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Temperature Detection and Control Circuit

Peng Chen

Xihua University, Chengdu, Sichuan, China

Abstract: ***In order to realize energy saving, emission reduction and green development, this design uses one of the basic analog electronic technology and digital electronic technology knowledge to detect the environmental temperature in real time in daily life. If the environmental temperature is lower or higher than the set temperature, it will alarm and regulate. Thermocouple and temperature compensation principle are adopted for temperature sensing in this design; The AD conversion part uses the integrated chip AD574A; The conversion from binary to 8421BCD code is realized by EEPROM 281024; The display decoding part is realized by 74ls48 and digital tube; The temperature control range is set by digital setting, which is realized by 74ls160 decimal plus counter and latch 74ls175; The cascade implementation of the temperature judgment comparison value comparator 74ls85; The multi-channel temperature cycle monitoring function is realized by using 74ls160 and adg508f. Monostable state is added to the audible and visual alarm.***

Keywords: Energy saving and emission reduction; Temperature Sensor; A/D conversion; Control temperature; Audible and visual alarm; Binary to bcd; Decoding display.

1. INTRODUCTION

As people's living standards improve and automated facilities and equipment penetrate deeply into our daily lives, temperature detection and control circuits can be applied in all aspects of our daily lives.

1.1 Background and significance

Temperature detection and control circuits can be used in many places in our lives, such as temperature control of small ornamental fish tanks, air conditioners, and floor heating. The functions of this design include:

(1) Measure the temperature of the environment and display it

(2) The control temperature is adjustable

(3) When the temperature exceeds the set value, an audible and visual alarm will be generated

1.2 Design goals

The goal of this design is to design a system that can detect and display temperature. After setting a temperature range, if the ambient temperature exceeds the set temperature, it will issue an audible and visual alarm.

1.3 Implementation Plan

The first step is to clarify the block diagram to implement the design. Under the guidance of the overall block diagram, make a specific circuit diagram. Based on the functions to be designed and implemented, calculate the values of each circuit component and select each component one by one. Finally, use simulation software to simulate the design, debug the software, and make necessary corrections based on the errors found in the design to ensure that the design is correct.

1.4 Prerequisites

To realize the design of this circuit, the first thing is to formulate the implementation block diagram of the design, and under the guidance of the teacher and reference materials, make a specific circuit diagram and select various components to implement the design. In addition, the necessary software should be used to assist in the completion of the design.

2. OVERALL PLAN DESIGN

By consulting a large amount of relevant technical information and combining it with my own practical knowledge, I mainly proposed two technical solutions to realize the system functions. Below I will first explain the block diagrams and implementation principles of the two solutions, analyze and compare their characteristics, and then explain the reasons for my final choice.

2.1 Compare plan

2.1.1 Option One

As shown in Figure 1, the temperature sensor part linearly converts the temperature into a voltage signal. After filtering and amplification, one channel is input to the A/D conversion circuit, which is decoded for digital display. The other channel and the sliding voltage are passed through the voltage comparator. Compare and output high and low level indication signals, temperature control execution module and sound and light alarm part.

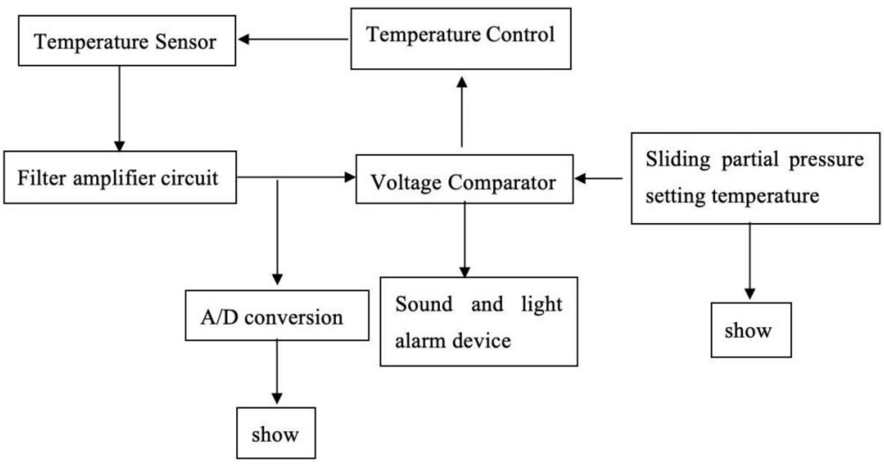

Figure 1

2.1.2 Option II

As shown in Figure 2, the temperature sensing, A/D conversion, decoding display, temperature control execution and alarm are the same as the solution 1. The difference lies in the control temperature setting method and the temperature over-limit judgment method.

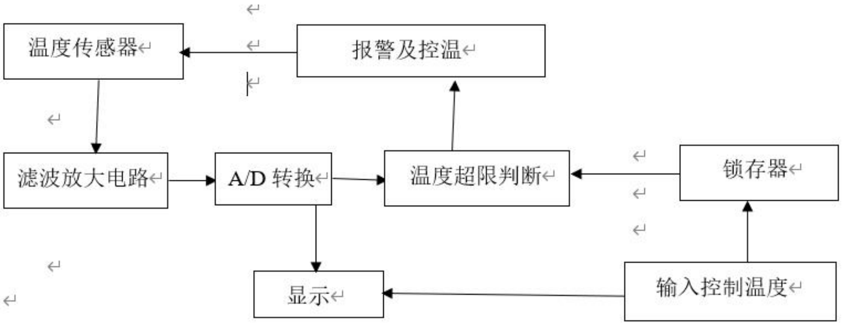

Figure 2

2.2 Demonstration program

The over-limit judgment module and control temperature setting of Scheme 1 mainly use analog signals. This scheme is susceptible to external interference such as the operating environment temperature and other factors. In addition, it is difficult to adjust the temperature accurately by sliding. In practice, if battery power is used, the power supply Changes in voltage will affect the accuracy of its temperature control range. Option 2 is mainly implemented using digital chip logic control, which has strong working stability, accuracy and functional scalability.

2.3 plan selection

Considering the stability, accuracy and future scalability of the system, option 2 was chosen.

3. UNIT MODULE DESIGN

This temperature detection and control circuit consists of four modules.

3.1 Function introduction and circuit design of each unit module

The four modules are temperature sensing module, digital display and temperature range control module, sound and light alarm module, and temperature control execution module. The modules are introduced below.

3.1.1 Temperature sensing module design

The temperature sensing module converts the temperature into a voltage signal and transmits it to the digital display and temperature range control module. When using, place the hot end (working end) of the thermocouple into the environment being measured. Make sure that the connecting wire is made of materials whose resistance is less affected by temperature and is wrapped with good insulation materials. The circuit can be calibrated after long-term use. At standard temperature, the output voltage value is measured and calibrated by adjusting the sliding rheostat. The relationship between the output voltage Uo (V) and the temperature T (°C) is Uo=0.02384*T.

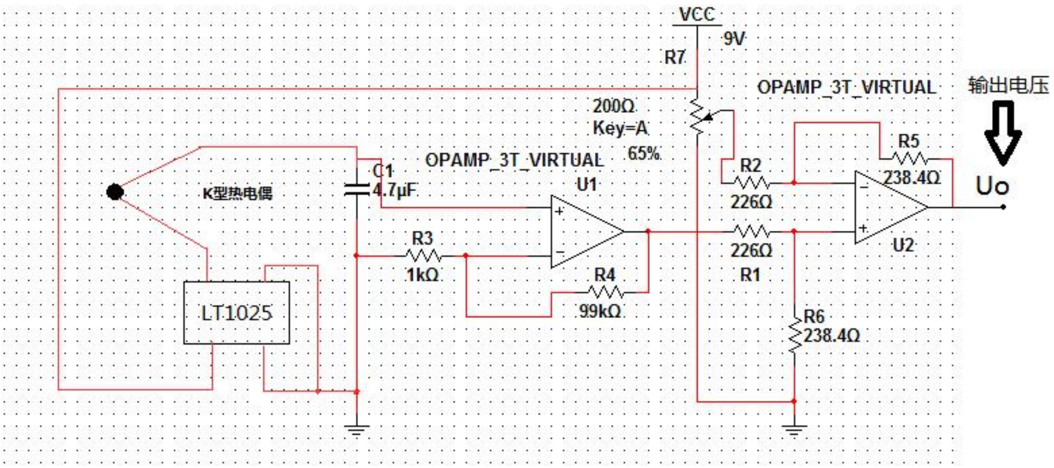

Figure 3: The circuit diagram of the module

3.1.2 Digital display and temperature range control module design

This module is mainly divided into A/D conversion and code conversion parts and temperature range setting and temperature over-limit behavior judgment parts.

A/D conversion and code conversion part: The integrated chip AD574A is used as the analog-to-digital conversion chip. AD574A is a single-chip high-speed 12-bit sequential comparison A/D converter launched by the American Analog Digital Company (Analog), with built-in bipolar circuits. The hybrid integrated conversion chip has the characteristics of fewer external components, low power consumption, high accuracy, and has automatic zero calibration and automatic polarity conversion functions. It only needs a small number of external resistors and capacitors to form a complete A/D converter. AD574A can convert voltage signals into binary numbers, but binary numbers cannot be directly displayed on the digital tube, so 281024 CMOS EEPROM is used to implement binary to 8421BCD codes.

Temperature over-limit behavior judgment part: accurately set the temperature control range through the counter, save it in the latch in the form of 8421BCD code, and compare it with the 8421BCD code representing the temperature output by the cascaded numerical comparator and the EEPROM. To determine whether the temperature exceeds the limit, the numerical comparator outputs high and low levels as indication signals to control the alarm and temperature control execution circuit.

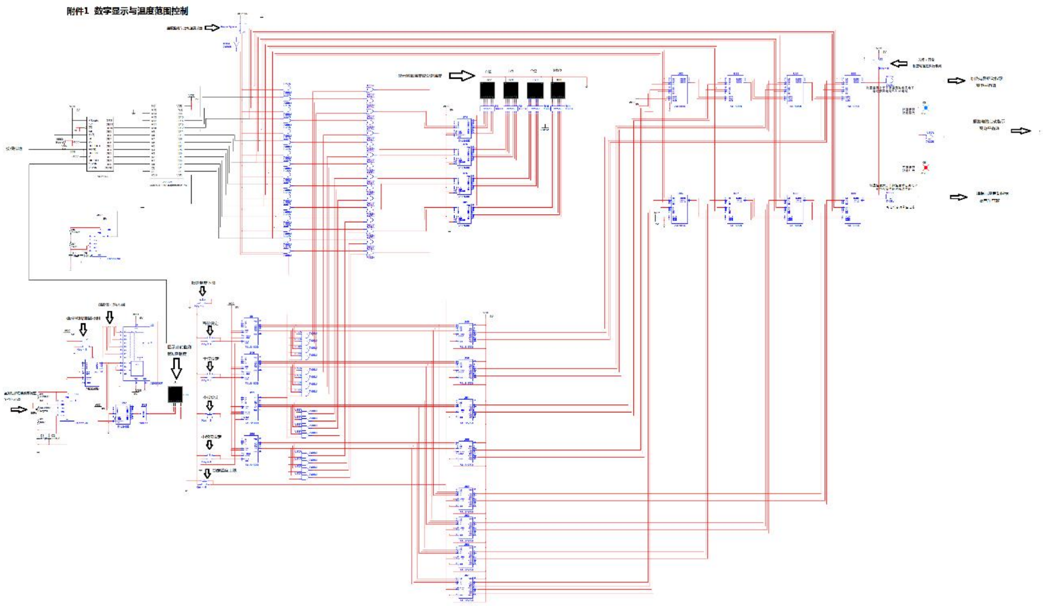

Figure 4: The circuit diagram of the module

3.1.3 Sound and light alarm module design

When the input signal is low level, the alarm circuit does not work. When there is a high-level signal input, the analog switch is closed and the multivibrator circuit starts to work. The LED flashes and a buzzer alarm sounds.

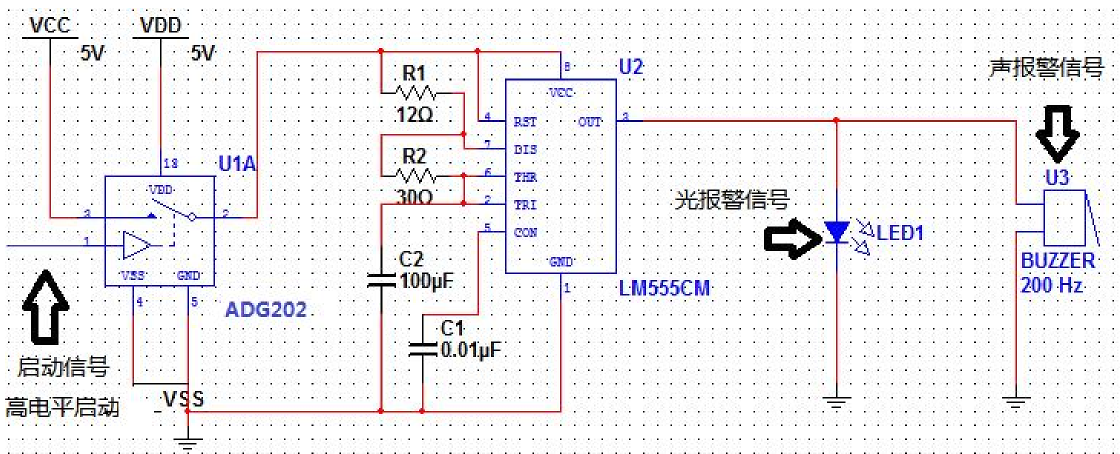

Figure 5: The circuit diagram of the module

3.1.4 Temperature control execution module design

When the input signal of the temperature control execution circuit is low level, the heating or cooling circuit does not work. When there is a high-level signal input, the heating circuit enters a temporary stable state, pin 3 outputs a high level, the relay is closed, and the heating and cooling equipment is started for heating and cooling operations. After 1 to 10 minutes (can be adjusted by sliding rheostat R3, R4 according to the actual situation), if the temperature is still lower than or higher than the set temperature, the circuit cannot be reset, pin 3 still outputs high level, and the heating or cooling operation continues. If the temperature returns to the set range, the circuit is reset to a stable state, pin 3 outputs low level, the relay is disconnected, and the heating or cooling operation stops.

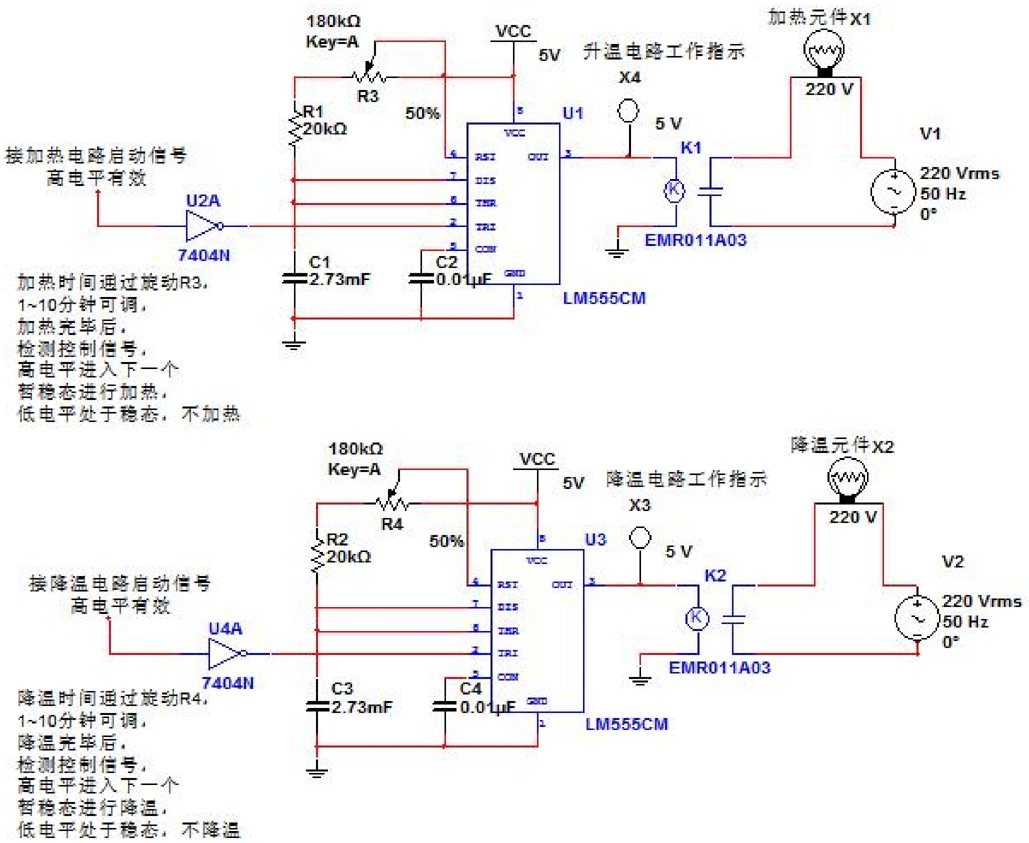

Figure 6: The circuit diagram of the module

3.2 Introduction to special devices

This system mainly uses AD574A, 74LS160D, ADG508F, and K-type hot-spot couples. The functional characteristics, main parameters, and usage methods of the devices are explained below.

3.2.1 Introduction to AD574A

AD574A is a single-chip high-speed 12-bit sequential comparison A/D converter launched by Analog. It is a hybrid integrated conversion chip composed of built-in bipolar circuits. It has the characteristics of fewer external components, low power consumption, and high accuracy. , and has automatic zero calibration and automatic polarity conversion functions. It only needs to connect a small number of external resistors and capacitors to form a complete A/D converter. Its main functional characteristics are as follows:

Resolution: 12 bits

Nonlinear error: less than ±1/2LBS or ±1LBS

Conversion rate: 25us

Analog voltage input range: 0—10V and 0—20V, 0—±5V and 0—±10V, two levels and four types

Supply voltage: ±15V and 5V

Data output format: 12 bit/8 bit
Chip working mode: full speed working mode and single working mode.

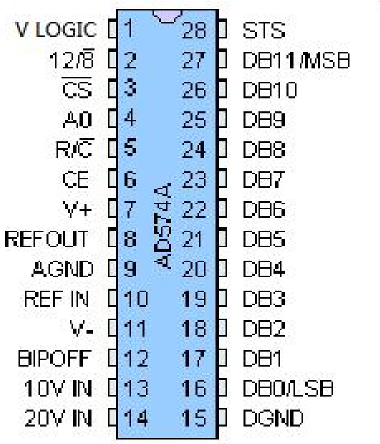

Figure 7: AD574A pin diagram

3.2.2 74LS160D device introduction

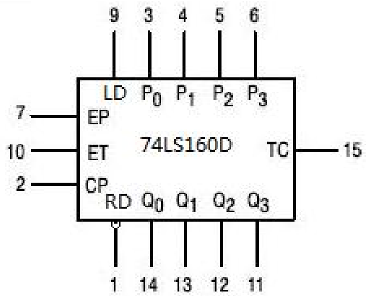

Figure 8: 74LS160D pin diagram

Table 1: 74LS160D truth table

Clear	Preset	Enable	clock	Preset data entry	Output	Operating mode
RD	LD	EP ET	CP	P3P2P1P0	Q3Q2Q1Q0	
0	X	X X	X	X X X X	0 0 0 0	Asynchronous clearing
1	0	X X	↑	p3p2p1p0	p3p2p1p0	Synchronous setting
1	1	0 X	X	X X X X	Keep	Data retention
1	1	X 0	X	X X X X	Keep	Data retention
1	1	1 1	↑	X X X X	decimal counting	Addition counting

3.2.3 ADG508F device introduction

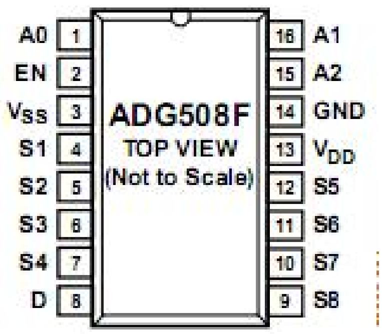

Figure 9: ADG508F pin diagram

Table 2: ADFG508F truth table

A2	A1	A0	EN	开关导通状态
X	X	X	0	None
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8

3.2.4 Introduction to K-type hot spot couple devices

The relationship between voltage and temperature of K-type hot spot couple is: U=0.226T-0.707

The temperature compensation voltage required for K-type thermocouple is: 41.269μV/K

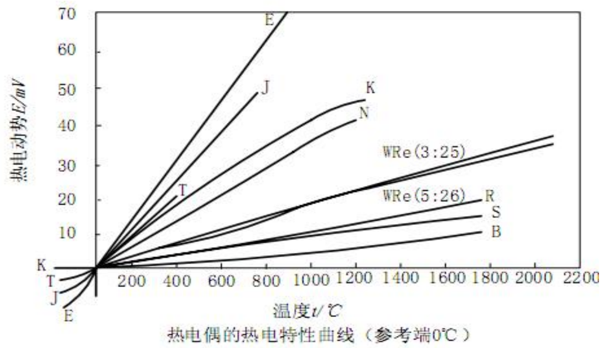

Figure 10

4. SYSTEM DEBUGGING

To achieve perfect operation of the circuit, you need to install simulation software first. Here, Multisim software is used for simulation debugging.

4.1 Debugging environment

Multisim is a Windows-based simulation tool launched by National Instruments (NI) Co., Ltd., which is suitable for board-level analog/digital circuit board design work. It includes graphical input of circuit schematic diagrams, circuit hardware description language input methods, and has rich simulation analysis capabilities. It includes graphical input of circuit schematic diagrams, circuit hardware description language input methods, and has rich simulation analysis capabilities. In order to adapt to different application scenarios, Multisim has launched many versions, and users can choose according to their own needs.

4.2 Hardware debugging

4.2.1 Simulation debugging of sound and light alarm module

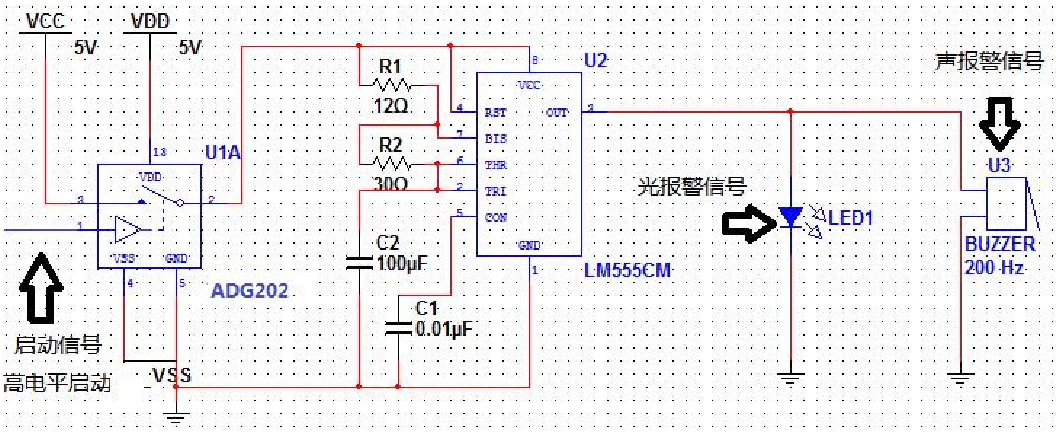

Figure 11: The circuit diagram of the module

Give high voltage to pin 1 of ADG202, observe the situation of the LED and BUZZER on the right side, stop the high voltage input, and then observe the situation on the right side: when there is a high voltage input, the LED will light up, and the BUZZER will beep.

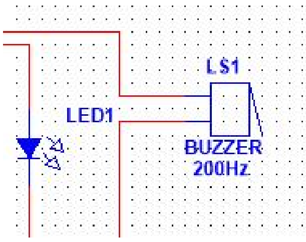

Figure 12

4.2.2 Simulation debugging of AD conversion and decoding

As shown in Figure 13, after accessing the analog signal, the 8421BCD code can be obtained.

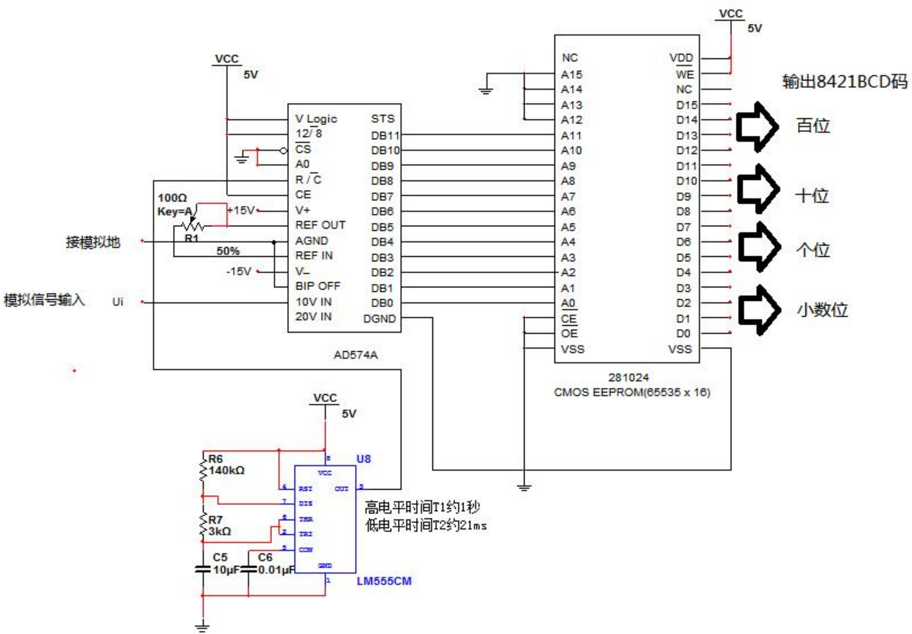

Figure 13: The circuit diagram of this module

5. SYSTEM FUNCTIONS AND INDICATOR PARAMETERS

This section mainly introduces the functions implemented by the temperature detection and control circuits and the original parameter testing of each module.

5.1 Functions that the system can implement

Implement corresponding functions in small ornamental fish tanks. It mainly has the following functions: 1. You can check the temperature of the fish tank through the temperature display. 2. Set the alarm temperature. 3. Sound and light alarm when the fish tank temperature exceeds the alarm temperature.

5.2 System indicator parameter test

For the parameter testing of this design system, each part of our circuit is simulated separately. The simulation software Multisim can be used for this simulation. After the correct results are achieved for each part of the simulation, the individual modules are then connected together for overall testing. The simulation proves that the electronic code lock circuit I designed works normally.

5.3 Analysis of system functions and indicator parameters

Through the previous parameter calculation and simulation experiments, the main parameters of each component of the system are shown in Table 3.

Table 3

S/N	Component model name	Nominal value or function	Quantity
1	AD574A	AD converter	1
2	281024	CMOS EEPROM(65535x16)	1
3	7408J	AND gate	9
4	7432N	OR gate	5
5	LM555CM	555 time base chip	4
6	74LS160D	counter	5
7	ADG508F	Analog switch	1
8	74LS48D	7-segment display decoder	5
9	SEVEN_SEG_COM_K	Seven-segment digital tube	5
10	7404N	inverter	3
11	PB_DPST	push button switch	5
12	74LS175D	4-bit latch	8
13	SPDT	SPDT switch	3
14	R、C	Common RC components	several
15	PROBE	indicator light	4
16	EMR011A03	5V relay	2
17	DC power supply	5V、15V	one of each
18	K type thermocouple	Thermocouple	1
19	LT1025	Temperature Sensor	1
20	OPAMP_3T_VIRTUAL	amplifier	2
21	ADG202	Analog switch	1
22	BZZER	buzzer	1

6. CONCLUSION

The temperature detection and control circuit designed using Multisim simulation software is like connecting lines in the laboratory and is not limited by components. Able to fully discover problems and make corrections. Design requirements can be implemented and expanded as much as possible. In this design, the basic functions of temperature detection and control circuits can be realized. However, there are still some problems in daily life. For example, the sound and light alarm cannot be stopped manually. The sound and light alarm can only stop automatically when the temperature returns to the set temperature.