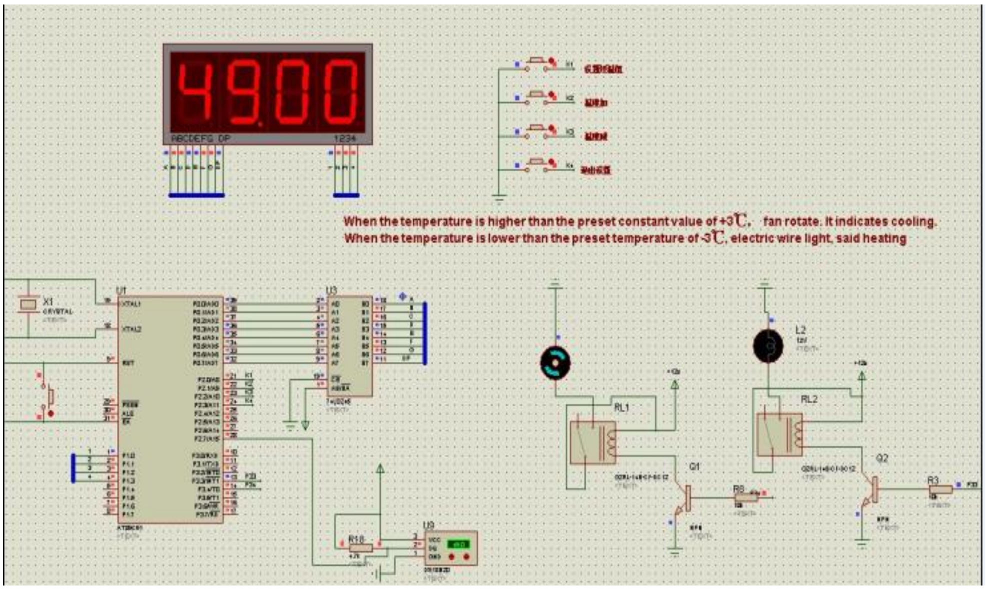

Figure 18 (1). High Temperature Test

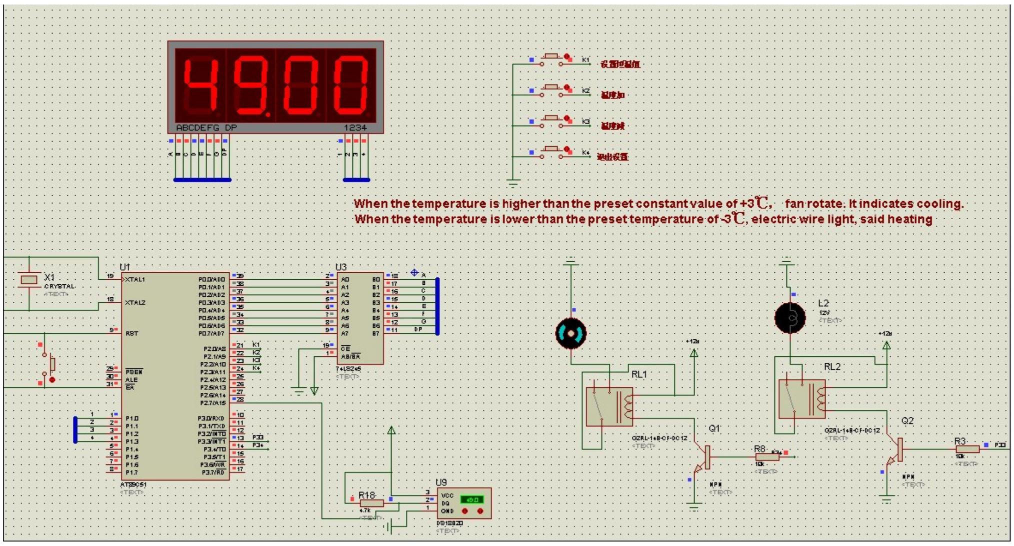

Figure 18 (2). High Temperature Test

5.3. Low Temperature Test

When the indoor temperature is lowered, the temperature sensor detects a temperature of 42 ℃, has been lower than the preset temperature, warming device electric wire work, namely electric wire shiny, warming the environment, which is shown in Figure19, until the temperature rise high to 45 ℃, the electric wire is stopped, turned gray, maintain a constant temperature.

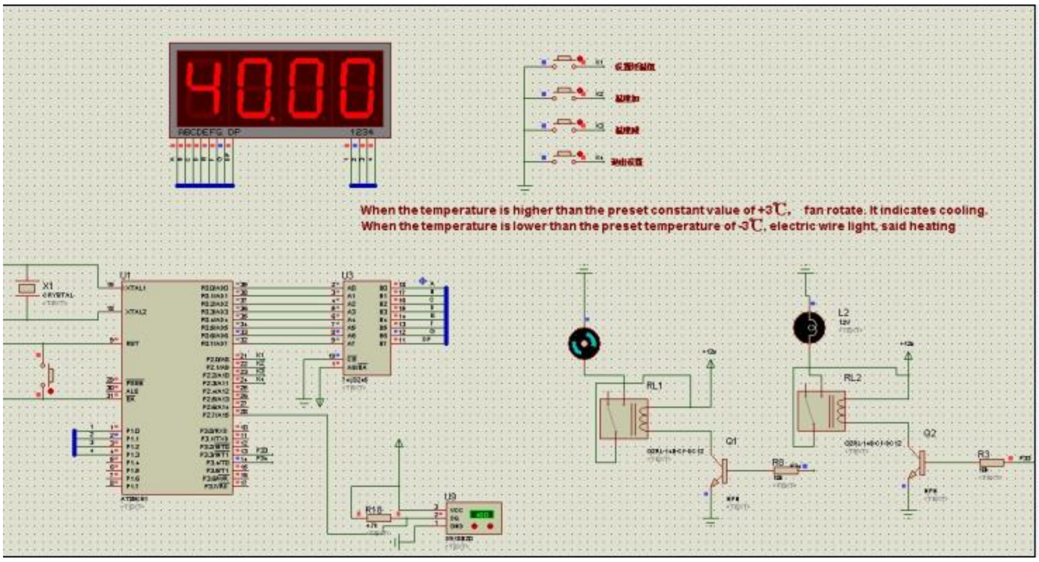

Figure 19. Low Temperature Test

6. Conclusion

Temperature control is quite extensive in our daily lives and industrial applications, many sites require temperature monitoring to prevent accidents. To solve this problem, the system design a continuous high-precision thermostat temperature monitoring and control systems, real-time detection of the use of temperature sensors on the temperature, cooling and heating automatically according to the test results by using the system cooling fan and an electric wire, so as to achieve the purpose of temperature control. This system has features of powerful, compact appearance, easy to carry, is one that is both practical and inexpensive control system.

Acknowledgements

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